KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

King County
Department of Natural Resources

September 1998
DRAFT*

AR 031748

* Note: This document contains the Department of Natural Resources proposed rules for implementing King County Adopted Ordinances 13189, 13190, and 13191. These ordinances are effective as of September 1, 1998. The proposed rules are draft pending approval by the King County Executive.

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KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

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INTRODUCTION

OVERVIEW

King County's surface water features -- the rivers, lakes, wetlands, streams, and Puget Sound -- are a significant part of our natural beauty and rich heritage. Spawning salmon, meandering rivers, and clean water are important natural resources which must be managed wisely to protect their values.

This Surface Water Design Manual contains the requirements and standards for designing surface and storm water management systems in King County. As part of the permit approval process for certain types of permits for proposed projects, King County requires the construction of surface water and storm water management systems to mitigate the impacts on natural and existing man-made drainage systems.

This manual regulates proposed projects by a mixture of requirements, performance, and design standards. Requirements are quite specific. Performance and design standards are less specific, directing the design engineer to accomplish a defined goal in a consistent manner considering site constraints, objectives of a project, and technical limitations.

These requirements and standards are enforced by the King County Department of Development and Environmental Services (DDES). DDES is responsible for the drainage review and approval of the engineering plans and for the administration of the Sensitive Areas Ordinance and Rules and all other King County codes governing development.

The Water and Land Resources (WLR) Division of the King County Department of Natural Resources is responsible for developing the requirements and standards, which includes publishing, updating and providing the technical support for this manual. The WLR Division also reviews requests for experimental design adjustments and blanket adjustments as described in Chapter 1, Section 1.4.

The chapters of this manual are organized as follows:

Chapter 1 - DRAINAGE REVIEW AND REQUIREMENTS

Describes the basic drainage requirements that implement King County adopted surface water runoff policies and explains how these requirements are applied to proposed projects through the drainage review process.

Chapter 2 - DRAINAGE PLAN SUBMITTAL

Describes the requirements and specifications for submittal of design plans for drainage review, including report and plan formats, and scopes.

Chapter 3 - HYDROLOGIC ANALYSIS AND DESIGN

Presents the acceptable methods of hydrologic analysis used to estimate runoff and design flow control, conveyance and water quality facilities.

Chapter 4 - CONVEYANCE SYSTEM ANALYSIS AND DESIGN

Presents the acceptable methods, details and criteria for analysis and design of conveyance systems.

Chapter 5 - FLOW CONTROL DESIGN

Presents the acceptable methods, details and criteria for analysis and design of flow control facilities.

Chapter 6 - WATER QUALITY DESIGN

Presents the acceptable methods, details and criteria for analysis and design of water quality facilities.

DEFINITIONS - A formal list of the words, terms and abbreviations accompanied by their meaning as applied in this manual.

APPENDICES:

APPENDIX A - MAINTENANCE REQUIREMENTS FOR PRIVATELY MAINTAINED DRAINAGE FACILITIES

Contains the frequency, thresholds and standards for maintenance of all privately maintained storm drainage facilities.

APPENDIX B - MASTER DRAINAGE PLAN OBJECTIVES, CRITERIA AND COMPONENTS AND REVIEW PROCESS

Describes in a general outline, the objectives, criteria, components and review process for Master Drainage Plans prepared for Urban Planned Developments and very large projects.

APPENDIX C - SMALL SITE DRAINAGE REQUIREMENTS (Separate Detached Publication)

Describes in a separate booklet available from the WLR Division or DDES, the simplified drainage requirements for smaller projects that qualify for small site drainage review.

APPENDIX D - EROSION & SEDIMENT CONTROL STANDARDS (Separate Detached Publication)

Describes in a separate booklet available from the WLR Division or DDES, the required measures to be implemented during construction to prevent discharges of sediment laden runoff from the project site. It also describes effective management practices which may be needed to supplement the required erosion and sedimentation control measures.

REFERENCE - Includes materials which are strictly **for reference only** and have not been adopted by the public rule adopting this manual. The applicant is responsible to insure that the most current materials are used in preparing a permit application.

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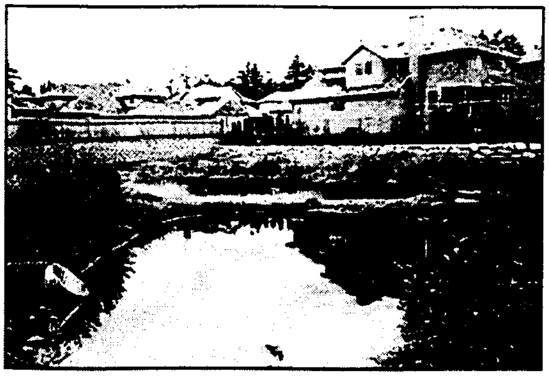
Chapter 1

CHAPTER 1

DRAINAGE REVIEW AND REQUIREMENTS



KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

CHAPTER 1

DRAINAGE REVIEW AND REQUIREMENTS

This chapter describes the drainage review procedures and types, the drainage requirements, and the adjustment procedures necessary to implement surface water runoff policies codified in Chapter 9.04 of the King County Code (KCC). It also provides direction for implementing more detailed procedures and design criteria found in subsequent chapters of this manual.

Chapter Organization

The information presented in Chapter 1 is organized into four main sections as follows:

Each of these sections begins on an odd page so that tabs can be inserted by the user if desired for quicker reference.

Key Words and Phrases

Several key words and phrases have specific definitions as they are used in this manual; those of particular importance in determining drainage requirements are listed below. These and other terms are defined in the "Definitions" section in the back of this manual. Many of these terms are also defined when first used in this chapter.

- Acceptable discharge point
- Closed depression
- Construct or modify
- Direct discharge
- Drainage area
- Equivalent area
- Existing site conditions
- Flow durations
- Flowpath
- High-use site
- Hydraulically connected
- Natural discharge area
- New impervious surface
- Pollution-generating impervious surface
- Pollution-generating pervious surface
- Project site
- Redevelopment project
- Replaced impervious surface
- Single family residential project
- Site (*see also onsite and offsite*)
- Surface flow
- Threshold discharge area

1.1 DRAINAGE REVIEW

Drainage review is the evaluation by the Department of Development and Environmental Services (DDES) permit review staff of a proposed project's compliance with the drainage requirements of this manual. During drainage review, DDES permit review staff also evaluate the proposed project for compliance with other King County requirements (which are not covered in this manual), such as those specified in the Sensitive Areas Ordinance, basin plans, and Critical Drainage Areas. If required, drainage review becomes an integral part of the overall permit review process. **This section describes when and what type of drainage review is required for a proposed project and how to determine which drainage requirements apply.**

Guide to Using Section 1.1

The following steps are recommended for efficient use of Section 1.1:

1. Determine whether your proposed project is subject to the requirements of this manual by seeing if it meets any of the thresholds for drainage review specified in Section 1.1.1 (p. 1-6). Making this determination requires an understanding of the Key Definitions listed below.
2. If drainage review is required per Section 1.1.1, use the flow chart in Figure 1.1.2.A (p. 1-7) to determine what type of drainage review will be conducted by DDES. The type of drainage review defines the scope of drainage requirements that will apply to your project as summarized in Table 1.1.2.A (p. 1-8).
3. Check the more detailed threshold information in Section 1.1.2 (beginning on page 1-7) to verify that you have determined the correct type of drainage review.
4. After verifying drainage review type, use the information in Section 1.1.2 to determine which core requirements (found in Section 1.2) and which special requirements (found in Section 1.3) must be evaluated for compliance by your project. To determine what actions are necessary to comply with each applicable core and special requirement, see the more detailed information on these requirements contained in Sections 1.2 and 1.3 of this chapter.

Note: For Steps 2 through 4, it is recommended that you arrange a predesign meeting with DDES permit review staff to confirm the type of drainage review and scope of drainage requirements that apply to your proposed project.

❑ KEY DEFINITIONS

Proper application of the drainage review thresholds in this section requires an understanding of the key definitions listed below. Other definitions can be found in the "Definitions" section of this manual.

Construct or modify: To install a new drainage pipe/ditch or make improvements to an existing drainage pipe/ditch (for purposes other than routine maintenance, repair, or emergency modifications, and excluding driveway culverts installed as part of single family residential building permits) that either serves to concentrate previously unconcentrated surface and storm water runoff or serves to increase, decrease, and/or redirect the conveyance of surface and storm water runoff.

Critical Drainage Area: An area where the Department of Natural Resources (DNR) has determined that additional drainage controls (beyond those in this manual) are needed to address a severe flooding, drainage, and/or erosion condition which poses an imminent likelihood of harm to the welfare and safety of the surrounding community. Critical Drainage Areas (CDAs) are formally adopted by administrative rule under the procedures specified in KCC 2.98. When CDAs are adopted, they are inserted in Reference Section 3 of this manual and their requirements are implemented through Special Requirement #1 (see Section 1.3.1).

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High-use site: A commercial or industrial site that (1) has an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area; (2) is subject to petroleum storage or transfer in excess of 1,500 gallons per year, not including delivered heating oil; or (3) is subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons net weight (trucks, buses, trains, heavy equipment, etc.). Also included is any road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Natural discharge area: An onsite area tributary to a single natural discharge location.

Natural discharge location: The location where runoff leaves the project site under existing site conditions.

New impervious surface: The addition of a hard or compacted surface such as roofs, pavement, gravel, or dirt, or the addition of a more compacted surface such as the paving of pre-existing dirt or gravel.

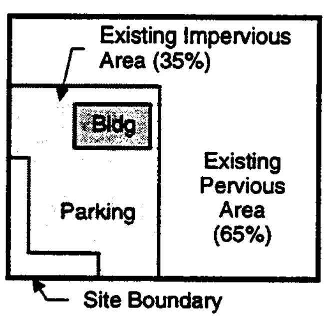
Landslide Hazard Drainage Areas: Specially mapped areas where the County has determined that overland flows from new projects will pose a significant threat to health and safety because of their close proximity to SAO-defined landslide hazard areas that are on slopes greater than 15% (a delineation of the known SAO landslide hazard areas can be found in King County's *Sensitive Areas Map Folio).* Such areas are delineated on the Landslide Hazard Drainage Areas Map adopted with this manual (see map pocket on inside of back cover).

Pollution-generating impervious surface (PGIS): Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are subject to vehicular use or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall (for more details, see page 1-50). Metal roofs are also considered to be PGIS unless they are treated to prevent leaching.

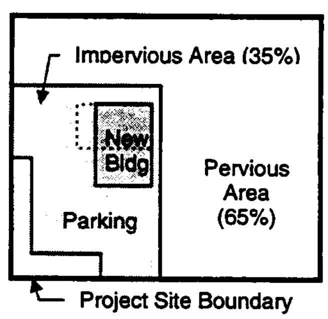
Project site: That portion of a property or properties subject to proposed project improvements including those required by this manual.

Redevelopment project: A project that proposes to add, replace, and/or alter impervious surface (for purposes other than routine maintenance, resurfacing, regrading, or repair) on a site that is already substantially developed (i.e., has 35% or more of existing impervious surface coverage). The following examples illustrate the application of this definition.

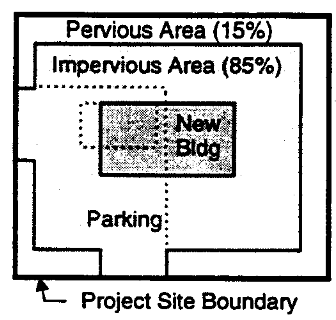
Example of an Existing Site Condition for a Redevelopment Project



Example of a Proposed Redevelopment Project that Alters Existing Impervious Surface



Example of a Proposed Redevelopment Project that Adds to Existing Impervious Surface



Replaced impervious surface: Any existing impervious surface on the project site that is proposed to be removed down to bare soil or base course and replaced with pollution-generating impervious surface, excluding impervious surface removed for the sole purpose of installing utilities.

Single family residential project: A project that constructs or modifies a single family dwelling unit and/or makes related onsite improvements, such as driveways, roads, outbuildings, play courts, etc., or a project that creates single family residential lots such as a plat or short plat.

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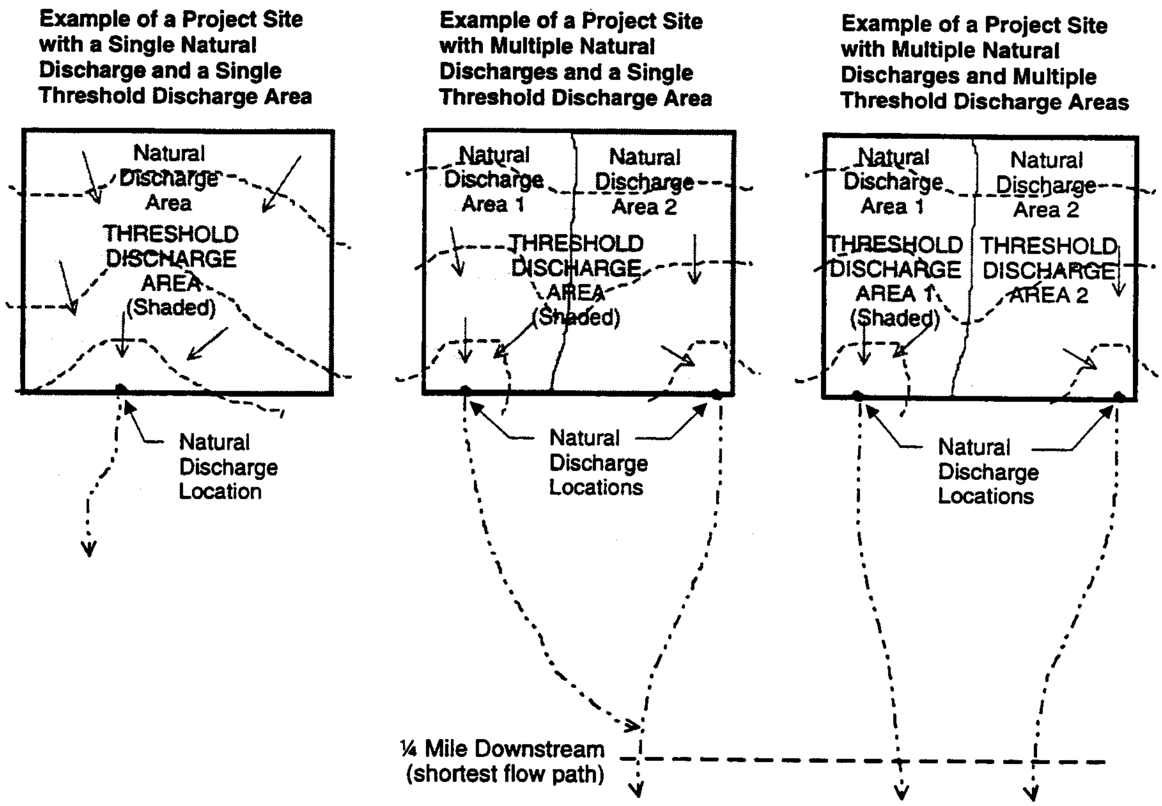
Site: The legal boundaries of the parcel or parcels of land for which an applicant has or should have applied for authority from King County to carry out a development activity, including any drainage improvements required by this manual.

Threshold discharge area: An onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter-mile downstream (as determined by the shortest flowpath). The examples below illustrate this definition. The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge points.



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1.1.1 PROJECTS REQUIRING DRAINAGE REVIEW

THRESHOLD

Drainage review is required for any proposed project (except those proposing only routine maintenance, repair, or emergency modifications) that is subject to a King County development proposal, permit, or approval listed at right, AND which meets any one of the following conditions:

1. Adds 5,000 square feet[1] or more of **new impervious surface**, OR
2. Proposes to **construct or modify** a drainage pipe/ditch that is 12 inches or more in size/depth, or receives surface and storm water runoff from a drainage pipe/ditch that is 12 inches or more in size/depth, OR
3. Contains or is adjacent to a floodplain, stream, lake, wetland, closed depression, or other **sensitive area** as defined by the Sensitive Areas Ordinance (codified in KCC 21A.24), excluding seismic, coal mining, and volcanic hazard areas, OR
4. Is located within a **Landslide Hazard Drainage Area**[2] and adds 2,000 square feet or more of new impervious surface, OR
5. Is located within a **Critical Drainage Area**,[3] OR
6. Is located within a **rural zoned area subject to areal clearing limits**[4] under KCC 16.82.150(c) and clears more than 7,000 square feet or 35% of the **site**, whichever is greater, OR
7. Is a **redevelopment project** proposing $100,000[5] or more of improvements to an existing **high-use site**, OR
8. Is a **redevelopment project** proposing $500,000 or more of site improvements and creates 5,000 square feet or more of *contiguous*[6] **pollution-generating impervious surface** through any combination of **new and/or replaced impervious surface**.

King County Permits and Approvals
Administrative Subdivision (Short Plat)
Conditional Use*
Clearing
Commercial Building
Experimental Design Adjustment*
Formal Subdivision (plat)
Franchise Utility Right-of-Way Use
Grading
Preapplication Adjustment*
Right-of-Way Use
Shoreline Substantial Development*
Single Family Residential Building
Special Use*
Unclassified Use*
Urban Planned Development
Zoning Reclassification*
Zoning Variance*
**Note: If the proposed project will require subsequent permits subject to drainage review, then DDES may allow the drainage review to be deferred until application for the later permits.*

If drainage review is required for the proposed project, the type of drainage review must be determined based on project and site characteristics as described in Section 1.1.2. The type of drainage review defines the scope of drainage requirements which must be evaluated for project compliance with this manual.

---

1 The threshold of 5,000 square feet or more of new impervious surface shall be applied by **threshold discharge area** and shall include all impervious surface that will ultimately result from the proposed project (e.g., impervious surface that will result from future homes within a plat or short plat).

2 Landslide Hazard Drainage Areas are delineated on a map adopted with this manual (see map pocket inside of back cover).

3 See Reference Section 3 for a list of Critical Drainage Areas.

4 See Reference Section 1 for a list of rural zoned areas where this threshold applies.

5 This is the "project valuation" as declared on the permit application submitted to DDES. The cost thresholds in this manual are considered to be in 1998 dollars and may be adjusted on an annual basis using the local consumer price index (CPI).

6 *Contiguous* pollution-generating impervious surface (PGIS) means a discrete patch of PGIS that is all together as opposed to being separated in different locations on the project site. The intent is to identify those redevelopment projects that are replacing and/or adding enough impervious surface in one location to allow for opportune installation of a water quality treatment facility. The threshold of 5,000 square feet or more of contiguous PGIS shall be applied by **threshold discharge area**.

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1.1.2 DRAINAGE REVIEW TYPES AND REQUIREMENTS

For most projects adding 5,000 square feet or more of impervious surface, the full range of core and special requirements contained in Sections 1.2 and 1.3 must be evaluated for compliance through the drainage review process. However, for some types of projects the scope of requirements applied is narrowed to allow more efficient, customized review. Each of the following four drainage review types tailors the review process and application of drainage requirements to a project's size, location, type of development, and anticipated impacts to the local and regional surface water system:

- Small Site Drainage Review, Section 1.1.2.1 (p. 1-9)
- Targeted Drainage Review, Section 1.1.2.2 (p. 1-10)
- Full Drainage Review, Section 1.1.2.3 (p. 1-13)
- Large Site Drainage Review, Section 1.1.2.4 (p. 1-13).

Each project requires only one of the above drainage review types, with the single exception that a project which qualifies for Small Site Drainage Review may also require Targeted Drainage Review. Figure 1.1.2.A can be used to determine which drainage review type would be required. This may entail consulting the more detailed thresholds for each review type specified in the above-referenced sections.

Table 1.1.2.A (next page) can be used to quickly identify which requirements are applied under each type of drainage review. The applicant must evaluate those requirements that are checked off for a particular drainage review type to determine what is necessary to meet compliance.

FIGURE 1.1.2.A FLOW CHART FOR DETERMINING TYPE OF DRAINAGE REVIEW REQUIRED

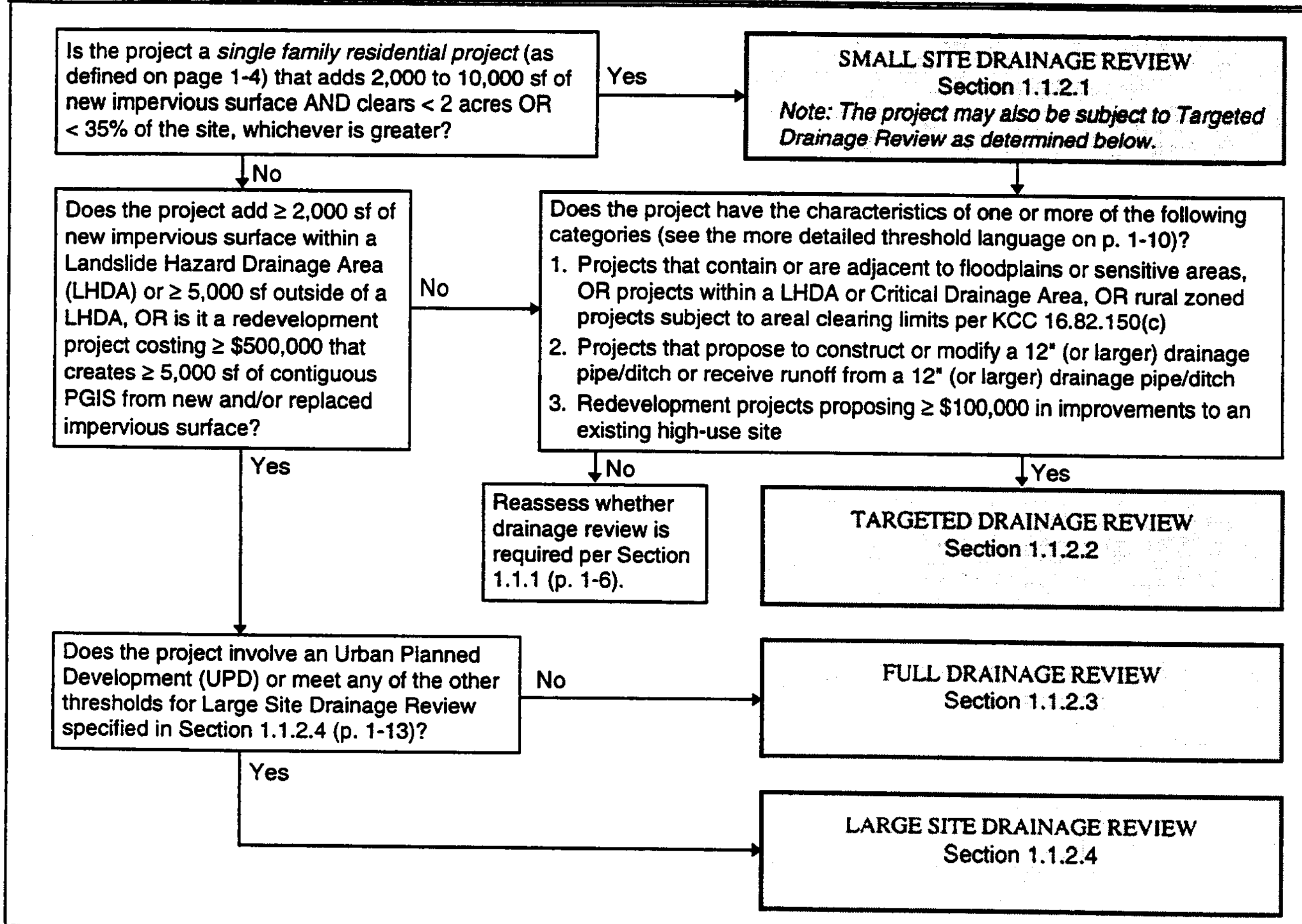

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TABLE 1.1.2.A REQUIREMENTS APPLIED UNDER EACH DRAINAGE REVIEW TYPE

	Small Site Drainage Review	Targeted Drainage Review			Full Drainage Review	Large Site Drainage Review
	Single family residential projects that add 2,000 to 10,000 sf of new impervious surface AND clear < 2 acres or < 35% of the site, whichever is greater.	Small Site projects or other small projects that are not subject to Full or Large Site Drainage Review as determined in Sections 1.1.2.3 (p. 1-13) and 1.1.2.4 (p. 1-13), AND which have the characteristics of **one or more** of the following categories of projects: 1. Projects containing or adjacent to floodplains/sensitive areas; or projects within a Landslide Hazard Drainage Area (LHDA) or Critical Drainage Area; or rural zoned projects subject to areal clearing limits per KCC 16.82.150(c) 2. Projects that propose to construct or modify a 12" (or larger) drainage pipe/ditch or receive runoff from a 12" (or larger) drainage pipe/ditch 3. Redevelopment projects proposing ≥ $100,000 in improvements to a high-use site.[1]			All projects, including redevelopment projects, that add ≥ 5,000 sf (2,000 sf within a LHDA) of new impervious surface but do not qualify for Small Site Drainage Review, OR redevelopment projects costing ≥ $500,000 that create ≥ 5,000 sf of contiguous PGIS from new and/or replaced impervious surface.	UPDs, OR projects that result in ≥ 50 acres of new impervious surface within a subbasin or multiple subbasins that are hydraulically connected, OR projects on sites ≥ 50 acres within the recharge area of a sole-source aquifer.
		Category 1	**Category 2**	**Category 3**		
SMALL SITE REQUIREMENTS	✓					
CORE REQUIREMENT #1 Discharge at Natural Location		*[2]	✓		✓	✓
CORE REQUIREMENT #2 Offsite Analysis		*[2]	✓[3]		✓[3]	✓[3]
CORE REQUIREMENT #3 Flow Control		*[2]			✓[3]	✓[3]
CORE REQUIREMENT #4 Conveyance System		*[2]	✓		✓	✓
CORE REQUIREMENT #5 Erosion & Sediment Control		✓	✓	✓	✓	✓
CORE REQUIREMENT #6 Maintenance & Operations		*[2]	✓	✓	✓	✓
CORE REQUIREMENT #7 Financial Guarantees & Liability		*[2]	✓[3]	✓[3]	✓[3]	✓[3]
CORE REQUIREMENT #8 Water Quality		*[2]			✓[3]	✓[3]
SPECIAL REQUIREMENT #1 Other Adopted Requirements		✓[3]			✓[3]	✓[3]
SPECIAL REQUIREMENT #2 Floodpln/Floodwy Delineation		✓[3]			✓[3]	✓[3]
SPECIAL REQUIREMENT #3 Flood Protection Facilities		✓[3]			✓[3]	✓[3]
SPECIAL REQUIREMENT #4 Source Control		✓[3]	✓[3]	✓[3]	✓[3]	✓[3]
SPECIAL REQUIREMENT #5 Oil Control				✓[3]	✓[3]	✓[3]

(1) Category 3 projects that install oil controls which construct or modify a 12-inch pipe/ditch are also Category 2 projects.
(2) May be applied by DDES based on project or site-specific conditions.
(3) These requirements have exemptions or thresholds which may preclude or limit their application to a specific project.

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1.1.2.1 SMALL SITE DRAINAGE REVIEW

Small Site Drainage Review is a simplified alternative to Full Drainage Review for small residential building and subdivision projects adding less than 10,000 square feet of new impervious surface and restricting site clearing to less than 2 acres or less than 35% of the site, whichever is greater. The core and special requirements applied under Full Drainage Review are replaced with simplified small site requirements which can be applied by a non-engineer. These requirements include flow control Best Management Practices (BMPs) such as setting aside open space to limit future site clearing, and using simple measures such as splash blocks and gravel trenches to disperse or infiltrate runoff from impervious areas. Also included are simple BMPs for erosion and sediment control (ESC). Formal water quality treatment is not necessary. This alternative to Full Drainage Review acknowledges that drainage impacts for many small development proposals can be effectively mitigated without construction of costly flow control and water quality facilities.

The Small Site Drainage Review process minimizes the time and effort required to design, submit, review, and approve drainage facilities for these proposals. In most cases, the requirements can be met with submittals prepared by contractors, architects, or homeowners without the involvement of a licensed civil engineer.

Threshold

THRESHOLD

Small Site Drainage Review is allowed for any project that is subject to drainage review as determined in Section 1.1.1 (p. 1-6) and that meets all of the following criteria:

- The project is a *single family residential project,*[7] AND
- The project adds 2,000 to 10,000 square feet[8] of new impervious surface, AND
- The project clears less than 2 acres or less than 35% of the site, whichever is greater.

Note: Some projects qualifying for Small Site Drainage Review may also require Targeted Drainage Review if they meet any of the threshold criteria in Section 1.1.2.2 (p. 1-10).

Any potential small site proposal may elect to go through Full Drainage Review described in Section 1.1.2.3 (p. 1-13).

Scope of Requirements

REQMTS

IF Small Site Drainage Review is allowed, THEN the applicant may apply the simplified small site submittal and drainage design requirements detailed in *Small Site Drainage Requirements* adopted as Appendix C to this manual (detached) and available as a separate booklet from DNR or DDES. These requirements include simplified BMPs for flow control and erosion and sediment control. *Note: An open space tract or covenant may be required to preserve uncleared areas.*

Exemption from Core and Special Requirements

The simplified drainage requirements applied under Small Site Drainage Review are considered sufficient to meet the overall intent of the core and special requirements in Sections 1.2 and 1.3, except under certain conditions when a proposed project has characteristics that trigger Targeted Drainage Review (see the threshold for Targeted Drainage Review in Section 1.1.2.2, p. 1-10) and may require the involvement of a licensed civil engineer. Therefore, any proposed project that qualifies for Small Site Drainage Review as determined above and complies with the small site drainage requirements detailed in Appendix C is considered exempt from all core and special requirements in Sections 1.2 and 1.3 **except** those which would apply to the project if it is subject to Targeted Drainage Review as specified in Section 1.1.2.2 (p. 1-10).

[7] *Single family residential project* is defined on page 1-4.

[8] The threshold of 10,000 square feet of new impervious surface shall be applied by **threshold discharge area** and shall include all impervious surface that will ultimately result from the proposed project (e.g., impervious surface that will result from future homes within a plat or short plat).

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1.1.2.2 TARGETED DRAINAGE REVIEW

Targeted Drainage Review (TDR) is an abbreviated evaluation by DDES permit review staff of a proposed project's compliance with selected core and special requirements. Projects subject to this type of drainage review are typically small-site proposals or other small projects that have site-specific or project-specific drainage concerns that must be addressed by a licensed civil engineer or DDES engineering review staff. Under Targeted Drainage Review, engineering costs associated with drainage design and review are kept to a minimum because the review includes only those requirements that would apply to the particular project.

Threshold

THRESHOLD

Targeted Drainage Review is required for those projects subject to drainage review as determined in Section 1.1.1 (p. 1-6), AND which are not subject to Full or Large Site Drainage Review as determined in Sections 1.1.2.3 (p. 1-13) and 1.1.2.4 (p. 1-13), AND which have the characteristics of one or more of the following project categories:

- **TDR Project Category #1:** Projects that contain or are adjacent to a floodplain, stream, lake, wetland, closed depression, or other **sensitive area** as defined by the Sensitive Areas Ordinance (codified in KCC 21A.24) excluding seismic, coal mining, and volcanic hazard areas; OR projects located within a Landslide Hazard Drainage Area[9] or a Critical Drainage Area[10]; OR projects located within a rural zoned area[11] subject to areal clearing limits under KCC 16.82.150(c) and which clear more than 7,000 square feet or 35% of the **site**, whichever is greater.
- **TDR Project Category #2:** Projects that propose to *construct or modify*[12] a drainage pipe/ditch that is 12 inches or more in size/depth or receives surface and storm water runoff from a drainage pipe/ditch that is 12 inches or more in size/depth.
- **TDR Project Category #3:** Redevelopment projects that propose $100,000 or more of improvements to an existing *high-use site.*[13]

Scope of Requirements

REQMTS

IF Targeted Drainage Review is required, THEN the applicant must demonstrate that the proposed project complies with the selected core and special requirements corresponding to the project category or categories that best match the proposed project. The project categories and applicable requirements for each are described below and summarized in Table 1.1.2.A (p. 1-8).

Note: If the proposed project has the characteristics of more than one project category, the requirements of each applicable category shall apply.

Compliance with these requirements requires submittal of engineering plans and/or calculations stamped by a licensed civil engineer registered in the state of Washington, unless deemed unnecessary by DDES. The engineer need only demonstrate compliance with those core and special requirements that have been predetermined to be applicable based on specific project characteristics as detailed below and summarized in Table 1.1.2.A (p. 1-8). The procedures and requirements for submittal of engineering plans and calculations can be found in Section 2.3.

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[9] Landslide Hazard Drainage Areas are delineated on a map adopted with this manual (see map pocket inside of back cover).

[10] See Reference Section 3 for a list of Critical Drainage Areas.

[11] See Reference Section 1 for a list of rural zoned areas where this threshold applies.

[12] *Construct and modify* is defined on page 1-3.

[13] See the full definition of high-use site on page 1-12.

TDR Project Category #1

This category includes projects that are too small to trigger application of most core requirements, but may be subject to site-specific floodplain or sensitive area requirements, or other area-specific drainage requirements adopted by the County. Such projects primarily include single family residential projects in Small Site Drainage Review.

REQMTS

IF the proposed project meets the characteristics of TDR Project Category #1, THEN the applicant must demonstrate that the project complies with the following five requirements:

- Core Requirement #5: Erosion and Sediment Control, Section 1.2.5 (p. 1-43)
- Special Requirement #1: Other Adopted Area-Specific Requirements, Section 1.3.1 (p. 1-59)
- Special Requirement #2: Floodplain/Floodway Analysis, Section 1.3.2 (p. 1-60)
- Special Requirement #3: Flood Protection Facilities, Section 1.3.3 (p. 1-61)
- Special Requirement #4: Source Control, Section 1.3.4 (p. 1-61).

In addition, **DDES may require** the applicant to demonstrate compliance with any one or more of the **remaining seven core requirements** in Section 1.2 based on project or site-specific conditions. For example, if the proposed project contains or is adjacent to a SAO-defined landslide or steep slope hazard area, DDES may require compliance with "Core Requirement #1: Discharge at the Natural Location" (Section 1.2.1, p. 1-17). This may in turn require compliance with "Core Requirement #2: Offsite Analysis" (Section 1.2.2, p. 1-19) if a tightline is required by Core Requirement #1. If a tightline is found to be unfeasible, DDES may instead require a flow control facility per "Core Requirement #3: Flow Control" (Section 1.2.3, p. 1-25). If a tightline is feasible, "Core Requirement #4: Conveyance System" (Section 1.2.4, p. 1-38) would be required to ensure proper size and design. Any required flow control facility or tightline system may also trigger compliance with "Core Requirement #6: Maintenance and Operations" (Section 1.2.6, p. 1-46), "Core Requirement #7: Financial Guarantees and Liability" (Section 1.2.7, p. 1-47), and possibly "Core Requirement #8, Water Quality" (Section 1.2.8, p. 1-49) if runoff from pollution-generating impervious surfaces is collected.

The applicant may also have to address compliance with any applicable sensitive areas requirements in KCC 21A.24 as determined by DDES.

TDR Project Category #2

This category is intended to apply selected core and special requirements to those projects that propose to construct or modify a drainage system of specified size, but are not adding sufficient impervious surface to trigger Full Drainage Review or Large Site Drainage Review.

REQMTS

IF the proposed project meets the characteristics of TDR Project Category #2, THEN the applicant must demonstrate that the proposed project complies with the following requirements:

- Core Requirement #1: Discharge at the Natural Location, Section 1.2.1 (p. 1-17)
- Core Requirement #2: Offsite Analysis, Section 1.2.2 (p. 1-19)
- Core Requirement #4: Conveyance System, Section 1.2.4 (p. 1-38)
- Core Requirement #5: Erosion and Sediment Control, Section 1.2.5 (p. 1-43)
- Core Requirement #6: Maintenance and Operations, Section 1.2.6 (p. 1-46)
- Core Requirement #7: Financial Guarantees and Liability, Section 1.2.7 (p. 1-47)
- Special Requirement #4: Source Control, Section 1.3.4 (p. 1-61).

TDR Project Category #3

This category is intended to improve water quality by applying source control and oil control requirements to redevelopment projects located on the most intensively used sites developed prior to current water quality requirements. These are referred to as *high-use sites* and are defined below.

High-Use Site Definition: A *high-use site* is any one of the following:

- A commercial or industrial site with an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area, OR
- A commercial or industrial site subject to petroleum storage or transfer in excess of 1,500 gallons per year, not including delivered heating oil, OR
- A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons net weight (e.g., trucks, buses, trains, heavy equipment, etc.), OR
- A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

IF the proposed project meets the characteristics of TDR Project Category #3, THEN the applicant must demonstrate that the proposed project complies with the following requirements:

REQMTS

- Core Requirement #5: Erosion and Sediment Control, Section 1.2.5 (p. 1-43)
- Core Requirement #6: Maintenance and Operations, Section 1.2.6 (p. 1-46)
- Core Requirement #7: Financial Guarantees and Liability, Section 1.2.7 (p. 1-47)
- Special Requirement #4: Source Control, Section 1.3.4 (p. 1-61)
- Special Requirement #5: Oil Control, Section 1.3.5 (p. 1-62).

Note: In some cases, DDES may determine that application of these requirements does not require submittal of engineering plans and calculations stamped by a licensed civil engineer. For example, if catch basin inserts are proposed to meet oil control requirements, engineered plans and calculations may not be necessary. A plot plan showing catch basin locations may suffice.

1.1.2.3 FULL DRAINAGE REVIEW

Full Drainage Review is the evaluation by DDES permit review staff of a proposed project's compliance with the full range of core and special requirements in this chapter. This review addresses the impacts associated with adding new impervious surface and changing land cover on typical sites.

Threshold

THRESHOLD

Full Drainage Review is required for any proposed projects, including redevelopment projects, that are subject to drainage review as determined in Section 1.1.1 (p. 1-6), AND which meet one or more of the following criteria:

- Projects which add 5,000 square feet or more of new impervious surface[14] but which do not qualify for Small Site Drainage Review as specified in Section 1.1.2.1 (p. 1-9), OR
- Projects located within a Landslide Hazard Drainage Area[15] which add 2,000 square feet or more of new impervious surface but which do not qualify for Small Site Drainage Review per Section 1.1.2.1, OR
- **Redevelopment projects** proposing $500,000 or more of site improvements which create 5,000 square feet or more of *contiguous pollution-generating impervious surface*[16] through any combination of new and/or *replaced impervious surface.*[17]

Scope of Requirements

REQMTS

IF Full Drainage Review is required, THEN the applicant must demonstrate that the proposed project complies with the following requirements:

- All eight core requirements in Section 1.2
- All five special requirements in Section 1.3

Engineering plans and calculations stamped by a licensed civil engineer registered in the state of Washington must be submitted to demonstrate compliance with these requirements. The procedures and requirements for submittal of engineering plans and calculations can be found in Section 2.3.

1.1.2.4 LARGE SITE DRAINAGE REVIEW

Large Site Drainage Review is applied to development proposals that are large and/or involve resources or problems of special sensitivity or complexity. Because of the large size and complexities involved, there is usually a greater risk of significant impact or irreparable damage to sensitive resources. Such proposals often require a more definitive approach to drainage requirements than that prescribed by the core and special requirements in Sections 1.2 and 1.3; it may be appropriate to collect additional information about site resources, use more sophisticated models, and prepare special studies not specified in this manual. Large Site Drainage Review entails preparation of a master drainage plan (MDP) or limited scope MDP which is reviewed and approved by DDES.

[14] The threshold of 5,000 square feet or more of new impervious surface shall be applied by **threshold discharge area** and shall include all impervious surface that will ultimately result from the proposed project (e.g., impervious surface that will result from future homes within a plat or short plat).

[15] Landslide Hazard Drainage Areas are delineated on a map adopted with this manual (see map pocket inside of back cover).

[16] *Pollution-generating impervious surface* (PGIS) is partially defined on page 1-4 and fully defined on page 1-50. *Contiguous* pollution-generating impervious surface (PGIS) means a discrete patch of PGIS that is all together as opposed to being separated in different locations on the project site. The intent is to identify those redevelopment projects that are replacing and/or adding enough impervious surface in one location to allow for opportune installation of a water quality treatment facility.

[17] *Replaced impervious surface* is defined on page 1-4.

Threshold

THRESHOLD

Large Site Drainage Review is required for any proposed project that is subject to drainage review as determined in Section 1.1.1 (p. 1-6), AND that meets any one of the following criteria:

- The project is designated for an Urban Planned Development (UPD) on the King County Comprehensive Plan Land Use Map, OR
- The project would, at full buildout, result in 50 acres or more of new impervious surface within a single subbasin or multiple subbasins that are *hydraulically connected*[18] across subbasin boundaries, OR
- The project is on a site of 50 acres or more (including open space, sensitive areas, and growth reserve) within the recharge area of a sole-source aquifer as designated by the EPA and depicted as such on the Areas Highly Susceptible to Groundwater Contamination Map adopted as part of the King County Comprehensive Plan.

Scope of Requirements

REQMTS

IF Large Site Drainage Review is required, THEN the applicant must do the following:

1. Prepare a master drainage plan (MDP), limited scope MDP, or special study in accordance with the process and requirements described in the MDP guidelines, *Master Drainage Planning for Large or Complex Site Developments,* available from DNR or DDES. The MDP or special study shall be completed, or a schedule for completion identified and agreed to by DDES, prior to permit approval. *Note: Generally, it is most efficient for the MDP process to parallel the State Environmental Policy Act (SEPA) process.*
2. Demonstrate that the proposed project complies with all the core and special requirements in Sections 1.2 and 1.3, with some potential modifications as follows:
   - Core Requirement #2, Offsite Analysis, is typically modified during MDP scoping.
   - Core Requirement #3, Flow Control, may be modified to require more sophisticated hydrologic modeling.
   - Core Requirement #5, ESC, may be modified to require enhanced construction monitoring.
   - Core Requirement #7, Financial Guarantees and Liability, may be modified to implement a monitoring fund.
   - Core Requirement #8, Water Quality, may be modified to require the water quality Resource Stream Protection menu in areas where additional fisheries protection is needed and experimental facilities may be pursued without additional adjustments.
   - Special pre- and post-development monitoring may also be required if deemed necessary by DDES to adequately characterize sensitive site and downstream resources, and to ensure that onsite drainage controls and mitigation measures are effective in protecting sensitive or critical resources. Detailed guidelines for monitoring are appended to the MDP guidelines referenced above.

[18] *Hydraulically connected* means connected through surface flow or water features such as wetlands or lakes.

1.1.3 DRAINAGE REVIEW REQUIRED BY OTHER AGENCIES

Drainage review for a proposed project's impact on surface and storm waters may be addressed by processes or requirements apart from King County's. Agencies such as those listed below may require some form of drainage review and impose drainage requirements that are separate from and in addition to King County's drainage requirements. The applicant is responsible for coordinating with these agencies and resolving any conflicts in drainage requirements. *Note: King County is required to advise the Muckleshoot Indian Tribe of development proposals affecting certain sensitive areas or water bodies bearing anadromous fish.*

Agency	Permit/Approval
Seattle/King County Department of Public Health	Onsite Sewage Disposal and Well permits
Washington State	
Department of Transportation	Developer/Local Agency Agreement
Department of Fish and Wildlife	Hydraulic Project Approval
Department of Ecology	Short Term Water Quality Modification Approval Dam Safety permit NPDES Stormwater permit
Department of Natural Resources	Forest Practices Class IV permit
United States Army Corps of Engineers	Sections 10, 401, and 404 permits

1.1.4 DRAINAGE DESIGN BEYOND MINIMUM COMPLIANCE

This manual presents King County's minimum standards for engineering and design of drainage facilities. While the County believes these standards are appropriate for a wide range of development proposals, compliance solely with these requirements does not relieve the professional engineer submitting designs of his or her responsibility to ensure drainage facilities are engineered to provide adequate protection for natural resources and public and private property.

Compliance with the standards in this manual does not necessarily mitigate all probable and significant environmental impacts to aquatic biota. Fishery resources and other living components of aquatic systems are affected by a complex set of factors. While employing a specific flow control standard may prevent stream channel erosion or instability, other factors affecting fish and other biotic resources (such as increases in stream flow velocities) are not directly addressed by this manual. Likewise, some wetlands, including bogs, are adapted to a very constant hydrological regime. Even the most stringent flow control standard employed by this manual does not prevent increases in runoff volume which can adversely affect wetland plant communities by increasing the duration and magnitude of water level fluctuations. Thus, compliance with this manual should not be construed as mitigating all probable and significant stormwater impacts to aquatic biota in streams and wetlands, and additional mitigation may be required.

In addition, the requirements in this manual primarily target the types of impacts associated with the most typical land development projects occurring in the lowland areas of the County. Applying these requirements to vastly different types of projects, such as rock quarries or dairy farms, or in different climatic situations, such as for ski areas, may result in poorer mitigation of impacts. Therefore, different mitigation may be required.

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1.2 CORE REQUIREMENTS

This section details the following eight core requirements:

- Core Requirement #1: Discharge at the Natural Location, Section 1.2.1 (p. 1-17)
- Core Requirement #2: Offsite Analysis, Section 1.2.2 (p. 1-19)
- Core Requirement #3: Flow Control, Section 1.2.3 (p. 1-25)
- Core Requirement #4: Conveyance System, Section 1.2.4 (p. 1-38)
- Core Requirement #5: Temporary Erosion and Sediment Control, Section 1.2.5 (p. 1-43)
- Core Requirement #6: Maintenance and Operations, Section 1.2.6 (p. 1-46)
- Core Requirement #7: Financial Guarantees and Liability, Section 1.2.7 (p. 1-47)
- Core Requirement #8: Water Quality, Section 1.2.8 (p. 1-49).

1.2.1 CORE REQUIREMENT #1: DISCHARGE AT THE NATURAL LOCATION

All surface and storm water runoff from a project must be discharged at the natural location so as not to be diverted onto or away from downstream properties. The manner in which runoff is discharged from the project site must not create a significant adverse impact to downhill properties or drainage systems (see "Discharge Requirements" below).

Intent: To prevent adverse impacts to downstream properties caused by diversion of flow from one flowpath to another, and to discharge in a manner that does not significantly impact downhill properties or drainage systems. Diversions can cause greater impacts (due to greater runoff volumes) than would otherwise occur from new development discharging runoff at the natural location. Diversions can also impact properties that rely on runoff water to replenish wells and ornamental or fish ponds. *Projects that do not discharge at the natural location will require an approved adjustment of this requirement (see Section 1.4).*

❑ DISCHARGE REQUIREMENTS

Proposed projects must comply with the following discharge requirements (1, 2, and 3) as applicable:

1. Where no conveyance system exists at the abutting downstream property line and the natural (existing) discharge is unconcentrated, any runoff concentrated by the proposed project must be discharged as follows:

   a) IF the 100-year peak discharge[19] is less than or equal to 0.2 cfs under existing conditions and will remain less than or equal to 0.2 cfs under developed conditions, THEN the concentrated runoff may be discharged onto a rock pad or to any other system that serves to disperse flows.

   b) IF the 100-year peak discharge is less than or equal to 0.5 cfs under existing conditions and will remain less than or equal to 0.5 cfs under developed conditions, THEN the concentrated runoff may be discharged through a dispersal trench or other dispersal system provided the applicant can demonstrate that there will be no significant adverse impact to downhill properties or drainage systems.

   c) IF the 100-year peak discharge is greater than 0.5 cfs for either existing or developed conditions, or if a significant adverse impact to downhill properties or drainage systems is likely, THEN a

[19] Peak discharges for applying this requirement are determined using KCRTS as detailed in Chapter 3.

conveyance system must be provided to convey the concentrated runoff across the downstream properties to an acceptable discharge point.[20] Drainage easements for this conveyance system must be secured from downstream property owners and recorded prior to engineering plan approval.

2. IF a proposed project or any **natural discharge area** within a project is located within a *Landslide Hazard Drainage Area*[21] and, in fact, ultimately drains over the erodible soils of a SAO-defined landslide hazard area with slopes steeper than 15%, THEN a **tightline system must be provided** through the landslide hazard area to an acceptable discharge point unless one of the following exceptions applies. The tightline system must comply with the design requirements in Core Requirement #4 and in Section 4.2.2 unless otherwise approved by DDES. Drainage easements for this system must be secured from downstream property owners and recorded prior to engineering plan approval.

   Exceptions: A tightline is not required for any **natural discharge location** where one of the following conditions can be met:

   a) Less than 2,000 square feet of new impervious surface will be added within the **natural discharge area**, OR

   b) All runoff from the **natural discharge area** will be infiltrated for runoff events up to and including the 100-year event, OR

   c) The *developed conditions runoff volume*[22] from the **natural discharge area** is less than 50% of the existing conditions runoff volume from other areas draining to the location where runoff from the natural discharge area enters the landslide hazard area onto slopes steeper than 15%, AND the provisions of Discharge Requirement 1 are met, OR

   d) DDES determines that a tightline system is not physically feasible or will create a significant adverse impact based on a soils report by a geotechnical engineer.

3. For projects adjacent to or containing SAO-defined landslide, steep slope, or erosion hazard areas, the applicant must demonstrate that onsite drainage facilities and/or flow control BMPs will not create a significant adverse impact to downhill properties or drainage systems.

[20] *Acceptable discharge point* means an enclosed drainage system (i.e., pipe system, culvert, or tightline) or open drainage feature (e.g., ditch, channel, swale, stream, river, pond, lake, or wetland) where concentrated runoff can be discharged without creating a significant adverse impact.

[21] *Landslide Hazard Drainage Areas* are areas mapped by the County where it has been determined that overland flows from new projects will pose a significant threat to health and safety because of their close proximity to SAO-defined landslide hazard areas that are on slopes steeper than 15% (see the Defininitions Section for a more detailed definition of SAO landslide hazard areas). Such areas are delineated on the Landslide Hazard Drainage Areas map adopted with this manual (see map pocket on inside of back cover).

[22] For the purposes of applying this exception, the *developed conditions runoff volume* is the average annual runoff volume as computed with KCRTS per Chapter 3. Any areas assumed not to be cleared when computing the developed conditions runoff volume must be set aside in an open space tract or covenant in order for the proposed project to qualify for this exception. Preservation of existing forested areas in Landslide Hazard Drainage Areas is encouraged.

1.2.2 CORE REQUIREMENT #2: OFFSITE ANALYSIS

REQMT

All proposed projects must submit an offsite analysis report that assesses potential offsite drainage impacts associated with development of the project site and proposes appropriate mitigations of those impacts. The initial permit submittal shall include, at minimum, a **Level 1 downstream analysis** as described in Section 1.2.2.1 below.

Intent: To identify and evaluate offsite drainage problems that may be created or aggravated by the proposed project, and to determine appropriate measures for preventing aggravation of those problems in accordance with the requirements of this manual.

The primary component of an offsite analysis report is the **downstream analysis**, which examines the drainage system within one-quarter mile downstream of the project site or farther as described in Section 1.2.2.1 below. It is intended to identify existing or potential/predictable downstream problems so that appropriate mitigation, as specified in Section 1.2.2.2 (p. 1-22), can be provided to prevent aggravation of these problems. A secondary component of the offsite analysis report is an **evaluation of the upstream drainage system** to verify and document that impacts will not occur as a result of the proposed project. The evaluation must extend upstream to a point where any backwater effects created by the project cease.

❑ EXEMPTION FROM CORE REQUIREMENT #2

A proposed project is exempt from Core Requirement #2 if any one of the following is true:

1. DDES determines there is sufficient information for them to conclude that the project will not have a significant adverse impact on the downstream and/or upstream drainage system, OR
2. The project adds less than 5,000 square feet of new impervious surface, AND does not construct or modify a drainage pipe/ditch that is 12 inches or more in size/depth or that receives runoff from a drainage pipe/ditch that is 12 inches or more in size/depth, AND does not contain or lie adjacent to a SAO-defined landslide, steep slope, or erosion hazard area, OR
3. The project does not change the rate, volume, duration, or location of discharges to and from the project site (e.g., where existing impervious surface is replaced with other impervious surface having similar runoff-generating characteristics, or where pipe/ditch modifications do not change existing discharge characteristics).

1.2.2.1 DOWNSTREAM ANALYSIS

The downstream analysis must consider the existing conveyance system(s) for a minimum flowpath distance downstream of one-quarter mile and beyond that as needed to reach a point where the project site area constitutes less than 15% of the tributary area. This minimum distance may be increased as follows:

- **Task 2** of a Level 1 downstream analysis (described in detail in Section 2.3.1.1) is a review of all available information on the downstream area and is intended to identify existing drainage problems. In all cases, **this information review shall extend one mile downstream** of the project site. The existence of flooding, erosion, or nuisance problems may extend the one-quarter-mile minimum distance for other tasks to allow evaluation of impacts from the proposed development to the identified problems.
- If a project's impacts to flooding, erosion, or nuisance problems are mitigated by improvements to the downstream conveyance system, the downstream analysis will extend a minimum of one-quarter mile beyond the improvement. This is necessary because many such improvements result in a reduction of stormwater storage or an increase in peak flows from the problem site.
- At their discretion, DDES may extend the downstream analysis beyond the minimum distance specified above on the reasonable expectation of impacts.

The **Level 1 downstream analysis** is a qualitative survey of each downstream system and is the first step in identifying flooding, erosion, or nuisance problems as defined below under "Downstream Problems Requiring Special Attention." Each Level 1 analysis is composed of four tasks at a minimum:

- Task 1: Define and map the study area
- Task 2: Review all available information on the study area
- Task 3: Field inspect the study area
- Task 4: Describe the drainage system, and its existing and predicted problems.

Upon review of the Level 1 analysis, DDES may require a Level 2 or 3 downstream analysis, depending on the presence of existing or predicted flooding, erosion, or nuisance problems identified in the Level 1 analysis.

Levels 2 and 3 downstream analysis quantify downstream problems by providing information on the severity and frequency of an existing problem or the likelihood of creating a new problem. A Level 2 analysis is a rough quantitative analysis (non-survey field data, uniform flow analysis). Level 3 is a more precise analysis (survey field data, backwater analysis) of significant problems. If conditions warrant, additional, more detailed analysis may be required beyond Level 3.

A detailed description of offsite analysis scope and submittal requirements is provided in Section 2.3.1.1. Hydrologic analysis methods and requirements for Levels 2 and 3 downstream analysis are contained in Chapter 3; hydraulic analysis methods are contained in Chapter 4.

❑ DOWNSTREAM PROBLEMS REQUIRING SPECIAL ATTENTION

While the basic flow control standards in Core Requirement #3 serve to minimize the creation and aggravation of many types of downstream drainage problems, there are some types that are more sensitive to aggravation than others depending on the nature or severity of the problem and which basic flow control standard is being applied. In particular, there are three types of downstream problems where the County has determined that the nature and/or severity of the problem warrants additional attention through the downstream analysis and possibly additional mitigation to ensure no aggravation:

1. Conveyance system nuisance problems
2. Severe erosion problems
3. Severe flooding problems.

Conveyance system nuisance problems are minor but chronic flooding or erosion problems that result from the overflow of a constructed conveyance system that is substandard or has become too small due to upstream development. Such problems warrant additional attention because of their chronic nature and because they result from the failure of a conveyance system to provide a minimum acceptable level of protection (see definition below). Severe flooding and erosion problems as defined below also warrant additional attention because they either pose a significant threat to health and safety or can cause significant damage to public or private property.

Conveyance System Nuisance Problems (Type 1)

Nuisance problems in general are defined as any existing or predicted flooding or erosion which does not constitute a severe flooding or erosion problem as defined below. Conveyance system nuisance problems are defined as any nuisance flooding or erosion that results from the overflow of a constructed conveyance system for runoff events less than or equal to a 10-year event. Examples include inundation of a shoulder or lane of a roadway, overflows collecting in yards or pastures, shallow flows across driveways, minor flooding of crawl spaces or unheated garages/outbuildings, and minor erosion.

If a conveyance system nuisance problem is identified or predicted downstream, the need for additional mitigation must be evaluated as specified in Section 1.2.2.2 under "Problem-Specific Mitigation

Requirements"(p. 1-23). This may entail additional onsite flow control or other measures as needed to prevent creation or significant aggravation of the problem.

For any other nuisance problem which may be identified downstream, this manual does not require mitigation beyond the basic flow control standard applied in Core Requirement #3. This is because to prevent aggravation of such problems (e.g., those caused by the elevated water surfaces of ponds, lakes, wetlands, and closed depressions or those involving downstream erosion) can require two to three times as much onsite detention volume, which is considered unwarranted for addressing nuisance problems. However, if under some unusual circumstance, the aggravation of such a nuisance problem is determined by DDES to be a significant adverse impact, additional mitigation may be required.

Severe Erosion Problems (Type 2)

severeSevere erosion problems are defined as downstream channels, ravines, or slopes with evidence of or potential for erosion/incision sufficient to pose a sedimentation hazard to downstream conveyance systems or pose a landslide hazard by undercutting adjacent slopes. Severe erosion problems do not include roadway shoulder rilling or minor ditch erosion.

If a severe erosion problem is identified or predicted downstream, additional mitigation must be considered as specified in Section 1.2.2.2 under "Problem-Specific Mitigation Requirements" (p. 1-23). This may entail additional onsite flow control or other measures as needed to prevent creation or aggravation of the problem.

Severe Flooding Problems (Type 3)

severeSevere flooding problems can be caused by conveyance system overflows or the elevated water surfaces of ponds, lakes, wetlands, or closed depressions. Severe flooding problems are defined as follows:

- Flooding of the *finished area*[23] of a *habitable building*,[24] or the electrical/heating system of a habitable building for runoff events less than or equal to a 100-year event. Examples include flooding of finished floors of homes and commercial or industrial buildings, or flooding of electrical/heating system components in the crawl space or garage of a home. Such problems are referred to in this manual as "**severe building flooding problems.**"
- Flooding over all lanes of a *roadway*[25] or *severely impacting a sole access driveway*[26] for runoff events less than or equal to the 100-year event. Such problems are referred to in this manual as "**severe roadway flooding problems.**"

If a severe flooding problem is identified or predicted downstream, the need for additional mitigation must be evaluated as specified in Section 1.2.2.2 under "Problem-Specific Mitigation Requirements" (p. 1-23). This may entail consideration of additional onsite flow control or other measures as needed to prevent creation or significant aggravation of the problem.

[23] *Finished area*, for the purposes of this definition, means any enclosed area of a building that is designed to be served by the building's permanent heating or cooling system.

[24] *Habitable building* means any residential, commercial, or industrial building that is equipped with a permanent heating or cooling system and an electrical system.

[25] *Roadway*, for the purposes of this definition, means the traveled portion of any public or private road or street classified as such in the *King County Road Standards*.

[26] *Sole access driveway* means there is no other unobstructed, flood-free route for emergency access to a habitable building. *Severely impacting* means the flooding overtops a culverted section of the driveway, posing a threat of washout or unsafe access conditions due to indiscernible driveway edges, or the flooding is deeper than 6 inches on the driveway, posing a severe impediment to emergency access.

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1.2.2.2 IMPACT MITIGATION

A proposed project must not significantly aggravate existing downstream problems or create new problems as a result of developing the site. This manual does not require development proposals to fix or otherwise reduce the severity of existing downstream drainage problems, although doing so may be an acceptable mitigation.

❑ PRINCIPLES OF IMPACT MITIGATION

Aggravation of an existing downstream problem means increasing the frequency of occurrence and/or severity of the problem. Increasing peak flows at the site of a problem caused by conveyance system overflows can increase the frequency of the problem's occurrence. Increasing durations of flows at or above the overflow return frequency can increase the severity of the problem by increasing the depth and duration of flooding. Controlling peaks and durations through onsite detention can prevent aggravation of such problems by releasing the increased volumes due to development only at return frequencies below the conveyance overflow return frequency, with the net result of causing the conveyance system to flow full for a longer period of time.

When a problem is caused by high water-surface elevations of a volume-sensitive water body, such as a lake, wetland, or closed depression, aggravation means the same as for problems caused by conveyance overflows. Increasing the volume of flows to a volume-sensitive water body can increase the frequency of the problem's occurrence. Increasing the duration of flows for a range of return frequencies both above and below the problem return frequency can increase the severity of the problem; mitigating these impacts requires control of flow durations for a range of return frequencies both above and below the problem return frequency. The net effect of this duration control is to release the increased volumes due to development only at water surface elevations below that causing the problem, which in turn can cause an increase in these lower, but more frequently occurring, water surface elevations. This underscores an unavoidable impact of development upstream of volume-sensitive water bodies: the increased volumes generated by the development will cause some range of increase in water surface elevations, no matter what detention standard is applied.

Creating a new problem means increasing peak flows and/or volumes such that after development, the frequency of conveyance overflows or water surface elevations exceeds the thresholds for the various problem types discussed in Section 1.2.2.1. For example, application of the Level 1 flow control standard requires matching predeveloped and developed 2- and 10-year peak flows. The 100-year peak flow is only partially attenuated, and the flow increase may be enough to cause a "severe flooding problem" as described on page 1-21. The potential for causing a new problem is often identified during the Level 1 downstream analysis, where the observation of a reduction in downstream pipe sizes, for example, may be enough to predict creation of a new problem. A Level 2 or 3 analysis will typically be required to verify the capacity of the system and determine whether 100-year flows can be safely conveyed.

❑ SIGNIFICANCE OF IMPACTS TO EXISTING PROBLEMS

The determination of whether additional onsite mitigation or other measures are needed to address an existing downstream problem depends on the significance of the proposed project's predicted impact on that problem. For some identified problems, DDES will make the determination as to whether the project's impact is significant enough to require additional mitigation. For the downstream problems defined on pages 1-21 and 1-21, this threshold of significant impact or aggravation is defined below.

For **conveyance system nuisance problems**, the problem is considered significantly aggravated if there is any *preventable increase*[27] in the frequency of occurrence and/or severity of the problem for runoff events less than or equal to the 10-year event.

[27] *Preventable increase* means the impact can be mitigated with additional onsite flow control as specified in Core Requirement #3 and further detailed in Chapter 3.

For **severe erosion problems**, the problem is considered significantly aggravated if there is any preventable increase in the *flow duration*[28] of discharge rates ranging from 50% of the 2-year peak flow up to the full 50-year peak flow to the eroded area.

For **severe building flooding problems**, the problem is considered significantly aggravated if there is any preventable increase in the frequency, depth, and/or duration of the problem for runoff events less than or equal to the 100-year event.

For **severe roadway flooding problems**, the problem is considered significantly aggravated if any of the following thresholds are exceeded and there is a preventable increase in the frequency, depth, and/or duration of the problem for runoff events less than or equal to the 100-year event:

- The *existing flooding*[29] over all lanes of a roadway or overtopping the culverted section of a "sole access driveway" is predicted to increase in depth more than a quarter-inch or 10% (whichever is greater) for the 100-year runoff event.
- The "existing flooding" over all lanes of a roadway or "severely impacting a sole access driveway" is more than 6 inches deep or faster than 5 feet per second for runoff events less than or equal to the 100-year event.
- The "existing flooding" over all lanes of a *sole access roadway*[30] is more than 3 inches deep or faster than 5 feet per second for runoff events less than or equal to the 100-year event, or is at any depth for runoff events less than or equal to the 10-year event.

❑ PROBLEM-SPECIFIC MITIGATION REQUIREMENTS

1. IF a proposed project or threshold discharge area within a project drains to one or more of the three types of downstream drainage problems defined in Section 1.2.2.1 (pages 1-21 and 1-21) as identified through a downstream analysis, THEN the applicant must do one of the following:

   a) Submit a Level 2 or Level 3 downstream analysis per Section 2.3.1 demonstrating that the proposed project will not create or significantly aggravate the identified downstream problem(s), OR

   b) Show that the proposed project (or discharge area) qualifies for an exemption from Core Requirement #3: Flow Control, OR

   c) Document that the basic area-specific flow control standard required in Core Requirement #3 is adequate to prevent creation or significant aggravation of the identified downstream problem(s) as indicated in Table 1.2.3.A (p. 1-26) with the phrase, "No additional flow control needed," OR

   d) Provide additional onsite flow control necessary to prevent creation or significant aggravation of the downstream problem(s) as specified in Table 1.2.3.A (p. 1-26) and further detailed in Section 3.3.5, OR

   e) Provide offsite improvements necessary to prevent creation or significant aggravation of the identified downstream problem(s) as detailed in Chapter 3 unless identified as not necessary in Table 1.2.3.A (p. 1-26), OR

   f) Provide a combination of additional onsite flow control and offsite improvements sufficient to prevent creation or significant aggravation of the downstream problem(s) as demonstrated by a Level 2 or Level 3 downstream analysis.

[28] *Flow duration* means the aggregate time that peak flows are at or above a particular flow rate of interest (e.g., the amount of time over the last 40 years that peak flows were at or above the 2-year flow rate).

[29] *Existing flooding*, for the purposes of this definition, means flooding over all lanes of the roadway or driveway has occurred in the past and can be verified by County records, County personnel, photographs, or other physical evidence.

[30] *Sole access roadway* means there is no other flood-free route for emergency access to one or more dwelling units.

2. IF it is identified that the manner of discharge from a proposed project may create a significant adverse impact as described in Core Requirement #1, THEN DDES may require the applicant to implement additional measures or demonstrate the impact will not occur.

Intent: To ensure provisions are made (if necessary) to prevent creation or significant aggravation of the three types of downstream problems requiring special attention by this manual, and to ensure compliance with the discharge requirements of Core Requirement #1.

In addressing downstream problems per Problem-Specific Mitigation Requirement 1 above, the easiest of the provisions to implement will often be that of additional onsite flow control. This involves designing the required onsite flow control facility to meet an additional set of performance criteria targeted to prevent significant aggravation of specific downstream problems. To save time and analysis, a set of predetermined flow control performance criteria corresponding to each of the three types of downstream problems is provided in Table 1.2.3.A (p. 1-26) and described in more detail in Chapter 3.

Note that in some cases the basic area-specific flow control standard applicable to the proposed project per Section 1.2.3.1 (p. 1-31) is already sufficient to prevent significant aggravation of many of the defined downstream problem types. Such situations are noted in Table 1.2.3.A (p. 1-26) as not needing additional onsite flow control or offsite improvements. For example, if the Level 2 flow control standard is required by Section 1.2.3.1 (p. 1-32), and a "severe erosion problem" is identified through offsite analysis per Core Requirement #2, no additional onsite flow control is needed, and no offsite improvements are necessary.

1.2.3 CORE REQUIREMENT #3: FLOW CONTROL

REQMT

All proposed projects, including redevelopment projects, must provide onsite flow control facilities to mitigate the impacts of increased storm and surface water runoff generated by the addition of new impervious surface and any related land cover conversion. These facilities shall, at a minimum, meet the performance criteria for one of the area-specific flow control standards described in Section 1.2.3.1 (p. 1-31) and be implemented according to the applicable flow control implementation requirements in Section 1.2.3.2 (p. 1-35).

Intent: To ensure the minimum level of control needed to protect downstream properties and resources from increases in peak, duration, and volume of runoff generated by new development. The level of control varies depending on location and downstream conditions identified under Core Requirement #2.

Guide to Applying Core Requirement #3

Core Requirement #3 requires that onsite detention and/or infiltration facilities be constructed to control runoff discharges from the project site. These facilities must meet a minimum flow control performance standard as set forth in Section 1.2.3.1, "Area-Specific Flow Control Standards" (page 1-31), and may need to be even larger to ensure that downstream problems are not created or significantly aggravated as set forth in Section 1.2.2.2, "Problem-Specific Mitigation Requirements" (p. 1-23). Table 1.2.3.A (p. 1-26) provides a quick guide for selecting the flow control performance criteria necessary to meet both of these requirements.

Area-specific flow control standards target the level of flow control performance to the protection needs of specific regions or areas of the county. These areas are called *flow control areas*, and there are three such areas depicted on the Flow Control Applications Map adopted with this manual (see map pocket on inside of back cover). Each flow control area has a basic flow control standard that is specific to that area. The performance criteria of that basic standard may need to be increased to address a specific downstream drainage problem as explained in Step 4 below.

Flow control implementation requirements are the minimum requirements for analyzing, designing, and maintaining flow control facilities.

For efficient application of Core Requirement #3, the following steps are recommended:

1. Use the Flow Control Applications Map to determine the flow control area in which your project is located. If this determination can not be made from the map, a more detailed delineation of flow control areas is available on King County's Geographic Information System (GIS).
2. Check the list of exemptions beginning on page 1-27 to determine if and/or which portions of your project must provide flow control facilities per Core Requirement #3.
3. If flow control facilities are required, determine (for the flow control area identified above) which area-specific flow control standard applies to your project by consulting the detailed threshold information in Section 1.2.3.1. The applicable flow control standard will determine the minimum flow control performance required for your proposed project.
4. If downstream problems were identified through offsite analysis per Core Requirement #2 and are proposed to be addressed through onsite flow control, use Table 1.2.3.A (p. 1-26) to determine if and what additional flow control performance is necessary to mitigate impacts (i.e., to prevent creation or aggravation of the identified problems).
5. Use Section 1.2.3.2 (p. 1-35) to determine the minimum requirements for implementing flow controls.

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TABLE 1.2.3.A
SUMMARY OF FLOW CONTROL PERFORMANCE CRITERIA ACCEPTABLE FOR IMPACT MITIGATION[1]

Downstream Problems Identified through Offsite Analysis per Core Requirement #2	AREA-SPECIFIC STANDARD		
	Level 1 Flow Control	**Level 2 Flow Control**	**Level 3 Flow Control**
No problem identified. Apply basic standard performance criteria.	Match 2-yr & 10-yr peaks	Match durations for 50% of 2-yr through 50-yr peaks	Match durations for 50% of 2-yr though 50-yr peaks AND match 100-year peaks
Type 1 **Conveyance System Nuisance Problem**	Additional Flow Control Hold 10-yr peak to overflow T_r peak[2][3]	*No additional flow control or other mitigation is needed*	*No additional flow control or other mitigation is needed*
Type 2 **Severe Erosion Problem**	Additional Flow Control Apply Level 2 flow control[3][4]	*No additional flow control is needed, but other mitigation may be required*[4]	*No additional flow control is needed, but other mitigation may be required*[4]
Type 3 **Severe Flooding Problem**	Additional Flow Control Apply Level 3 flow control. If flooding is from conveyance system overflow, Level 3 may be modified to match durations above the overflow T_r peak rather than 50% of the 2-yr peak. If flooding is from a closed depression, make design adjustments as needed to meet the "special provision for closed depressions"[3][5]	Additional Flow Control Apply Level 3 flow control. If flooding is from a closed depression, make design adjustments as needed to meet the "special provision for closed depressions"[3][5]	Additional Flow Control If flooding is from a closed depression, make design adjustments as needed to meet the "special provision for closed depressions"[3][5]

Notes:

(1) More than one set of problem-specific performance criteria may apply if two or more downstream problems are identified through offsite analysis per Core Requirement #2. If this happens, the performance goals of each applicable problem-specific criteria must be met. This can require extensive, time-consuming analysis to implement multiple sets of outflow performance criteria if additional onsite flow control is the only viable option for mitigating impacts to these problems. In these cases, it may be easier and more prudent to implement the **Level 3 flow control standard** in place of the otherwise required area-specific standard. Use of the Level 3 flow control standard satisfies the specified performance criteria for all the area-specific and problem-specific requirements except if adjustments are required per the special provision for closed depressions described below in Note 5.

(2) Overflow T_r is the return period of conveyance system overflow. To determine T_r requires a minimum Level 2 downstream analysis as detailed in Section 2.3.1.1. To avoid this analysis, a T_r of 2 years may be assumed.

(3) Offsite improvements may be implemented in lieu of or in combination with additional flow control as allowed in Section 1.2.2.2 (p. 1-22) and detailed in Section 3.3.5.

(4) A tightline system may be required regardless of the flow control standard being applied if needed to meet the discharge requirements of Core Requirement #1 (p. 1-17) or the outfall requirements of Core Requirement #4 (p. 1-41), or is deemed necessary by DDES where the risk of severe damage is high.

(5) **Special Provision for Closed Depressions with a Severe Flooding Problem:**
IF the proposed project discharges by overland flow or conveyance system to a closed depression experiencing a "severe flooding problem" AND the amount of impervious surface area proposed by the project is greater than or equal to 10% of the 100-year water surface area of the closed depression, THEN use the "point of compliance analysis technique" described in Section 3.3.6 to verify that water surface levels are not increasing for the return frequencies at which flooding occurs, up to and including the 100-year frequency. If necessary, iteratively adjust onsite flow control performance to prevent increases. *Note: The "point of compliance analysis" relies on certain field measurements taken directly at the closed depression (e.g., soils tests, topography, etc.). If permission to enter private property for such measurements is denied, DDES may waive this provision and apply the Level 3 flow control standard with a mandatory 20% safety factor on the storage volume.*

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❑ EXEMPTIONS FROM CORE REQUIREMENT #3

There are eight possible exemptions from the requirement to provide **a formal flow control facility** per Core Requirement #3. The intent of these exemptions is to provide for situations where a facility may not be practical or needed, where other alternatives to a facility can be just as effective, or where it makes sense to provide incentives for retaining native vegetation or for maximizing use of existing developed areas.

1. Impervious Surface Exemption

A proposed project or any **threshold discharge area** within a project is exempt if less than 5,000 square feet of new impervious surface will be added and the project or threshold discharge area is not within a Landslide Hazard Drainage Area.[31] If the project or threshold discharge area is located within a Landslide Hazard Drainage Area, this exemption only applies to new impervious surface less than 2,000 square feet.

2. Impervious Surface Exemption Using Flow Control BMPs

Any **threshold discharge area** within a proposed project is exempt if less than 10,000 square feet of new impervious surface will be added, AND all of the following criteria are met:

a) The area cleared to accommodate the proposed project must be less than 35% or less than 2 acres of the **threshold discharge area** (whichever is greater), AND

b) If the project is a **single family residential project**, flow control BMPs must be applied within the threshold discharge area as specified in *Small Site Drainage Requirements* (detached Appendix C), AND

c) For **projects other than single family residential projects**, the new impervious surface within the threshold discharge area must be comprised of either non-pollution-generating roofs that comply with the roof downspout controls in Section 5.1, OR roads, trails, or driveways that comply with the rural roadway dispersion requirements in Section 5.2.1, AND

d) The **manner in which runoff is discharged** from the project site must not create a significant adverse impact per Core Requirement #1.

3. Peak Flow Exemption Using Flow Control BMPs

Any **threshold discharge area** within a proposed project is exempt if the project improvements within the threshold discharge area generate less than a 0.1 cfs increase in the *existing site conditions*[32] 100-year peak flow rate, AND all of the following criteria are met:

a) If the project is a **redevelopment project,** flow control BMPs must be applied as specified in Section 5.2, and the project improvements must not significantly impact a "severe erosion problem" or "severe flooding problem" (see page 1-21), and must not be located within a Landslide Hazard Drainage Area, AND

b) If the project is a **single family residential project**, the runoff from impervious surfaces must be infiltrated or dispersed using flow control BMPs specified in Appendix C, and any areas of native

[31] *Landslide Hazard Drainage Areas* are delineated on a map adopted with this manual (see map pocket on inside of back cover).

[32] *Existing site conditions* depend on what, if any, land conversion activity has occurred on the site since May 1979 when King County first required flow control on developments adding more than 5,000 square feet of new impervious surface. IF a drainage plan has been approved by the County since May 1979 for any land conversion activity which includes the addition of more than 5,000 square feet of new impervious surface, THEN *existing site conditions* are those created by the site improvements and drainage facilities constructed per the approved engineering plans. OTHERWISE, *existing site conditions* are those that existed prior to May 1979 as determined from aerial photographs and, if necessary, on knowledge of individuals familiar with the area. The intent is to mitigate unaddressed impacts created by site alterations or improvements, such as clearing, which have occurred since May 1979.

vegetation assumed not to be cleared for the purposes of computing the increase in 100-year peak flow must be preserved within a tract or by covenant as described in Appendix C, AND

c) For **projects other than redevelopment projects and single family residential projects**, the new impervious surface within the threshold discharge area must be comprised of either non-pollution-generating roofs that comply with the roof downspout controls in Section 5.1, OR roads, trails, or driveways that comply with the rural roadway dispersion requirements in Section 5.2.1, AND

d) The **manner in which runoff is discharged** from the project site must not create a significant adverse impact per Core Requirement #1.

4. Peak Flow Exemption for Urban Redevelopment Projects

Any **natural discharge area** of a redevelopment project located within the Urban Growth Area is exempt if the project improvements within the natural discharge area generate less than a 0.1 cfs increase in the existing site conditions 100-year peak flow, AND all of the following criteria are met:

a) The application of this exemption to natural discharge areas within a proposed project must not result in more than a 0.4 cfs increase in the existing site conditions 100-year peak flow rate for any **threshold discharge area** of the project, AND

b) **Flow control BMPs** must be applied to the runoff from new impervious surfaces as specified in Section 5.2.1, AND

c) The project improvements within the **natural discharge area** must not be located within a Landslide Hazard Drainage Area and must not significantly impact a "**severe erosion problem**" or "**severe flooding problem**" (see page 1-21), AND

d) The **manner in which runoff is discharged** from the project site must not create a significant adverse impact per Core Requirement #1.

5. Forested Open Space Exemption for Rural Residential Projects

Any **natural discharge area** within a proposed rural residential project (zoned RA-2.5, RA-5, RA-10, or RA-20) is exempt if all of the following criteria are met:

a) At least 65% of the *unsubmerged portion*[33] of the natural discharge area will be set aside as **forested open space** as specified in Section 5.2.1, AND

b) The runoff from new impervious surfaces within the natural discharge area will be dispersed over native vegetation using the **flow control BMPs** detailed in Section 5.2.1, AND

c) The **manner in which runoff is discharged** from the project site will not create a significant adverse impact per Core Requirement #1.

6. Direct Discharge Exemption

Any **natural discharge area** within a proposed project is exempt if it drains to one of the "major receiving waters" listed in Table 1.2.3.B, AND meets all of the following criteria for *direct discharge*[34] to that receiving water:

a) The **flowpath** from the project site discharge point to the edge of the 100-year floodplain of the major receiving water shall be **no longer than a quarter mile**, except for discharges to Lake Sammamish, Lake Washington, and Puget Sound, AND

b) The conveyance system between the project site and the ordinary high water line of the major receiving water shall be **comprised of manmade conveyance elements** (pipes, ditches, outfall

[33] *Unsubmerged portion* means any portion outside the ordinary high water line of streams, lakes, and wetlands.

[34] *Direct discharge* means undetained discharge from a proposed project to a "major receiving water."

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protection, etc.) and shall be within public right-of-way or a public or private drainage easement, AND

c) The conveyance system shall have **adequate capacity** per Core Requirement #4, Conveyance System, for the entire contributing drainage area, assuming **build-out conditions** to current zoning for the "**equivalent area**" portion (defined in Figure 1.2.3.A, below) and existing conditions for the remaining area, AND

d) The conveyance system will be adequately **stabilized to prevent erosion**, assuming the same basin conditions as assumed in Criteria (c) above, AND

e) The direct discharge proposal will not divert flows from or increase flows to an existing wetland or stream sufficient to cause a significant adverse impact.

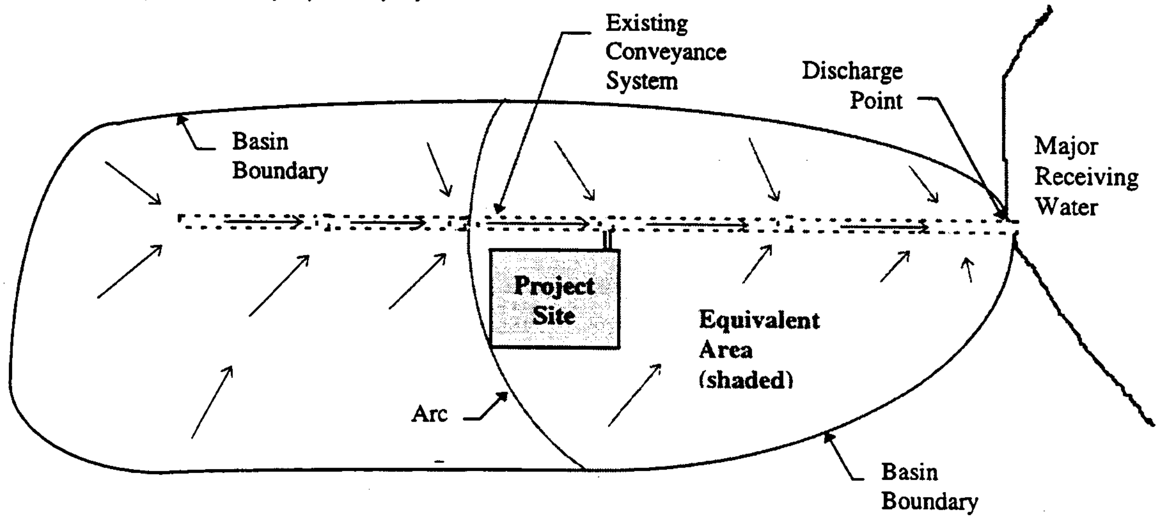
TABLE 1.2.3.B MAJOR RECEIVING WATERS

• Cedar River	• Tolt River
• Green/Duwamish River below River Mile 6 (S. Boeing Access Road) and above SR 18	• Lake Meridian
• Snoqualmie River (includes the North, South, and Middle Forks)	• Lake Sawyer
• Sammamish River	• Lake Sammamish
• White/Stuck River	• Lake Washington
• Skykomish River	• Puget Sound

Note: "Major Receiving Waters" do not include side channels, spring- or groundwater-fed streams, or wetland habitats that provide salmonid spawning or rearing habitat that may be connected or adjacent to major rivers.

FIGURE 1.2.3.A EQUIVALENT AREA DEFINITION AND ILLUSTRATION

Equivalent area: The area tributary to a direct discharge conveyance system that is contained within an arc formed by the shortest, straight line distance from the conveyance system discharge point to the furthermost point of the proposed project.



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7. Peak Flow Exemption for Urban Residential Infill Projects

Any **single family residential project** located within the Urban Growth Area is exempt if the total project improvements (within a single threshold discharge area) will generate less than a 0.4 cfs increase in the existing site conditions 100-year peak flow, AND all of the following criteria are met:

a) The surrounding area within 1/4 mile of the project site must be over **90% built-out**[35] to the zoned density as of the year 1998, AND

b) The project must be within a **Level 1 Flow Control Area** as indicated on the Flow Control Applications Map adopted with this manual or otherwise subject to Level 1 flow control (see page 1-31), AND

c) The proposed project must not drain to a **"severe flooding problem"** or **"severe erosion problem"** as defined on page 1-21, AND

d) The runoff from new impervious surfaces must be infiltrated or dispersed using **flow control BMPs** specified in Appendix C, and any areas of native vegetation assumed not to be cleared for the purposes of computing the increase in 100-year peak flow must be preserved within a tract or by covenant as described in Appendix C, AND

e) The **manner in which runoff is discharged** from the project site must not create a significant adverse impact per Core Requirement #1.

8. Discretionary Exemption for Infill Projects

Using the procedures detailed in Sections 1.4.3 and 1.4.4 of the adjustment process, the DDES Land Use Services Division Manager/designee or Building Services Division Manager/designee may grant an exemption from the flow control requirements in Core Requirement #3 provided all of the following criteria are met:

a) The catchment (defined as the tributary area to a point where the project site comprises 15% of the tributary area, or 1/4 mile downstream, whichever is greatest) is over **90% built-out** to the zoned density, AND

b) Eighty percent of the existing development within the catchment was **constructed prior to 1979** (as determined from aerial photos) or is otherwise without formal flow control, AND

c) There are no **Class 1 or 2 streams** with salmonids within 1/2 mile downstream of the project site (except streams designated as major receiving waters), AND

d) There are no **Class 1 wetlands** within 1/2 mile downstream of the project site, AND

e) There are no "**severe building flooding problems**" (see page 1-21) within 1 mile downstream of the project site, AND

f) Undetained flows from the proposed project will generate less than a 10% increase in the 10-year peak flows to a downstream "**conveyance system nuisance problem**" (see page 1-21).

[35] *Percent build-out* is defined as being the number of non-subdividable, improved (with a house) residential building lots divided by the ultimate number of lots allowable under current zoning and land-use restrictions. Publicly-owned property (e.g., parks, schools, arterial roadways, stormwater tracts) and permanent open-space areas (e.g., sensitive areas and buffers, recreational tracts) may be considered non-subdividable for the purpose of these calculations.

1.2.3.1 AREA-SPECIFIC FLOW CONTROL STANDARDS

REQMT

Projects subject to Core Requirement #3 must, **at a minimum, comply with one of the three** area-specific flow control standards: Level 1, Level 2, or Level 3, whichever applies per the threshold information detailed in this section.

❑ LEVEL 1 FLOW CONTROL

Level 1 flow control is a **peak-matching performance standard** primarily applied in areas where maintaining peak flows is sufficient to protect the natural and constructed conveyance systems that are not sensitive to development-induced increases in runoff volumes and flow durations. King County designates these areas as **Level 1 Flow Control Areas**. Most Level 1 Flow Control Areas are delineated on the Flow Control Applications Map adopted with this manual (see map pocket on inside of back cover). Any urban-zoned areas of unincorporated King County not shown on this map shall also be considered Level 1 Flow Control Areas.

Threshold

THRESHOLD

The **Level 1 flow control standard** shall be applied to the design of required flow control facilities for any proposed project which meets one of the following criteria:

- The project is located within a Level 1 Flow Control Area as defined above, OR
- The project is located within a Level 2 Flow Control Area as defined on page 1-32, but does not meet the threshold for application of the Level 2 flow control standard (see p. 1-33).

Performance Criteria

REQMT

Level 1 Flow Control: Match the developed peak discharge rates to the *existing site conditions*[36] peak discharge rates for 2- and 10-year return periods.

Reduced Level 1 Flow Control: A modified version of this standard, controlling only the 10-year frequency peak flow rate, is allowed if the applicant demonstrates both of the following:

- The proposed project site discharges to a conveyance system not subject to erosion that extends from the project discharge point to one of the major receiving waters listed in Table 1.2.3.B (p. 1-29), AND
- There is no evidence of capacity problems along this conveyance system as determined by offsite analysis per Core Requirement #2, or such problems will be resolved prior to project construction.

Intent

Level 1 flow control is intended to protect flow-carrying capacity and limit increased erosion within the downstream conveyance system for runoff events less than or equal to the 10-year event. Matching the 2- and 10-year peak flows is intended to prevent increases in return-frequency peak flows less than or equal to the 10-year peak flow down to the 2-year peak flow. This level of control is also intended to prevent creation of new "conveyance system nuisance problems" as defined in Section 1.2.2 (p. 1-21).

Effectiveness in Addressing Downstream Problems

While the Level 1 flow control standard provides reasonable protection from many development-induced conveyance problems (up to the 10-year event), it does not prevent increases in runoff volumes or flow durations that tend to aggravate the three types of downstream problems described in Section 1.2.2.1. Consequently, if one or more of these problems are identified through offsite analysis per Core Requirement #2, additional onsite flow control and/or offsite improvements will likely be required (see "Problem-Specific Mitigation Requirements" in Section 1.2.2.2, p. 1-23).

[36] *Existing site conditions* is defined in footnote 32 on page 1-27.

❑ LEVEL 2 FLOW CONTROL

Level 2 flow control is a **duration-matching performance standard** which is effective in preventing increases in existing erosion rates. The standard is applied in areas where the County has determined that a greater level of control is needed and will be effective in preventing severe erosion and sedimentation damage caused by development-induced increases in *flow durations*.[37] Such areas include those draining through SAO-defined erosion hazard areas or to salmonid-bearing streams considered sensitive to increased flow durations based on County studies or resource assessments. These areas are designated by King County as **Level 2 Flow Control Areas**, and they collectively include the following five types of special defined drainage areas and/or basin plan subbasins:

1. **Basin Plan Stream Protection Areas:** These are subbasins in adopted basin plans where the County has determined through hydrologic modeling that increases in flow durations from future development will cause erosion and sedimentation damage to salmonid-bearing streams. They are identified as requiring increased onsite detention to prevent acceleration of in-stream channel erosion as well as sediment-generating erosion in the stream's tributary areas.
2. **Rural Stream Protection Areas:** These are areas not covered by basin plans that drain to relatively undisturbed high-value resource streams on the rural side of GMA urban growth boundaries. There are nine such areas originating from a group of 17 basins identified by King County as having the highest value habitat and aquatic resources from among the county's 72 basins. The 17 basins were identified through a county-wide assessment of habitat/resource values conducted in 1994 as part of the Waterways 2000 Program. Although extensive modeling has not been done to confirm the sensitivity of these streams to increased flow durations, there is a high probability they are sensitive based on County modeling of similar streams in adopted basin plans. Given this high probability and the high value of the resource, application of Level 2 flow control in these areas is warranted. The rural portions of the following nine stream basins are designated as Rural Stream Protection Areas:
   - Tokel Creek
   - Harris Creek
   - Griffin Creek
   - Patterson Creek
   - Snoqualmie River
   - Tolt River
   - Raging River
   - Middle Green River
   - White River

   In addition to the above nine basins, any rural zoned areas of the County not shown on the Flow Control Applications Map are also considered Rural Stream Protection Areas.
3. **Sensitive Slope Protection Areas:** These are areas outside of stream protection areas that drain to those SAO-defined "erosion hazard areas" that are on slopes steeper than 15% (a delineation of all known SAO erosion hazard areas can be found in King County's *Sensitive Areas Map Folio*) and where the potential for future severe erosion is high based on the amount of upstream area yet to be developed. These areas require Level 2 flow control to prevent creation or aggravation of severe erosion problems.
4. **Landslide Hazard Drainage Areas:** These are areas both inside and outside of adopted basin plans which are mapped on the Landslide Hazard Drainage Area Map adopted with this manual (see map pocket on inside of back cover) and which drain to SAO-defined "landslide hazard areas" that are on slopes steeper than 15% (a delineation of known SAO landslide hazard areas can be found in King County's *Sensitive Areas Map Folio*). Because these hazard areas pose a significant threat to health and safety, Level 2 flow control is required and must be implemented in a manner which infiltrates as much runoff as is feasible to prevent significant disturbance of these areas by overland flows (see "Facility Requirement in Landslide Hazard Drainage Areas," Section 1.2.3.2, p. 1-37). For some

[37] *Flow duration* means the aggregate time that peak flows are at or above a particular flow rate of interest (e.g., the amount of time over the last 40 years that peak flows were at or above the 2-year flow rate).

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projects, a tightline system may be required (per Core Requirement #1) to convey runoff through the landslide hazard area. If a tightline is provided, Level 1 flow control may be applied if the project is not within a Basin Plan Stream Protection Area or a Rural Stream Protection Area as defined above, and if there are no other SAO-defined erosion or steep slope hazard areas or severe erosion problems downstream.

5. **Forest Production Zone:** These areas are typically steeper in slope and often drain to the County's most pristine streams. Level 2 flow control is therefore required to prevent creation or aggravation of severe erosion problems.

Most Level 2 Flow Control Areas are delineated on the **Flow Control Applications Map** adopted with this Manual (see map pocket on inside of back cover). Any forest production zone or rural-zoned areas of unincorporated King County not shown on this map shall also be considered Level 2 Flow Control Areas. *Note: A more detailed delineation of Level 2 Flow Control Areas, including the five component areas described above, is available on King County's Geographic Information System (GIS).*

Threshold

THRESHOLD

The **Level 2 flow control standard** shall be applied to the design of required flow control facilities for any proposed project which is located within a Level 2 Flow Control Area as defined above, AND which is confirmed to meet one of the following criteria for application of the Level 2 flow control standard:

- The project is located within a Basin Plan Stream Protection Area as defined above and confirmed by detailed delineation information in the applicable basin plan, OR
- The project is located within a Rural Stream Protection Area as defined above and, in fact, drains to a natural stream within that area, OR
- The project is located within a Sensitive Slope Protection Area as defined above and, in fact, drains over the erodible soils of a SAO-defined "erosion hazard area" with slopes steeper than 15%, OR
- The project is located within a Landslide Hazard Drainage Area as defined above and, in fact, ultimately drains over the erodable soils of a SAO-defined "landslide hazard area" with slopes steeper than 15%, OR
- The project is located within a designated Forest Production Zone.

Note: If the proposed project does not meet the above threshold criteria, then the Level 1 flow control standard shall apply as detailed on page 1-31.

Performance Criteria

REQMT

Level 2 Flow Control: Match developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow, assuming existing site conditions as the predeveloped condition. *Note: The peak-matching criteria of Level 1 flow control must also be met.*

Intent

Level 2 flow control is intended to prevent initiation or aggravation of erosion or stream channel instability by maintaining existing erosion rates. This is accomplished by maintaining at predevelopment levels the aggregate time that developed flows exceed an erosion-causing threshold (i.e., 50% of the 2-year peak flow). Maintaining existing erosion rates within streams and their tributary areas is important for preventing increases in channel erosion and sediment loading detrimental to fish habitat and production. Maintaining existing erosion rates on sensitive slopes is important for preventing initiation and/or aggravation of severe erosion problems.

Effectiveness in Addressing Downstream Problems

While the **Level 2 flow control standard** provides an excellent level of protection for preventing most development-induced problems, it does not necessarily prevent increases in 100-year peak flows which can aggravate "severe flooding problems" as defined in Core Requirement #2 (see page 1-21), nor does it necessarily prevent aggravation of all "severe erosion problems." Consequently, if one or more of these problems are identified through offsite analysis per Core Requirement #2, additional onsite flow control and/or offsite improvements will likely be required (see "Problem-Specific Mitigation Requirements" in Section 1.2.2.2, p. 1-23).

❑ LEVEL 3 FLOW CONTROL

Level 3 flow control is a **duration-matching and peak-matching performance standard** which is effective in preventing significant increases in water surface levels of lakes, wetlands, and closed depressions. The standard is primarily applied in areas that drain to certain lakes, wetlands, or closed depressions where the County has determined that a higher average level of flow control is needed to prevent aggravation of existing documented flooding problems; the County has designated such areas as **Level 3 Flow Control Areas**. Note that these areas are not specifically delineated on the Flow Control Applications Map (located inside the back cover of this manual), but they are listed on the map by name of lake, wetland code number (from the *King County Wetlands Inventory*), or approximate address.

Threshold

The **Level 3 flow control standard** shall be applied to the design of required flow control facilities for any proposed project which is located within the contributing drainage area of one of the County-inventoried wetlands or lakes listed on the Flow Control Applications (FCA) Map.

Note: If the proposed project does not meet the above threshold criteria, then apply the area-specific standard for the flow control area in which the project is located as indicated on the FCA map.

Performance Criteria

Level 3 Flow Control: Apply the Level 2 flow control standard AND match the developed 100-year peak discharge rate to the 100-year peak discharge rate for existing site conditions. *Note: The peak-matching criteria of Level 1 flow control must also be met.*

Intent

Level 3 flow control is intended to prevent significant increases in existing water surface levels for 2-year through 100-year return frequencies. Such increases are expected to occur as the volume of runoff discharging to the water body is increased by upstream development. Because inflow rates to these water bodies are typically much higher than the outflow rates, increased runoff volumes from upstream development are, in effect, stacked on top of existing volumes in the water body, resulting in higher water surface levels. The duration-matching and 100-year peak-matching criteria of the Level 3 flow control standard counteract this stacking effect by slowing the arrival of additional runoff volumes.

Effectiveness in Addressing Downstream Problems

If the Level 3 flow control standard is implemented onsite, no additional measures are required to prevent aggravation of the three types of downstream problems defined in Core Requirement #2. The one exception is when the wetland or lake is a closed depression with a "severe flooding problem," and the proposed project is adding impervious surface area amounting to more than 10% of the 100-year water surface area of the closed depression. In this case, additional onsite flow control or offsite improvements may be necessary as determined by a "point of compliance analysis" (see "Special Provision for Closed Depressions" in Table 1.2.3.A (p. 1-26), and see Section 3.3.6, "Point of Compliance Analysis").

1.2.3.2 FLOW CONTROL IMPLEMENTATION REQUIREMENTS

Onsite vs. Offsite Implementation

All required flow control must be implemented onsite except where the below requirements can be met for direct discharge to a regional or shared facility constructed to provide flow control for the proposed project. Regional facilities are typically constructed as part of a basin plan or master drainage plan. Shared facilities may be constructed under a County-developed shared facility drainage plan or under an agreement between two or more private developers.

1. The regional or shared facility must be of adequate size and design to meet the current flow control requirements for the proposed project's increased storm and surface water runoff. The requirements are those documented by an adopted King County basin plan or master drainage plan, approved shared facility drainage plan, or, for private development proposals, a detailed drainage analysis approved by the County.
2. The regional or shared facility must be fully operational at the time of construction of the proposed project. In the case of a shared facility, the proposed project must comply with the terms and conditions of all contracts, agreements, and permits associated with the shared facility.
3. The conveyance system between the project site and the regional facility must meet the same criteria specified for direct discharge to a major receiving water except for Criterion (a) (see "Direct Discharge Exemption" on page 1-28). In the case of a shared facility, the criteria are the same, except the conveyance system need only have adequate capacity and erosion protection for buildout of the *participating portion*[38] of the contributing drainage area.

Methods of Analysis and Design

Flow control facilities must be analyzed and designed using a continuous flow simulation method such as HSPF (Hydrologic Simulation Program FORTRAN) or the simplified HSPF-based runoff files method. Specifications for use of the runoff files method and associated computer program, KCRTS, are found in Chapter 3. Detailed design specifications for flow control facilities are found in Chapter 5.

Land Cover Assumptions

Land cover assumptions for designing flow control facilities are detailed in Chapter 3. For residential development (plats, short plats, and large single family projects), flow control facilities must be sized for the ultimate potential development of the site; this assumes that all forest and shrub cover (outside of proposed impervious surface areas) will be converted to grass unless protected by an open space tract or covenant. For rural residential developments, all forest/shrub cover outside of proposed impervious surface areas will be assumed to be converted to 50% pasture and 50% grass, unless likewise protected.

Roof Downspout Controls in Subdivisions

All proposed single family residential subdivision projects must, on a lot-specific basis, provide for or implement one of three types of roof downspout controls in the order of preference specified in Section 5.1. These include downspout infiltration, dispersion, or a perforated stub-out connection.

[38] The *participating portion* includes those properties that have agreements for use of the shared facility.

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Sizing Credits for Roof Downspout Controls

When sizing flow control facilities serving single family residential subdivisions, the following credits may be applied:

- Where roof runoff is infiltrated according to the requirements of Section 5.1.1, the roof area may be discounted from the net impervious area used for sizing flow control facilities.
- Where roof runoff is dispersed according to the requirements of Section 5.1.2 on lots 22,000 square feet or larger, and the vegetated flowpath of the roof runoff is 50 feet or longer, the roof area may be modeled as grass surface rather than impervious surface when sizing flow control facilities.

Note: These credits do not apply when determining eligibility for exemptions from Core Requirement #3.

Onsite Runoff Bypass

Proposed project runoff may bypass proposed onsite flow control facilities provided that all of the following are true:

1. Runoff from both the bypass area and the flow control facility converges within a quarter-mile downstream of the project site discharge point, AND
2. The flow control facility is designed to compensate for the uncontrolled bypass area such that the net effect at the point of convergence downstream is the same with or without bypass, AND
3. The 100-year peak discharge from the bypass area will not exceed 0.4 cfs, AND
4. Runoff from the bypass area will not create a significant adverse impact to downstream drainage systems or properties, AND
5. Water quality requirements applicable to the bypass area ar. met.

Offsite Bypass Requirement

IF the existing 100-year peak flow rate from any upstream offsite area is greater than 50% of the 100-year developed peak flow rate (undetained) for the project site, THEN the runoff from the offsite area must bypass onsite flow control facilities. The bypass of offsite runoff must be designed so as to achieve all of the following:

1. Any existing contribution of flows to an onsite wetland must be maintained, AND
2. Offsite flows that are naturally attenuated by the project site under predeveloped conditions must remain attenuated, either by natural means or by providing additional onsite detention so that peak flows do not increase, AND
3. Offsite flows that are dispersed or unconcentrated on the project site under predeveloped conditions must be discharged in a safe manner as described in Core Requirement #1 under "Discharge Requirements" (p. 1-17).

Manifold Detention Facilities

A *manifold detention facility* is a single detention facility designed to take the place of two or more otherwise required detention facilities. It combines the runoff from two or more onsite drainage areas having separate natural discharge points, and redistributes the runoff back to the natural discharge points following detention. Because manifold detention facilities divert flows from one natural discharge point to another and then back, they are not allowed except by an approved adjustment (see Section 1.4, "Adjustment Process").

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Facility Requirement in Landslide Hazard Drainage Areas

Proposed projects subject to Discharge Requirement 2 in Core Requirement #1 (see p. 1-18) must provide a tightline system unless the 100-year runoff from the project site can be feasibly infiltrated or one of the other exceptions listed on page 1-18 apply. For infiltration to be used as an alternative to the tightline requirement, it must be feasible per the facility design requirements and limitations specified in Section 5.4. When evaluating the feasibility of infiltration, multiple facility locations scattered throughout the project site shall be considered and used where feasible and practical to avoid concentrating infiltrated water in one location. If multiple facilities are not feasible or practical, then a single infiltration facility meeting the minimum setback requirements in Section 5.4 may be used.

Where infiltration is not feasible, a proposed project may still qualify for one of the other exceptions to the tightline requirement specified in Core Requirement #1 (p. 1-18). If such a project is subject to Core Requirement #3, then the required flow control facility must be a detention pond sized to meet Level 2 flow control performance with a safety factor of 20% applied to the storage volume. The detention pond must be sited and designed so as to maximize the opportunity for infiltration in the pond. To accomplish this, all of the following design requirements must be met:

1. The detention pond must be preceded by either a water quality treatment facility per Core Requirement #8 or a presettling basin per Section 5.4, AND
2. All detention pond side slopes must be 3H:1V or flatter and must be earthen, AND
3. Detention pond liners which impede infiltration shall not be used, AND
4. The pond bottom shall be at or above the seasonal high groundwater table, AND
5. The detention pond outflow must meet the discharge dispersal requirements specified in Discharge Requirement 1 of Core Requirement #1 (p. 1-17).

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1.2.4 CORE REQUIREMENT #4: CONVEYANCE SYSTEM

REQ MT

All engineered conveyance system elements for proposed projects must be analyzed, designed, and constructed to provide a minimum level of protection against overtopping, flooding, erosion, and structural failure as specified in the following groups of requirements:

- "Conveyance Requirements for New Systems," Section 1.2.4.1 (below)
- "Conveyance Requirements for Existing Systems," Section 1.2.4.2 (p. 1-39)
- "Conveyance System Implementation Requirements," Section 1.2.4.3 (p. 1-40)

Intent: To ensure proper design and construction of engineered conveyance system elements. *Conveyance systems* are natural and engineered drainage facilities that collect, contain, and provide for the flow of surface and storm water. This core requirement applies to the engineered elements of conveyance systems—primarily pipes, culverts, and ditches/channels.

1.2.4.1 CONVEYANCE REQUIREMENTS FOR NEW SYSTEMS

All *new conveyance system elements*,[39] both onsite and offsite, shall be analyzed, designed, and constructed according to the following requirements.

Pipe Systems

1. New pipe systems shall be designed with sufficient capacity to convey and contain (at minimum) the 25-year peak flow, assuming developed conditions for onsite tributary areas and existing conditions for any offsite tributary areas.
2. Pipe system structures may overtop for runoff events that exceed the 25-year design capacity, provided the overflow from a 100-year runoff event does not create or aggravate a "severe flooding problem" or "severe erosion problem" as defined in Core Requirement #2, Section 1.2.2 (p. 1-31). Any overflow occurring onsite for runoff events up to and including the 100-year event must discharge at the natural location for the project site. In residential subdivisions, such overflow must be contained within an onsite drainage easement, tract, covenant, or public right-of-way.
3. The upstream end of a pipe system that receives runoff from an open drainage feature (pond, ditch, etc.) shall be analyzed and sized as a culvert as described below.

Culverts

1. New culverts shall be designed with sufficient capacity to meet the headwater requirements in Section 4.3.1 and convey (at minimum) the 25-year peak flow, assuming developed conditions for onsite tributary areas and existing conditions for any offsite tributary areas.
2. New culverts must also convey as much of the 100-year peak flow as is necessary to preclude creating or aggravating a "severe flooding problem" or "severe erosion problem" as defined in Core Requirement #2, Section 1.2.2 (p. 1-31). Any overflow occurring onsite for runoff events up to and including the 100-year event must discharge at the natural location for the project site. In residential subdivisions, such overflow must be contained within an onsite drainage easement, tract, covenant, or public right-of-way.
3. New culverts proposed in Class 1 streams or Class 2 streams with salmonids shall be designed to provide for fish passage as detailed in Section 4.3.2. *Note: The SAO or the state Department of Fish and Wildlife may require a bridge to facilitate fish passage.*

[39] *New conveyance system elements* are those that are proposed to be constructed where there are no existing constructed conveyance elements.

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Ditches/Channels

1. New ditches/channels shall be designed with sufficient capacity to convey and contain, at minimum, the 25-year peak flow, assuming developed conditions for onsite tributary areas and existing conditions for any offsite tributary areas.
2. New ditches/channels must also convey as much of the 100-year peak flow as is necessary to preclude creating or aggravating a "severe flooding problem" or "severe erosion problem" as defined in Core Requirement 2, Section 1.2.2 (p. 1-31). Any overflow occurring onsite for runoff events up to and including the 100-year event must discharge at the natural location for the project site. In residential subdivisions, such overflow must be contained within an onsite drainage easement, tract, covenant, or public right-of-way.

Tightline Systems Traversing Steep Slopes

New tightline conveyance systems traversing slopes that are steeper than 15% and greater than 20 feet in height, or are a "sensitive area steep slope," shall be designed with sufficient capacity to convey and contain (at minimum) the 100-year peak flow, assuming *full build-out conditions*[40] for all tributary areas, both onsite and offsite. Tightline systems shall be designed as detailed in Section 4.2.2.

Bridges

New bridges shall be designed to pass the 100-year peak flow with clearance as specified in Section 4.3.3.

1.2.4.2 CONVEYANCE REQUIREMENTS FOR EXISTING SYSTEMS

The following conveyance requirements for existing systems are less rigorous than those for new systems to allow some salvaging of existing systems that are in useable condition. Existing systems may be utilized if they are capable of providing a minimum level of protection as-is or with minor modifications.

Existing Onsite Conveyance Systems

No Change in Flow Characteristics: Existing onsite conveyance systems that will not experience a change in flow characteristics (e.g., peak flows or volume of flows) as a result of the proposed project need not be analyzed for conveyance capacity.

Change in Flow Characteristics: Existing onsite conveyance systems that will experience a change in flow characteristics as a result of the proposed project must comply with the following conveyance requirements:

1. The existing system must be analyzed and shown to have sufficient capacity to convey and contain (at minimum) the 10-year peak flow assuming developed conditions for onsite tributary areas and existing conditions for any offsite tributary areas.
2. The applicant must demonstrate that the 100-year peak flow to the existing system will not create or aggravate a "severe flooding problem" or "severe erosion problem" as defined in Core Requirement #2, Section 1.2.2 (p. 1-31).
3. Minor modifications may be made to the conveyance system to achieve the required capacity stated above. Examples of minor modifications include raising a catch-basin rim, replacing or relaying a section of pipe to match the capacity of other pipes in the system, improving a pipe inlet, or enlarging a short, constricted reach of ditch or channel.
4. Modifications to an existing conveyance system or element which acts to attenuate peak flows due to the presence of upstream detention storage shall be made in a manner that does not significantly

[40] *Full build-out conditions* means the tributary area is developed to its full zoning potential except where there are existing sensitive areas, open space tracts, and/or native growth protection easements/covenants.

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increase peak flows downstream. For example, if water is detained in a pond upstream of a restrictive road culvert, then installing an overflow system for the culvert should prevent overtopping of the road without significantly reducing existing detention storage.

Existing Offsite Conveyance Systems

1. Existing offsite conveyance systems need not be analyzed for conveyance capacity except as required by Core Requirement #2, or if offsite improvements or direct discharge are proposed per Core Requirement #3.
2. Improvements made to existing offsite conveyance systems to address the problem-specific mitigation requirements in Section 1.2.2.2 (p. 1-23) need only change existing conveyance capacity sufficient to prevent aggravation of the drainage problem(s) being addressed.
3. Existing offsite conveyance systems proposed to be used for direct discharge to a major receiving water per Core Requirement #3 (p. 1-28) shall meet the same conveyance requirements specified in Section 1.2.4.1 (p. 1-38) for new systems.

1.2.4.3 CONVEYANCE SYSTEM IMPLEMENTATION REQUIREMENTS

Methods of Analysis and Design

Properly-sized conveyance elements provide sufficient hydraulic capacity to convey peak flows of the return frequencies indicated in Sections 1.2.4.1 and 1.2.4.2. Conveyance system element capacity shall be demonstrated by using either the uniform flow analysis or backwater analysis method described in Chapter 4. Peak flows for designing conveyance systems are to be determined through use of either the Rational Method or KCRTS model, as detailed in Section 3.2.

Spill Control Provisions

Projects proposing to construct or replace onsite conveyance system elements that receive runoff from *pollution-generating impervious surface*[41] must provide a spill control device as detailed in Section 4.2.1 prior to discharge from the project site or into a *natural onsite drainage feature.*[42] More specifically, this requirement applies whenever a proposed project does either of the following:

- Constructs a new onsite conveyance system that receives runoff from pollution-generating impervious surface, OR
- Removes and replaces an existing onsite conveyance system element that receives runoff from 5,000 square feet or more of onsite pollution-generating impervious surface.

The intent of this device is to temporarily detain oil or other floatable pollutants before they enter the downstream drainage system in the event of an accidental spill or illegal dumping. It may consist of a Tee section in a manhole or catch basin, or another alternative as specified in Section 4.2.1. *Note: Spill control devices were referred to as "oil/water separation devices" in previous editions of this manual.*

Composition

Where feasible, conveyance systems shall be constructed of vegetation-lined channels, as opposed to pipe systems. Vegetative channels shall generally be considered feasible if all of the following conditions are present:

1. The channel gradient generally does not exceed five percent, AND

[41] *Pollution-generating impervious surface* means impervious surface which is subject to vehicular use or storage of leachable materials, wastes, or chemicals, and which receives direct rainfall or the run-on or blow-on of rainfall. For more details, see page 1-50.

[42] *Natural onsite drainage feature* means a natural swale, channel, stream, closed depression, wetland, or lake.

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2. No modifications to currently adopted standard roadway cross sections in the *King County Road Standards* are necessitated by the channel, AND
3. The channel will be accessible for maintenance (see Section 1.2.6), AND
4. The channel will not be subject to erosion.

Exceptions: The following are exceptions to the requirement for vegetative channels:

- Conveyance systems proposed under roadways, driveways, or parking areas
- Conveyance systems proposed between houses in urban-zoned plats and short plats
- Conveyance systems conveying roof runoff only.

Outfalls

An *outfall* is defined as a point where collected and concentrated surface and storm water runoff is discharged from a pipe system or culvert.

Energy Dissipation: At a minimum, rock erosion protection is required at outfalls from all drainage systems and elements except where DDES determines that erosion protection is being provided by other means or is not needed. Details on outfall structures are included in Section 4.2.2.

New Point Discharges Over Steep Slopes: Proposed outfalls that will discharge runoff in a location where the natural (existing) discharge is unconcentrated over a slope steeper than 15% and greater than 20 feet in height, or over a SAO-defined steep slope hazard area, must meet the following criteria:

1. IF the 100-year peak discharge is less than or equal to 0.2 cfs[43] under existing conditions and will remain less than or equal to 0.2 cfs under developed conditions, THEN outfall runoff may be discharged onto a rock pad shaped in a manner so as to disperse flow. The outfall and rock pad must be located upstream from any landslide or steep slope buffer and no less than 50 feet from the top of a SAO-defined steep slope unless otherwise approved by DDES based on an evaluation/report by a geotechnical engineer.
2. IF the 100-year peak discharge is greater than 0.2 cfs but less than or equal to 0.5 cfs under existing conditions and will remain less than or equal to 0.5 cfs under developed conditions, THEN runoff must be conveyed to a dispersal trench or other dispersal system. The dispersal trench or system must be located upstream from any landslide or steep slope buffer and no less than 50 feet from the top of a SAO-defined steep slope unless otherwise approved by DDES based on an evaluation/report by a geotechnical engineer.
3. IF the 100-year peak discharge is greater than 0.5 cfs for either existing or developed conditions, THEN a tightline conveyance system must be constructed to convey the runoff to the bottom of the slope unless other measures are approved by DDES based on an evaluation/report by a geotechnical engineer. Tightline systems must be designed such that existing baseflow conditions are not significantly changed and adequate energy dissipation is provided at the bottom of the slope.

Outfalls to the Green River

New stormwater outfalls or modifications to existing stormwater outfalls discharging to the Green River between River Mile 6 (South Boeing Access Road) and SR 18 are allowed *only* through the adjustment process. These outfalls must comply with requirements of the Green River Pump Operations Procedure Plan, which establishes storage volumes and release rate criteria for developments proposing to construct or modify outfalls. Copies of the plan are available from DNR.

[43] Peak discharges shall be as computed using KCRTS as detailed in Chapter 3.

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Interflow and Interception

Interflow is near-surface groundwater that moves laterally through the soil horizon following the hydraulic gradient of underlying relatively impermeable soils. When interflow is expressed on the surface, it is termed a *spring* or *seepage*. Any significant springs or seepage areas that impact a roadway or structure proposed by the project must be intercepted and directed into a conveyance system. Where roadways may impede the passage of interflow to downstream wetlands or streams, provision for passage of unconcentrated flows must be made.

Pump Systems

Pump systems may be used to convey water from one location or elevation to another within the project site provided they meet the design criteria specified for such systems in Section 4.2.3 and will be privately owned and maintained.

Pump systems that discharge flows from the project site that would not have discharged by gravity flow under existing site conditions will require an approved adjustment to Core Requirement #1 (see Section 1.4, "Adjustment Process"). These pump systems will be considered only when they are the sole alternative to solving a flooding or erosion problem as defined in Section 1.2.2. Typical conditions of approval for these systems are available in Reference Section 8-J under "Adjustment Application Form and Process Guidelines."

1.2.5 CORE REQUIREMENT #5: EROSION AND SEDIMENT CONTROL

R E Q M T

All proposed projects that will clear, grade, or otherwise disturb the site must provide erosion and sediment controls to prevent, to the maximum extent possible, the transport of sediment from the project site to downstream drainage facilities, water resources, and adjacent properties. To prevent sediment transport, **Erosion and Sediment Control (ESC)** measures are required and shall perform as described in Section 1.2.5.2. Both temporary and permanent erosion and sediment controls shall be implemented as described in Section 1.2.5.3.

Intent: To prevent the transport of sediment to streams, wetlands, lakes, drainage systems, and adjacent properties. Erosion on construction sites can result in excessive sediment transport to adjacent properties and to surface waters. Sediment transport can result in major adverse impacts, such as flooding due to obstructed drainageways, smothering of salmonid spawning beds, and creation of algal blooms in lakes.

1.2.5.1 ESC MEASURES

The following ESC measures shall be provided as specified below and as further detailed in the King County *Erosion and Sediment Control (ESC) Standards,* adopted as Appendix D of this manual:

- **Clearing Limits:** Prior to any site clearing or grading, areas to remain undisturbed during project construction shall be delineated. At a minimum, clearing limit delineation flagging shall be provided at the edges of all sensitive area buffers.
- **Cover Measures:** Temporary and permanent cover measures shall be provided when necessary to protect disturbed areas. Temporary cover shall be installed if an area is to remain unworked for more than seven days during the dry season (May 1 to September 30) or for more than two days during the wet season (October 1 to April 30), unless otherwise determined by the County. Any area to remain unworked for more than 30 days shall be seeded or sodded, unless the County determines that winter weather makes vegetation establishment unfeasible. **During the wet season, slopes and stockpiles 3H:1V or steeper with more than 10 feet of vertical relief** shall be covered if they are to remain unworked for more than 12 hours. The intent of these measures is to prevent erosion by having as much area as possible covered during any period of precipitation.
- **Perimeter Protection:** When necessary, perimeter protection to filter sediment from sheet flow shall be provided downstream of all disturbed areas. Perimeter protection includes the use of vegetated strips, as well as more conventional constructed measures such as silt fences. Such protection shall be installed prior to upstream grading.
- **Traffic Area Stabilization:** Unsurfaced entrances, roads, and parking areas used by construction traffic shall be stabilized to minimize erosion and tracking of sediment offsite.
- **Sediment Retention:** Surface water collected from disturbed areas of the site shall be routed through a sediment pond or trap prior to release from the site. This does not apply to areas at the perimeter of the site small enough to be treated solely with perimeter protection. Sediment retention facilities shall be installed prior to grading any contributing area.
- **Surface Water Controls:** Surface water controls shall be installed to intercept all surface water from disturbed areas, convey it to a sediment pond or trap, and discharge it downstream of any disturbed areas. However, areas at the perimeter of the site which are small enough to be treated solely with perimeter protection do not require surface water controls. Significant sources of upstream surface water that drain onto disturbed areas shall be intercepted and conveyed to a stabilized discharge point downstream of the disturbed areas. Surface water controls shall be installed concurrently with or immediately following rough grading.

- **Dust Control:** Preventative measures to minimize wind transport of soil shall be implemented when a traffic hazard may be created or when sediment transported by wind is likely to be deposited in water resources.

1.2.5.2 ESC PERFORMANCE

The above ESC measures shall be applied and maintained so as to prevent, to the maximum extent possible, the transport of sediment from the project site or into onsite wetlands, streams, or lakes. This performance is intended to be achieved through proper selection, installation, and operation of the above ESC measures as detailed in the *ESC Standards* (detached Appendix D) and approved by the County. However, the County may determine at any time during construction that such approved measures are not sufficient and additional action is required based on one of the following criteria:

1. IF a **sieve test** of storm and surface water discharges indicates that sand-sized sediment (soil particles coarser than the #200 sieve, 0.075 mm) is leaving the project site or entering onsite wetlands, streams, or lakes, THEN corrective actions and/or additional measures beyond those specified in Section 1.2.5.1 shall be implemented as deemed necessary by the County. *Note: The County can require that the ESC supervisor have a #200 sieve on site. Also, "leaving the project site" will be interpreted liberally. For example, if this criterion is applied to individual lots within a subdivision, it may, depending on the site, be appropriate to conduct the sieve test at the outlet of the drainage system rather than at the edge of the lot.*
2. IF the County determines that the condition of the construction site poses a **hazard to adjacent property** or may **adversely impact drainage facilities or water resources,** THEN additional measures beyond those specified in Section 1.2.5.1 can be required by the County.

1.2.5.3 IMPLEMENTATION REQUIREMENTS

ESC Plan

As specified in Chapter 2, all proposed projects must submit a plan for providing ESC measures. The ESC plan shall include a detailed construction sequence as proposed by the design engineer and shall identify required ESC measures. All ESC measures shall conform to the details and specifications in the *ESC Standards* unless an alternative is approved by King County (see "Alternative and Experimental Measures" in the *ESC Standards*, detached Appendix D). The ESC plan shall be accompanied by any calculations or information necessary to size ESC measures and demonstrate compliance with Core Requirement #5. The County may require large, complex projects to phase construction and to submit multiple ESC plans for the different stages of construction. Development of new ESC plans is not required for changes that are necessary during construction.

Wet Season Construction

During the wet season (October 1 to April 30) any site with exposed soils shall be subject to the "Wet Season Requirements" contained in the *ESC Standards*. In addition to the ESC cover measures, these provisions include covering any newly-seeded areas with mulch and seeding as much disturbed area as possible during the first week of October in order to provide grass cover for the wet season.

Construction within Sensitive Areas and Buffers

Any construction that will result in disturbed areas on or within a stream or associated buffer, within a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake shall be subject to the "Sensitive Area Restrictions" contained in the *ESC Standards*. These provisions include phasing the project whenever possible so that construction in these areas is limited to the dry season.

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Maintenance

All ESC measures shall be maintained and reviewed on a regular basis as prescribed in the *ESC Standards.* The applicant shall designate an ESC supervisor who shall be responsible for maintenance and review of ESC measures and for compliance with all permit conditions relating to ESC as described in the *ESC Standards.*

Final Stabilization

Prior to obtaining final construction approval, the site shall be stabilized, structural ESC measures (such as silt fences and sediment traps) shall be removed, and drainage facilities shall be cleaned as specified in the *ESC Standards.*

Flexible Compliance

Some projects may meet the intent of Core Requirement #5 while varying from specific ESC requirements contained here and in the *ESC Standards.* If a project is designed and constructed such that it meets the intent of this core requirement, the County may determine that strict adherence to a specific ESC requirement is unnecessary; an approved adjustment (see Section 1.4) is not required in these circumstances. Certain types of projects are particularly likely to warrant this greater level of flexibility; for instance, projects on relatively flat, well drained soils, projects that are constructed in closed depressions, or projects that only disturb a small percentage of a forested site may meet the intent of this requirement with very few ESC measures. More information on intent and general ESC principles is contained in the *ESC Standards.*

Roads and Utilities

Road and utility projects often pose difficult erosion control challenges because they frequently cross surface waters and are long and narrow with limited area available to treat and store sediment-laden water. Because of these factors, road and utility projects are allowed greater flexibility in meeting the intent of Core Requirement #5 as described in the *ESC Standards.* Projects that pose a very low risk of erosion or sediment transport due to site conditions or project scope may also warrant greater flexibility.

Consideration of Other Required Permits

Consideration should be given to the requirements and conditions which may be applied by other agencies as part of other permits required for land-disturbing activities. In particular, the following permits may be required and should be considered when implementing ESC measures:

- A **Class IV Special Forest Practices Permit** is required by the Washington State Department of Natural Resources for projects that will clear more than two acres of forest or 5,000 board feet of timber. All such clearing is also subject to the State Environmental Policy Act (RCW 43.21C) and will require SEPA review. King County assumes lead agency status for Class IV permits, and the application can be consolidated with the associated King County development permit or approval.
- A **NPDES[44] General Permit for Construction** (pursuant to the Washington State Department of Ecology's Baseline General Permit for Stormwater) is required for projects that will disturb more than five acres. The five-acre threshold applies even where the five acres are to be disturbed in phases, as long as the construction is "part of a larger common plan of development or sale."

[44] *NPDES* stands for National Pollutant Discharge Elimination System.

1.2.6 CORE REQUIREMENT #6: MAINTENANCE AND OPERATIONS

REQMT

Maintenance and operation of all drainage facilities is the responsibility of the applicant or property owner, except those facilities for which King County is granted an easement, tract, or right-of-way and officially assumes maintenance and operation as described below. Drainage facilities must be maintained and operated in compliance with King County maintenance standards.

Intent: To ensure that the maintenance responsibility for drainage facilities is clearly assigned and that these facilities will be properly maintained and operated in perpetuity.

Drainage Facilities to be Maintained by King County

King County will assume maintenance and operation[45] of the flow control and water quality facilities and the conveyance system within improved public road right-of-way for any residential subdivision with two or more lots, and any similar development where at least two-thirds of the developed contributing area is from single family or duplex residential structures on individual lots, except where such facilities are approved by King County to be maintained by the homeowners association. *Note: King County may assume maintenance of such facilities serving any mix of developments as part of a shared facilities plan.*

King County **will assume maintenance** and operation of these facilities **two years after final construction approval** by DDES and an inspection by the County to ensure the facilities have been properly maintained and are operating as designed.

Flow control and water quality facilities to be maintained and operated by King County must be located in a tract or right-of-way dedicated to King County. Access roads serving these facilities must also be located in the tract or right-of-way and must be connected to an improved public road right-of-way. Underground flow control or water quality facilities (tanks or vaults) may be allowed in private rights-of-way or roads if the easement includes provisions for facility access and maintenance.

Conveyance systems to be maintained and operated by King County must be located in a drainage easement, tract, or right-of-way granted to King County. *Note: King County does not normally assume maintenance responsibility for conveyance systems which are outside of improved public road right-of-way.*

Drainage Facilities to be Maintained by Private Parties

All privately-maintained drainage facilities must be maintained as specified in **Appendix A**, "Maintenance Requirements for Privately Maintained Drainage Facilities," and as further prescribed in **Chapter 6** for water quality facilities. A copy of the **Operation and Maintenance Manual** submitted as part of the permit application (see Section 2.3.1) shall be retained on site and shall be transferred with the property to the new owner. A log of maintenance activity indicating when cleaning occurred and where waste was disposed of shall also be kept by the owner and be available for inspection by the County. King County may inspect all privately-maintained drainage facilities for compliance with these requirements. If property owner(s) fail to maintain their facilities to the acceptable standards, the County may issue a written notice specifying the required actions. If these actions are not performed in a timely manner, the County may enter the property to perform the actions needed and bill the property owner(s) for the cost of the actions. In the event a hazard to public safety exists, written notice may not be required.

If the proposed project is a commercial, industrial, or multifamily development or redevelopment, or a single family residential building permit, a "**Declaration of Covenant**" (see Reference Section 8-F) must be recorded at the King County Office of Records and Elections prior to engineering plan approval.

If the proposed project is a **residential subdivision development**, all privately maintained conveyance systems or other drainage facilities which convey flows through private property must be located in a

[45] King County does not assume maintenance of lot drainage systems or drainage stub-outs serving single family residential lot downspout, footing, or yard drains, nor does King County assume maintenance of those water quality facilities installed and integrated into site landscaping.

drainage easement dedicated to convey surface and storm water. Individual owners of the properties containing such easements must maintain the drainage facilities through their property. The legal instrument creating drainage easements on private property must contain language that requires a private property owner to obtain written approval from King County prior to removing vegetation (except by routine mowing) from any drainage easement containing open, vegetated drainage facilities (such as swales, channels, ditches, ponds, etc.). See "Drainage Easements" in Reference Section 8-H.

1.2.7 CORE REQUIREMENT #7: FINANCIAL GUARANTEES AND LIABILITY

REQMT

All drainage facilities constructed or modified for projects (except downspout infiltration and dispersion systems) must comply with the financial guarantee requirements in King County Ordinance 12020 and the liability requirements of King County Code 9.04.100. There are two types of financial guarantees for projects constructing or modifying drainage facilities: the drainage facilities restoration and site stabilization guarantee, and the drainage defect and maintenance guarantee.

Intent: To ensure financial guarantees are posted to sufficiently cover the cost of correcting, if necessary, incomplete or substandard drainage facility construction work, and to warrant for two years the satisfactory performance and maintenance of those newly-constructed drainage facilities to be assumed by King County for maintenance and operation. Core Requirement #7 is also intended to ensure that a liability policy is provided which protects the proponent and the County from any damages relating to the construction or maintenance of required drainage facilities by private parties.

Drainage Facilities Restoration and Site Stabilization Financial Guarantee

Prior to commencing construction, the applicant required to construct drainage facilities pursuant to the drainage requirements in this manual and KCC 9.04.050 must post a drainage facilities restoration and site stabilization financial guarantee. This guarantee must be an amount sufficient to cover the cost of corrective work on or off the site performed specifically for the given project. *Note: DDES may waive the requirement of this guarantee on projects proposing only minor modifications or improvements to the drainage system (e.g., catch basin inserts, spill control devices, pipe replacements, etc.). In addition, this guarantee may be combined with other required guarantees as allowed in Ordinance 12020.*

Before King County will release the project's drainage facilities restoration and site stabilization financial guarantee, the applicant must do the following:

1. Construct the drainage facilities
2. Receive final construction approval from DDES
3. Pay all required fees.

Drainage Defect and Maintenance Financial Guarantee

For any constructed or modified drainage facilities to be maintained and operated by King County, the applicant must do the following:

1. Post a drainage defect and maintenance financial guarantee for a period of two years (see Reference Section 8-E, "Maintenance and Defect Agreement").
2. Maintain the drainage facilities (per the maintenance standards in Appendix A) during the two-year period following posting of the drainage defect and maintenance financial guarantee.

Before King County will release the drainage defect and maintenance financial guarantee and assume maintenance and operation of drainage facilities, the applicant must do the following:

1. For plats, record the final plat.

2. For tracts containing drainage facilities to be maintained by King County and not located within the final plat, deed the tract to King County and set property corners in conformance with state surveying standards.
3. For easements containing drainage facilities to be maintained by King County and not located within the final plat, provide easement documents and set temporary survey markers to delineate the easement location.
4. Receive a final County inspection to ensure the drainage facilities have been properly maintained and are operating as designed.
5. Correct any defects noted in the final inspection.

1.2.8 CORE REQUIREMENT #8: WATER QUALITY

REQMT

All proposed projects, including redevelopment projects, must provide water quality (WQ) facilities to treat the runoff from new and/or replaced pollution-generating impervious surfaces and pollution-generating pervious surfaces. These facilities shall be selected from one of the area-specific WQ menus described in Section 1.2.8.1 (p. 1-52) and implemented according to the applicable WQ implementation requirements in Section 1.2.8.2 (p. 1-57).

Intent: To require an efficient, cost-effective level of water quality treatment tailored to the sensitivities and resource protection needs of the downstream receiving water to which the project site drains, or, in the case of infiltration, protection of the receiving groundwater system.

Guide to Applying Core Requirement #8

Core Requirement #8 requires that WQ treatment facilities be provided to remove pollutants from runoff discharging from the project site in accordance with one of the four area-specific WQ menus found in Section 1.2.8.1 (p. 1-52).

Area-specific WQ menus are groups of facility options designed to provide levels of treatment targeted to the resource protection needs of specific areas of King County called *WQ treatment areas*. There are four such areas depicted on the WQ Applications Map adopted with this manual (see the map pocket inside the back cover). Each WQ treatment area has a different area-specific WQ menu as described in Section 1.2.8.1.

WQ implementation requirements are the minimum requirements for analyzing, designing, and maintaining WQ facilities.

For efficient application of Core Requirement #8, the following steps are recommended:

1. Check the exemption language on page 1-50 to determine if and/or which portions of your project must provide WQ treatment facilities per Core Requirement #8.
2. If your project is a redevelopment project, you may apply the Basic WQ menu as described on page 1-52, irrespective of the WQ Applications Map, and proceed to Step 5 below.
3. Use the WQ Applications Map to determine the "WQ treatment area" where your project is located. If this determination can not be made from the map, a more detailed delineation of WQ treatment areas is available on King County's Geographic Information System.
4. For the WQ treatment area identified above, determine which area-specific WQ menu applies to your project by consulting the detailed threshold information in Section 1.2.8.1 (p. 1-52).
5. Use Section 1.2.8.2 (p. 1-57) to determine the minimum requirements for implementing water quality treatment.

Other Important Information about Core Requirement #8

Core Requirement #8 is the primary component of an overall water quality protection strategy required by this manual. Other requirements include the following:

- Core Requirement #4: **Conveyance System, Spill Control Provisions**, Section 1.2.4 (p. 1-40)—This provision generally applies whenever a project constructs or replaces onsite conveyance system elements that receive runoff from pollution-generating impervious surfaces. The provision requires that runoff from such impervious surfaces be routed through a spill control device prior to discharge from the project site or into a natural onsite drainage feature.
- Special Requirement #4: **Source Control**, Section 1.3.4 (p. 1-61)—This requirement applies water quality source controls from the *King County Stormwater Pollution Control Manual* to those projects proposing to develop or redevelop a commercial, industrial, or multifamily site.

- Special Requirement #5: **Oil Control**, Section 1.3.5 (p. 1-62)—This requirement applies special oil controls to those projects proposing to develop or redevelop a high-use site.

Key Definitions

- **Pollution-generating impervious surface (PGIS) Definition:** Those impervious surfaces considered to be a significant source of pollutants in stormwater runoff. Such surfaces include those which are *subject to vehicular use*[46] or storage of *erodable or leachable materials, wastes, or chemicals*,[47] and which receive direct rainfall or the run-on or blow-in of rainfall.[48] Metal roofs are also considered to be PGIS unless they are treated to prevent leaching.
- **Pollution-generating pervious surface (PGPS) Definition:** Any non-impervious surface with vegetative ground cover subject to use of pesticides and fertilizers. Such surfaces include, but are not limited to, the lawn and landscaped areas of residential or commercial sites, golf courses, parks and sports fields.

❑ EXEMPTIONS FROM CORE REQUIREMENT #8

There are five possible exemptions from the requirement to provide **a formal water quality facility** per Core Requirement #8:

1. Surface Area Exemption

A proposed project or any **threshold discharge area** within a project is exempt if it meets all of the following criteria:

a) Less than 5,000 square feet of *new PGIS*[49] will be added, AND

b) Less than 5,000 square feet of *contiguous PGIS*[50] will be created through any combination of new and/or replaced impervious surface as part of a redevelopment project, AND

c) Less than 1 acre of *contiguous PGPS*[51] will be added and/or *modified*,[52] OR there is a formal agreement with King County to implement a *landscape management plan*[53] for the PGPS areas on the site (or a farm management plan in the case of an agricultural land use).

[46] A surface, whether paved or not, shall be considered *subject to vehicular use* if it is regularly used by motor vehicles. The following are considered *regularly-used surfaces*: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced firelanes, diesel equipment storage yards, and airport runways. The following are not considered regularly-used surfaces: road shoulders primarily used for emergency parking, paved bicycle pathways, bicycle lanes adjacent to unpaved or paved road shoulders primarily used for emergency parking, fenced firelanes, and infrequently used maintenance access roads.

[47] *Erodable or leachable materials, wastes, or chemicals* are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff (examples include erodable soil, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, garbage dumpster leakage, etc.).

[48] A covered parking area would be considered pollution-generating if runoff from uphill could regularly run through it, or if rainfall could regularly blow in and wet the pavement surface. The same parking area would not be included if it were enclosed by walls or if a low wall and berm prevented stormwater from being blown in or from running onto the covered area.

[49] *New PGIS* means new impervious surface (as defined on page 1-4) that is pollution-generating.

[50] *Contiguous PGIS* means a discrete patch of PGIS that is all together as opposed to being separated in different locations on the project site. As used in this and other exemptions, the intent is to apply Core Requirement #8 to those redevelopment projects that are replacing and/or adding enough impervious surface in one location to allow for opportune installation of a water quality facility.

[51] *Contiguous PGPS* means a patch of PGPS that is all together as opposed to being separated in different locations on the project site.

[52] *Modified* PGPS means any existing PGPS that is re-graded or re-contoured by the proposed project.

[53] *Landscape management plan* means a King County approved plan for defining the layout and long-term maintenance of landscaping features to minimize the use of pesticides and fertilizers, and to reduce the discharge of suspended solids and other pollutants. Guidelines for preparing landscape management plans can be found in Reference Section 4-A. Submittal requirements are detailed in Section 2.3.1.4.

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2. Cost Exemption for Redevelopment Projects

A redevelopment project or any **threshold discharge area** within a redevelopment project is exempt if it meets all of the following criteria:

a) Less than $500,000 of total site improvements is proposed, AND

b) Less than 5,000 square feet of new PGIS will be added, AND

c) Less than 1 acre of contiguous PGPS will be added and/or modified, OR there is a formal agreement with King County to implement a landscape management plan for the PGPS areas.

3. Forested Open Space Exemption for Rural Residential Projects

Any **natural discharge area** within a proposed rural residential project (zoned RA-2.5, RA-5, RA-10, or R-20) is exempt if all of the following criteria are met:

a) At least 65% of the *unsubmerged portion*[54] of the **natural discharge area** is set aside as forested open space as specified in Section 5.2.1, AND

b) The runoff from roads and driveways is dispersed through at least 100 feet of native vegetation as described in Section 5.2.1, AND

c) The runoff from contiguous lawn areas of 1 acre or more is dispersed through at least 25 feet of native vegetation onsite as specified in Section 1.2.8.2 (p. 1-57).

4. Standard Infiltration Exemption

A proposed project or any drainage area within a project is exempt if the runoff from pollution-generating pervious and impervious surfaces is infiltrated in soils with a *measured infiltration rate*[55] of less than or equal to 9 inches per hour, except in designated *sole-source aquifer areas*[56] where the measured rate must be less than or equal to 2.4 inches per hour.

5. Soil Treatment Exemption

A proposed project or any drainage area within a project is exempt if the runoff from pollution-generating impervious surfaces is infiltrated in soils which meet the "groundwater protection criteria" outlined below, except where the measured infiltration rate is greater than 9 inches per hour in designated sole-source aquifer areas or areas within one-quarter-mile of a *sensitive lake*.[57]

Groundwater Protection Criteria: The first 2 feet or more of the soil beneath an infiltration facility must meet one of the following specifications for general protection of groundwater:

a) The soil must have a *cation exchange capacity*[58] greater than 5 and an *organic content*[59] greater than 0.5%, OR

b) The soil must be composed of less than 25% gravel by weight with at least 75% of the soil passing the #4 sieve, and the portion passing the #4 sieve must meet one of the following gradations:

- At least 50% must pass the #40 sieve and at least 2% must pass the #100 sieve, OR
- At least 25% must pass the #40 sieve and at least 5% must pass the #200 sieve.

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[54] *Unsubmerged portion* means any portion outside the ordinary high water line of streams, lakes, and wetlands.

[55] *Measured infiltration rate* shall be as measured by the EPA method or the Double Ring Infiltrameter Method (ASTM D3385). For some soils, an infiltration rate of less than 9 inches per hour may be assumed based on a soil texture determination rather than a rate measurement. For more details, see the "Groundwater Protection" requirements in Section 5.4.1.

[56] *Sole-source aquifer areas* are designated by the EPA and depicted on the Areas Highly Susceptible to Groundwater Contamination Map adopted as part of the King County Comprehensive Plan.

[57] *Sensitive lake* is a designation applied by the County to lakes that are particularly prone to eutrophication from development-induced increases in phosphorus loading. Such lakes are identified on the Water Quality Applications Map adopted with this manual (see map pocket on inside of back cover).

[58] *Cation exchange capacity* shall be tested using EPA Laboratory Method 9081.

[59] *Organic content* shall be measured on a dry weight basis using ASTM D2974.

1.2.8.1 AREA-SPECIFIC WATER QUALITY MENUS

REQMT

Projects subject to Core Requirement #8 **must provide a facility selected from one of the four area-specific WQ treatment menus** listed below, whichever applies per the threshold information detailed in this section:

- Basic Water Quality menu
- Sensitive Lake Protection menu
- Resource Stream Protection menu
- Sphagnum Bog Protection menu.

Exception: **Redevelopment projects** subject to Core Requirement #8 need only apply the Basic WQ menu as described below, regardless of where they are located. *Note: A higher standard may be imposed by an adopted resource management plan through Special Requirement #1, Section 1.3.1, or the proposed project may apply a higher standard voluntarily.*

Intent: To apply an appropriate level of water quality treatment based on the sensitivities of receiving waters for the drainage area in which the project lies. These drainage areas are identified as WQ treatment areas on the WQ Applications Map adopted with this manual. In addition to a minimum basic standard which applies broadly to most geographic areas, special menus are provided for sites within the watersheds of sensitive lakes, regionally significant stream reaches, and sphagnum bog wetlands. Redevelopment projects may apply the Basic WQ menu for all WQ treatment areas because application of WQ treatment to these projects incrementally reduces existing pollutant loads and concentrations to all water bodies. This benefits sensitive as well as typical water bodies and limits the cost of stormwater treatment in areas that are already developed.

❑ BASIC WQ MENU

The Basic WQ menu is primarily applied in areas of King County where a general, cost-effective level of treatment is desired and where more intensive, targeted pollutant removal is not needed to protect receiving bodies. Such areas are designated by King County as **Basic WQ Treatment Areas**. Most Basic WQ Treatment Areas are delineated on the WQ Applications Map adopted with this manual (see the map pocket inside the back cover). The forest production zone and any other areas of unincorporated King County not shown on this map are also considered to be Basic WQ Treatment Areas. *Note: The Basic WQ menu is also applied to all **redevelopment projects** that are subject to Core Requirement #8 regardless of the WQ treatment area in which they are located.*

Threshold

THRESHOLD

A treatment option from the **Basic WQ menu** shall be used to treat runoff from any of the following types of proposed projects:

1. A project located within a Basic WQ Treatment Area as defined above, OR
2. A project located within another WQ treatment area but which does not meet the threshold for application of the area-specific requirement for that area, OR
3. A redevelopment project located in any WQ treatment area.

Treatment Goal and Options

The treatment goal for facility options in the Basic WQ menu is 80% removal of total suspended solids (TSS) for a typical rainfall year, assuming typical pollutant concentrations in urban runoff.[60] TSS is the

[60] For evaluation purposes, typical concentrations of TSS in Seattle area runoff are between 30 and 100 mg/L (Table 1, "Water Quality Thresholds Decision Paper," King County Surface Water Management Division, April 1994).

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general performance indicator for basic water quality protection because it is the most obvious pollutant of concern. The Basic WQ menu includes facilities such as wetponds, combined detention/wetponds, biofiltration swales, filter strips, and sand filters. See Chapter 6 for specific facility choices and design details.

Intent

The **Basic WQ menu** is intended to be applied to both the stormwater discharges that drain to surface waters and those that infiltrate into soils which do not provide adequate groundwater protection (see Exemptions 4 and 5 from Core Requirement #8). Overall, the 80% TSS removal objective, in conjunction with special requirements for source control and high-use site controls, is expected to result in good stormwater quality for all but the most sensitive water bodies. Additional water quality treatment is indicated only for sensitive lakes, regionally-significant stream reaches, and sphagnum bog wetlands.

❑ SENSITIVE LAKE PROTECTION MENU

The Sensitive Lake Protection menu is primarily applied in areas of King County that drain to lakes which have a combination of water quality characteristics and watershed development potential that makes them particularly prone to eutrophication induced by development. Such areas are designated by King County as **Sensitive Lake WQ Treatment Areas** and are delineated on the WQ Applications Map adopted with this manual (see the map pocket inside the back cover).

Threshold

THRESHOLD

A treatment option from the **Sensitive Lake Protection menu** shall be used to treat runoff from any proposed project (excluding redevelopment projects) which is located within a Sensitive Lake WQ Treatment Area as indicated on the WQ Applications Map, AND which discharges runoff in either of the following ways:

1. Discharges runoff by *surface flow*[61] to the lake in question, OR
2. Infiltrates runoff in soils having *high infiltration rates*[62] and located within one-quarter-mile of the lake's mean-high-water level.

Notes:

- *If the proposed project is located within a Sensitive Lake WQ Treatment Area but does not meet the above threshold criteria, then the Basic WQ menu shall apply as detailed on page 1-52.*
- *If a lake management plan has been prepared and adopted by King County, additional treatment and/or other water quality measures may be required as specified in the plan and pursuant to Special Requirement #1, Section 1.3.1 (p. 1-59). A list of adopted lake management plans is provided in Reference Section 2-B.*
- *If the project site discharges to more than one special WQ feature (i.e., a sensitive lake, regionally-significant stream reach, or sphagnum bog), the following order of precedence shall apply:*
  1. *Sphagnum Bog Protection menu*
  2. *Sensitive Lake Protection menu*
  3. *Resource Stream Protection menu.*

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[61] *Surface flow* means that which travels over land or in an open or piped conveyance system.

[62] *High infiltration rates* are those in excess of 9 inches per hour as measured by the EPA method or the Double Ring Infiltrameter method (ASTM D3385). These will typically be medium to coarse sand or gravel soil with low silt content. See Section 5.4.1 for information on measuring infiltration rates.

Treatment Goal and Options

The treatment goal for facility options in the Sensitive Lake Protection menu is 50% annual average total phosphorus (TP) removal assuming typical pollutant concentrations in urban runoff.[63] This goal was chosen as a realistic and cost-effective level of phosphorus removal. The Sensitive Lake Protection menu includes options for using Basic WQ facilities that are sized larger, combinations of two facilities in series,[64] or a single facility in combination with land use planning elements that reduce phosphorus. See Chapter 6 for specific facility options and design details.

Intent

A project discharging runoff via surface flow contributes phosphorus loading to a sensitive lake regardless of distance from the lake. If discharge is via infiltration through coarse soils, it is also possible that phosphorus would be transported through the ground for some distance without attenuation. This groundwater transport distance is considered to typically be no more than one-quarter mile. Therefore, onsite treatment using the **Sensitive Lake Protection menu** is required prior to infiltration within one-quarter mile of a sensitive lake. Infiltration through finer soils is expected to provide significant attenuation of TP, so the general groundwater protection criteria specified on page 1-51 under "Soil Treatment Exemption" are considered sufficient for infiltration through finer soils.

❑ RESOURCE STREAM PROTECTION MENU

The Resource Stream Protection menu is primarily applied in areas of King County that drain to stream reaches identified as "regionally significant" during King County studies and inventories conducted in support of watershed planning or management activities. These stream reaches are important fishery resources where substantial aggregations of fish are likely to be present all or part of the year. Only five regional drainage basins have been inventoried at present. The tributary drainage areas to these stream reaches are designated by King County as **Resource Stream WQ Treatment Areas** and are delineated on the WQ Applications Map (see the map pocket inside the back cover). As additional regionally significant stream reaches are identified, the WQ Applications Map will be updated.

Threshold

THRESH

A treatment option from the **Resource Stream Protection menu** shall be used to treat runoff from any proposed project (excluding redevelopment projects) which is located within a Resource Stream WQ Treatment Area as indicated on the WQ Applications Map, AND which discharges runoff by surface flow which ultimately reaches a regionally significant stream reach.

Notes:

- *If the proposed project is within a Resource Stream WQ Treatment Area, but meets neither the above threshold criteria nor the criteria for application of the Sensitive Lake Protection menu (p. 1-53) or Sphagnum Bog Protection menu (p. 1-55), then the Basic WQ menu shall apply as detailed on page 1-52.*
- *If the project site discharges to more than one special WQ feature (i.e., a sensitive lake, regionally-significant stream reach, or sphagnum bog), the following order of precedence shall apply:*
  1. *Sphagnum Bog Protection menu*
  2. *Sensitive Lake Protection menu*
  3. *Resource Stream Protection menu.*

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[63] Phosphorus concentrations of between 0.10 and 0.50 mg/L are considered typical of Seattle area runoff (Table 1, "Water Quality Thresholds Decision paper," King County Surface Water Management Division, April 1994).

[64] *In series* means that the entire treatment water volume flows from one facility to the other in turn.

Treatment Goals and Options

The treatment goal for facility options in the **Resource Stream Protection menu** is 50% reduction of total zinc. Zinc is an indicator of a wider range of metals typically found in urban runoff that are potentially toxic to fish and other aquatic life. The Resource Stream Protection menu includes options for use of a large sand filter or a combination of two facilities in series, one of which is either a sand filter or a leaf compost filter. See Chapter 6 for specific facility options and designs.

Intent

Facility options in the Resource Stream Protection menu are intended to remove more metals than expected from the Basic WQ menu. Lower metal concentrations reduce the risk to fish of exposure to both chronic and acutely toxic concentrations of metals such as copper and zinc. The Resource Stream Protection menu is intended to apply to the entire tributary drainage area for the regionally significant stream reach.

❑ SPHAGNUM BOG PROTECTION MENU

The Sphagnum Bog Protection menu is primarily applied in areas of King County that drain to *sphagnum bog wetlands*.[65] These wetlands support unique vegetation communities, and they tend to develop in areas where water movement is minimized. Bogs are typically isolated from significant sources of surface and ground water and receive their main water supply from rainfall. Sphagnum bog wetlands are generally uncommon in the Puget Sound area; of all the inventoried wetlands in King County, only a small percentage have sphagnum bog components.[66]

Only a portion of all sphagnum bog wetlands have been identified and mapped by King County. Consequently, many of these wetlands and their contributing drainage areas must be identified during wetland identification and delineation for the project site and during offsite analysis as required in Core Requirement #2. A list of identified sphagnum bog wetlands is included on the WQ Applications Map; however, if a wetland is found downstream of the project site that meets the definition of a sphagnum bog wetland, this menu still applies whether the wetland is listed or not.

Threshold

THRESH

A treatment option from the **Sphagnum Bog Protection menu** shall be used to treat runoff from any proposed project which discharges runoff by surface flow to the plant community of a sphagnum bog wetland greater than 0.25 acres in *size*[67] as indicated on the WQ Applications Map or as identified through offsite analysis per Core Requirement #2.

Notes:

- *If the proposed project does not meet the threshold above, then apply the area-specific WQ menu for the WQ treatment area in which the project is located as indicated on the WQ Applications Map.*
- *If the proposed project meets the threshold above, the Sphagnum Bog Protection menu will apply regardless of the WQ treatment area in which the project is located.*
- *If the proposed project is a redevelopment project, the Sphagnum Bog Protection menu is not required but is highly recommended.*

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[65] A *sphagnum bog wetland* is defined as a wetland dominated by sphagnum moss and which has an associated acid-loving plant community. A technical definition can be found in the Definition section.

[66] Approximately 3% of wetlands in the 1990 sensitive areas inventory are either sphagnum bogs or have portions of the lake or wetland with bog characteristics.

[67] The *size* of a sphagnum bog wetland is defined by the boundaries of the sphagnum bog plant community.

Treatment Goals and Options

The treatment goals for protection of sphagnum bog wetlands include the control of nutrients, alkalinity, and pH. Although these goals may change as additional information about these wetlands becomes available, target pollutant removals for sphagnum bog protection are currently as follows:

- Total phosphorus reduction of 50%
- Nitrate + nitrite reduction of 40%
- pH below 6.5
- Alkalinity below 10 mg/L.

Facility options to meet these goals are limited; therefore, the County discourages developments from discharging runoff to sphagnum bog wetlands. Treatment facility options include either infiltration of stormwater up to the 10-year event or a *treatment train*[68] of two or three facilities in series. One of the facilities in the train must be a sand filter. The order of facilities in the treatment train is important; see Chapter 6 for specific facility options and design details.

Intent

Sphagnum bog wetlands support unique vegetation communities that are extremely sensitive to changes in alkalinity and nutrients from surface water inputs. Treatment facility options emphasize reduction of mineral elements (alkalinity) and nutrients in the runoff. Little is known about the ability of the identified facility options to reduce alkalinity or to actually protect sphagnum-based plant communities. In addition, the effect of frequent water level changes on the sphagnum plant community is also unknown, but it could be damaging. Hence, the **Sphagnum Bog Protection menu** is expected to be changed over time as more information becomes available.

[68] A *treatment train* is a combination of two or more treatment BMPs connected in series (i.e., the design water volume passes through each facility in turn).

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1.2.8.2 WATER QUALITY IMPLEMENTATION REQUIREMENTS

Methods of Analysis and Design

Water quality treatment facilities shall be analyzed and designed as detailed in Chapter 6.

Siting of Treatment Facilities

Required treatment facilities shall be located to treat the runoff from all contiguous PGIS exceeding the threshold for application of Core Requirement #8 to redevelopment projects and all new PGIS on other projects, except as allowed below under "Treatment Trades" and "Untreated Discharges." In addition, all runoff from 1 acre or more of new and/or modified contiguous PGPS must also be directed to a treatment facility.

Any other onsite or offsite runoff draining to a proposed treatment facility must be treated whether it is from a pollution-generating surface or not. This is because treatment effectiveness is determined in part by the total volume of runoff entering the facility.

Treatment of Pervious Surfaces

Pollution-generating pervious surfaces subject to Core Requirement #8 need only be treated using the Basic WQ menu regardless of location, except for those surfaces draining to sphagnum bog wetlands. It is also possible for the facility requirement to be waived if there is a good faith agreement with the King Conservation District to implement a farm management plan for agricultural uses, or DDES approves a landscape management plan that controls solids, pesticides, and fertilizers leaving the site.

For **rural residential projects utilizing Exemption 3** on page 1-51, the runoff from contiguous lawn areas, 1 acre or larger, must be dispersed through 25 feet of native vegetation in accordance with the following criteria:

1. The contributing flowpath of the lawn area being dispersed must be no more than 150 feet, AND
2. The 25-foot minimum flowpath through native vegetation must be contained within the onsite tract or easement area being set aside as forested open space per Section 5.2.1, AND
3. Slopes within the 25-foot minimum flowpath through native vegetation should be no steeper than 8%. If this criteria can not be met due to site constraints, the 25-foot flowpath length must be increased 1.5 feet for each percent increase in slope above 8%.

Treatment Trades

Runoff from areas subject to water quality treatment requirements may be excused from the onsite treatment requirement if a pre-existing area of impervious surface of equivalent size and pollutant characteristics lying within the same watershed or stream reach tributary area is treated on the project site. Such substitution is subject to the following restrictions:

1. The pre-existing impervious surface is not currently being treated, is not required to be treated by any phase of the proposed project, is not subject to NPDES or other permit requirements, and is not under a compliance order or other regulatory action, AND
2. The proposal is reviewed and approved by DDES.

Untreated Discharges

If site topographic constraints are such that runoff from an area must be pumped to be treated by the water quality facility, then DDES may allow the area to be released untreated (except for those sites draining to a sphagnum bog wetland) provided that the following conditions are met:

1. Treatment of the constrained area by filter strip, biofiltration, or a linear sand filter is not feasible, and a "treatment trade" as described above is not possible, AND

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2. The untreated area is less than 5,000 square feet of new PGIS and is less than 5,000 square feet of contiguous PGIS being created through any combination of new and/or replaced impervious surface as part of a redevelopment project.

3. Any PGPS within the area to be released untreated shall be addressed with a landscape management plan unless otherwise exempt from Core Requirement #8.

Use of Experimental Water Quality Facilities

Treatment facilities other than those identified in Chapter 6 are allowed on an experimental basis if it can be demonstrated they are likely to meet the pollutant removal goal for the applicable receiving water. Use of such facilities requires an experimental design adjustment to be approved by King County according to Section 1.4, "Adjustment Process" (p. 1-65). When sufficient data on performance has been collected and if performance is acceptable, the new facility will be added to the appropriate water quality menu for common use.

Owner Responsibility for Water Quality

Regardless of the means by which a property owner chooses to meet the water quality requirements of this manual – whether a treatment facility, a train of facilities, a treatment trade or an experimental treatment facility – it is ultimately the responsibility of the property owner to ensure that runoff from their site does not create water quality problems or degrade downstream beneficial uses. It is also ultimately the responsibility of the property owner to ensure that the discharge from their property is not in violation of State and Federal laws.

1.3 SPECIAL REQUIREMENTS

This section details the following five special drainage requirements which may apply to the proposed project depending on its location or site-specific characteristics:

- Special Requirement #1: Other Adopted Area-Specific Requirements, Section 1.3.1 (p. 1-59)
- Special Requirement #2: Floodplain/Floodway Delineation, Section 1.3.2 (p. 1-60)
- Special Requirement #3: Flood Protection Facilities, Section 1.3.3 (p. 1-61)
- Special Requirement #4: Source Control, Section 1.3.4 (p. 1-61)
- Special Requirement #5: Oil Control, Section 1.3.5 (p. 1-62).

1.3.1 SPECIAL REQUIREMENT #1: OTHER ADOPTED AREA-SPECIFIC REQUIREMENTS

This manual is one of several adopted regulations in King County which apply requirements for controlling drainage on an area-specific basis. Special District Overlays in KCC 21A.38 and areal clearing limits in KCC 16.82.150 (see Reference Sections 1 and 2-C) are examples of zoning and land use restrictions used to reduce drainage impacts in certain areas of the County. Other adopted area-specific regulations include requirements which have a more direct bearing on the drainage design of a proposed project. These regulations include the following:

- **Critical Drainage Areas (CDAs):** DNR establishes CDAs in areas where flooding and/or erosion conditions present an imminent likelihood of harm to the welfare and safety of the surrounding community. The special requirements in CDAs typically include more restrictive flow control and clearing standards. Maps showing CDA boundaries are available from DNR or DDES.
- **Master Drainage Plans (MDPs):** MDPs are comprehensive drainage plans prepared for urban planned developments (UPDs) or other large, complex projects (described in Section 1.1.2.4). Projects covered by a MDP must meet any adopted requirements specific to that plan.
- **Basin Plans (BPs):** The King County Council adopts basin plans to provide for the comprehensive assessment of resources and to accommodate growth while controlling adverse impacts to the environment. A basin plan may recommend specific land uses, regional capital projects, and special drainage requirements for future development within the basin area it covers.
- **Lake Management Plans (LMPs):** The King County Council adopts lake management plans to provide for comprehensive assessment of resources and to accommodate growth while controlling adverse impacts from nutrient loading to selected lakes. A lake management plan may recommend nutrient control through special drainage and source control requirements for proposed projects within the area it covers.
- **Shared Facility Drainage Plans (SFDPs):** SFDPs are approved by King County to allow two or more projects to share drainage facilities required by this manual. Projects covered by a SFDP must meet any specific requirements of that plan.

Threshold	Requirement
IF a proposed project is in a designated Critical Drainage Area or in an area included in an adopted master drainage plan, basin plan, lake management plan, or shared facility drainage plan . . .	THEN the proposed project shall comply with the drainage requirements of the Critical Drainage Area, master drainage plan, basin plan, lake management plan, or shared facility drainage plan, respectively.

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Application of this Requirement

The drainage requirements of adopted CDAs, MDPs, BPs, LMPs, and SFDPs shall be applied in addition to the drainage requirements of this manual unless otherwise specified in the adopted regulation. Where conflicts occur between the two, the drainage requirements of the adopted area-specific regulation shall supersede those in this manual.

Examples of drainage requirements found in other adopted area-specific regulations include the following:

- More or less stringent flow control
- More extensive water quality controls
- Forest retention requirements
- Infiltration restrictions
- Groundwater recharge provisions
- Discharge to a constructed regional flow control or conveyance facility.

Adjustments to vary from the specific drainage requirements mandated by CDAs, BPs, and LMPs may be pursued through the adjustment process described in Section 1.4 of this manual.

Information on adopted basin plans can be found in Reference Section 2-B of this manual. Copies of all adopted CDAs, basin plans, and lake management plans are available from DNR or DDES.

Projects covered by SFDPs shall demonstrate that the shared facility will be available by the time of construction of the project and that all onsite requirements are met. Projects covered by a SFDP are still required to provide any onsite controls necessary to comply with drainage requirements not addressed by the shared facility.

1.3.2 SPECIAL REQUIREMENT #2: FLOODPLAIN/FLOODWAY DELINEATION

Floodplains and floodways are subject to inundation during extreme events. The 100-year floodplains are delineated in order to minimize flooding impacts to new development and to prevent aggravation of existing flooding problems by new development. Regulations and restrictions concerning development within a 100-year floodplain are found in the Sensitive Areas Ordinance.

Threshold	Requirement
IF a proposed project contains or is adjacent to a stream, lake, wetland, or closed depression, or if other King County regulations require study of flood hazards . . .	THEN the 100-year floodplain boundaries (and floodway, if available or if improvements are proposed within the 100-year floodplain) based on an approved flood hazard study (described below) shall be delineated on the site improvement plans and profiles, and on any final subdivision maps prepared for the proposed project.

Application of this Requirement

If an approved flood hazard study exists, then it may be used as the basis for delineating the floodplain and floodway boundaries provided the study was prepared in a manner consistent with this manual and other King County flood hazard regulations. If an approved flood hazard study does not exist, then one shall be prepared based on the requirements described in Section 4.4.2, "Floodplain/Floodway Analysis."

Note: The site may also be located in a channel relocation migration hazard area where any new proposed structures will have to comply with KCC 21A.24.275.

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1.3.3 SPECIAL REQUIREMENT #3: FLOOD PROTECTION FACILITIES

Developing sites protected by levees, revetments, or berms requires a high level of confidence in their structural integrity and performance. Proper analysis, design, and construction is necessary to protect against the potentially catastrophic consequences if such facilities should fail.

Threshold	Requirement
IF a proposed project either: • contains or is adjacent to a Class 1 or 2 stream that has an existing flood protection facility (such as a levee, revetment, or berm), OR • proposes to construct a new or to modify an existing flood protection facility . . .	THEN the flood protection facilities shall be analyzed and/or designed to conform with the Federal Emergency Management Administration (FEMA) regulations (44 CFR).

Application of this Requirement

The applicant is required to demonstrate conformance with FEMA regulations using the methods specified in Section 4.4.2. In addition, certain easement requirements (outlined in Section 4.1) must be met in order to allow County access for maintenance of the facility.

1.3.4 SPECIAL REQUIREMENT #4: SOURCE CONTROLS

Water quality source controls prevent rainfall and runoff water from coming into contact with pollutants, thereby reducing the likelihood that pollutants will enter public waterways and violate water quality standards and County stormwater discharge permit limits. A *Stormwater Pollution Control Manual* was prepared for citizens, businesses, and industries to identify and implement source controls for activities that often pollute water bodies. King County provides advice on source control implementation upon request. The County may, however, require mandatory source controls at any time through formal code enforcement if complaints or studies reveal water quality violations or problems.

Threshold	Requirement
IF a proposed project is either: • a commercial, industrial, or multifamily site development, OR • a redevelopment project proposing improvements to an existing commercial, industrial, multifamily site . . .	THEN the project must provide water quality source controls applicable to the proposed project in accordance with the *King County Stormwater Pollution Control Manual* and King County Code 9.12.

Application of this Requirement

When applicable, structural source control measures, such as car wash pads or dumpster area roofing, shall be shown on the site improvement plans submitted for engineering review and approval. Other nonstructural source control measures, such as covering storage piles with plastic or isolating areas where pollutants are used or stored, are to be implemented after occupancy and need not be addressed during the plan review process. All commercial and industrial projects (irrespective of size) undergoing drainage review are required to implement applicable source controls.

1.3.5 SPECIAL REQUIREMENT #5: OIL CONTROL

Projects proposing to develop or redevelop a high-use site (defined below) must provide oil controls in addition to any other water quality controls required by this manual. Such sites typically generate high concentrations of oil due to high traffic turnover or the frequent transfer of oil.

A **high-use site** is any one of the following:

- A commercial or industrial site subject to an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area, OR
- A commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, not including routinely delivered heating oil, OR
- A commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons gross weight (trucks, buses, trains, heavy equipment, etc.), OR
- A road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

The oil control requirement for high-use sites applies to all sites that generate high concentrations of oil, regardless of whether the project creates new impervious surface or makes site improvements to an existing high-use site. The traffic threshold identified focuses on vehicle turnover per square foot of building area (trip generation) rather than ADT alone. This is because oil leakage is greatest when engines are idling or cooling. In general, all-day parking areas are not intended to be captured by these thresholds except for diesel vehicles, which tend to leak oil more than non-diesel vehicles. The petroleum storage and transfer stipulation is intended to address regular transfer operations such as service stations, not occasional filling of heating oil tanks.

Threshold	Requirement
IF a proposed project either: • develops a site which will have high-use site characteristics (defined above), OR • is a redevelopment project proposing $100,000 or more of improvements to an existing high-use site . . .	THEN the project must treat runoff from the high-use portion of the site using oil control treatment options from the High-Use menu (described below and detailed in Chapter 6).

High-Use Menu

High-use oil control options are selected to capture and detain oil and associated pollutants. The goal of treatment is to have no visible sheen for runoff leaving the facility, or to have less than 10 mg/L total petroleum hydrocarbons (TPH), depending on the BMP. Oil control options include facilities that are small, handle only a limited site area, and require frequent maintenance, as well as facilities that treat larger areas and generally have less frequent maintenance needs. Facility choices include catch basin inserts, linear sand filters, and oil/water separators. See Chapter 6 for specific facility choices and design details.

Application of this Requirement

For high-use sites located within a larger commercial center, only the impervious surface associated with the high-use portion of the site is subject to treatment requirements. If common parking for multiple businesses is provided, treatment shall be applied to the number of parking stalls required for the high-use business only. However, if the treatment collection area also receives runoff from other areas, the treatment facility must be sized to treat all water passing through it.

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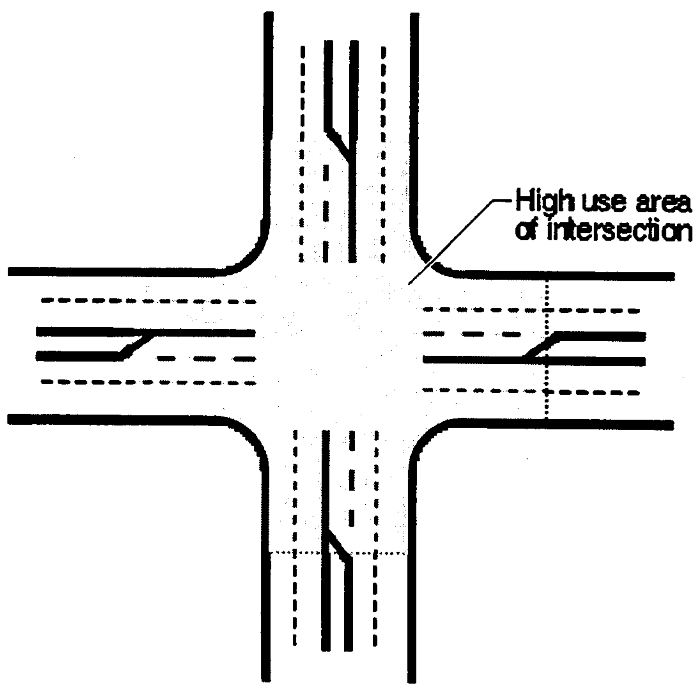
High-use roadway intersections shall treat lanes where vehicles accumulate during the signal cycle, including left and right turn lanes and through lanes, from the beginning of the left turn pocket (see Figure 1.3.5.A below). If no left turn pocket exists, the treatable area shall begin at a distance equal to three car-lengths from the stop line. If runoff from the intersection drains to more than two collection areas that do not combine within the intersection, treatment may be limited to any two of the collection areas.

Note: For oil control facilities to be located in public road right-of-way and maintained by King County, only coalescing plate or baffle oil/water separators shall be used unless otherwise approved by a adjustment.

Methods of Analysis

The traffic threshold for the High-Use menu shall be estimated using information from *Trip Generation*, published by the Institute of Transportation Engineers, or from a traffic study prepared by a professional engineer or transportation specialist with experience in traffic estimation.

FIGURE 1.3.5.A TREATABLE AREAS FOR HIGH-USE ROAD INTERSECTIONS



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1.4 ADJUSTMENT PROCESS

For proposed projects subject to drainage review by the Department of Development and Environmental Services (DDES), this process is provided for the occasions when a project proponent desires to vary from one of the core or special requirements, or any other specific requirement or standard contained in this manual. Proposed adjustments should be approved prior to final permit approval, but they may be accepted up to the time King County approves final construction or accepts drainage facilities for maintenance. The adjustment application form (one standard form serves all types of adjustments) is included in Reference Section 8-J.

Types of Adjustments

To facilitate the adjustment process and timely review of adjustment proposals, the following types of adjustments are provided:

- **Standard Adjustments:** These are adjustments of the standards and requirements contained in the following chapters and sections of this manual:
  - Chapter 2, "Drainage Plan Submittal"
  - Chapter 4, "Conveyance System Analysis and Design"
  - Chapter 5, "Flow Control Design"
  - Appendix C, *Small Site Drainage Requirements* (detached)
  - Appendix D, *Erosion and Sediment Control Standards* (detached).

  Requests for standard adjustments will be accepted only for permits pending approval or approved permits which have not yet expired.
- **Complex Adjustments:** Complex adjustments typically require more in-depth review because they deal with more complicated requirements or requirements that affect basic County policies or other agencies. These adjustments deviate from the requirements contained in the following chapters and sections of this manual:
  - Chapter 1, "Drainage Review and Requirements"
  - Chapter 3, "Hydrologic Analysis and Design"
  - Chapter 6, "Water Quality Design"
  - Appendix A, "Maintenance Standards"
  - Appendix B, "Master Drainage Plans."

  Requests for complex adjustments will be accepted only for permits pending approval or approved permits which have not yet expired.
- **Preapplication Adjustments:** This type of adjustment may be requested when the applicant needs an adjustment decision to determine if a project is feasible or when the results are needed to determine if a project is viable before funding a full application. The approval of preapplication adjustments is tied by condition to the project proposal presented at a preapplication meeting with DDES.
- **Experimental Design Adjustments:** This type of adjustment is used for proposing new designs or methods that are not covered in this manual, that are not uniquely site specific, and that do not have sufficient data to establish functional equivalence.
- **Blanket Adjustments:** This type of adjustment may be established by the County based on approval of any of the above-mentioned adjustments. Blanket adjustments are usually based on previously approved adjustments that can be applied routinely or globally to all projects where appropriate. Blanket adjustments are also used to effect minor changes or corrections to manual design requirements or to add new designs and methodologies to this manual.

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1.4.1 ADJUSTMENT AUTHORITY

The Department of Development and Environmental Services (DDES) shall have full authority to determine if and what type of adjustment is required for any proposed project subject to drainage review by DDES. The authority to grant adjustments for such projects is distributed as follows:

- DDES shall have full authority to approve or deny standard, complex, and preapplication adjustments.
- DNR shall have full authority to approve or deny experimental design adjustments.
- Both DDES and DNR must approve blanket adjustments.

At any time, this adjustment authority may be transferred between DDES and DNR through a memorandum or an amendment to this manual. This memorandum or amendment must include specific guidelines for deferral of adjustment authority.

1.4.2 CRITERIA FOR GRANTING ADJUSTMENTS

Adjustments to the requirements in this manual may be granted provided that granting the adjustment will achieve the following:

1. Produce a compensating or comparable result that is in the public interest, AND
2. Meet the objectives of safety, function, appearance, environmental protection, and maintainability based on sound engineering judgment.

Where it has been demonstrated that meeting the criteria for producing a compensating or comparable result will deny reasonable use of a property, the applicant shall produce the best practicable alternative as determined by the director of DDES. The director or his/her designee shall assess the case to affirm that denial of reasonable use would occur and to require the practicable alternative that best achieves the spirit and intent of the requirement. DDES staff shall provide recommendations to the director on the best practicable alternative to be required.

Granting any adjustment that would be in conflict with the requirements of any other King County department will require review and concurrence with that department.

Experimental Design Adjustments

Experimental design adjustments that request use of an experimental water quality facility or flow control facility will be approved by DNR on a limited basis if, upon evaluation, DNR agrees the following criteria are met:

1. The new design is likely to meet the identified target pollutant removal goal or flow control performance based on limited data and theoretical considerations, AND
2. Construction of the facility can, in practice, be successfully carried out, AND
3. Maintenance considerations are included in the design, and costs are not excessive or are born and reliably performed by the applicant or property owner, AND
4. A share of the cost of monitoring to determine facility performance is contributed by the applicant or property owner.

Conditions for approval of these adjustments may include a requirement for setting aside an extra area and posting a financial guarantee for construction of a conventional facility should the experimental facility fail. Once satisfactory operation of the experimental facility is verified, the set aside area could be developed and the financial guarantee released.

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1.4.3 ADJUSTMENT APPLICATION PROCESS

Standard and Complex Adjustments

The application process for standard and complex adjustments is as follows:

- Requests for standard and complex adjustments will be accepted only for permits pending approval or approved permits which have not yet expired.
- The completed adjustment request application forms must be submitted to DDES along with sufficient engineering information (described in Chapter 2) to evaluate the request. The application shall note the specific requirement for which the adjustment is sought.
- If the adjustment request involves use of a previously unapproved construction material or construction practice, the applicant should submit documentation that includes, but is not limited to, a record of successful use by other agencies and/or evidence of meeting criteria for quality and performance, such as that for the American Association of State Highway and Transportation Officials (AASHTO) and the American Society of Testing and Materials (ASTM).
- A fee reduction may be requested if it is demonstrated that the adjustment request requires little or no engineering review.

Preapplication Adjustments

The application process is the same as for standard and complex adjustments except that requests will be accepted prior to permit application, but only if:

- The applicant provides justification at a preapplication meeting with DDES that an adjustment decision is needed to determine the viability of the proposed project, AND
- Sufficient engineering information to evaluate the request is provided.

Experimental Design Adjustments

The application process is the same as for standard and complex adjustments except that requests will be accepted prior to permit application.

Blanket Adjustments

There is no application process for blanket adjustments because they are initiated and issued solely by the County.

1.4.4 ADJUSTMENT REVIEW PROCESS

All adjustments are classified as Type 1 land use decisions in King County Code, Title 20, and as such, are governed by the review procedures and time lines set forth in KCC 20. Consistent with these procedures, the general steps of the review process for specific types of adjustments are presented as follows.

Standard and Complex Adjustments

- DDES staff will review the adjustment request application forms and documentation for completeness and inform the applicant in writing as to whether additional information is required from the applicant in order to complete the review. The applicant will also be informed if DDES determines that special technical support is required from DNR in cases where the adjustment involves a major policy issue or potentially impacts a DNR drainage facility.
- The Land Use Services Division Manager/designee or Building Services Division Manager/designee of DDES will review and either approve or deny the adjustment request following DDES's determination that all necessary information has been received from the applicant.

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- Approvals of standard and complex adjustments will expire upon expiration of the permit to which they apply.

Preapplication Adjustments

The review process is the same as for standard and complex adjustments except that approvals will expire one year after the approval date, unless a complete permit application is submitted and accepted.

Experimental Design Adjustments

- DDES staff will refer requests for experimental design adjustments to DNR staff, along with any recommendations.
- DNR staff will review the submitted material and any DDES staff recommendations, and inform the applicant as to whether additional information is required in order to complete the review. DNR will also inform the applicant as to how much time is estimated to complete the review.
- The DNR director or designee will review and either approve or deny the adjustment request in writing.

Blanket Adjustments

Blanket adjustments will each be established by memorandum between DDES and DNR based on:

1. A previously approved standard, complex, preapplication, or experimental design adjustment and supporting documentation, AND
2. Information presenting the need for the blanket adjustment. Typically, blanket adjustments should apply globally to design or procedural requirements and be independent of site conditions.

Both DDES and DNR must approve a blanket adjustment.

1.4.5 APPEAL PROCEDURE

The applicant may appeal the denial or approval conditions of an adjustment request by submitting a formal letter to the director of the department in which the decision was made within 15 working days of the decision. This letter must include justification for review of the decision, along with a copy of the adjustment request with the conditions (if applicable) and a listing of all previously submitted material. The department director shall respond to the applicant in writing within 15 working days; this decision shall be final. A per-hour review fee will be charged to the applicant for County review of an appeal.

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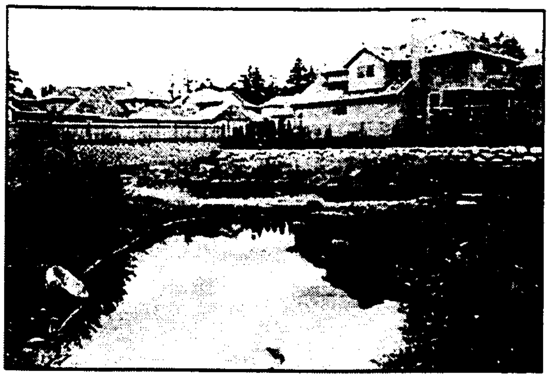
Chapter 2

CHAPTER 2

DRAINAGE PLAN SUBMITTAL



KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

CHAPTER 2
DRAINAGE PLAN SUBMITTAL

This chapter details the drainage related submittal requirements for engineering design plans as part of a permit application to the Department of Development and Environmental Services (DDES). The intent of these requirements is to present consistent formats for design plans and the technical support data required to develop the plans. These conventions are necessary to review engineering designs for compliance with King County ordinances and regulations, and to ensure the intent of the plan is easily understood and implemented in the field. Properly drafted design plans and supporting information also facilitate the construction, operation, and maintenance of the proposed system long after its review and approval. When plans comply with the formats and specifications contained herein, they facilitate review and approval with a minimum of time-consuming corrections and resubmittals.

Note that this chapter primarily describes how to submit drainage plans for review—what must be submitted, in what formats, at what times and to what offices. The basic drainage requirements that these plans must address are contained in Chapter 1, "Drainage Review and Requirements." The specific design methods and criteria to be used are contained in Chapters 3, 4, 5, and 6.

Several key forms used in the plan review process are reproduced in Reference Section 8, "Plan Review Forms and Worksheets." The drainage submittal requirements for different types of developments are contained in this chapter with the exception of Master Drainage Plans, which are contained in a separate publication titled *Master Drainage Planning for Large or Complex Site Developments*, available from the King County Department of Natural Resources (DNR) or DDES. For information on general requirements for any permit type and on the appropriate submittal location, refer to the **customer information bulletins** prepared by DDES for this purpose.

Chapter Organization

The information presented in this chapter is organized into four main sections as follows:

These sections begin on odd pages so that tabs can be inserted by the user if desired for quicker reference.

2.1 PLANS FOR PERMITS AND DRAINAGE REVIEW

DDES is responsible for the review of all engineering aspects of private development proposals. Drainage review is a primary concern of engineering design. This section describes the **types of engineered drainage plans** required for engineering review at various permit review stages. *Refer to the DDES customer information bulletins for other details or requirements, such as the submittal and expiration periods set for each type of permit application, review fees, right-of-way use requirements, and other code requirements.*

❑ PLANS REQUIRED FOR PERMIT SUBMITTAL

Most projects require some degree of drainage plans or analysis to be submitted with the initial permit application (see Table 2.2.1.A, p. 2-4). Subdivisions, urban plan developments (UPDs), and binding site plans require engineered **preliminary plans** be submitted with the initial permit application. Short plats require **plot plans** (may be engineered or non-engineered) to be submitted with the initial permit application. Preliminary plans and plot plans provide general information on the proposal, including location of sensitive areas, road alignments and right-of-way, site topography, building locations, land use information, and lot dimensions. They are used to determine the appropriate drainage conditions and requirements to be applied to the proposal during the drainage review process.

Single family residential building permits and short plats with one undeveloped lot require only a **site plan** with the initial permit application. Commercial permits require full **engineering plans** (see below). Other permits may have project specific drainage requirements determined by DDES or described in DDES customer information bulletins.

❑ PLANS REQUIRED FOR DRAINAGE REVIEW

For drainage review purposes, **engineering plans** consist of the following:

1. Site improvement plans, which include all plans, profiles, details, notes, and specifications necessary to construct road, drainage, and off-street parking improvements (see Section 2.3.1.2, p. 2-17).
2. A technical information report (TIR), which contains all the technical information and analysis necessary to develop the site improvement plan (see Section 2.3.1.1, p. 2-8).
3. An erosion and sediment control (ESC) plan (see Section 2.3.1.3, p. 2-24).

Note: A landscape management plan is also included if applicable (see Section 2.3.1.4, p. 2-26).

Projects under Targeted Drainage Review usually require engineering plans, except that only certain sections of the technical information report are required to be completed and the site improvement plan may have a limited scope depending upon the characteristics of the proposed project. The scope of these plans should be confirmed during the **project predesign meeting** with DDES. For other permits, such as single family residential permits, the scope of the targeted engineering analysis is usually determined during DDES engineering review.

Projects without major drainage improvements may be approved to submit *a modified site improvement plan.* Major drainage improvements usually include water quality or flow control facilities, conveyance systems, bridges, and road right-of-way improvements. For projects requiring engineering plans for road construction, a modified site improvement plan is not allowed. See Section 2.3.1.2, (p. 2-17) for further information.

Plans Required for Small Site Drainage Review

Small site drainage plans are a simplified form of site improvement and ESC plans (without a TIR) which can be prepared by a non-engineer from a set of pre-engineered design details. Small site drainage plans are only allowed for projects in Small Site Drainage Review.

For single family residential permits, the level and scope of drainage plan requirements are determined by DDES during drainage review. Some projects qualifying for Small Site Drainage Review may also require Targeted Drainage Review.

TABLE 2.2.1.A DRAINAGE PLAN SUBMITTALS

Type of Permit or Project	Plans Required with Initial Permit Application	Type of Drainage Review	Plans Required for Drainage Review
SUBDIVISIONS, UPDs, AND BINDING SITE PLANS	Plat Map(5) Preliminary Plans Level 1 Downstream Analysis	Full or Targeted Drainage Review(2)	• Preliminary Plans(5) • Engineering Plans(1)
		Large Site Drainage Review	• Preliminary Plans(5) • Master Drainage Plan(4) or Special Study • Engineering Plans(1)
SHORT PLATS	Plot Plan(5)	Small Site Drainage Review	Small Site Drainage Plans(3)
	Plot Plan(5) Level 1 Downstream Analysis	Small Site Drainage Review AND Targeted Drainage Review(2)	• Small Site Drainage Plans(3) • Engineering Plans(1)
		Full or Targeted Drainage Review(2)	Engineering Plans(1)
COMMERCIAL	Engineering Plans(1),(2)	Full or Targeted Drainage Review	Engineering Plans(1)
SINGLE FAMILY RESIDENTIAL BUILDING PERMITS	Site Plan(5)	Small Site Drainage Review	Small Site Drainage Plans(3)
		Small Site Drainage Review AND Targeted Drainage Review(2)	• Small Site Drainage Plans(3) • Engineering Plans(1)
		Full or Targeted Drainage Review(2)	Engineering Plans(1)
OTHER PROJECTS OR PERMITS	Project-specific (contact DDES or use DDES customer information bulletins)	Full or Targeted Drainage Review(2)	Engineering Plans(1)

Notes:

(1) Submittal specifications for **engineering plans** are detailed in Section 2.3.1 (p. 2-7).

(2) Submittal specifications for **Targeted Drainage Review** are found in Section 2.3.2 (p. 2-27).

(3) Specifications for submittal of **small site drainage plans** are found in Appendix C, *Small Site Drainage Requirements* (detached).

(4) Specifications for submittal of **master drainage plans or special studies** are found in the King County publication titled *Master Drainage Planning for Large or Complex Site Developments.*

(5) Submittal specifications for these plans are found in the application packages and in DDES Customer information Bulletins.

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2.2 PLANS REQUIRED WITH INITIAL PERMIT APPLICATION

This section describes the submittal requirements for initial permit applications at DDES. The **timing for submittal** of engineering plans will vary depending on permit type. For subdivisions and short plats, this submittal usually follows the County's approval of preliminary plans. For commercial building permits, engineering plans must be submitted as part of the initial permit application. For other permit types the drainage plan requirements are determined during the permit review process.

Note: If engineering plans are required to be submitted with the initial permit application, they must be accompanied by the appropriate supporting documents (e.g., required application forms, an environmental checklist, etc.). For more details, see Reference Section 8 of this manual and DDES customer information bulletins.

Design Plan Certification

All preliminary plans and engineering plans **must be stamped** by a licensed civil engineer registered in the State of Washington.

All land boundary surveys and legal descriptions used for preliminary and engineering plans must be stamped by a professional land surveyor registered in the State of Washington. Topographic survey data and mapping prepared specifically for a proposed project may be performed by the licensed civil engineer stamping the engineering plans as allowed by the Washington State Board of Registration for Professional Engineers and Land Surveyors.

2.2.1 SUBDIVISION, UPD, AND BINDING SITE PLANS

Applications for proposed subdivision, UPD, and binding site plan projects must include engineered **preliminary plans**, which are used to help determine engineering plan requirements to recommend to the Hearing Examiner. Preliminary plans shall include the following:

1. **A conceptual drainage plan** prepared, stamped, and signed by a licensed civil engineer registered in the State of Washington. This plan must show the location and type of the following:
   a) Existing and proposed flow control facilities
   b) Existing and proposed water quality facilities
   c) Existing and proposed conveyance systems.

   The level of detail of the plan should correspond to the complexity of the project.
2. **A Level 1 Downstream Analysis** as required in Core Requirement #2 and outlined under "TIR Section 3, Offsite Analysis" (p. 2-9). This offsite analysis shall be submitted in order to assess potential offsite drainage impacts associated with development of the project, and to help propose appropriate mitigation of those impacts. A higher level of offsite analysis may be requested by DDES prior to preliminary approval, or as a condition of engineering plan submittal. The offsite analysis must be prepared, stamped, and signed by a licensed civil engineer registered in the State of Washington.
3. **Survey/topographic information.** The submitted site plan and conceptual drainage plan shall include the following:
   a) Field topographic base map to accompany application (aerial topography allowed with DDES permission)
   b) Name and address of surveyor and surveyor's seal and signature
   c) Notation for field or aerial survey

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d) Datum and benchmark/location and basis of elevation

e) Location of all sensitive areas (include the King County designation number, or identify as undesignated)

f) Contour intervals per the following chart:

Zoning Designation	Contour Intervals
Densities of developed area of over 2 DU per acre	2 feet at less than 15% slope 5 feet at 15% slope or more
Densities of developed area of 2 DU or less per acre	5 feet

2.2.2 SHORT SUBDIVISIONS

Applications for proposed short plats[1] require a **plot plan** (simplified preliminary plan) and a **Level 1 Downstream Analysis.** Plot plans are usually engineered, except for projects exempt from drainage review or qualifying for Small Site Drainage Review for the entire project. The specifications for submittal of plot plans are outlined in DDES customer information bulletins.

The Level 1 Downstream Analysis is required for all short plats except those meeting the exemptions outlined in Section 1.2.2 or qualifying for Small Site Drainage Review for the entire project. A higher level of offsite analysis may be requested by DDES prior to preliminary approval, or as a condition of engineering plan submittal.

2.2.3 COMMERCIAL SITE DEVELOPMENT

Applications for commercial permits require that **engineering plans** be submitted as part of the initial permit application. Most commercial projects will go through Full Drainage Review and require complete engineering plans. Projects which may qualify for limited scope engineering design should request Targeted Drainage Review during the preapplication meeting with DDES.

2.2.4 SINGLE FAMILY RESIDENTIAL

Applications for single family residential permits[1] require a non-engineered **site plan** to be submitted. The specifications for site plans are outlined in DDES customer information bulletins.

2.2.5 OTHER PERMITS

Other permit applications[1] will require project-specific information. Initial submittal requirements can be obtained by contacting DDES or consulting the DDES customer information bulletins.

[1] The specific level of required drainage analysis and design is usually determined during the preliminary drainage review of the plans submitted with the application. The overall plan review process may be expedited if the project is submitted with the appropriate level of detail.

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2.3 PLANS REQUIRED FOR DRAINAGE REVIEW

This section presents the specifications and contents required of plans to facilitate drainage review. Most projects subject to Full Drainage Review will require **engineering plans** that include a **technical information report (TIR)**, **site improvement plans**, and an **erosion and sediment control (ESC) plan.** In addition, a **landscape management plan** may also be required to comply with Core Requirement #8 (see Section 1.2.8). For more information on the types of projects subject to Full Drainage Review, see Section 1.1.2.3.

Small projects with specific drainage concerns that are subject to **Targeted Drainage Review**, also require engineering plans that include the same elements, except that the TIR may be of limited scope. The site improvement plans and ESC plans may also be of limited scope, but must meet all applicable specifications. For more information on the types of projects subject to Targeted Drainage Review, see Section 1.1.2.2.

Projects which qualify for **Small Site Drainage Review** may be required to submit small site drainage plans. These are simplified drainage and erosion control plans which can be prepared by a non-engineer from a set of pre-engineered design details, and which do not require a TIR. The *Small Site Drainage Requirements* booklet available at DDES and appended to this manual (detached Appendix C) contains the specifications for small site drainage plans and details on the Small Site Drainage Review process.

Note: Projects in Small Site Drainage Review may be required to submit engineering plans if they are also subject to Targeted Drainage Review as determined in Section 1.1.2.2 and Appendix C. Also, short plats in Small Site Drainage Review will be required to submit engineering plans if roadway construction is a condition of preliminary approval.

Design Plan Certification

All preliminary plans and engineering plans must be **stamped by a licensed civil engineer** registered in the State of Washington.

All land boundary surveys, and legal descriptions used for preliminary and engineering plans must be **stamped by a professional land surveyor** registered in the State of Washington. Topographic survey data and mapping prepared specifically for a proposed project may be performed by the licensed civil engineer stamping the engineering plans as allowed by the Washington State Board of Registration for Professional Engineers and Land Surveyors.

2.3.1 ENGINEERING PLAN SPECIFICATIONS

For drainage review purposes, **engineering plans** must consist of the following:

1. A **technical information report (TIR)** as detailed in Section 2.3.1.1 (p. 2-8), AND
2. **Site improvement plans** as detailed in Section 2.3.1.2 (p. 2-17), AND
3. An **erosion and sediment control (ESC) plan** as detailed in Section 2.3.1.3 (p. 2-24).

Also, if applicable per Section 1.2.8, a **landscape management plan,** as detailed in Section 2.3.1.4 (p. 2-26), must be included.

Projects in Targeted Drainage Review require a limited scope TIR with site improvement plans and an ESC plan, as detailed in Section 2.3.2 (p. 2-27). DDES may allow a modified site improvement plan for some projects in Targeted Drainage Review (see Section 2.3.2, p. 2-27) or where major improvements (e.g., detention facilities, conveyance systems, bridges, road right-of-way improvements, etc.) are not proposed.

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2.3.1.1 TECHNICAL INFORMATION REPORT (TIR)

The full TIR should be a comprehensive supplemental report containing all technical information and analysis necessary to develop the site improvement plan. This report should contain all calculations, conceptual design analysis, reports, and studies required and used to construct a complete site improvement plan based on sound engineering practices and careful geotechnical and hydrological design. The TIR must be stamped and dated by a licensed civil engineer registered in the State of Washington.

The TIR shall contain the following **ten sections**, preceded by a table of contents:

1. Project Overview
2. Conditions and Requirements Summary
3. Offsite Analysis
4. Flow Control and Water Quality Facility Analysis and Design
5. Conveyance System Analysis and Design
6. Special Reports and Studies
7. Other Permits
8. ESC Analysis and Design
9. Bond Quantities, Facility Summaries, and Declaration of Covenant
10. Operations and Maintenance Manual.

Every TIR must contain each of these sections; however, if a section does not apply, the applicant may simply mark "N/A" with a brief explanation. This standardized format allows a quicker, more efficient review of information required to supplement the site improvement plan.

The **table of contents** should include a list of the ten section headings and their respective page numbers, a list of tables with page numbers, and a list of numbered references, attachments, and appendices.

When the TIR package requires **revisions**, the revisions must be submitted in a complete TIR package.

❑ TIR SECTION 1
PROJECT OVERVIEW

The project overview must provide a general description of the proposal, predeveloped and developed conditions of the site, site area and size of the improvements, and the disposition of stormwater runoff before and after development. The overview shall identify and discuss difficult site parameters, the natural drainage system, and drainage to and from adjacent property, including bypass flows.

The following figures are required:

Figure 1. TIR Worksheet

Include a copy of the TIR Worksheet (see Reference Section 8-A).

Figure 2. Site Location

Provide a map that shows the general location of the site. Identify all roads that border the site and all significant geographic features and sensitive areas (lakes, streams, steep slopes, etc.).

Figure 3. Drainage Basins, Subbasins, and Site Characteristics

This figure shall display the following:

1. Show acreage of subbasins.
2. Identify all site characteristics.
3. Show existing discharge points to and from the site.

4. Show routes of existing, construction, and future flows at all discharge points and downstream hydraulic structures.
5. Use a minimum USGS 1:2400 topographic map as a base for the figure.
6. Show (and cite) the length of travel from the farthest upstream end of a proposed storm system in the development to any proposed flow control facility.

Figure 4. Soils

Show the soils within the following areas:

1. The project site
2. The area draining to the site
3. The drainage system downstream of the site for the distance of the downstream analysis (see Section 1.2.2).

Copies of King County Soil Survey maps may be used; however, if the maps do not accurately represent the soils for a proposed project (including offsite areas of concern), it is the design engineer's responsibility to ensure that the actual soil types are properly mapped. Soil classification symbols which conform to the *SCS Soil Survey for King County* shall be used, and the equivalent KCRTS soil type (till, outwash, or wetlands) shall be indicated (see Table 3.2.2.B).

All urban plats and short plats (creating lots less than 22,000 square feet) must evaluate onsite soils for suitability for **roof downspout infiltration** as detailed in Section 5.1.1. This soils report, as well as geotechnical investigations necessary for proposed infiltration facilities, should be referenced in the TIR Overview and submitted under Special Reports and Studies, TIR Section VI. A figure in the required geotechnical report that meets the above requirements may be referenced to satisfy 1, 2, and 3 above.

☐ TIR SECTION 2 CONDITIONS AND REQUIREMENTS SUMMARY

The intent of this section is to ensure all preliminary approval conditions and applicable requirements pertaining to site engineering issues have been addressed in the site improvement plan. All conditions and requirements for the proposed project should be included.

In addition to the core requirements of this manual, **adopted basin plans** and other plans as listed in Special Requirement #1 should be reviewed and applicable requirements noted. Sensitive area requirements, conditions of plat approval, and conditions associated with development requirements (e.g., conditional use permits, rezones, variances and adjustments, SEPA mitigations, etc.) should also be included.

☐ TIR SECTION 3 OFFSITE ANALYSIS

All projects in engineering review shall complete, at a minimum, an Offsite Analysis, except for projects meeting the exemptions outlined in Section 1.2.2. The Offsite Analysis is usually completed as part of the initial permit application and review process, and is to be included in the TIR. *Note: If offsite conditions have been altered since the initial submittal, a new offsite analysis may be required.*

The primary component of the offsite analysis is the **downstream analysis** described in detail below. Upstream areas are included in this component to the extent they are expected to be affected by backwater effects from the proposed project. Other components of the offsite analysis could include, but are not limited to, evaluation of impacts to fish habitat, groundwater levels, groundwater quality, or other environmental features expected to be significantly impacted by the proposed project due to its size or proximity to such features.

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Levels of Analysis

The offsite analysis report requirements vary depending on the specific site and downstream conditions. Each project submittal shall include at least a Level 1 downstream analysis. Upon review of the Level 1 analysis, DDES may require a Level 2 or Level 3 analysis. If conditions warrant, additional, more detailed analysis may be required. *Note: Potential impacts upstream of the proposal shall also be evaluated.*

Level 1 Analysis

The Level 1 analysis is a qualitative survey of each downstream system leaving a site. This analysis is required for all proposed projects and shall be submitted with the initial permit application. Depending on the findings of the Level 1 analysis, a Level 2 or 3 analysis may need to be completed or additional information may be required. If further analysis is required, the applicant may schedule a meeting with DDES staff.

Level 2 or 3 Analysis

If problems are identified in the Level 1 analysis, a Level 2 (rough quantitative) analysis or a Level 3 (more precise quantitative) analysis may be required to further evaluate proposed mitigation for the problem. DDES staff will determine whether a Level 2 or 3 analysis is required based on the evidence of existing or potential problems identified in the Level 1 analysis and on the proposed design of onsite drainage facilities. The Level 3 analysis is required when results need to be as accurate as possible: for example, if the site is flat; if the system is affected by downstream controls; if minor changes in the drainage system could flood roads or buildings; or if the proposed project will contribute more than 15 percent of the total peak flow to the drainage problem location. The Level 2 or 3 analysis may not be required if DDES determines from the Level 1 analysis that adequate mitigation can be developed.

Additional Analysis

Additional, more detailed hydrologic analysis may be required if DDES determines that the downstream analysis has not been sufficient to accurately determine the impacts of a proposed project on an existing or potential drainage problem. This more detailed analysis may include a **point of compliance analysis** as detailed in Section 3.3.6.

Scope of Analysis

Regardless of the level of downstream analysis required, the applicant shall define and map the study area (Task 1), review resources (Task 2), inspect the study area (Task 3), describe the drainage system and problems (Task 4), and propose mitigation measures (Task 5) as described below.

Task 1. Study Area Definition and Maps

For the purposes of Task 2 below, the study area shall extend downstream one mile (minimum flowpath distance) from the proposed project discharge location and shall extend upstream as necessary to encompass the offsite drainage area tributary to the proposed project site. **For the purposes of Tasks 3, 4, and 5,** the study area shall extend downstream to a point on the drainage system where the proposed project site constitutes a minimum of 15 percent of the total tributary drainage area, but not less than one-quarter mile (minimum flowpath distance). The study area shall also extend upstream of the project site a distance sufficient to preclude any back water effects from the proposed project.

The offsite analysis shall include (1) a **site map** showing property lines, and (2) the **best available topographical map** (e.g., from DDES, Department of Transportation map Counter, Sewer District, or at a minimum a USGS 1:24000 Quadrangle Topographic map) with the study area boundaries, site boundaries, downstream flowpath, and potential/existing problems (Task 4) shown. Other maps, diagrams, and photographs such as aerial photos may be helpful in describing the study area.

Task 2. Resource Review

To assist the design engineer in preparing an offsite analysis, King County has gathered information regarding existing and potential flooding and erosion problems. For all levels of analysis, all of the resources described below shall be reviewed for existing/potential problems in the study area (**upstream and one mile downstream of the project site**):

- Adopted **basin plans** (available at DDES, DNR, and the library)
- Finalized **drainage studies** (available at DNR Water and Land Resources Division)
- **Basin Reconnaissance Summary Reports** and 1"=400' scale problem summary maps (available at DDES, DNR, and the library)
- **Critical Drainage Area** maps (available at DDES)
- Floodplain/floodway **(FEMA) maps** (available at DDES and the library)
- Other **offsite analysis reports** in the same subbasin, if available (check with DDES records staff)
- **Sensitive Areas Folio** (available at DDES, DNR and the library - must be used to document the distance downstream from proposed project to nearest sensitive areas identified in the folio)
- DNR **drainage problems maps** (available at DNR Water and Land Resources Division)
- **Road drainage problems** (check with the DOT Roads Maintenance and Operations Division)
- U.S. Department of Agriculture, *King County Soils Survey* (available at DDES and the library)
- **Wetlands Inventory** maps (available at DDES and DNR)
- **Migrating river studies** (available at DDES and the DNR Water and Land Resources Division)

Potential/existing problems identified in the above documents shall be documented in the **Drainage System Table** (see Reference Section 8-B) as well as described in the text of the **Level 1 Downstream Analysis Report.** If a document is not available for the site, note in the report that the information was not available as of a particular date. If necessary, additional resources are available from King County, the Washington State Department of Fisheries and Wildlife (WDFW), the State Department of Ecology (DOE), the United States Army Corps of Engineers (Corps), and the public works departments of other municipalities in the vicinity of the proposed project site.

Task 3. Field Inspection

The design engineer shall physically inspect the existing on- and offsite drainage systems of the study area for each discharge location. Specifically, he/she shall investigate any evidence of the following existing or potential problems and drainage features:

Level 1 Inspection:

1. Investigate any problems reported or observed during the resource review.
2. Locate all existing/potential constrictions or lack of capacity in the existing drainage system.
3. Identify all existing/potential flooding or nuisance problems as defined in Section 1.2.2.1.
4. Identify existing/potential overtopping, scouring, bank sloughing, or sedimentation.
5. Identify significant destruction of aquatic habitat or organisms (e.g., severe siltation, bank erosion, or incision in a stream).
6. Collect qualitative data on features such as land use, impervious surfaces, topography, and soil types.
7. Collect information on pipe sizes, channel characteristics, drainage structures, and sensitive areas (e.g., wetlands, streams, steep slopes).
8. Verify tributary basins delineated in Task 1.
9. Contact neighboring property owners or residents in the area about past or existing drainage problems, and describe these in the report (optional).
10. Note the date and weather conditions at the time of the inspection.

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Level 2 or 3 Inspection:

1. Perform a Level 1 Inspection.
2. Document existing site conditions (approved drainage systems or pre-1979 aerial photographs) as defined in Core Requirement #3.
3. Collect quantitative field data. For Level 2, collect non-survey field data using hand tapes, hand reel, and rods; for Level 3, collect field survey profile and cross-section topographic data prepared by an experienced surveyor.

Task 4. Drainage System Description and Problem Descriptions

Each drainage system component and problem shall be addressed in the offsite analysis report in three places: on a map (Task 1), in the narrative (Task 4), and in the *Offsite Analysis Drainage System Table* (see Reference Section 8-B).

Drainage System Descriptions: The following information about drainage system components such as pipes, culverts, bridges, outfalls, ponds, tanks, and vaults shall be included in the report:

1. Location (corresponding map label and distance downstream/upstream from site discharge)
2. Physical description (type, size, length, slope, vegetation, and land cover)
3. Problems
4. Field observations.

Problem Descriptions: All existing or potential problems (e.g., ponding water, high/low flows, siltation, erosion, etc.) identified in the resource review or field inspection shall be described in the offsite analysis. These descriptions will help in determining if such problems are one of three defined problem types that require special attention per Core Requirement #2 (see Section 1.2.2.1). Special attention may include more analysis, additional flow control, or other onsite or offsite mitigation measures as specified by the problem-specific mitigation requirements set forth in Section 1.2.2.2.

The following information shall be provided for each existing or potential problem:

1. Description of the problem (ponding water, high or low flows, siltation, erosion, slides, etc.).
2. Magnitude of or damage caused by the problem (siltation of ponds, dried-up ornamental ponds, road inundation, flooded property, flooded building, flooded septic system, significant destruction of aquatic habitat or organisms).
3. General frequency and duration of problem (dates and times the problem occurred, if available).
4. Return frequency of storm or flow (cfs) of the water when the problem occurs (optional for Level 1 and required for Levels 2 and 3). *Note: A Level 2 or 3 analysis may be required to accurately identify the return frequency of a particular downstream problem; see Section 3.3.3.*
5. Water surface elevation when the problem occurs (e.g., elevation of building foundation, crest of roadway, elevation of septic drainfields, or wetland/stream high water mark).
6. Names and concerns of involved parties (optional for all levels of analysis).
7. Current mitigation of the problem.
8. Possible cause of the problem.
9. Whether the proposed project is likely to aggravate (increase the frequency or severity of) the existing problem or create a new one based on the above information. For example, an existing erosion problem should **not** be aggravated if Level 2 flow control is already required in the region for the design of onsite flow control facilities. Conversely, a downstream flooding problem inundating a home every 2 to 5 years will likely be aggravated if only Level 1 flow control is being applied in the region. See Section 1.2.3.1 for more details on the effectiveness of flow control standards in addressing downstream problems.

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Task 5. Mitigation of Existing or Potential Problems

For any existing or potential offsite drainage problem determined to be one of the three defined problem types in Section 1.2.2.1, the design engineer must demonstrate that the proposed project neither aggravates (if existing) nor creates the problem as specified in the problem-specific mitigation requirements set forth in Section 1.2.2.2. To meet these requirements, the proposed project may need to provide additional onsite flow control as specified in Table 1.2.3.A (see also Section 3.3.5), or other onsite or offsite mitigation measures as described in Section 3.3.5.

❑ TIR SECTION 4 FLOW CONTROL AND WATER QUALITY FACILITY ANALYSIS AND DESIGN

Existing Site Hydrology (Part A)

This section of the TIR should include a discussion of assumptions and site parameters used in analyzing the existing site hydrology.

The acreage, soil types, and land covers used to determine existing flow characteristics, along with basin maps, graphics, and exhibits for each subbasin affected by the development, should be included.

The following information must be provided on a topographical map:

1. Delineation and acreage of areas contributing runoff to the site
2. Flow control facility location
3. Outfall
4. Overflow route.

The scale of the map and the contour intervals must be sufficient to determine the basin and subbasin boundaries accurately. The **direction of flow**, the acreage of **areas contributing drainage**, and the **limits of development** should all be indicated on the map.

Each subbasin contained within or flowing through the site should be individually labeled and KCRTS parameters referenced to that subbasin.

All natural streams and drainage features, including wetlands and depressions, must be shown. Rivers, closed depressions, streams, lakes, and wetlands must have the **100-year floodplain** (and floodway where applicable) delineated as required in Special Requirement #2 (see Section 1.3.2) and by the Sensitive Areas Ordinance and Rules.

Developed Site Hydrology (Part B)

This section should provide narrative, mathematical, and graphical presentations of **parameters selected and values used** for the developed site conditions, including acreage, soil types and land covers, roadway layouts, and all constructed drainage facilities.

Developed subbasin areas and flows should be clearly depicted on a map and cross-referenced to computer printouts or calculation sheets. Relevant portions of the calculations should be highlighted and tabulated in a listing of all developed subbasin flows.

All maps, exhibits, graphics, and references used to determine developed site hydrology must be included, maintaining the same **subbasin labeling** as used for the existing site hydrology whenever possible. If the boundaries of the subbasin have been modified under the developed condition, the labeling should be modified accordingly (e.g., Subbasin "Am" is a modified version of existing Subbasin "A").

Performance Standards (Part C)

The design engineer shall include brief discussions of the following:

- The **area-specific flow control standard** determined from the Flow Control Applications Map per Section 1.2.3.1 and any modifications to the standard to address onsite or offsite drainage conditions;
- The applicable **conveyance system capacity standards** per Section 1.2.4; and

- The applicable **area-specific water quality treatment menu** determined from the Water Quality Applications Map per Section 1.2.8.1, and any applicable special requirements for **source control** or **oil control** determined from Sections 1.3.4 and 1.3.5.

Flow Control System (Part D)

This section requires an **illustrative sketch** of the flow control facility and its appurtenances. This sketch must show basic measurements necessary to calculate the storage volumes available from zero to the maximum head, all orifice/restrictor sizes and head relationships, and control structure/restrictor orientation to the facility.

The applicant should include all computer printouts, calculations, equations, references, storage/volume tables, graphs, and any other aides necessary to **clearly show results and methodology used to determine the storage facility volumes.** KCRTS facility documentation files, "Compare Flow Durations" files, peaks files, return frequency or duration curves, etc., should be included to verify the facility meets the performance standards indicated in Part C. The **volumetric safety factor** used in the design should be clearly identified, as well as the reasoning used by the design engineer in selecting the safety factor for this project.

Water Quality System (Part E)

This section provides an **illustrative sketch** of the proposed water quality facility (or facilities), source controls, oil controls, and appurtenances. This sketch (or sketches) should show overall measurements and dimensions, orientation on the site, location of inflow, bypass, and discharge systems, etc. If the **water quality credit option** is used as allowed in Section 6.1.2, provide documentation in Part E of the actions that will be taken to acquire the requisite credits.

The applicant should include all computer printouts, calculations, equations, references, and graphs necessary to show the facility was designed and sized in accordance with the specifications and requirements in Chapter 6.

☐ TIR SECTION 5
CONVEYANCE SYSTEM ANALYSIS AND DESIGN

This section should present a detailed analysis of any existing conveyance systems, and the analysis and design of the proposed stormwater collection and conveyance system for the development. This information should be presented in a clear, concise manner that can be easily followed, checked, and verified. All pipes, culverts, catch basins, channels, swales, and other stormwater conveyance appurtenances must be clearly labeled and correspond directly to the engineering plans.

The minimum information included shall be pipe flow tables, flow profile computation tables, nomographs, charts, graphs, detail drawings, and other tabular or graphic aides used to design and confirm performance of the conveyance system.

Verification of capacity and performance must be provided for each element of the conveyance system. The analysis must show design velocities and flows for all drainage facilities within the development, as well as those offsite which are affected by the development. If the final design results are on a computer printout, a separate summary tabulation of conveyance system performance should also be provided.

☐ TIR SECTION 6
SPECIAL REPORTS AND STUDIES

Some site characteristics, such as steep slopes or wetlands, pose unique road and drainage design problems which are particularly sensitive to stormwater runoff. As a result, King County may require the preparation of special reports and studies which further address the site characteristics, the potential for impacts associated with the development, and the measures that would be implemented to mitigate impacts. Special reports shall be prepared by people with expertise in the particular area of analysis. Topics of special reports may include any of the following:

- Geotechnical/soils
- Wetlands

- Floodplains
- Slope protection/stability
- Groundwater
- Fluvial geomorphology
- Erosion and deposition
- Anadromous fisheries impacts
- Structural design
- Geology
- Hydrology
- Water quality
- Structural fill.

❑ TIR SECTION 7 OTHER PERMITS

Technical Information Report

Construction of road and drainage facilities may require additional permits from other agencies for some projects. These additional permits may contain more restrictive drainage plan requirements. This section of the TIR should provide the titles of any other permits, the agencies requiring the other permits, and the permit requirements that affect the drainage plan. Examples of other permits are listed in Section 1.1.3.

❑ TIR SECTION 8 ESC ANALYSIS AND DESIGN

This section must include all hydrologic and hydraulic information used to analyze and design the erosion and sediment control (ESC) facilities, including final site stabilization measures. The TIR shall explain how proposed ESC measures comply with the *Erosion and Sediment Control Standards* (detached Appendix D) and show compliance with the implementation requirements of Core Requirement #5, Section 1.2.5.

The following information must be included:

1. **Provide sufficient information to justify the overall ESC plan** and the choice of individual erosion control measures. At a minimum, there shall be a discussion of each of the measures specified in Section 1.2.5 and their applicability to the proposed project.
2. Include all **hydrologic and hydraulic information** used to analyze and size the ESC facilities shown in the engineering plans. Describe the methodology, and attach any graphics or sketches used to size the facilities.
3. Identify areas with a particularly high susceptibility to erosion because of slopes or soils. Discuss any **special measures** taken to protect these areas as well as any special measures proposed to protect water resources on or near the site.
4. Identify any **ESC recommendations in any of the special reports** prepared for the project. If these recommendations are not included in the ESC plan, provide justification.
5. If proposing **exceptions or modifications to the standards** detailed in the *Erosion and Sediment Control Standards* (detached Appendix D), clearly present the rationale. If proposing techniques or products different from those detailed in the *ESC Standards*, provide supporting documentation so the County can determine if the proposed alternatives provide similar protection.

❑ TIR SECTION 9
BOND QUANTITIES, FACILITY SUMMARIES, AND DECLARATION OF COVENANT

Bond Quantities Worksheet

Each plan submittal requires a construction quantity summary to establish appropriate bond amounts. Using the *Bond Quantities Worksheet* furnished by DDES (see Reference 8-D), the design engineer shall separate existing right-of-way and erosion control quantities from other onsite improvements. In addition, the engineer shall total the amounts based on the unit prices listed on the form.

Drainage facilities for single family residential building permits, which are normally not bonded, shall be constructed and approved prior to granting the certificate of occupancy.

Flow Control and Water Quality Facility Summary Sheet and Sketch

Following approval of the plans, a *Flow Control and Water Quality Facility Summary Sheet and Sketch* (see Reference 8-C) shall be submitted along with an $8^1/_2$" x 11" plan sketch for each facility proposed for construction. The plan shall show a north arrow, the tract, the facility access road, the extent of the facility, and the control structure location. The approximate street address shall be noted.

Declaration of Covenant
(Privately Maintained Flow Control and WQ Facilities Only)

A declaration of covenant (see Reference 8-F) must be signed and recorded at the office of King County Records and Elections before any permit with privately maintained flow control or water quality facilities are approved.

❑ TIR SECTION 10
OPERATIONS AND MAINTENANCE MANUAL

For each flow control and water quality facility that is to be privately maintained, and for those that have special non-standard features, the design engineer shall prepare an operations and maintenance manual. The manual should be simply written and should contain a brief description of the facility, what it does, and how it works. In addition, the manual shall include a copy of the *Maintenance Requirements for Privately Maintained Drainage Facilities* (see Appendix A) and provide an outline of maintenance tasks and the recommended frequency each task should be performed. This is especially important for water quality facilities where proper maintenance is critical to facility performance. For this reason, most of the **water facility designs in Chapter 6 include "maintenance considerations" important to the performance of each facility.**

2.3.1.2 SITE IMPROVEMENT PLAN

Site improvement plans shall portray design concepts in a clear and concise manner. The plans must present all the information necessary for persons trained in engineering to review the plans, as well as those persons skilled in construction work to build the project according to the design engineer's intent. Supporting documentation for the site improvement plans must also be presented in an orderly and concise format that can be systematically reviewed and understood by others.

The **vertical datum** on which all engineering plans, plats, binding site plans, and short plats are to be based must be the North American Vertical Datum (NAVD) of 1988, and the datum must be tied to at least one King County Survey Control Network benchmark. The benchmark(s) shall be shown or referenced on the plans. If a King County Control Network benchmark does not exist within 1/2 mile of the subject property, or if 250 feet or greater of total vertical difference exists between the starting benchmark and the project, an assumed or alternate vertical datum may be used. Datum correlations can be found in Table 4.4.2.C.

Horizontal control for all plats, binding site plans, and short plats shall reference the North American Datum of 1983/91 as the coordinate base and basis of bearings. All horizontal control for these projects must be referenced to a minimum of two King County Survey Horizontal Control monuments. If two horizontal control monuments do not exist within one mile of the project, an assumed or alternate coordinate base and basis of bearings may be used. Horizontal control monument and benchmark information is available from the King County Survey Department.

The site improvement plans consist of all the plans, profiles, details, notes, and specifications necessary to construct road, drainage structure, and off-street parking improvements. Site improvement plans include the following:

- A **base map** (described on page 2-20), and
- **Site plan and profiles** (beginning on page 2-21).

Note: Site improvement plans must also include grading plans if onsite grading extends beyond the roadway.

Modified Site Improvement Plan

DDES may allow a modified site improvement plan for some projects in Targeted Drainage Review (see Section 2.3.2, p. 2-27) or where major improvements (e.g., detention facilities, conveyance systems, bridges, road right-of-way improvements, etc.) are not proposed. The modified site improvement plan must:

1. Be drawn on a 11" x 17" or larger sheet,
2. Accurately locate structure(s) and access, showing observance of the setback requirements given in this manual, the Sensitive Areas Ordinance, or other applicable documents,
3. Provide enough information (datum, topography, details, notes, etc.) to address issues as determined by DDES.

❑ GENERAL PLAN FORMAT

Site improvement plans should use *King County Roads Standard Map Symbols* as appropriate, and must include *Standard Plan Notes* (see Reference Section 7). Each plan must follow the general format detailed below:

1. Plan sheets and profile sheets, or combined **plan and profile sheets**, specifications, and detail sheets as required shall be on "D-size" sheets (24" x 36"). "E-size" sheets (36" x 42") are also acceptable for commercial proposals, except that associated right-of-way improvements must be on "D-size" sheets (24" x 36"). Original sheets shall be archive quality reproducibles, mylar or equal.
2. **Drafting details** shall generally conform to *King County Standard Map Symbols* (see Reference Section 7-A) with lettering size (before reduction) no smaller than Leroy 80 (Leroy 100 is preferred). Existing features shall be shown with dashed lines or as half-toned (screened) in order to clearly

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distinguish existing features from proposed improvements.

3. Each submittal shall contain a **project information/cover sheet** with the following:

   a) Title: Project name and DDES file number

   b) Table of contents (if more than three pages)

   c) Vicinity map

   d) Name and phone number of utility field contacts (e.g., water, sanitary sewer, gas, power, telephone, and TV) and the One-Call number (1-800-424-5555)

   e) King County's preconstruction/inspection notification requirements

   f) Name and phone number of the erosion control supervisor

   g) Name and phone number of the surveyor

   h) Name and phone number of the owner/agent

   i) Name and phone number of the applicant

   j) Legal description

   k) Plan approval signature block for DDES

   l) Name and phone number of the engineering firm preparing the plans (company logos acceptable)

   m) Fire Marshal's approval stamp (if required)

   n) Statement that mailbox locations have been designated or approved by the U.S. Postal Service (where required)

   o) List of conditions of preliminary approval on all site improvements.

Note: If this information is provided on the architectural plans for commercial building permits, then it may be omitted from the commercial engineering site plans. A blank sample or computer file of the information sheet format is available from DDES upon request.

4. An **overall site plan** shall be included if more than three plan sheets are used. The overall plan shall be indexed to the detail plan sheets and include the following:

   a) The complete property area development

   b) Right-of-way information

   c) Street names and road classification

   d) All project phasing and proposed division boundaries

   e) All natural and proposed drainage collection and conveyance systems with catch basin numbers shown.

5. Each sheet of the plan set shall be stamped, signed, and dated by a **licensed civil engineer** registered in the State of Washington. At least one sheet showing all boundary survey information must be provided and stamped by a **professional land surveyor** licensed in the State of Washington.

6. **Detail sheets** shall provide sufficient information to construct complex elements of the plan. Details may be provided on plan and profile sheets if space allows.

7. A **title block** shall be provided on each plan sheet. At a minimum, the title block shall list the following:

   a) Development title

   b) Name, address, and phone number of the firm or individual preparing the plan

   c) A revision block

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d) Page (of pages) numbering

e) Sheet title (e.g., road and drainage, grading, erosion and sediment control).

8. The **location and label** for each section or other detail shall be provided.
9. **Sensitive Area Setbacks** shall be designated as required by the Sensitive Areas Ordinance (KCC 21A.24).
10. All **match lines** with matched sheet number shall be provided.
11. All division or phase lines and the **proposed limits of construction** under the permit application shall be indicated.
12. **Wetlands** shall be labeled with the number from the wetland inventory, or shall be labeled as "uninventoried" if not listed on the wetland inventory.
13. The **standard plan notes** that apply to the project shall be provided on the plans (see Reference Section 7-B).
14. Commercial building permit applications shall include the **designated zoning** for all properties adjacent to the development site(s).

❑ BASE MAP

A site improvement plan **base map** provides a common base and reference in the development and design of any project. A base map helps ensure that the engineering plans, grading plans, and ESC plans are all developed from the same background information. This base map shall include the information listed in Table 2.3.1.A.

TABLE 2.3.1.A BASE MAP REQUIREMENTS

Feature	Requirements
Ground Surface Topography	Provide topography within the site and extending beyond the property lines. Contour lines must be shown as described in "Plan View: Site Plan and Roadway Elements" (p. 2-21).
Surface Water Discharge	Provide ground surface elevations for a reasonable "fan" around points of discharge extending at least 50 feet downstream of all point discharge outlets.
Hydrologic Features	Provide spot elevations in addition to contour lines to aid in delineating the boundaries and depth of all existing floodplains, wetlands, channels, swales, streams, storm drainage systems, roads (low spots), bogs, depressions, springs, seeps, swales, ditches, pipes, groundwater, and seasonal standing water.
Other Natural Features	Show the location and relative sizes of other natural features such as rock outcroppings, existing vegetation, and trees 12 inches in diameter and greater that could be disturbed by the project improvements and construction activities (within tree canopy), noting species.
Flows	Provide arrows that indicate the direction of surface flow on all public and private property and for all existing conveyance systems.
Floodplains/ Floodways	Show the floodplain/floodways as required by the flood hazard portion of the Sensitive Areas Ordinance and Rules and Section 4.4.2.
General Background Information	Show the location and limits of all existing: • Property boundaries • Structures • Easements (including dimensions) • Total property (including dimensions) • Roads and right-of-way • Sanitary sewers and water utilities • Common open space • Public dedications • Other manmade features affecting existing topography/proposed improvements.
Development Limitations	Delineate limitations to the development that may occur as identified on the TIR worksheet, Part 8 (see Reference 8-A).

❑ SITE PLAN AND PROFILES

The design engineer shall provide plans and profiles for all construction, including but not limited to the following information.

Plan View: Site Plan and Roadway Elements

1. Provide property lines, right-of-way lines, and widths for proposed roads and intersecting roads.
2. Provide all existing and proposed **roadway features**, such as centerlines, edges of pavement and shoulders, ditchlines, curbs, and sidewalks. In addition, show points of access to abutting properties and roadway continuations.
3. Show existing and proposed **topography contours** at 2-foot intervals (5-foot intervals for slopes greater than 15 percent, 10-foot intervals for slopes greater than 40 percent). Contours may be extrapolated from USGS mapping, aerial photos, or other topography map resources. However, contours shall be field verified for roadway and stream centerlines, steep slopes, floodplains, drainage tracts easements, and conveyance systems. Contours shall extend 50 feet beyond property lines to resolve questions of setback, cut and fill slopes, drainage swales, ditches, and access or drainage to adjacent property.
4. Show the location of all existing **utilities** and proposed utilities (except those designed by the utility and not currently available) to the extent that these will be affected by the proposed project. Clearly identify all existing **utility poles**.
5. Identify all roads and adjoining subdivisions.
6. Show **right-of-way** for all proposed roadways, using sufficient dimensioning to clearly show exact locations on all sections of existing and proposed dedicated public roadway.
7. Clearly differentiate areas of **existing pavement** and areas of **new pavement**.
8. For subdivision projects, generally use **drawing scales** of 1"=50'; however, 1"=100' is optional for development of lots one acre or larger. For commercial, multi-family, or other projects, generally use scales of 1"=20'; however, 1"=10', 1" = 30', 1"=40' and 1"=50' are acceptable. Show details for clarification, including those for intersections and existing driveways, on a larger scale.

Plan View: Drainage Conveyance

1. Sequentially **number all catch basins and curb inlets** starting with the structure farthest downstream.
2. Represent **existing storm drainage facilities** in dashed lines and label with "Existing."
3. Clearly label existing storm drainage **facilities to be removed** with "Existing to be removed."
4. Show the length, diameter, and material for all **pipes, culverts, and stub-outs**. Include the slope if not provided on the profile view. Material may be noted in the plan notes.
5. Clearly label **catch basins** as to size and type (or indicate in the plan notes).
6. Clearly label downspout and footing drain **stub-out locations** for those lots intending to connect to the storm drainage flow control system. Locate all stub-outs to allow gravity flow from the lowest corner of the lot to the connecting catch basin.
7. Show **datum, benchmark locations, and elevations** on each plan sheet.
8. Clearly label all stub-out locations for any **future pipe connections.**
9. Clearly show on the plans all drainage **easements, tracts**, access easements, Native Growth Retention Areas, Sensitive Area Tracts, Sensitive Area Setback Areas, and building setback lines. Show dimensions, type of restriction, and use.
10. Using arrows, indicate **drainage direction** of hydraulic conveyance systems.

Plan View: Other

1. Show the location, identification, and dimensions of all **buildings, property lines, streets, alleys, and easements.**
2. Verify the condition of all **public right-of-way** and the rights to use them as proposed.
3. Show the locations of **structures on abutting properties** within 50 feet of the proposed project site.
4. Show the location of all proposed **drainage facility fencing**, together with a typical section view of each fencing type.
5. Provide section details of all **retaining walls and rockeries**, including sections through critical portions of the rockeries or retaining walls.
6. Show all existing and proposed **buildings with projections and overhangs.**
7. Show the location of all **wells** on site and within 100 feet of the site. Note wells to be abandoned.
8. Show **structural BMPs** required by the *King County Water Pollution Control Manual.*

Profiles: Roadway and Drainage

1. Provide **existing centerline ground profile** at 50-foot stations and at significant ground breaks and topographic features, with average accuracy to within 0.1 feet on unpaved surface and 0.02 feet on paved surface.
2. For publicly maintained roadways, provide **final road and storm drain profile** with the same stationing as the horizontal plan, reading from left to right, to show stationing of points of curve, tangent, and intersection of vertical curves, with elevation of 0.01 feet. Include tie-in with intersecting pipe runs.
3. On a grid of numbered lines, provide a continuous plot of **vertical positioning against horizontal.**
4. Show finished **road grade and vertical curve data** (road data measured at centerline or edge of pavement). Include stopping sight distance.
5. Show all **roadway drainage**, including drainage facilities, that are within the right-of-way or easement.
6. On the profile, show slope, length, size, and type (in plan notes or on a detail sheet) for all **pipes and detention tanks in public right-of-way.**
7. Indicate the **inverts** of all pipes and culverts and the elevations of catch basin grates or lids. It is also desirable, but not required, to show invert elevations and grate elevations on plan sheets.
8. For pipes that are proposed to be within 2.0 feet of finished grade, indicate the **minimum cover dimensions.**
9. Indicate **roadway stationing** and offset for all catch basins.
10. Indicate **vertical and horizontal scale.**
11. Clearly label all profiles with respective street names and plan sheet reference numbers, and indicate all profile sheet reference numbers on plan sheets, if drawn on separate sheets.
12. Locate **match points with existing pavements**, and show elevations.
13. Show all **property boundaries.**
14. Label all **match line locations.**
15. Provide profiles for all **12-inch and larger pipes** and for **channels** (that are not roadside ditches).
16. Show the location of all existing and proposed (if available or critical for clearance) **gas, water, and sanitary sewer crossings.**
17. Show **energy dissipater locations.**

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18. Identify **datum** used and all **benchmarks** (may be shown on plan view instead). Datum and benchmarks must refer to established control when available.
19. Use a **vertical scale** of 1"=5'. As an exception, vertical scale shall be 1"=10' if the optional 1"=100' horizontal scale is used on projects with lots one acre or larger. Clarifying details, including those for intersections and existing driveways, should use a larger scale.
20. **Split sheets**, with the profile aligned underneath the plan view, are preferred but not required.

❑ DETAILS

The design engineer shall provide details for all construction, including but not limited to the following.

Flow Control, Water Quality, and Infiltration Facility Details

1. Provide a scaled drawing of each detention pond or vault and water quality facility, including the tract boundaries.
2. Show predeveloped and finished grade **contours** at 2-foot intervals. Show and label **maximum design water elevation.**
3. Dimension all **berm widths.**
4. Show and label at least two **cross sections** through a pond or water quality facility. One cross section must include the restrictor.
5. Specify **soils and compaction requirements** for pond construction.
6. Show the location and detail of **emergency overflows, spillways, and bypasses.**
7. Specify **rock protection/energy dissipation** requirements and details.
8. Provide **inverts** of all pipes, grates, inlets, tanks, and vaults, and **spot elevations** of the pond bottom.
9. Show the location of **access roads** to control manholes and pond/forebay bottoms.
10. Provide plan and section views of all **energy dissipaters**, including **rock splash pads**. Specify the size of rock and thickness.
11. Show **bollard locations** on plans. Typically, bollards are located at the entrance to drainage facility access roads.
12. On the pond or water quality facility detail, show the size, type (or in plan notes), slope, and length of all **pipes.**
13. Show to scale the section and plan view of **restrictor and control structures.** The plan view must show the location and orientation of all inlet pipes, outlet pipes, and flow restrictors.
14. Draw details at one of the following **scales:** 1"=1', 1"=2', 1"=4', 1"=5', 1"=10', or 1"=20'.

Structural Plan Details

Any submittal that proposes a structure (e.g., bridge crossing, reinforced concrete footings, walls, or vaults) shall include plan sheets that include complete working drawings showing dimensions, steel placement, and specifications for construction. Structures may require a design prepared and **stamped by a professional structural engineer** licensed in the State of Washington, and an application for a separate commercial building permit.

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2.3.1.3 EROSION AND SEDIMENT CONTROL (ESC) PLAN

This section details the specifications and contents for ESC plans. Note that the ESC plan may be simplified by the use of the symbols and codes provided for each ESC measure in the *Erosion and Sediment Control Standards* (detached Appendix D). In general, the ESC plan shall be submitted as a separate plan sheet(s). However, there may be some relatively simple projects where providing separate grading and ESC plans is unnecessary.

General Specifications

The **site improvement plan shall be used as the base of the ESC plan**. Certain detailed information that is not relevant (e.g., pipe/catch basin size, stub-out locations, etc.) may be omitted to make the ESC plan easier to read. At a minimum, the ESC plan shall include all of the information required for the base map (see Table 2.3.1.A, p. 2-20), as well as existing and proposed roads, driveways, parking areas, buildings, drainage facilities, utility corridors not associated with roadways, all sensitive areas and buffers, and proposed final topography. A smaller scale may be used to provide better comprehension and understanding.

The ESC plan shall generally be designed for proposed topography, not existing topography, since rough grading is usually the first step in site disturbance. The ESC plan shall **address all phases of construction** (e.g., clearing, grading, installation of utilities, surfacing, and final stabilization). If construction is being phased, separate ESC plans may need to be prepared to address the specific needs for each phase of construction.

The ESC plan shall be consistent with the information provided in Section 8 of the TIR and shall show the following:

1. Identify areas with a high **susceptibility to erosion.**
2. Provide all details necessary to clearly illustrate the **intent of the ESC design.**
3. Include ESC measures for all on- and offsite **utility construction** included in the project.
4. Specify the **construction sequence.** The construction sequence shall be specifically written for the proposed project. An example construction sequence is provided in Appendix D.
5. Include *ESC Standard Plan Notes* (see Reference Section 7-B).

Clearing Limits

1. Delineate clearing limits.
2. Provide details sufficient to install and maintain the clearing limits.

Cover Measures

1. Specify the type and location of **temporary cover measures** to be used onsite.
2. If more than one type of cover is to be used onsite, indicate the areas where the different measures will be used, including steep cut and fill slopes.
3. If the type of cover measures to be used will vary depending on the time of year, soil type, gradient, or some other factor, specify the conditions that control the use of the different measures.
4. Specify the nature and location of **permanent cover measures.** If a landscaping plan is prepared, this may not be necessary.
5. Specify the approximate amount of cover measures necessary to cover all disturbed areas.
6. If **netting or blankets** are specified, provide typical detail sufficient for installation and maintenance.
7. Specify the **seed mixes, fertilizers, and soil amendments** to be used, as well as the application rate for each item.

Perimeter Protection

1. Specify the location and type of perimeter protection to be used.
2. Provide typical details sufficient to install and maintain the perimeter protection.
3. If silt fence is to be used, specify the type of fabric to be used.

Traffic Area Stabilization

1. Locate the construction entrance(s).
2. Provide typical details sufficient to install and maintain the construction entrance.
3. Locate the construction roads and parking areas.
4. Specify the measure(s) that will be used to create stabilized construction roads and parking areas. Provide sufficient detail to install and maintain.

Sediment Retention

1. Show the locations of all sediment ponds and traps.
2. Dimension pond **berm widths** and all inside and outside pond slopes.
3. Indicate the **trap/pond storage** required and the depth, length, and width dimensions.
4. Provide typical **section views** through pond and outlet structures.
5. Provide typical details of the **control structure** and **dewatering mechanism**.
6. Detail stabilization techniques for outlet/inlet.
7. Provide details sufficient to install **cell dividers**.
8. Specify mulch or recommended cover of berms and slopes.
9. Specify the **1-foot marker** indicating when sediment removal is required.
10. Indicate catch basins that are to be protected.
11. Provide details of the **catch basin protection** sufficient to install and maintain.

Surface Water Control

1. Locate all pipes, ditches, interceptor ditches, and swales that will be used to convey stormwater.
2. Provide details sufficient to install and maintain all **conveyances**.
3. Indicate locations of **outlet protection**, and provide detail of protections.
4. Indicate locations and outlets of any possible **dewatering systems**.
5. Indicate the location of any **level spreaders**, and provide details sufficient to install and maintain.
6. Show all **temporary pipe inverts**.
7. Provide location and specifications for the **interception of runoff from disturbed areas** and the conveyance of the runoff to a non-erosive discharge point.
8. Provide location and details of **rock check dams**.
9. Provide front and side sections of typical rock check dams.

Wet Season Requirements

Provide a list of all applicable wet season requirements.

Sensitive Areas Restrictions

1. Specify the type, locations, and details of any measures necessary to comply with requirements to **protect surface waters**.
2. Specify the type, locations, and details of any measures necessary to comply with any additional protection required to **protect steep slopes**.

2.3.1.4 LANDSCAPE MANAGEMENT PLANS (IF APPLICABLE)

Approved landscape management plans are allowed to be used as an alternative to the requirement to formally treat (with a facility) the runoff from pollution-generating pervious surfaces subject to Core Requirement #8 (see Section 1.2.8). A *landscape management plan* is a King County approved plan for defining the layout and long-term maintenance of landscaping features to minimize the use of pesticides and fertilizers, and reduce the discharge of suspended solids and other pollutants. **General guidance for preparing landscape management plans** is provided in Reference Section 4-A.

If a landscape management plan is proposed, it must be submitted with the engineering plans for the proposed project. The elements listed below are required for evaluation of landscape management plans.

1. Provide a site **vicinity map** with topography.
2. Provide a **site plan** with topography. Indicate areas with saturated soils or high water tables.
3. Provide a **plant list** (provide both common and scientific names) which includes the following information:
   a) Indicate any drought-tolerant plants, disease resistant varieties, species for attracting beneficial insects (if any) and native plants.
   b) For shrubs and groundcovers, indicate the proposed spacing.
   c) For turf areas, indicate the grass mix or mixes planned. Indicate sun/shade tolerance, disease susceptibility, drought tolerance and tolerance of wet soil conditions.
4. Provide a **landscape plan**. Indicate placement of landscape features, lawn areas, trees, and planting groups (forbes, herbs, groundcovers, etc.) on the site.
5. Include information on **soil preparation** and fertility requirements.
6. Provide information on the design of the **irrigation method** (installed sprinkler system, drip irrigation system, manual, etc.)
7. Provide a **landscape maintenance plan**, including the following:
   a) Physical care methods, such as thatch removal or aeration, and mowing height and frequency
   b) Type of fertilizer (including N-P-K strength) and fertilization schedule or criteria
   c) Type of chemicals to be used for common pests such as cranefly larvae, and the criteria or schedule for application
   d) Any biocontrol methods.
8. Provide information about the **storage of pesticides or other chemicals**, and **disposal measures** that will be used.
   a) If applicable, indicate how the chemicals will be stored on the site between applications to prevent contact with stormwater or spills into the storm drainage system.
   b) Indicate how excess quantities of fertilizers or chemicals will be handled for individual applications.
9. Provide an **implementation plan** (see Reference Section 4-A for guidance on preparing the implementation plan).

2.3.2 PROJECTS IN TARGETED DRAINAGE REVIEW

This section outlines the specifications and contents of limited scope engineering plans allowed for projects in Targeted Drainage Review. Table 2.3.2.A specifies the minimum required elements of the targeted technical information report based on the type of permit or project, and on the three categories of project characteristics subject to Targeted Drainage Review per Section 1.1.2.2.

TABLE 2.3.2.A MINIMUM ENGINEERING PLAN ELEMENTS[1] FOR PROJECTS IN TARGETED DRAINAGE REVIEW

Type of Permit or Project	Drainage Review Type	Project Category 1[2] Projects in Targeted Drainage Review that contain or are adjacent to floodplains or sensitive areas, or are subject to drainage requirements per Drainage Review Thresholds #4 & #5 (Sec. 1.1.1)	Project Category 2[2] Projects in Targeted Drainage Review that propose to construct or modify a 12" or larger pipe/ditch, or receive runoff from a 12" or larger pipe/ditch	Project Category 3[2] Redevelopment projects in Targeted Drainage Review that propose $100,000 or more of improvements to an existing high-use site
SINGLE FAMILY RESIDENTIAL BUILDING PERMITS (SFRs) & SHORT PLATS	Targeted Drainage Review ONLY	• TIR Sections 1, 2, and 6 (minimum) • Small Site ESC Plan[3] • Site Improvement Plan[5].	• TIR Sections 1, 2, 3, 5, 6, 7, and 8 (minimum) • Small Site ESC Plan[3] • ESC Plan[4] for conveyance work • Site Improvement Plan[5]	N/A
	Targeted Drainage Review COMBINED WITH Small Site Drainage Review	• TIR Sections 1, 2, and 6 (minimum) • Small Site ESC Plan[3] • Site Improvement Plan[5]	• TIR Sections 1, 2, 3, 5, 6, 7, and 8 (minimum) • Small Site ESC Plan[3] • ESC Plan[4] for conveyance work • Site Improvement Plan[5]	N/A
OTHER PROJECTS OR PERMITS	Targeted Drainage Review ONLY	• TIR Sections 1, 2, 6, and 8 (minimum) • ESC Plan[4] for any site disturbance work • Site Improvement Plan[5]	• TIR Sections 1, 2, 3, 5, 6, 7, and 8 (minimum) • ESC Plan[4] for any site disturbance work • Site Improvement Plan[5]	• TIR Sections 1, 2, 4, 8, and 10 (minimum) • ESC Plan[4] for any site disturbance work • Site Improvement Plan[5]

Notes:

(1) The above plan elements are considered the recommended minimum for most development cases in Targeted Drainage Review. DDES may add to these elements if deemed necessary for proper drainage review. **Predesign meetings with DDES are recommended to identify all required elements.**

(2) For more detailed descriptions of project categories, see Section 1.1.2.2. *If the proposed project has the characteristics of more than one category, the plan elements under each applicable category shall apply.*

(3) **Small site ESC plans** are an element of the small site drainage plan as explained in the *Small Site Drainage Requirements* booklet (detached Appendix C).

(4) **ESC plans** shall meet the applicable specifications detailed in Section 2.3.1.3 (p. 2-24)

(5) **Site improvement plans** shall meet the applicable specifications detailed in Section 2.3.1.2 (p. 2-17). DDES may allow **modified site improvement plans** as described in Section 2.3.1.2.

2.4 PLANS REQUIRED AFTER DRAINAGE REVIEW

This section includes the specifications and contents required of those plans submitted at the end of the permit review process or after a permit has been issued.

2.4.1 PLAN CHANGES AFTER PERMIT ISSUANCE

If changes or revisions to the originally approved engineering plans require additional review, the revised plans shall be submitted to DDES for approval prior to construction. The plan change submittals shall include all of the following:

1. The appropriate Plan Change Order form(s)
2. One copy of the revised TIR or addendum
3. Three sets of the engineering plans
4. Other information needed for review.

2.4.2 FINAL CORRECTED PLAN SUBMITTAL

During the course of construction, changes to the approved engineering plans are often required to address unforeseen field conditions or design improvements. Once construction is completed, it is the applicant's responsibility to submit to DDES a **final corrected plan** ("as-builts"), which is an engineering drawing that accurately represents the project as constructed. These corrected drawings must be professionally drafted revisions applied to the original approved plan and must include all changes made during the course of construction; the ESC plan, however, should not be included. The final corrected plan must be stamped, signed, and dated by a licensed civil engineer registered in the State of Washington.

Disposition of Approved Engineering Plans for Subdivisions

Upon engineering plan approval of any subdivision (including PUDs, binding site plans, and short plats), DDES will make a set of reproducible mylars (cost to be paid by the applicant) and return the original set to the applicant's engineer. DDES will retain this reproducible set, utilizing it to make copies for public inspection, distribution, and base reference as required. At the time the development is accepted for maintenance by King County, the DDES set of reproducibles shall be replaced by the corrected original set for permanent public records at the Department of Transportation Map Counter, 9th floor, King County Administration Building, Seattle, Washington.

2.4.3 FINAL PLAT, SHORT PLAT, AND BINDING SITE PLAN SUBMITTALS

Any subdivision to be finalized, thereby completing the subdivision process and legally forming new lots, requires a final submittal for approval and recording. Binding site plans and short plats also require a final submittal for approval and recording. The final plat or map page shall contain the elements summarized and specified in detail in DDES customer information bulletins. Submittals shall be accompanied by appropriate fees as prescribed by ordinance. Final submittals will be allowed only after the approval of preliminary plans (for subdivisions only) and any required engineering plans, and after the construction of any required drainage facilities.

All final map sheets and pages shall be prepared by a professional land surveyor registered in the State of Washington and shall conform with all state and local statutes.

The final submittal for recording only applies to **subdivisions** (plats), **binding site plans**, and **short plats.** This plan is required by state and local statutes.

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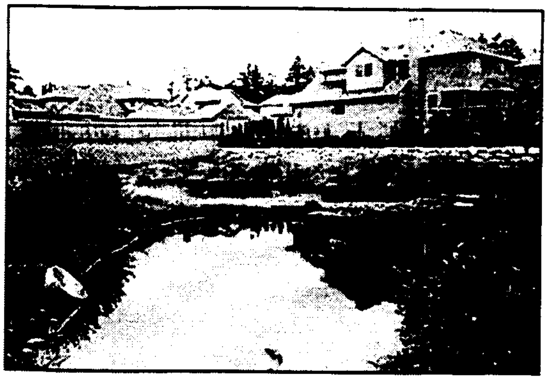
In addition to the requirements described in the DDES customer information bulletins, submittals for final recording of subdivisions, short plats, and binding site plans must include the following information:

1. Indicate dimensions of all easements, tracts, building setbacks, tops of slopes, wetland boundaries, and floodplains.
2. Include pertinent restrictions as they apply to easements, tracts, and building setback lines.
3. Include the **dedication and indemnification clause** as provide in Reference Section 8-K.
4. State the **maximum amount of added impervious surface** and **proposed clearing per lot** as determined through engineering review. The maximum amount of impervious surface may be expressed in terms of percentage of lot coverage or square feet.
5. **Specify roof downspout controls by lot** based on the "Sizing Credits for Roof Downspout Controls" (see Section 1.2.3.2) as determined through engineering review and approval.
6. For a plat or short plat, **record a note** conditioning single family residential permit approval **on compliance with approved roof downspout controls** (see notes in Section 5.1).

Chapter 3

CHAPTER 3

HYDROLOGIC ANALYSIS & DESIGN



KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

CHAPTER 3
HYDROLOGIC ANALYSIS & DESIGN

This chapter presents the concepts and rationale for the surface water controls and designs required by this manual, the acceptable methods for estimating the quantity and characteristics of surface water runoff, and the assumptions and data requirements of the methods. These methods are used to analyze existing and to design proposed drainage systems and facilities. Specifically, hydrologic tools and methodologies are presented for the following tasks:

- Calculating runoff time series and flow statistics
- Designing detention and infiltration facilities
- Sizing conveyance facilities
- Analyzing conveyance capacities.

Chapter Organization

The information presented in this chapter is organized into three main sections:

These sections begin on odd pages so that tabs can be inserted by the user if desired for quicker reference.

Other Supporting Information

Background information on development of the hydrologic methods presented in this chapter is available from DNR and is listed in the bibliography of research materials in Reference Section 5. For specific guidance on the mechanics of using the KCRTS software for hydrologic analysis and design, refer to the *KCRTS Computer Software Reference Manual*.

3.1 HYDROLOGIC DESIGN STANDARDS AND PRINCIPLES

This section presents the rationale for and approach to hydrologic analysis and design in King County.

3.1.1 HYDROLOGIC IMPACTS AND MITIGATIONS

Hydrologic Effects of Urbanization

The hydrologic effects of development can cause a multitude of problems, including minor nuisance flooding, degradation of public resources, diminished fish production, and significant flooding endangering life and property. Increased stormwater flows expand floodplains, bringing flooding to locations where it did not occur before and worsening flood problems in areas already flood-prone. Increased stormwater flows also hasten channel erosion, alter channel structure, and degrade fish habitat.

Human alteration of the landscape, including clearing, grading, paving, building construction, and landscaping, changes the physical and biological features that affect hydrologic processes. Soil compaction and paving reduce the infiltration and storage capacity of soils. This leads to a runoff process called *Horton overland flow* whereby the rainfall rate exceeds the infiltration rate, and the excess precipitation flows downhill over the soil surface. This type of flow rapidly transmits rainfall to the stream or conveyance system, causing much higher peak flow rates than would occur in the unaltered landscape.

Horton overland flow is almost nonexistent in densely vegetated areas, such as forest or shrub land, where the vast majority of rainfall infiltrates into the soil. Some of this infiltrated water is used by plants, and depending on soil conditions, some of it percolates until it reaches the groundwater table. Sometimes the percolating soil water will encounter a low-permeability soil or rock layer. In this case, it flows laterally as interflow over the low-permeability layer until it reaches a stream channel. Generally, forested lands deliver water to streams by subsurface pathways, which are much slower than the runoff pathways from cleared and landscaped lands. Therefore, **urbanization of forest and pasture land leads to increased stormwater flow volumes and higher peak flow rates.**

Land development increases not only peak flow rates but also changes annual and seasonal runoff volumes. **In forested basins in King County, about 55% of the rain that falls each year eventually appears as streamflow.** This percentage is called the *yield of a basin*. The remaining 45% of the rain evaporates and returns to the atmosphere. As trees are cleared and the soil is graded to make way for lawns and pastures, and as part of the land is covered with asphalt or concrete, the basin yield increases. More of the rain becomes streamflow, and less evaporates. In lowland King County, the yield of a basin covered with landscaped lawns would be about 65%, while the yield of an impervious basin would be about 85 to 90%.

For these reasons, development without mitigation increases peak stormwater rates, stormwater volumes, and annual basin yields. Furthermore, the reduction of groundwater recharge decreases summer base flows.

In summary, the following are the hydrologic impacts of unmitigated development:

- Increased peak flows
- Increased durations of high flows
- Increased stormwater runoff volumes
- Decreased groundwater recharge and base flows
- Seasonal flow volume shifts
- Altered wetland hydroperiods.

The resulting economic and ecological consequences of these hydrologic changes include the following:

- Increased flooding
- Increased stream erosion
- Degraded aquatic habitat
- Changes to wetland species composition.

Mitigations of Hydrologic Effects of Urbanization

Engineered facilities can mitigate many of the hydrologic changes associated with development. Detention facilities can maintain the rates and/or durations of high flows at predevelopment levels. Infiltration facilities can control flow volumes and increase groundwater recharge as well as control flow rates and durations. Conveyance problems can be avoided through analysis and appropriate sizing and design of conveyance facilities. Engineered mitigations of the hydrologic impacts of development include the following:

- Managing peak flow rates with detention facilities
- Managing high flow durations with detention facilities
- Reducing flow volumes and maintaining or enhancing groundwater recharge with infiltration facilities
- Avoiding flooding problems with appropriately sized and designed conveyance systems
- Bypassing erosion problems with tightlines.

However, **engineered facilities cannot mitigate all of the hydrologic impacts of development.** Detention facilities do not mitigate seasonal volume shifts, wetland water level fluctuations, groundwater recharge reductions, or base flow changes. Certain hydrologic impacts of development can only be mitigated through site planning and landscaping. For instance, clustering of units to reduce impervious cover while maintaining site density is an effective way to limit change. Minimizing soil disturbance or compaction in pervious areas also reduces hydrologic change. Such non-engineered mitigation measures are encouraged by the County but are not covered in this manual.

Many new stormwater mitigation options, such as porous roadway pavements and soil amendments for landscaped areas appear to be beneficial in reducing increases in surface water volumes. The incorporation of these concepts in the design of the project is encouraged. However, as these approaches are relatively untested, no reduction in the standard flow control facility requirements will be granted.

Detention Facility Concepts

The basic concept of a *detention facility* is simple: water is collected from developed areas and released at a slower rate than it enters the collection system. The excess of inflow over outflow is temporarily stored in a pond or a vault and is typically released over a few hours or a few days. The volume of storage needed is determined by (1) how much stormwater enters the facility (determined by the size and density of the contributing area), (2) how rapidly water is allowed to leave the facility, and (3) the level of hydrologic control the facility is designed to achieve.

To prevent increases in the frequency of flooding due to new development, detention facilities are often designed to **maintain peak flow rates at their predevelopment levels** for recurrence intervals of concern (e.g., 2- and 10-year). Such mitigation can prevent increases in the frequency of downstream flooding. Facilities that control only peak flow rates, however, usually allow the duration of high flows to increase, which may cause increased erosion of the downstream system. For example, the magnitude of a 2-year flow may not increase, but the amount of time that flow rate occurs may double. Therefore, stream systems, including salmonid habitat streams, that require protection from erosion warrant detention systems that **control the durations of geomorphically significant flows** (flows capable of moving sediment). Such detention systems employ lower release rates and are therefore larger in volume.

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3.1.2 FLOW CONTROL STANDARDS

Core Requirement #3 requires peak rate control (Level 1), duration control (Level 2), or a combination of the two (Level 3), depending on the needs of the downstream system.

Level 1 Flow Control

Level 1 flow control is designed to control flood flows at their current levels and to maintain peak flows within the capacity of the conveyance system for most storm events. Specifically, Level 1 flow control requires **maintaining the predevelopment peak flow rates for the 2-year and 10-year runoff events.** This standard may be modified to ensure that downstream problems are neither created nor aggravated (see Sections 1.2.2 and 1.2.3).

The Level 1 flow control standard is applied to basins with little habitat value or basins with resilient stream channels. This standard is also applied to the lower end of sensitive basins where additional flow attenuation provides little benefit to the receiving waters. Basin planning areas designated as Level 0 flow control must comply with Level 1 requirements unless the exemption criteria for direct discharge to a major receiving water are met (see Section 1.2.3).

Level 2 Flow Control

Level 2 flow control is designed to control the durations of geomorphically significant flows and thereby maintain existing channel and streambank erosion rates. A geomorphically significant flow is one which moves channel bedload sediments. The flow that initiates transport of channel sediments varies from channel to channel, but one-half of the 2-year flow is considered a good general estimate of the erosion-initiating flow. Specifically, Level 2 flow control requires **maintaining the durations of high flows at their predevelopment levels for all flows greater than one-half of the 2-year peak flow up to the 50-year peak flow.** *Note: The predevelopment peak flow rates for the 2-year and 10-year runoff events are also intended to be maintained when applying Level 2 flow control.*

This standard is applied to stream systems with erosion-prone channels and/or important aquatic habitat. Application of this standard is most critical in headwater basins where runoff enters the stream system in numerous small streams and rivulets that are very sensitive to changes in flow regime.

Level 3 Flow Control

Level 3 flow control is **intended to mitigate water level changes** in certain volume-sensitive water bodies such as lakes, wetlands, closed depressions where severe flooding problems have been documented. It is the most stringent standard applied in this manual (see Section 1.2.3). Because such water bodies act as natural flow dampeners, it is difficult to detain collected stormwater beyond the natural residence time of these systems. Therefore, the increased volume of runoff from new development inevitably increases the water level fluctuations of these water bodies. The Level 3 flow control standard provides additional storage and increases the detention time to minimize these downstream impacts.

This standard requires **maintaining the durations of high flows at their predevelopment levels for all flows greater than one-half of the 2-year flow up to the 50-year flow and holding the 100-year peak flow rate at its predevelopment level.** *Note: The predevelopment peak flow rates for the 2-year and 10-year runoff events are also intended to be maintained when applying Level 3 flow control.*

This standard is primarily applied in the contributing areas of specific water bodies with severe flooding problems, and which are known to be sensitive to flow volume changes.

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3.1.3 HYDROLOGIC ANALYSIS USING CONTINUOUS MODELS

The Need for Continuous Hydrologic Modeling

This manual prescribes the use of a **continuous hydrologic model** for most hydrologic analyses rather than an event model. Event models such as the Santa Barbara Urban Hydrograph (SBUH) and the Soil Conservation Service (SCS) method were used in previous versions of this manual for all hydrologic analyses. A continuous model was chosen because hydrologic problems in western Washington are associated with the high volumes of flow from sequential winter storms rather than high peak flows from short duration, high intensity rainfall events. The continuous hydrologic analysis tool prescribed in this manual is the **King County Runoff Time Series (KCRTS)**, which is a variant of the Hydrologic Simulation Program-FORTRAN (HSPF) model.

Continuous models are well suited to accounting for the climatological conditions in the lowland Puget Sound area. Continuous models include algorithms that maintain a continuous water balance for a catchment to account for soil moisture and hydraulic conditions antecedent to each storm event (Linsley, Kohler, Paulhus, 1982), whereas event models assume initial conditions and only address single hypothetical storm events. As a result, continuous hydrologic models are more appropriate for evaluating runoff during the extended wet winters typical of the Puget Sound area.

The **drawbacks of event models** are summarized as follows:

- Event methods inherently overestimate peak flows from undeveloped land cover conditions. The overestimation is due, in part, to the assumption that runoff from forest and pasture land covers flows across the ground surface. In actuality, the runoff from forests and pastures, on till soils, is dominated by shallow subsurface flows (interflow) which have hydrologic response times much longer than those used in event methods. This leads to an overestimatation of predeveloped peak flows, which results in detention facility release rates being overestimated and storage requirements being underestimated.
- A single event cannot represent the sequential storm characteristics of Puget Sound winters.
- Event models assume detention facilities are empty at the start of a design event, whereas actual detention facilities may be partially full as a result of preceding storms.
- Testing of event-designed detention facilities with calibrated, long-term continuous hydrologic simulations demonstrates that these facilities do not achieve desired performance goals.
- Event methods do not allow analysis of flow durations or water level fluctuations.

The **benefits of continuous hydrologic modeling** are summarized as follows:

- A continuous model accounts for the long duration and high precipitation volume of winter wet periods characterized by sequential, low-intensity rainfall events. Continuous simulation uses continuous long-term records of observed rainfall rather than short periods of data representing hypothetical storm events. As a result, continuous simulation explicitly accounts for the long duration rainfall events typically experienced in the Pacific Northwest as well as the effects of rainfall antecedent to major storm events.
- HSPF has been shown to more accurately simulate runoff from basins with a wide range of sizes and land covers using the regional parameters developed by the United States Geologic Survey (USGS).
- Continuous simulation allows direct examination of flow duration data for assessing the impacts of development on stream erosion and morphology. An event model, whether using a 1-day or a 7-day storm, cannot provide such information.
- A continuous model allows water level analysis for wetlands, lakes, and closed depressions whose water level regime is often dependent on seasonal runoff rather than on 1-day or 7-day event runoff.
- Continuous models produce flow control facilities that more accurately and effectively achieve desired performance goals.

The importance of continuous modeling in the Puget Sound area is illustrated in Figure 3.1.3.A (p. 3-8), which shows a small basin's runoff response to a series of winter storms and the outflow from a detention pond designed to control the peak annual flows from this basin. Note that the largest outflow from the detention pond corresponds not to the peak inflow on 11/6/86, but rather to the high volume of flow from the sequential storms beginning on 11/19/86. This demonstrates a key difference between continuous and event based models.

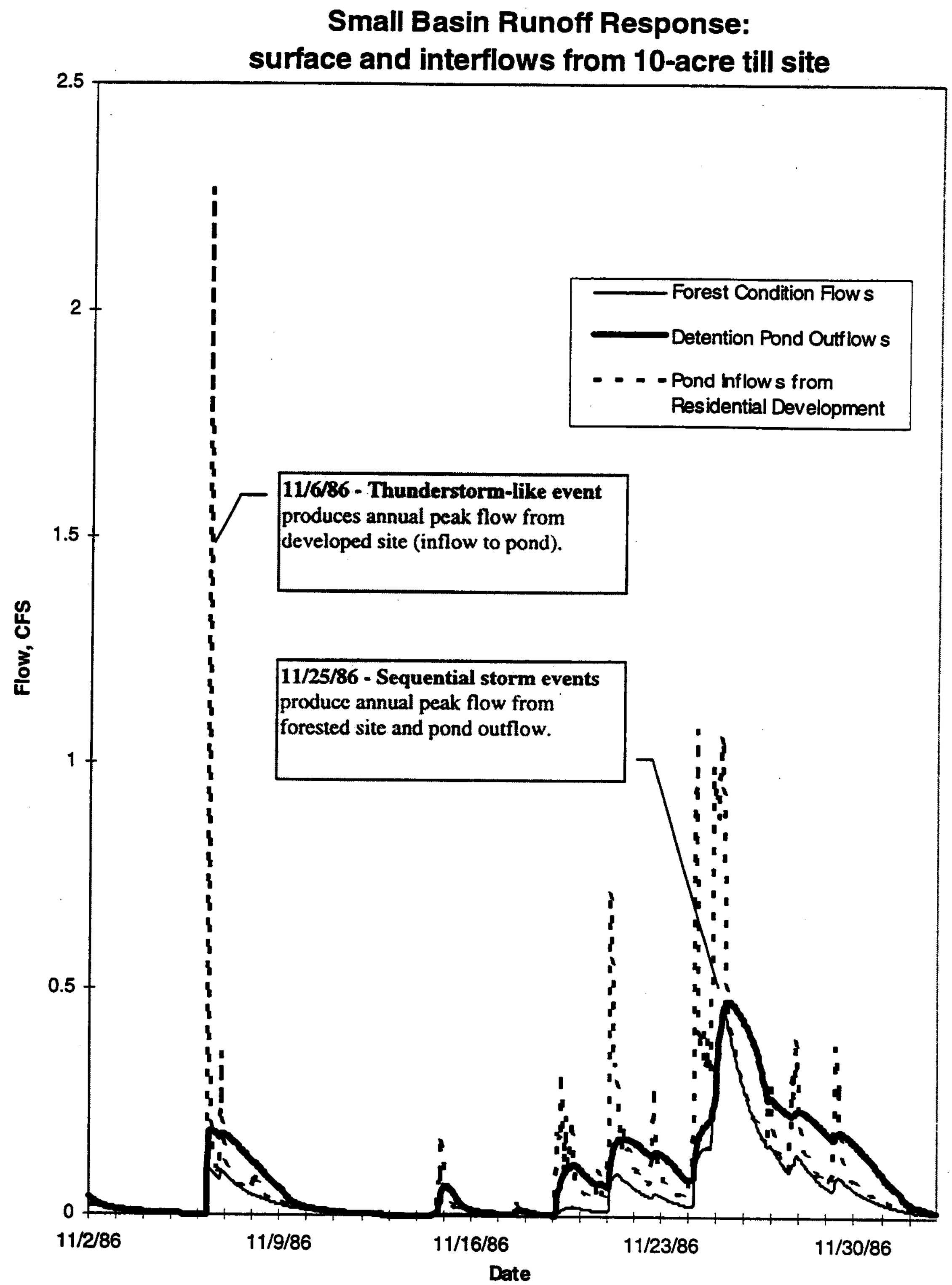
With an event model, designers are accustomed to working with a single design storm event (e.g., 10-year), which by definition has the same return period once routed through a reservoir (10-year inflow will always generate 10-year outflow). With a continuous model, flow recurrence estimates are based on annual peak flow rates, with each time series being analyzed independently. Events that generate annual peak inflows to a reservoir may not generate annual peak discharges from the reservoir. In other words, the runoff event containing the 10-year inflow peak, when routed, may not create the 10-year outflow peak. This is due to natural variability of storm peaks and volumes (e.g., high intensity/short duration thunderstorms as compared to moderate intensity/long duration winter storms) contained within a continuous record.

Requirements of Continuous Hydrologic Modeling

For the entire period of simulation, a continuous hydrologic model requires a continuous record of precipitation and evaporation at discrete time steps small enough to capture the temporal variability of hydrologic response, and it provides a continuous record of simulated flows at the same time step. The quicker a basin responds hydrologically (e.g., due to small size, land cover, or lack of detention), the smaller the time step should be. Time steps of 15 minutes or one hour are sufficient for most basins in the Puget Sound area.

The continuous hydrologic model must include mathematical representations of hydrologic processes to determine the fate and movement of rainfall. For example, a good continuous hydrologic model must include representations of infiltration processes to determine how much water infiltrates the soil and how much runs off the surface. It must represent shallow and deep soil storage as well as the release of subsurface water to streams via interflow and groundwater flow, and it must also account for the loss of soil water to the atmosphere via evapotranspiration between rainfall events. The benefit of all this computation is a complete hydrologic assessment including information on peak flow rates, flow durations, storm volumes, seasonal volumes, annual volumes, and water levels of receiving bodies.

FIGURE 3.1.3.A EFFECTS OF SEQUENTIAL STORMS ON DETENTION PERFORMANCE



3.2 RUNOFF COMPUTATION AND ANALYSIS METHODS

This section presents the following four runoff computation methods accepted for hydrologic analysis and design in King County:

- The Rational Method, Section 3.2.1 (p. 3-11)
- The TR-55 or SBUH methods
- The King County Runoff Time Series (KCRTS)/Runoff Files method, Section 3.2.2 (p. 3-19)
- The Hydrologic Simulation Program-FORTRAN (HSPF) model, Section 3.2.3 (p. 3-35).

Methods for analysis and design of detention storage and water levels are also presented in "Storage Routing/Water Level Analysis Methods," Section 3.2.4 (p. 3-36).

❑ ACCEPTABLE USES OF RUNOFF COMPUTATION METHODS

Acceptable uses of the four runoff computation methods are summarized below and in Table 3.2 (p. 3-10):

- **Rational Method:** This method is most appropriate for sizing new conveyance systems that drain smaller, quickly responding tributary areas (i.e., less than 10 acres) where very short, intense storms tend to generate the highest peak flows. The Rational Method may also be used for conveyance sizing in any size basin if the attenuation effects of existing storage features within the basin are ignored.
- **TR-55/SBUH Methods:** The Soil Conservation Service (SCS) TR-55 method or the SBUH method of the 1990 *King County Surface Water Design Manual* may be used for conveyance sizing where tributary areas are greater than or equal to 10 acres and if storage features are ignored. The peak flows from these single-event models are considered conservative for larger tributary areas if the flows are not routed through existing storage features. These methods are not described in this manual; refer to *SCS Publication 210-VI-TR-55, Second Edition* (June 1986) or the *1990 King County Surface Water Design Manual.*
- **KCRTS/Runoff Files Method:** This method is the most versatile for quickly performing many of the computations summarized in Table 3.2 (p. 3-10). For conveyance sizing and analysis, the peak flows from KCRTS are most accurate where tributary areas are greater than or equal to 10 acres and when the shortest possible time step (15 minutes) is used with **flowpath adjustments** made to reflect the hydrologic responsiveness of the tributary area (see Section 3.3.3). KCRTS may also be used for tributary areas less than 10 acres where there is a significant storage feature(s). For sizing and analysis of storage features and volume-based water quality facilities, KCRTS works equally well when using hourly time steps for determination of predevelopment discharges and for routing purposes (see Sections 3.3.1 and 3.3.2). King County requires hourly time steps for sizing of all flow control facilities to provide consistent management of surface water and protect against cumulative increases in peak flows on a basin-wide basis. *Note: The KCRTS runoff files were developed using local historical precipitation and evaporation data, so application of the King County data outside the King County vicinity is discouraged. Contact the Department of Natural Resources for information on generating runoff files for other gage sites. An HSPF-level of historical meteorological data is required.*
- **HSPF Model:** For projects in Large Site Drainage Review (see Section 1.1.2.4) such as Urban Planned Developments and large subdivisions, the County may require HSPF modeling for formulating a Master Drainage Plan (*see Master Drainage Planning for Large Site Developments - Process and Requirement Guidelines* available from DNR or DDES). The County also generally encourages use of HSPF for tributary areas larger than 200 acres. The model can be used wherever KCRTS is allowed for sizing and analysis of conveyance systems, flow control facilities, and water quality facilities. For such projects draining to a Class 1 wetland or potentially impacting groundwater resources or stream base flows, the County may require the collection of actual rainfall and runoff data to be used in developing and calibrating the HSPF model.

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TABLE 3.2 ACCEPTABLE USES OF RUNOFF COMPUTATION METHODS

TYPE OF COMPUTATION	APPLIED TO	Rational Method	TR 55/SBUH	KCRTS	HSPF
CONVEYANCE SIZING (DESIGN FLOWS) (See Chapter 4 for hydraulic analysis procedures)	**Tributary Areas < 10 ac** (measured to individual conveyance elements)	REQUIRED for undetained areas,(1) and OKAY for detained areas if no storage routing(2) is performed		OKAY if majority of tributary area is detained(3) and 15-minute time steps with flowpath adjustments(4) are used	OKAY if majority of tributary area is detained(3) and 15-minute time steps with flowpath adjustments(4) are used
	Tributary Areas ≥ 10 ac	OKAY if no storage routing(2) is performed	OKAY if no storage routing(2) is performed	OKAY if using 15-minute time steps with flowpath adjustments(4) (storage routing is allowed)	OKAY if using 15-minute time steps with flowpath adjustments(4) (storage routing is allowed)
FLOW CONTROL (NEW/EXIST.) & WQ FACILITY SIZING AND ANALYSIS	**Projects in Full Drainage Review**			OKAY (must use 1-hour time steps)	OKAY (must use 1-hour time steps)
	Projects in Large Site Drainage Review			MAY BE ALLOWED(5) (must use 1-hour time steps)	MAY BE REQUIRED(5) (must use 1-hour time steps)
DOWNSTREAM ANALYSIS	**Projects in Full or Targeted Drainage Review**	OKAY if no storage routing(2) is performed	OKAY for tributary areas ≥ 10 ac. if no storage routing(2) is performed	OKAY if using 15-minute time steps with flowpath adjustments(4)	OKAY if using 15-minute time steps with flowpath adjustments(4)
	Projects in Large Site Drainage Review	MAY BE ALLOWED(5) if used as described in the box above	MAY BE ALLOWED(5) if as described in the box above	MAY BE ALLOWED(5) if used as described in the box above	MAY BE ALLOWED(5) if used as described in the box above
PEAK FLOWS FOR APPLYING EXEMPTIONS & THRESHOLDS	**All Projects**			OKAY (must use 1-hour time steps)	OKAY (must use 1-hour time steps)

Notes:

(1) *Undetained areas* are those **not** draining to (or detained by) a detention facility or other storage feature.

(2) *Storage routing* uses the Level Pool Routing technique (described in Section 3.2.4) or other similar method to account for the attenuation of peak flows passing through a detention facility or other storage feature.

(3) The majority of the tributary area is considered *detained* if more than 50% of the tributary area drains to (or is detained by) a detention facility or other storage facility.

(4) See Section 3.3.3 (p. 3-46) for details on *flowpath adjustments.*

(5) For projects in Large Site Drainage Review, the selection of methodology for detention sizing and/or downstream analysis becomes a site-specific or basin-specific decision that is usually made by DDES during the scoping process for master drainage plans. Guidelines for selecting either KCRTS, HSPF, or calibrated HSPF are found in the King County publication *Master Drainage Planning for Large or Complex Site Developments,* available from DNR or DDES.

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3.2.1 RATIONAL METHOD

The Rational Method is a simple, conservative method for analyzing and sizing conveyance elements serving small drainage subbasins, subject to the following specific **limitations**:

- Only for use in predicting peak flow rates for sizing conveyance elements
- Drainage subbasin area A cannot exceed 10 acres for a single peak flow calculation
- The time of concentration T_c must be computed using the method described below and cannot exceed 100 minutes. It is also set equal to 6.3 minutes when computed to be less than 6.3 minutes. *Note: Unlike other methods of computing times of concentration, the 6.3 minutes is **not** an initial collection time to be added to the total computed time of concentration.*

❑ RATIONAL METHOD EQUATION

The following is the traditional Rational Method equation:

$$Q_R = CI_RA \qquad (3\text{-}1)$$

where Q_R = peak flow (cfs) for a storm of return frequency R
C = estimated runoff coefficient (ratio of rainfall that becomes runoff)
I_R = peak rainfall intensity (inches/hour) for a storm of return frequency R
A = drainage subbasin area (acres)

"C" Values

The allowable runoff coefficients to be used in this method are shown in Table 3.2.1.A (p. 3-13) by type of land cover. These values were selected following a review of the values previously accepted by King County for use in the Rational Method and as described in several engineering handbooks. The values for single family residential areas were computed as composite values (as illustrated in the following equation) based on the estimated percentage of coverage by roads, roofs, yards, and unimproved areas for each density. For drainage basins containing several land cover types, the following formula may be used to compute a composite runoff coefficient, C_c:

$$C_c = (C_1A_1 + C_2A_2 + ... + C_nA_n)/A_t \qquad (3\text{-}2)$$

where A_t = total area (acres)
$A_{1,2,...n}$ = areas of land cover types (acres)
$C_{1,2,...n}$ = runoff coefficients for each area land cover type

"I_R" Peak Rainfall Intensity

The peak rainfall intensity I_R for the specified design storm of return frequency R is determined using a unit peak rainfall intensity factor i_R in the following equation:

$$I_R = (P_R)(i_R) \qquad (3\text{-}3)$$

where P_R = the total precipitation at the project site for the 24-hour duration storm event for the given return frequency. Total precipitation is found on the Isopluvial Maps in Figure 3.2.1.A through Figure 3.2.1.D beginning on page 3-14.
i_R = the unit peak rainfall intensity factor

The unit peak rainfall intensity factor i_R is determined by the following equation:

$$i_R = (a_R)(T_c)^{(-b_R)} \tag{3-4}$$

where T_c = time of concentration (minutes), calculated using the method described below and subject to equation limitations ($6.3 \le T_c \le 100$)

a_R, b_R = coefficients from Table 3.2.1.B (p. 3-13) used to adjust the equation for the design storm return frequency R

This "i_R" equation was developed by DNR from equations originally created by Ron Mayo, P.E. It is based on the original **Renton/Seattle Intensity/Duration/Frequency (I.D.F.) curves**. Rather than requiring a family of curves for various locations in King County, this equation adjusts proportionally the Renton/Seattle I.D.F. curve data by using the 24-hour duration total precipitation isopluvial maps. This adjustment is based on the assumption that the localized geo-climatic conditions that control the total volume of precipitation at a specific location also control the peak intensities proportionally.

Note: Due to the mathematical limits of the equation coefficients, values of T_c less than 6.3 minutes or greater than 100 minutes cannot be used. Therefore, real values of T_c less than 6.3 minutes must be assumed to be equal to 6.3 minutes, and values greater than 100 minutes must be assumed to be equal to 100 minutes.

"T_c" Time of Concentration

The time of concentration is defined as the time it takes runoff to travel overland (from the onset of precipitation) from the most hydraulically distant location in the drainage basin to the point of discharge. *Note: When C_c (see Equation 3-2) of a drainage basin exceeds 0.60, it may be important to compute T_c and peak rate of flow from the impervious area separately.* The computed peak rate of flow for the impervious surface alone may exceed that for the entire drainage basin using the value at T_c for the total drainage basin. The higher of the two peak flow rates shall then be used to size the conveyance element.

T_c is computed by summation of the travel times T_t of overland flow across separate flowpath segments defined by the six categories of land cover listed in Table 3.2.1.C (p. 3-13), which were derived from a chart published by the Soil Conservation Service in 1975. The equation for time of concentration is:

$$T_c = T_1 + T_2 + ... + T_n \tag{3-5}$$

where $T_{1,2,...n}$ = travel time for consecutive flowpath segments with different land cover categories or flowpath slope

Travel time for each segment t is computed using the following equation:

$$T_t = \frac{L}{60V} \tag{3-6}$$

where T_t = travel time (minutes) *Note: T_t through an open water body (such as a pond) shall be assumed to be zero with this method*

L = the distance of flow across a given segment (feet)

V = average velocity (fps) across the land cover = $k_R \sqrt{s_o}$

where k_R = time of concentration velocity factor; see Table 3.2.1.C

s_o = slope of flowpath (feet/feet)

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TABLE 3.2.1.A RUNOFF COEFFICIENTS - "C" VALUES FOR THE RATIONAL METHOD			
General Land Covers		**Single Family Residential Areas***	
Land Cover	C	Land Cover Density	C
Dense forest	0.10	0.20 DU/GA (1 unit per 5 ac.)	0.17
Light forest	0.15	0.40 DU/GA (1 unit per 2.5 ac.)	0.20
Pasture	0.20	0.80 DU/GA (1 unit per 1.25 ac.)	0.27
Lawns	0.25	1.00 DU/GA	0.30
Playgrounds	0.30	1.50 DU/GA	0.33
Gravel areas	0.80	2.00 DU/GA	0.36
Pavement and roofs	0.90	2.50 DU/GA	0.39
Open water (pond, lakes, wetlands)	1.00	3.00 DU/GA	0.42
		3.50 DU/GA	0.45
		4.00 DU/GA	0.48
		4.50 DU/GA	0.51
		5.00 DU/GA	0.54
		5.50 DU/GA	0.57
		6.00 DU/GA	0.60

* Based on average 2,500 square feet per lot of impervious coverage.
For combinations of land covers listed above, an area-weighted "C_c x A_t" sum should be computed based on the equation C_c x $A_t = (C_1 \times A_1) + (C_2 \times A_2) + ... + (C_n \times A_n)$, where $A_t = (A_1 + A_2 + ... + A_n)$, the total drainage basin area.

TABLE 3.2.1.B COEFFICIENTS FOR THE RATIONAL METHOD "i_R" EQUATION		
Design Storm Return Frequency	a_R	b_R
2 years	1.58	0.58
5 years	2.33	0.63
10 years	2.44	0.64
25 years	2.66	0.65
50 years	2.75	0.65
100 years	2.61	0.63

TABLE 3.2.1.C k_R VALUES FOR T_t USING THE RATIONAL METHOD	
Land Cover Category	k_R
Forest with heavy ground litter and meadow	2.5
Fallow or minimum tillage cultivation	4.7
Short grass pasture and lawns	7.0
Nearly bare ground	10.1
Grassed waterway	15.0
Paved area (sheet flow) and shallow gutter flow	20.0

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FIGURE 3.2.1.A 2-YEAR 24-HOUR ISOPLUVIALS

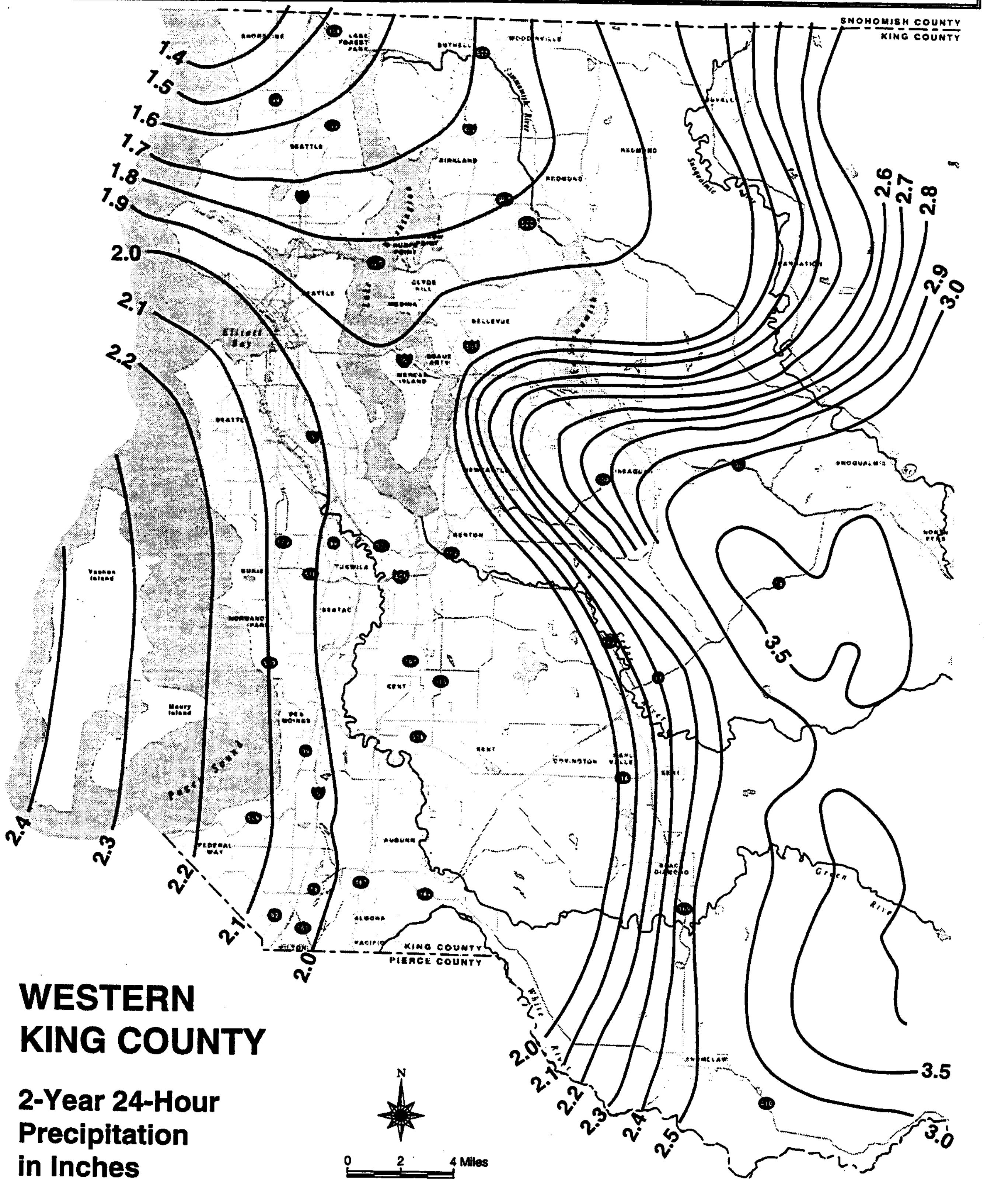

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FIGURE 3.2.1.B 10-YEAR 24-HOUR ISOPLUVIALS

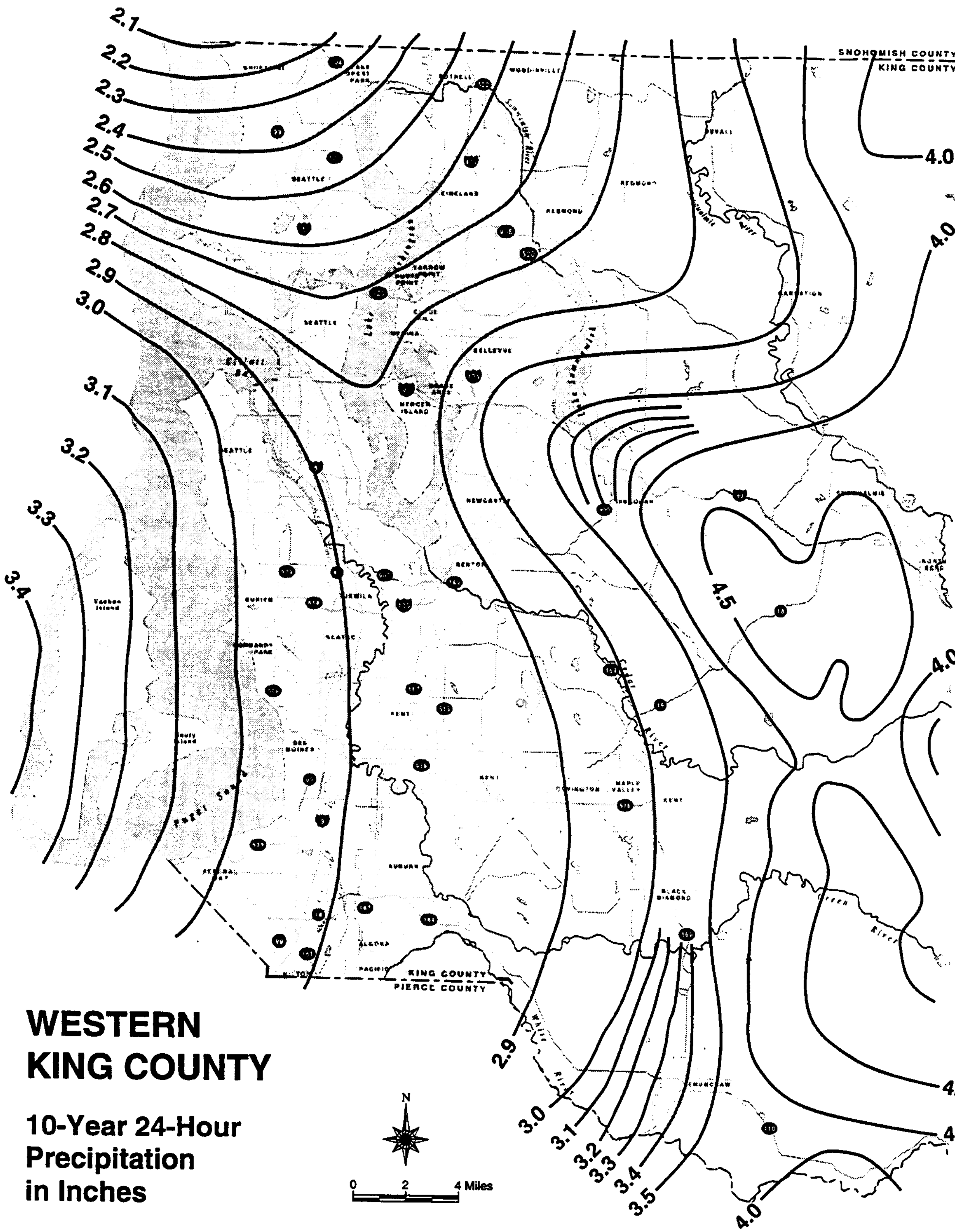

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FIGURE 3.2.1.C 25-YEAR 24-HOUR ISOPLUVIALS

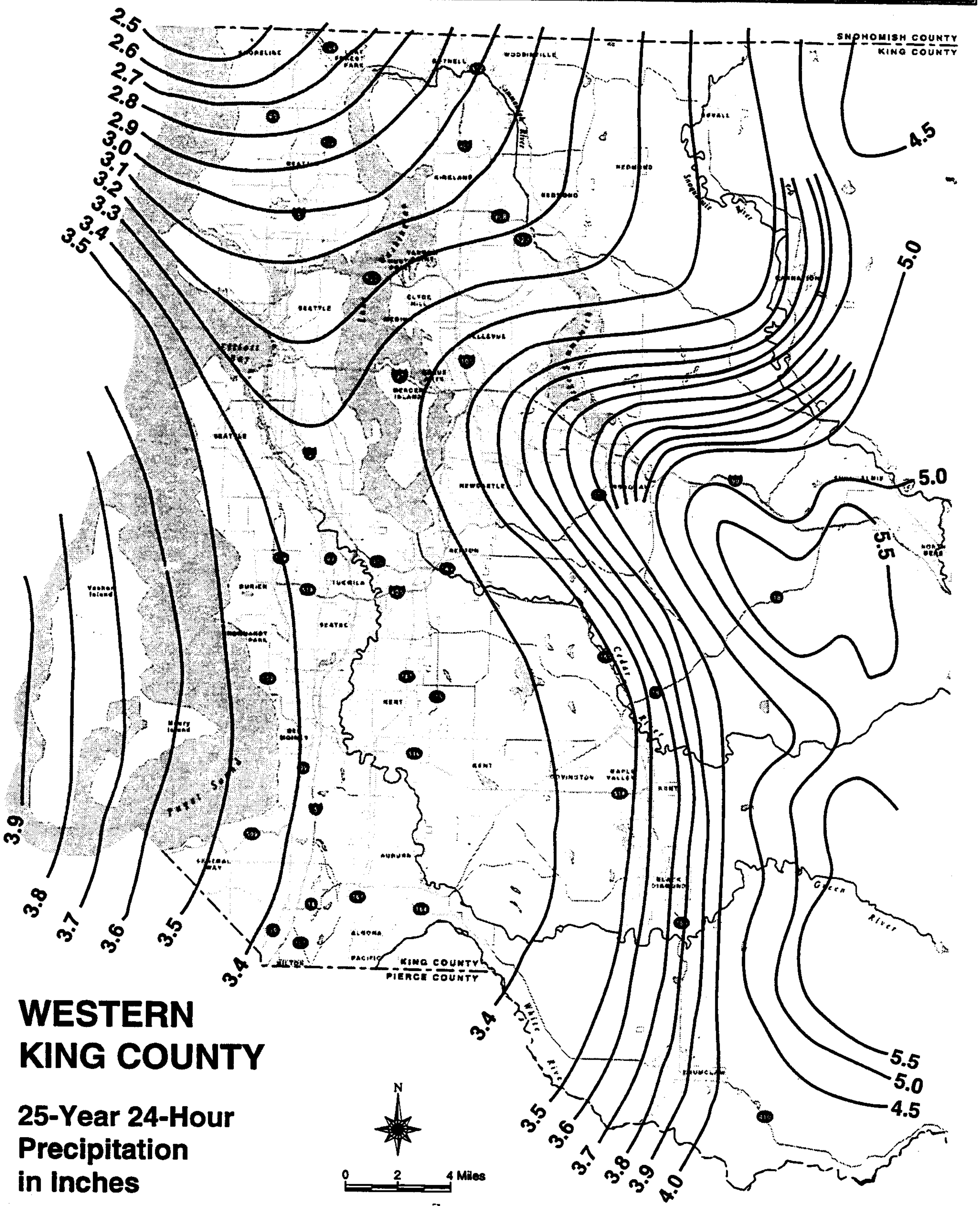

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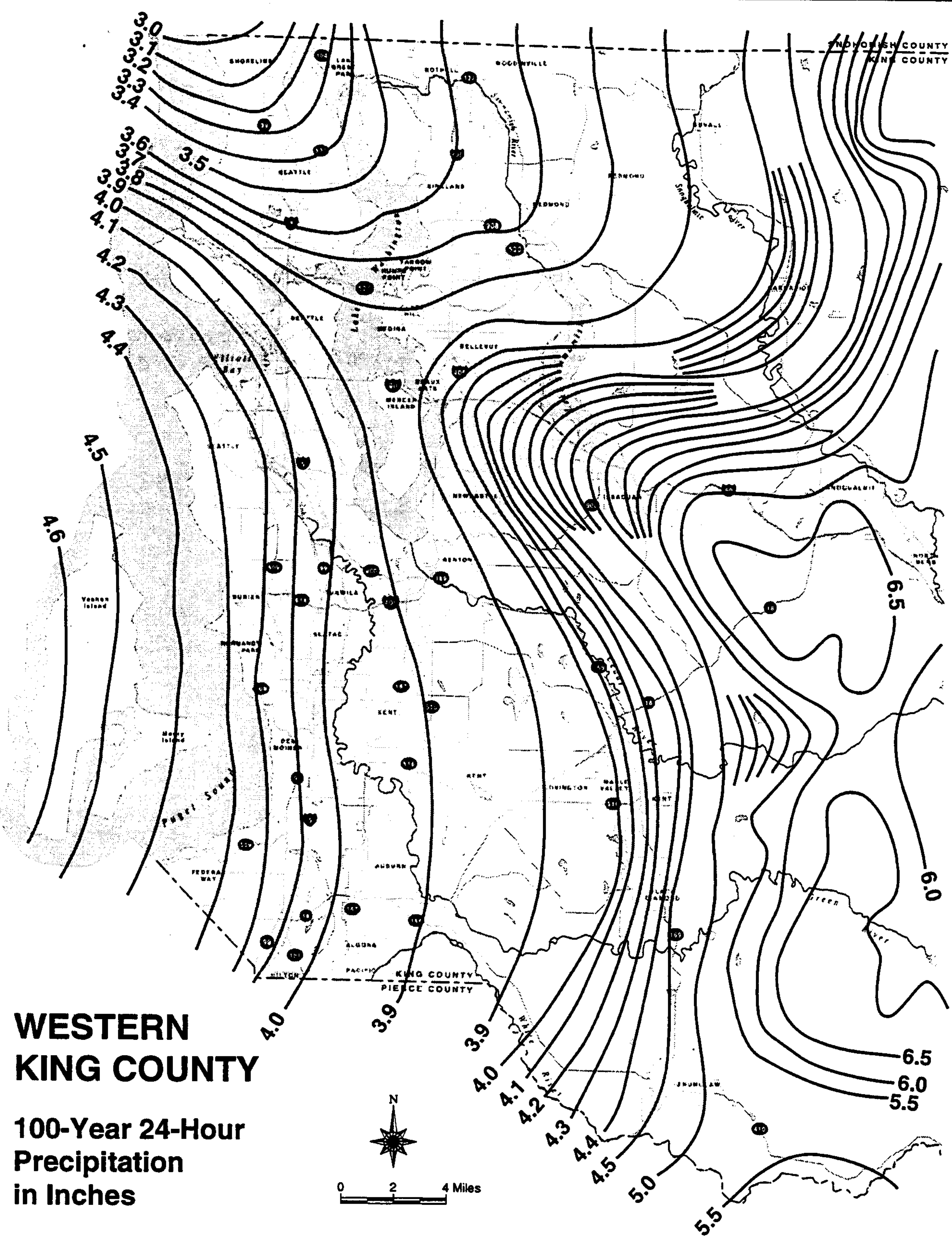
FIGURE 3.2.1.D 100-YEAR 24-HOUR ISOPLUVIALS



❑ RATIONAL METHOD EXAMPLE

Compute the peak flow Q_{25} to size a new roadway cross culvert for a 9.8-acre drainage basin east of Kent, $P_{25} = 3.42$ inches.

Given: <u>AREAS</u>

A_1 = 4.3 acres of single family residential area at 3.8 DU/GA
A_2 = 2.3 acres of light forest
A_3 = 3.2 acres of pasture
A_t = 9.8 total acres

<u>DESCRIPTION OF FLOWPATH SEGMENTS FOR T_c</u>

L_1 = 300 feet	s_1 = 0.08	forest land cover	$k_R = 2.5$
L_2 = 200 feet	s_2 = 0.03	meadow	$k_R = 2.5$
L_3 = 1000 feet	s_3 = 0.015	grassed waterway (ditch)	$k_R = 15.0$

Compute: <u>COMPOSITE RUNOFF COEFFICIENT C_c</u>

A_1: C_1 = From Table 3.2.1.A (p. 3-13), C for 4.00 DU/GA = 0.48, C for 3.50 DU/GA = 0.45. Therefore, C_1 for 3.80 DU/GA = 0.47 by visual interpolation.
A_2: C_2 = 0.15
A_3: C_3 = 0.20

$$C_c = [(C_1 \times A_1) + (C_2 \times A_2) + (C_3 \times A_3)]/A_t$$
$$= [(0.47 \times 4.3) + (0.15 \times 2.3) + (0.20 \times 3.2)]/9.8 = \underline{0.31}$$

<u>PEAK RAINFALL INTENSITY I_R</u>

First, compute T_c:

$$T_1 = \frac{L_1}{60V_1} = \frac{L_1}{60(k_R\sqrt{s_1})} = \frac{300}{60(2.5\sqrt{0.08})}$$
$$= \underline{7 \text{ minutes}}$$

$$T_2 = \frac{L_2}{60V_2} = \frac{L_2}{60(k_R\sqrt{s_2})} = \frac{200}{60(2.5\sqrt{0.03})}$$
$$= \underline{8 \text{ minutes}}$$

$$T_3 = \frac{L_3}{60V_3} = \frac{L_3}{60(k_R\sqrt{s_3})} = \frac{1000}{60(15\sqrt{0.015})}$$
$$= \underline{9 \text{ minutes}}$$

$$T_c = T_1 + T_2 + T_3 = 7 + 8 + 9 = \underline{24 \text{ minutes}}$$

Second, compute i_R for $R = 25$:

$$i_{25} = (a_R)(T_c)^{(-b_R)} = (2.66)(24)^{-(0.65)} = \underline{0.34}$$

Third, compute I_R for $R = 25$:

$$I_{25} = (P_{25})(i_{25}) = (3.42)(0.34) = \underline{1.16}$$

<u>PEAK RUNOFF RATE</u>

$$Q_{25} = C\,I_{25}\,A = C_c\,I_{25}\,A = (0.31)(1.16)(9.8) = \underline{3.5 \text{ cfs}}$$

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3.2.2 KCRTS/RUNOFF FILES METHOD

The KCRTS/runoff files implementation of HSPF was developed as a tool that has the accuracy and versatility of HSPF but is much simpler to use and provides a framework for efficient design of onsite stormwater detention facilities. This section describes the Runoff Files Method and KCRTS software. The term *runoff files* refers to a database of continuous flows presimulated by HSPF. The KCRTS software package is a tool for using this flow database.

The Runoff Files method was developed as a hydrologic modeling tool for western King County to produce results (design flows, detention pond sizing, etc.) comparable to those obtained with the U.S. Environmental Protection Agency's HSPF model but with significantly less effort. This is achieved by providing the user with a set of 15-minute and hourly time series files of unit area land surface runoff ("runoff files") presimulated with HSPF for a range of land cover conditions and soil types within King County. The design flows are estimated and detention facilities are designed by directly accessing and manipulating the runoff file data by means of the KCRTS software.

At present, the basic capabilities of the KCRTS software include:

- Estimating time series of flows for a specified land use and location within King County
- Analyzing flow frequency and duration
- Analyzing water surface frequency and duration
- Plotting analysis results
- Sizing detention facilities.

❑ DEVELOPMENT OF THE RUNOFF FILES

To compile the runoff files, the land surface hydrologic response (represented by a time series of unit area land surface runoff) was generated by HSPF with regional parameters for a variety of land use classifications and for two long-term (40-year) hourly rainfall stations, one representing the western lowlands of King County (Sea-Tac Airport) and the other representing the eastern foothills (Landsburg). Runoff time series were generated with data from these stations for the following **eight soil/land cover types:**

- Impervious
- Till forest
- Till pasture
- Till grass
- Outwash forest
- Outwash pasture
- Outwash grass
- Wetland.

These 40-year time series were analyzed to identify a set of seven individual years that could be used as a substitute for the full record of data in terms of flow durations. Further testing allowed flood frequency relationships to be developed from the **seven years of data selected to represent the 40-year record.** Selection of a comparatively short record on which to base analysis greatly reduces the computational effort of using continuous simulation without losing the benefit of the information available in the longer 40-year record.

The runoff files include an **eighth year** in which a **hypothetical 100-year event** was embedded. This 100-year event was created by scaling up simulated runoff from the severe storm of January 9-10, 1990, to

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produce peak runoff rates and volumes comparable to those for a 100-year event. A hypothetical event was necessary because of its regulatory importance (especially for floodplain management) and because the available 40-year records did not include such an event.

While HSPF simulates surface runoff, interflow, and groundwater flow, **only the surface and interflow components of runoff are included in the runoff files.** The large majority of developments are relatively small, and it is often not appropriate to include groundwater flows in estimates of the surface or near-surface runoff from a site. For example, in designing detention facilities for a small development on till soils, the total surface or near-surface runoff from the site would usually consist of surface runoff plus interflow. Groundwater generated on the site would seep through the underlying till and may reappear (in springs or seeps) some considerable distance from the site. **An interflow component of runoff is not computed for outwash soils** because there is assumed to be no low-permeability subsurface layer. Runoff files for onsite detention facility design were thus generated with the following components:

- Till soils → surface flow + interflow
- Outwash soils → surface flow
- Wetland soils → surface flow + interflow
- Impervious surfaces → surface flow.

The higher elevation eastern portions of King County have a temperature variable hydrologic cycle. **Snowmelt is not accounted for** in either the Sea-Tac or Landsburg runoff files. Additional work may be done to develop snowmelt-based runoff files for use in these areas. In the absence of additional information, analysis will be performed using the Landsburg runoff files scaled by 1.2 for all points east of the 1.2 isoline in Figure 3.2.2.A (p. 3-22).

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3.2.2.1 GENERATING TIME SERIES

Most hydrologic analyses will require time series of flows for different land use conditions. For example, to size a Level 1 flow control detention facility, 2- and 10-year peaks from the facility discharge time series must be compared with 2- and 10-year peaks from the predevelopment site time series. To generate a flow time series with KCRTS, the KCRTS user needs to specify the following:

1. The **rainfall region** of the county within which the project lies (i.e., determine the rainfall station—Sea-Tac or Landsburg—used in the analysis; see Figure 3.2.2.A, p. 3-22).
2. A multiplier or **regional scale factor** applied to the runoff files to account for variations in rainfall volumes between the project site and the rainfall station (see Figure 3.2.2.A, p. 3-22).
3. The **time step** to be used in the analysis:
   - Hourly — Used for detention sizing and volume analysis
   - 15 minutes — Used for peak flow analysis of conveyance systems; requires length and slope of the longest unconcentrated surface flowpath for each developed land cover type.
4. The **record type** used in the analysis:
   - Reduced — Eight-year runoff files data set, used for all analysis
   - Historical — Complete historical runoff record as described in Section 3.3.6 under "Offsite Closed Depressions" (p. 3-51).
5. The **amount of land** (acreage) of each soil/cover group for the subbasin under study.
6. The **percentage of impervious area** that is effectively connected to the drainage system.

Generating a new time series is simply a matter of entering the above data into KCRTS under the **"Create New Time Series" routine.** The KCRTS software will then access the appropriate runoff files (representing unit area runoff), scale those files to reflect the location of the project site, scale the files again according to the area of each soil/cover group contained on the project site or subbasin in question, and then sum the scaled files to produce a time series of simulated flows from the site.

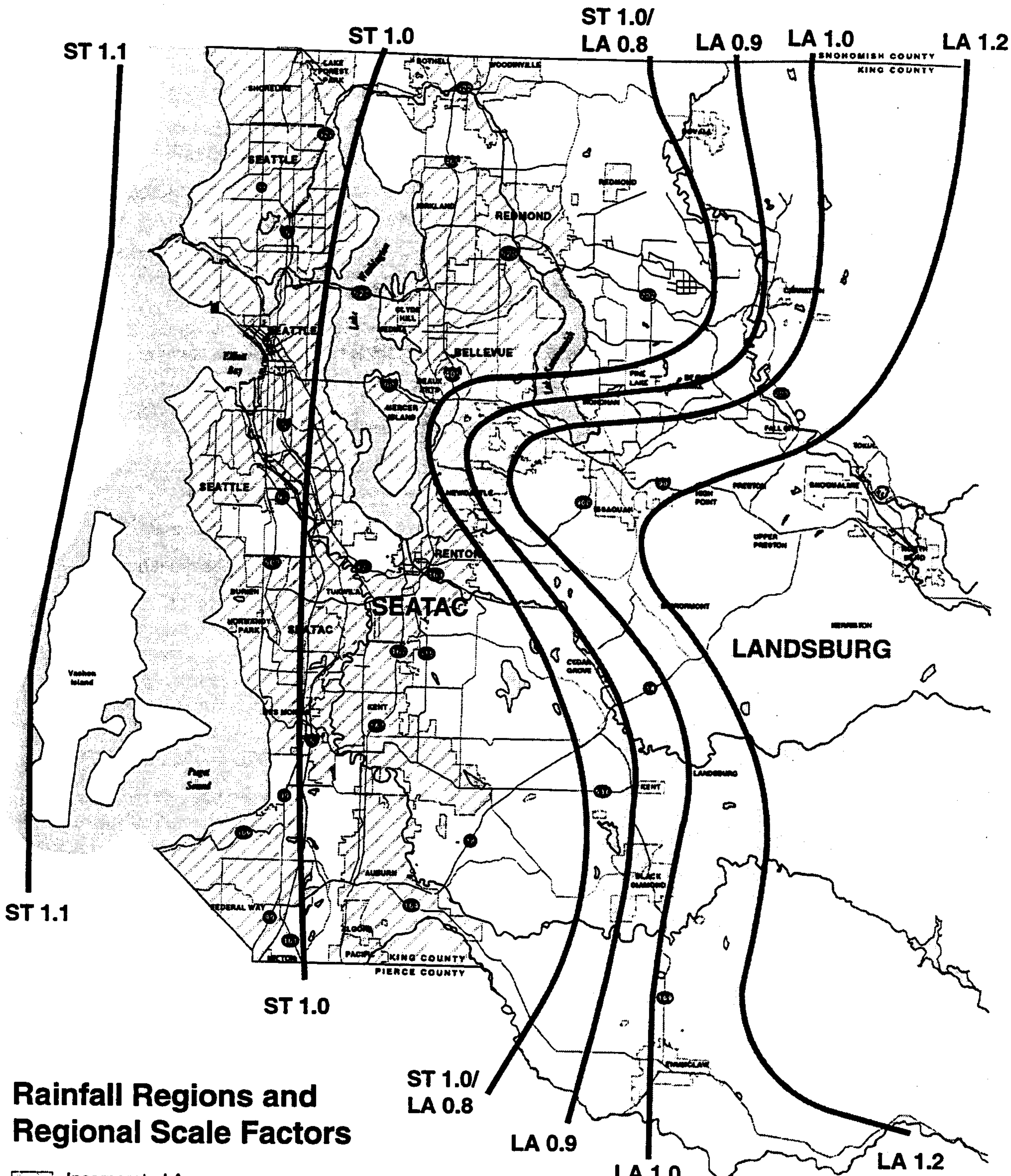
❑ SELECTION OF PRECIPITATION RECORD AND REGIONAL SCALE FACTOR

As noted in the previous section, runoff files for KCRTS were developed using data from two rainfall stations, Sea-Tac Airport and Landsburg. The regions within King County to which data from the two stations apply are shown in Figure 3.2.2.A (p. 3-22). These regions were delineated such that data from Sea-Tac Airport is applied to the drier western part of the county, while data from Landsburg is applied to the wetter eastern part of the county, including developable areas in the Cascade foothills. The line separating the two regions was based on daily rainfall depths.

The *regional scale factor* is a geographically variable multiplier applied to the flow time series to account for the considerable variations in rainfall amounts, and hence runoff, within the two regions, especially in the eastern region represented by rainfall data from Landsburg. Values of the scaling factor are interpolated from Figure 3.2.2.A (p. 3-22). A regional scale factor of 1.0 should be used for the area between the two ST 1.0 isolines.

A factor of 1.2 is applied to the Landsburg runoff files for all points east of the 1.2 isoline on Figure 3.2.2.A. While there is considerably greater variation in runoff in eastern King County than implied by the 1.2 multiplier, there is insufficient data to justify further refinement.

FIGURE 3.2.2.A RAINFALL REGIONS AND REGIONAL SCALE FACTORS



Rainfall Regions and Regional Scale Factors

Incorporated Area
River/Lake
Major Road

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❑ SELECTION OF RUNOFF FILE TIME STEPS AND RECORD TYPES

KCRTS runoff files are provided in both hourly and 15-minute time steps. The 15-minute time series were generated from the original historical hourly precipitation records, which were synthetically disaggregated into 15-minute time steps using 15-minute rainfall records from hydrologically similar gages.

The length of the runoff file records, or record type, are either reduced or historical. The reduced runoff files include eight water years as described on page 3-19. KCRTS can also analyze complete historical records of up to 99 years of simulated flow data in the historical record types. A set of full historical records for Sea-Tac and Landsburg have been generated but are applied only in the **point of compliance analysis** (see Section 3.3.6) of large storage features with long retention times, such as lakes and ponds, where storage carryovers between water years may become significant. Application of the time steps and record types are shown in Table 3.2.2.A below.

TABLE 3.2.2.A SELECTION OF RUNOFF FILE TIME STEPS AND RECORD TYPES

Analysis Type	Hourly Time Steps	15-Minute Time Steps	Runoff File Record Type(1)
Flow Control Analysis			
• Existing Conditions (target release rates)	Required(2)		Reduced (8-year) record
• Developed Conditions (facility inflows)	Acceptable	Acceptable	Reduced
Water Quality Facilities			
• Design Flow (60% 2-yr)		Required	Reduced
• Volume-Based Design	Acceptable	Acceptable	Reduced
Conveyance/Overflow Features		Required	Reduced
Level 2 Offsite Analysis	Acceptable for volume analysis	Required for peak flow analysis	
Closed Depression or Bypass Point of Compliance Analysis(3)	Acceptable for volume analysis (closed depression)	Required for peak flow analysis (bypass)	Full historical runoff files required only for analysis of downstream, volume-sensitive drainage features.

Notes:

(1) The runoff files do not contain a groundwater component. Therefore, KCRTS should be applied with caution where sources of groundwater express themselves as surface runoff, and the program should not be used to determine summer low-flow conditions in a stream. However, most analyses in this manual are of peak flow conditions where the groundwater contribution is usually small.

(2) Hourly time steps are used to determine predeveloped (target) release rates for all projects to provide for consistent control and protection against cumulative increases in peak flows. If 15-minute time steps were used, the predeveloped discharge rates from more quickly responding sites would be higher, and the onsite detention facilities under developed conditions would extend these rates for several hours. This extension of higher flow rates increases the chances that they will occur simultaneously with the peak flows from slower responding sites to create higher overall peaks in the downstream drainage system.

(3) See Section 3.3.6 (p. 3-51).

❑ CATEGORIZATION OF SOIL TYPES AND LAND COVER

The Runoff Files method with KCRTS currently supports eight land use classifications: till forest, till pasture, till grass, outwash forest, outwash pasture, outwash grass, wetland, and impervious. These classifications incorporate both the effects of soil type and land cover. In the SCS method, four different hydrologic soil groups are defined (A, B, C, and D) based on soil type as mapped by the SCS. The SCS also defines hydrologic response for about a dozen different land use or cover types. The SCS method therefore allows the user a considerably greater degree of flexibility in defining land cover and soil types than does KCRTS. However, the flexibility and apparent detail available with the SCS method cannot be supported on the basis of the data used to develop that method. The Runoff Files method minimizes the number of land use classifications, thereby simplifying both the analysis and review of development proposals.

KCRTS Soil Groups

Under KCRTS, three soil groups are currently defined: till, outwash, and wetland.

Till Soils

Till soils are underlain at shallow depths by relatively impermeable glacial till. The principal SCS soil group within King County classified as a till soil is the Alderwood series (SCS hydrological soil group C), which is the most common soil type throughout the western part of the county. The hydrologic response of till soils in an undeveloped, forested state is characterized by relatively slight surface runoff, substantial interflow occurring along the interface between the till soil and the underlying glacial till, and slight groundwater seepage into the glacial till.

Also included in the KCRTS till soil group are bedrock soils, primarily Beausite and Ovall soils, which are underlain by either sandstone or andesite bedrock, and a large group of alluvial soils.

Alluvial soils are found in valley bottoms. These are generally fine-grained and often have a high seasonal water table. There has been relatively little experience in calibrating the HSPF model to runoff from these soils, so in the absence of better information, these soils have been grouped as till soils. Most alluvial soils are classified by the SCS in hydrologic soil groups C and D.

Outwash Soils

Outwash soils are formed from highly permeable sands and gravels. The principal SCS soil group classified as an outwash soil is the Everett series. Where outwash soils are underlain at shallow depths (less than 5 feet) by glacial till or where outwash soils are saturated, they should be treated as till soils for the purpose of KCRTS application.

Wetland Soils

Wetland soils have a high water content, are poorly drained, and are seasonally saturated. For the purposes of applying KCRTS, wetland soils can be assumed to coincide with wetlands as defined in the current King County Sensitive Areas Ordinance.

The approximate correspondence between SCS soil types and the appropriate KCRTS soil group is given in Table 3.2.2.B (p. 3-25). If the soils underlying a proposed project have not been mapped, or if existing soils maps are in error or not of sufficient resolution, then a soils analysis and report shall be prepared and stamped by a professional civil engineer with expertise in soils to verify underlying soil conditions.

TABLE 3.2.2.B EQUIVALENCE BETWEEN SCS SOIL TYPES AND KCRTS SOIL TYPES

SCS Soil Type	SCS Hydrologic Soil Group	KCRTS Soil Group	Notes
Alderwood (AgB, AgC, AgD)	C	Till	
Arents, Alderwood Material (AmB, AmC)	C	Till	
Arents, Everett Material (An)	B	Outwash	1
Beausite (BeC, BeD, BeF)	C	Till	2
Bellingham (Bh)	D	Till	3
Briscot (Br)	D	Till	3
Buckley (Bu)	D	Till	4
Earlmont (Ea)	D	Till	3
Edgewick (Ed)	C	Till	3
Everett (EvB, EvC, EvD, EwC)	A/B	Outwash	1
Indianola (InC, InA, InD)	A	Outwash	1
Kitsap (KpB, KpC, KpD)	C	Till	
Klaus (KsC)	C	Outwash	1
Neilton (NeC)	A	Outwash	1
Newberg (Ng)	B	Till	3
Nooksack (Nk)	C	Till	3
Norma (No)	D	Till	3
Orcas (Or)	D	Wetland	
Oridia (Os)	D	Till	3
Ovall (OvC, OvD, OvF)	C	Till	2
Pilchuck (Pc)	C	Till	3
Puget (Pu)	D	Till	3
Puyallup (Py)	B	Till	3
Ragnar (RaC, RaD, RaC, RaE)	B	Outwash	1
Renton (Re)	D	Till	3
Salal (Sa)	C	Till	3
Sammamish (Sh)	D	Till	3
Seattle (Sk)	D	Wetland	
Shalcar (Sm)	D	Till	3
Si (Sn)	C	Till	3
Snohomish (So, Sr)	D	Till	3
Sultan (Su)	C	Till	3
Tukwila (Tu)	D	Till	3
Woodinville (Wo)	D	Till	3

Notes:

1. Where outwash soils are saturated or underlain at shallow depth (<5 feet) by glacial till, they should be treated as till soils.
2. These are bedrock soils, but calibration of HSPF by King County DNR shows bedrock soils to have similar hydrologic response to till soils.
3. These are alluvial soils, some of which are underlain by glacial till or have a seasonally high water table. In the absence of detailed study, these soils should be treated as till soils.
4. Buckley soils are formed on the low-permeability Osceola mudflow. Hydrologic response is assumed to be similar to that of till soils.

KCRTS Land Cover Types

KCRTS supports four land cover types: forest, pasture, grass, and impervious. These cover types shall be applied as specified in Table 3.2.2.C (below).

TABLE 3.2.2.C KCRTS COVER GROUPS AND AREAS OF APPLICATION

KCRTS Cover Group	APPLICATION	
	Predevelopment	**Post-Development**
Forest	All forest/shrub cover, irrespective of age.	All permanent (e.g., protected by covenant or SAO designation) onsite forest/shrub cover, irrespective of age, planted at densities sufficient to ensure 80%+ canopy cover within 5 years.
Pasture	All grassland, pasture land, lawns, and cultivated or cleared areas, except for lawns in redevelopment areas with predevelopment densities in excess of 4 DU/GA..	Unprotected forest in rural residential development may be considered half pasture, half grass.
Grass	Lawns in redevelopment areas with predevelopment densities in excess of 4 DU/GA..	All post-development grassland and landscaping and all onsite forested land not protected by covenant or SASA designation (except in rural areas as noted above).
Wetland	All delineated wetland areas (except cultivated/drained farmland).	All delineated wetland areas (except cultivated/drained farmland).
Impervious(1)	All impervious surfaces, including heavily compacted gravel and dirt roads, parking areas, etc., and open water bodies (ponds and lakes).	All impervious surfaces, including compacted gravel and dirt roads, parking areas, etc., and open water bodies, including onsite detention and water quality ponds.

(1) Impervious acreage used in KCRTS computations should be the **effective impervious area (EIA)**. This is the gross impervious area multiplied by the effective impervious fraction (see Table 3.2.2.E, p. 3-28). Non-effective impervious areas are considered the same as the surrounding pervious land cover.

The following four factors were considered in specifying the above land cover types to be used in hydrologic analysis with KCRTS:

- Cover types are **applied to anticipate ultimate land use conditions.** For example, probable clearing of woodland after development is nominally complete suggests that the post-development land use be specified as grassland (either pasture or grass) unless the forest cover is protected by covenant.
- In areas of redevelopment, there are often significant changes between the predevelopment and post-development efficiencies of the drainage system. For example, in conversion of low density residential areas to higher density land use, impervious areas prior to redevelopment may not be efficiently connected to a drainage system (e.g., downspouts draining to splash blocks, ditched instead of piped roadway systems). These problems are addressed by defining an "**effective impervious fraction**" for existing impervious areas and by generally requiring predevelopment grasslands to be modeled as pasture land.

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- All onsite, predevelopment forest/shrub cover and all offsite forest/shrub cover is defined as "forest," irrespective of age. Post-development onsite land use is defined as forested only if forested areas are in a sensitive area buffer or are otherwise protected and will have a minimum 80% canopy cover within 5 years. **In urban areas, unprotected onsite forest cover should be treated as either pasture or grass in the post-development analysis.** In rural areas, unprotected forest cover should be assumed 50% grass, 50% pasture.
- The HSPF grass parameters were developed by the USGS study of regional hydrology and have generally been interpreted as providing the hydrologic response for "urban" grasslands (lawns, etc.), which have relatively low infiltration rates and are drained effectively. The HSPF "pasture" parameters were developed by King County DNR to provide a hydrologic response intermediate to the USGS forest and grass parameters, as might be typified by ungrazed or lightly grazed pasture with good grass cover. Because it is impossible to adequately control grassland management after development, all **post-development grassland should be modeled as "grass"** (with the exception of unprotected forest in rural development as noted above). All **predevelopment grassland should be modeled as "pasture"** except for redevelopment of areas with predevelopment land use densities of 4 DU/GA or greater (which are modeled as grass).

❑ CALCULATION OF IMPERVIOUS AREA

Total Impervious Coverage

Table 3.2.2.D (p. 3-28) lists percent impervious coverage for use in KCRTS analysis of **existing** residential areas. The tabulated figures are useful in offsite analysis that includes large developed residential areas, making a detailed survey of impervious coverage impractical.

Impervious coverage for **proposed** residential and commercial development must be estimated for each specific proposal. Impervious coverage of streets, sidewalks, hard surface trails, etc., shall be taken from layouts of the proposal. House/driveway or building coverage shall be as follows:

- For urban residential development, the assumed impervious coverage shall not be less than 4,000 square feet per lot or the maximum impervious coverage permitted by code (K.C.C. 21A.12.030), whichever is less.
- For rural residential development, the assumed impervious coverage shall not be less than 8,000 square feet per lot or the maximum impervious coverage permitted by code, whichever is less.
- For commercial or multi-family development, impervious coverage shall be estimated from layouts of the proposal.

Effective Impervious Area

The net hydrologic response of an impervious area depends on whether that area is effectively connected (usually by pipes or a channel) to a storm drainage system. The impervious area that the user inputs to KCRTS is the "Effective Impervious Area" (EIA), the total impervious area multiplied by the **effective impervious fraction** (see Table 3.2.2.E, p. 3-28).

Non-effective impervious area (i.e., total impervious area less EIA) is assumed to have the same hydrologic response as the immediately surrounding pervious area. For example, for existing residential areas with rooftops draining to splash pads on lawns or landscaping, the non-effective portion of the roof areas would be treated as pasture for predevelopment conditions (if DU/GA < 4.0) and grass for post-development conditions. *Note: Credits for infiltration/dispersion of downspouts on individual lots in proposed single family residential subdivisions are applied separately on a site-specific basis (see Note 3, Table 3.2.2.E).*

The effective impervious fraction can be selected from Table 3.2.2.E or determined from detailed site surveys. With the exception of figures for compacted gravel and dirt roads and parking lots, the figures in Table 3.2.2.E are average figures cited by the USGS (Dinicola, 1990).

TABLE 3.2.2.D PERCENT IMPERVIOUS COVERAGE FOR EXISTING RESIDENTIAL AREAS

Dwelling Units/Gross Acre	% Impervious[1]	Dwelling Units/Gross Acre	% Impervious
1.0 DU/GA	15[2]	4.5 DU/GA	46
1.5 DU/GA	20	5.0 DU/GA	48
2.0 DU/GA	25	5.5 DU/GA	50
2.5 DU/GA	30	6.0 DU/GA	52
3.0 DU/GA	34	6.5 DU/GA	54
3.5 DU/GA	38	7.0 DU/GA	56
4.0 DU/GA	42	7.5 DU/GA	58
For PUDs, condominiums, apartments, commercial businesses, and industrial areas, percent impervious coverage must be computed.			

Notes:

(1) Includes streets and sidewalks.

(2) These figures should be adjusted by the effective impervious fraction given in Table 3.2.2.E, if applicable. Values from Table 3.2.2.E may be interpolated as necessary.

TABLE 3.2.2.E EFFECTIVE IMPERVIOUS FRACTION[1]

Land Use	Predevelopment	Post-Development
Commercial, Industrial, or Roads with Collection System	0.95	1.00
Multi-Family or High Density Single Family[2] (>4 DU/GA)	0.80	1.00[3]
Medium Density Single Family[2] (4 DU/GA)	0.66	1.00[3]
Low Density Single Family[2] (1 DU/GA)	0.50	1.00[3]
Rural[2] (< 1 DU/GA)	0.40	1.00[3]
Gravel/Dirt Roads and Parking Lots, Roads without Collection System	0.50	0.50

Notes:

(1) The *effective impervious fraction* is the fraction of actual total impervious area connected to the drainage system. These figures should be used in the absence of detailed surveys or physical inspection (e.g., via pipe, channel, or short sheet flowpath).

(2) Figures for residential areas include roadways.

(3) Where downspout infiltration is used, roofs are not counted as impervious area when sizing the flow control facility. Roofs are considered grass where downspouts are dispersed in rural residential development, or where dispersed flowpaths exceed 50 feet in urban residential development (see Section 5.1.2 for limitations on roof downspout dispersion).

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Example

Determining the KCRTS land use data for an existing 20-acre residential area, with an average lot size of 9600 square feet (4.5 DU/GA), surrounding a 5-acre forested open space tract would entail the following calculations:

From Table 3.2.2.D, the portion of basin assumed impervious at 4.5 DU/GA

Total Impervious = 0.46 x 20 acres = 9.2 acres
Existing Pervious (grass) = 20 acres - 9.2 acres = 11.8 acres
Existing Pervious (forest) = 5 acres

From Table 3.2.2.E, the effective impervious area

Effective Impervious Fraction = 0.8 (at 4.5 DU/GA)
Effective Impervious Area = 0.8 x 9.2 acres = 7.36 acres
Non-Effective Impervious Area = 9.2 acres - 7.36 acres = 1.84 acres

Add the non-effective impervious area to the area of the surrounding pervious land cover.

Total Grass Area = 11.8 acres + 1.84 acres = 13.64 acres
Total Forest Area = 5 acres
Effective Impervious Area = 7.36 acres

These are the acreages that would be input into the KCRTS model when creating the time series.

3.2.2.2 TIME SERIES STATISTICAL ANALYSIS

When using KCRTS to size flow control, water quality, and conveyance facilities, design flows and durations must be determined through statistical analysis of time series data generated by KCRTS. KCRTS provides for statistical analysis of both **flow frequency** and **flow duration** as described in this section. *Flow frequency analysis* is used for determining design peak flows while *flow duration analysis* is used for determining durations of flow exceedance.

❑ FLOW FREQUENCY ANALYSIS

Flow frequency is a commonly used but often misunderstood concept. The *frequency of a given flow* is the average return interval for flows equal to or greater than the given flow. The *flow frequency* is actually the inverse of the probability that the flow will be equaled or exceeded in any given year (the *exceedance probability*). For example, if the exceedance probability is 0.01, or 1 in 100, that flow is referred to as the 100-year flow. Assuming no underlying changes in local climate, one would expect to see about 10 peak annual flows equal to or greater than the 100-year flow in a 1,000 year period. Similarly, the 2-year flow is the flow with a probability of 0.5, or 1 in 2, of being equaled or exceeded in any given year. In a 100-year period, one would expect to observe 50 peak annual flows greater than or equal to the 2-year flow. The number of peak annual flows actually equal to the 2-year flow may be zero, since peak annual flows come from a continuous spectrum.

There are many **methods for estimating exceedance probabilities** and therefore flow frequencies. The *USGS Bulletin 17B* methods are commonly used, as are graphical methods using either the Gringorten, Cunane, or Weibull plotting schemes (Maidment, 1993). Graphical methods for flow frequency estimation involve assigning exceedance probabilities, and therefore return intervals, to each annual peak in a series of annual peak observations, and then plotting the peak flows against their assigned return periods. This plot is known as a *flow-frequency curve*, and it is a very useful tool for analyzing flood probabilities. Examples of flow-frequency curves for a small basin under various conditions are shown in Figure 3.2.2.B (p. 3-31).

Flow-frequency curves are used in continuous flow simulations to determine the effect of land use change and assess the effectiveness of detention facilities. Using continuous methodology to design detention facilities to control peak flows, the analyst must match the post-development (detained) and predevelopment flow-frequency curves at the frequencies of interest, as shown in Figure 3.2.2.B (p. 3-31), rather than match specific design events as when using an event model. KCRTS provides flow-frequency estimates and graphs flow-frequency curves from time series of either flow rates or water levels.

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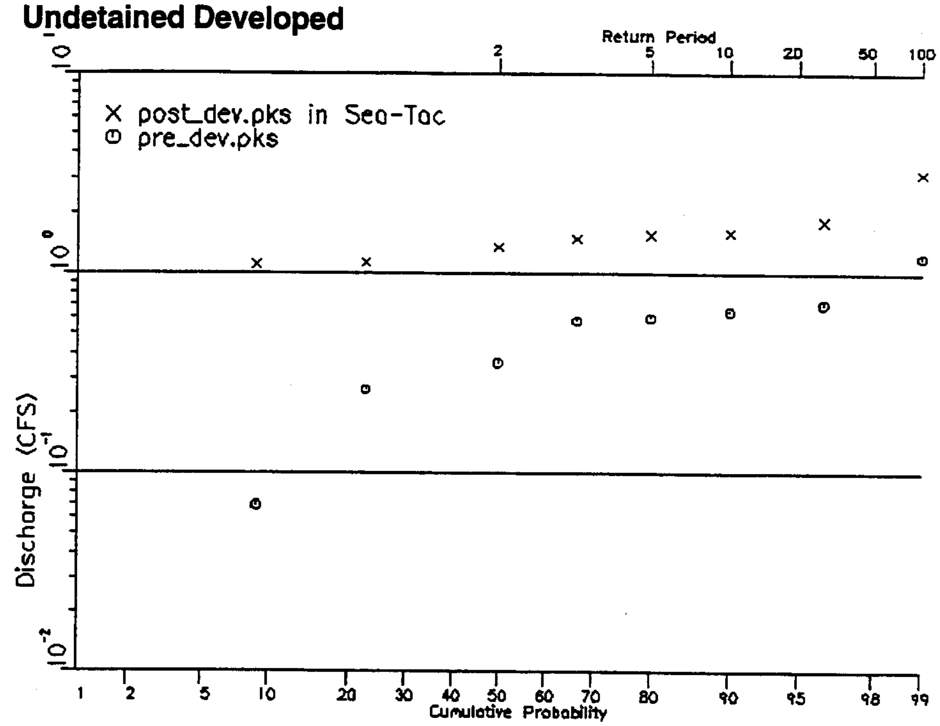
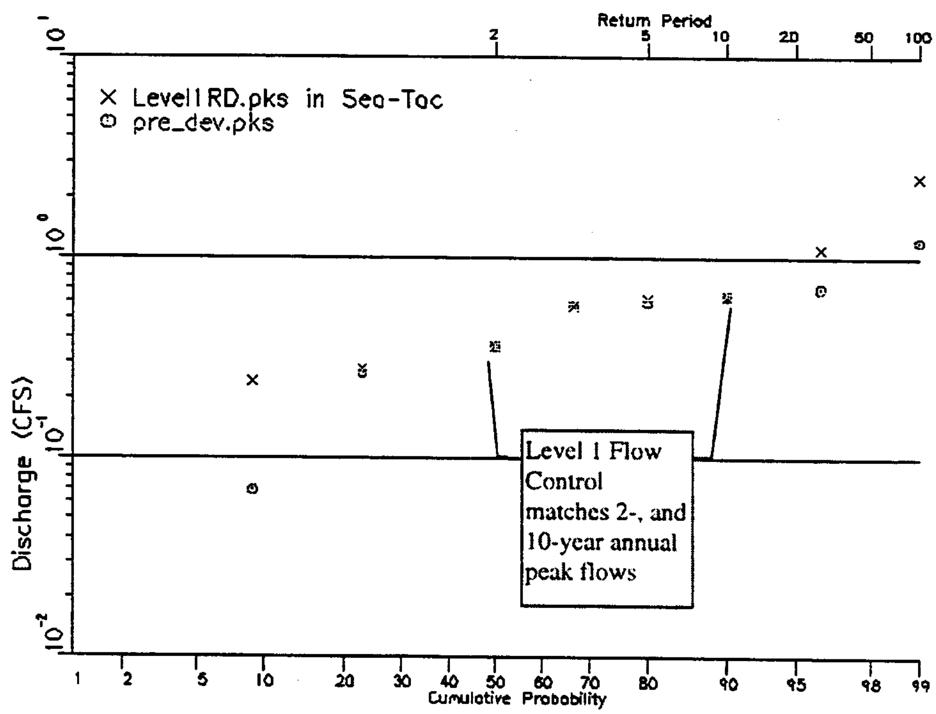
FIGURE 3.2.2.B EXAMPLE FLOW FREQUENCY ANALYSIS

Undetained Developed



Detained Developed



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Flow frequency information is derived from the 8-year time series flow file by assigning predetermined frequencies, or return periods, to the peak annual events in the runoff file. For example, a return period of 100 years is assigned to the peak annual flow from the highest ranked annual peak (hypothetical 100-year runoff event based on runoff for January 1990). These return periods were determined by King County DNR through analysis of the full 40-year record from which the runoff files were derived. The **return periods used in KCRTS** are as follows:

Rank of Annual Peak	Reduced Record Return Periods
one	100-year
two	25-year
three	10-year
four	5-year
five	3-year
six	2-year
seven	1.3-year
eight	1.1-year

Note: The 50-year peak flow is interpolated from the first and second ranked annual peak flows.

❑ FLOW DURATION ANALYSIS

Flow durations are important because they show the change in duration of all high flows rather than the change in frequency of the peak annual flows. Channel scour and bank erosion rates rise proportionally with increases in flow durations. Flow duration analysis can only be conducted with continuous flow models or from gage records.

A *flow duration curve* is simply a plot of flow rate against the percentage of time that the flow rate is exceeded. In a continuous flow model, the *percent exceedance* of a given flow is determined by counting the number of time steps during which that flow is equaled or exceeded and dividing that number by the total number of time steps in the simulation period. In KCRTS the percentage of time is based on analysis of the first 7 years of the simulated runoff file (i.e., excluding water year 8, which contains a scaled 100-year peak flow event). Flow duration curves are usually plotted with a linear flow scale versus a log scale of percent exceedance. The log scale for exceedance percentage is used because geomorphically significant flows (flows capable of moving sediment) and flows that exceed the 2-year flow typically occur less than one percent of the total time.

Durations for Flow Control Standards

The **Level 2 flow control standard** described in Section 3.1.2 (p. 3-5) requires matching predevelopment and post-development flow duration curves for all flows greater than one-half of the 2-year flow up to the 50-year flow. *Note: This performance standard is slightly modified for the reduced 8-year record used by KCRTS since there is not a 50-year peak flow in the shortened record. The modified standard calls for maintaining predevelopment durations of all flows in the first 7 years of the record greater than one-half of the 2-year peak flow. Usually, the largest peak flow rate of the first 7 years has an associated return frequency of 25 years.*

KCRTS provides flow duration curves for either flows or water levels. To support facility design, KCRTS will create a *"target" predevelopment duration curve* for the range of flows being analyzed. To simplify design, **brief excursions**[1] above the target predevelopment duration curve are allowed for flows greater than 50 percent of the predevelopment 2-year. These excursions shall not increase the discharge by more than 10% at any duration level. This allows efficient design using only two orifices for most applications;

[1] Brief excursions may not result in more than 50% of the target duration curve being exceeded.

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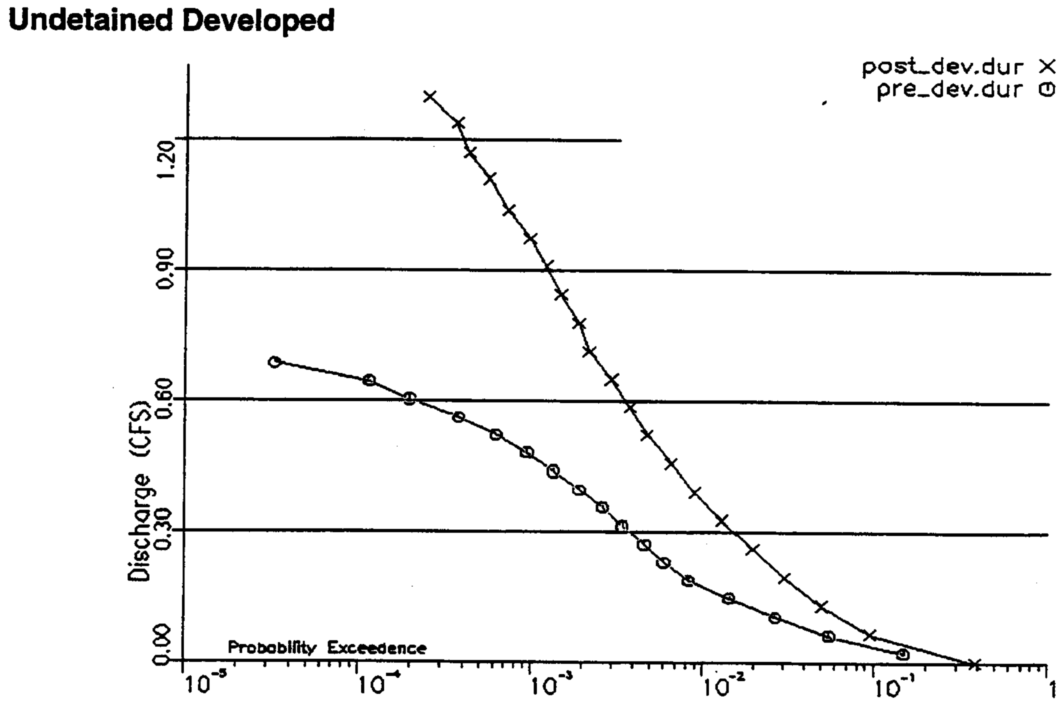
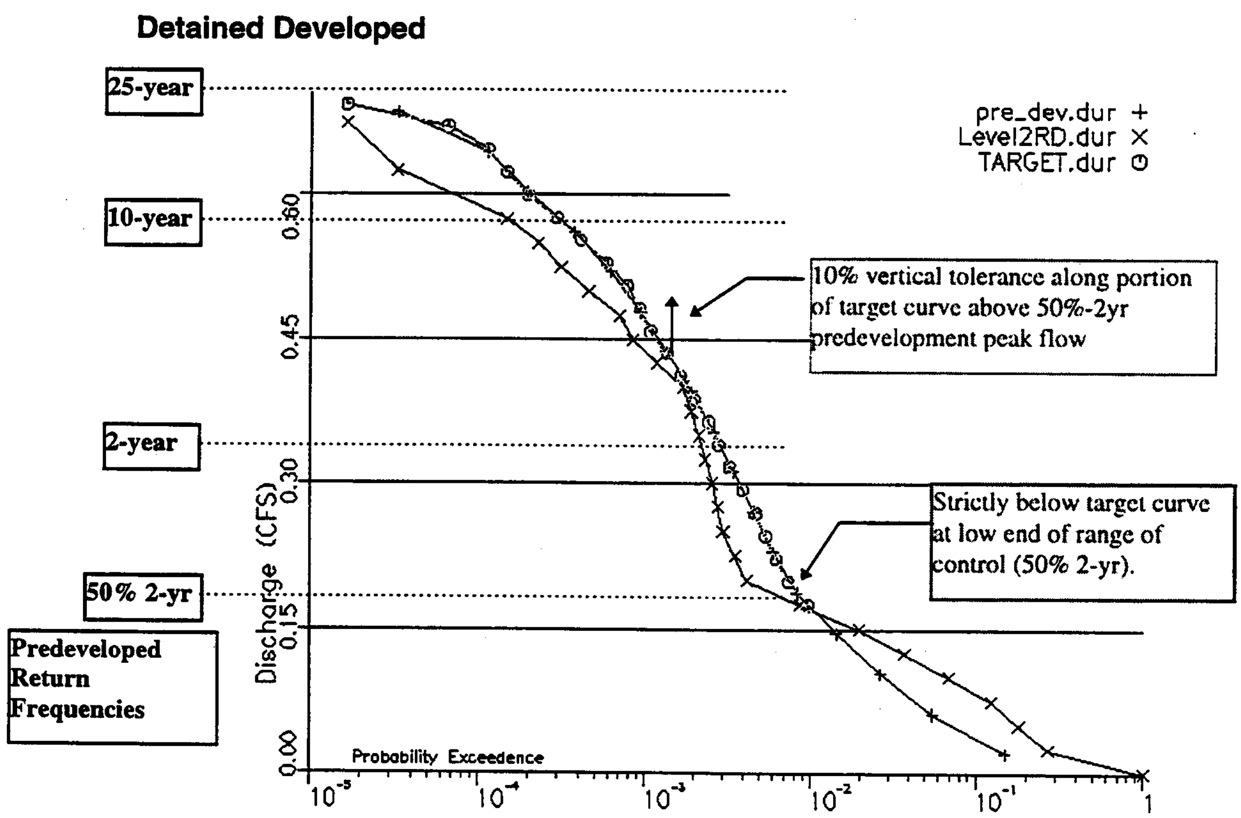
see the *KCRTS Computer Software Reference Manual* for a detailed example. An example of a flow duration analysis is shown in Figure 3.2.2.C (p. 3-34).

The **Level 3 flow control standard** matches predevelopment and post-development flow durations over the same range of predevelopment flows as the Level 2 flow control standard. In addition, the 100-year post-development peak flow must be contained within the facility and controlled to predevelopment levels. This standard provides additional storage volume over the Level 2 flow control facility, which substantially mitigates the impacts of increased volumes of surface runoff on downstream, volume-sensitive flooding problems.

The **Level 1 flow control standard** does not require flow duration analysis because it addresses peak flows only.

FIGURE 3.2.2.C EXAMPLE FLOW DURATION ANALYSIS





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3.2.3 HSPF MODEL

HSPF is the parent model from which the KCRTS Runoff Files method is built. It is a very versatile continuous hydrologic/hydraulic model which allows for a complete range of hydrologic analysis. This model has been extensively used in King, Snohomish, and Thurston counties and found to be an accurate tool for representing hydrologic conditions in this area. The USGS has developed **regional parameters** to describe the common soil/cover combinations found in this area. In many cases, these regional parameters can be used to represent rainfall/runoff relationships in lieu of site-specific calibration parameters.

Unfortunately, the HSPF model is very difficult to use. Design engineers using HSPF should study this model in detail and obtain training before using it on a project. For these reasons, the HSPF model is recommended only for large and complex projects where the capabilities of KCRTS are too limited.

The strengths of HSPF relative to KCRTS are as follows:

1. HSPF can be calibrated to local site conditions.
2. HSPF can model, link, and route many separate subbasins.
3. HSPF includes the groundwater component of streamflow.
4. HSPF can address groundwater connections and perform low-flow analysis.
5. HSPF can handle more complex hydrologic routing (e.g., evaporation, seasonal infiltration, etc.).

The HSPF model is generally recommended for large sites where these additional features are required for comprehensive hydrologic and/or hydraulic analysis. Anyone planning a project that is large enough to require Large Site Drainage Review and submittal of a Master Drainage Plan (MDP) per Section 1.1.2.4 should meet with DDES MDP review staff regarding appropriate hydrologic analysis prior to initiating such analysis. If a large site drains to either a Class 1 wetland, a salmonid stream with low-flow sensitivities, or a groundwater recharge area, it is likely that the County will require a calibrated HSPF model. If a large site drains to erosion-sensitive streams or has features with complex hydraulics, the County may recommend or require an HSPF model using the USGS regional parameters. Smaller or less sensitive subbasins within a MDP area can be analyzed with KCRTS.

Additional data is required to develop an HSPF model. At a minimum, development of an HSPF model requires collection of onsite rainfall data for a period from seven to twelve months. This data is used to determine which regional long-term rainfall record is most appropriate for modeling the site and for determining transposition factors for the long-term records. If calibration is required, the onsite rainfall data is used. Calibration also requires the installation of flow gages and the collection of flow data against which simulated flows can be compared. HSPF analysis is based on simulations with long-term rainfall records (greater than 30 years). Long-term precipitation records in HSPF format can be obtained from the County for the Sea-Tac, Landsburg, and Carnation gages.

Land surface representation with HSPF follows the same procedures and classification as used with KCRTS.

Conceptually, the outputs required from an HSPF analysis are consistent with those required from a KCRTS analysis, including frequency and durational analysis. Flow and/or water level frequencies shall be estimated using the full set of annual peaks from the long-term simulations using the *USGS Bulletin 17B* methods as well as the Gringorten or Cunane graphical methods. Durational analyses can be produced from the HSPF model and the results presented graphically. If a Class 1 wetland is modeled, water level analyses may be required. Monthly, seasonal, and annual water balance and flow information, if appropriate, can be calculated with the HSPF model.

3.2.4 STORAGE ROUTING/WATER LEVEL ANALYSIS METHODS

This section presents the methods used for sizing and analyzing detention storage and determining water levels for ponding water bodies. It begins with an introduction to the *level pool routing technique* (the basic method of storage routing used in King County) and then describes how this technique is used by KCRTS for storage routing of runoff time series and assessment of water levels.

❑ INTRODUCTION TO LEVEL POOL ROUTING

The level pool routing technique is one of the simplest and most commonly used routing methods. It is described in the *Handbook of Applied Hydrology* (Chow, Ven Te, 1964) and elsewhere, and it is based on the continuity equation:

Inflow - Outflow = Change in storage

$$\left[\left(\frac{I_1+I_2}{2}\right)-\left(\frac{O_1+O_2}{2}\right)\right]=\frac{\Delta S}{\Delta t}=S_2-S_1 \qquad (3\text{-}7)$$

where I = inflow at time 1 and time 2
O = outflow at time 1 and time 2
S = storage at time 1 and time 2
Δt = time interval, $t_2 - t_1$

The time interval, Δt, must be consistent with the time interval of the inflow hydrograph or time series. As indicated in Section 3.2.2, the time interval used for sizing and analyzing flow control facilities can be either 15 minutes or 60 minutes as specified in Table 3.2.2.A (p. 3-23). The Δt variable can be eliminated by dividing it into the storage variables to obtain the following rearranged equation:

$$I_1 + I_2 + 2S_1 - O_1 = O_2 + 2S_2 \qquad (3\text{-}8)$$

If the time interval, Δt, is in minutes, the units of storage S are now [cf/min] which can be approximated to cfs by multiplying by 1 min/60 sec.

The terms on the left-hand side of the equation are known from the inflow time series and from the storage and outflow values of the previous time step. The unknowns O_2 and S_2 can be solved using the stage-storage and stage-discharge relationships for the storage facility being analyzed or sized. The level pool routing procedure calls for this calculation to be made for each time step of the inflow time series in order to generate the outflow time series for the facility. Because of the repetitive nature of this procedure, it is best performed using a computer.

The KCRTS program includes a routine, described later in this section, for executing the level pool routing procedure. Level pool routing using KCRTS requires that the stage-storage and stage-discharge relationships be determined as explained below.

Developing the Stage-Storage Relationship

The following methods and equations are used for determining the stage-storage relationships of various facility types:

- **Facilities with Vertical Sides**

  For vertical-sided facilities such as vaults, the stored volume is simply the bottom area times the height.

- **Ponds with 3:1 Side Slopes**

For ponds with 3:1 side slopes, the stored volume can be approximated by averaging the pond surface area with the bottom area. The following equation was derived based on this assumption and for a square pond but provides a reasonable trial estimation for typical ponds of other shapes.

$$S(H) = 12H^3 + 6\sqrt{A_b}H^2 + A_bH \qquad (3\text{-}9)$$

where H = stage height (ft) or water depth above pond bottom
A_b = area of pond bottom (sf)
$S(H)$ = storage (cf) at stage height H

Note: Actual pond volumes and surface areas should be computed based on the methods outlined in Reference Section 6-B, or the following equation:

$$V = \frac{h}{3}(A_t + A_b + \sqrt{A_tA_b}) \qquad (3\text{-}10)$$

where h = *depth*
A_t = *area of top*
A_b = *area of the bottom*

- **Irregularly Shaped Storage Areas**

The stage-storage relationship for irregularly shaped storage areas may be developed as follows:

1. Obtain topographic contours of an existing or proposed storage facility site and determine (with a planimeter or otherwise) the area enclosed by each contour. For example, in Figure 3.2.4.A (p. 3-38) each contour represents a one-foot interval. Contour 71 is the lowest portion of the site and represents zero storage. Contour 76 represents a potential stage of 5 feet above the bottom the facility.

2. Calculate the average end area within each set of contours. For the example in Figure 3.2.4.A, the average end area between contours 71 and 72 would be:

$$\frac{600+4400}{2} = 2500 \text{ sf}$$

3. Calculate the volume between each set of contours by multiplying the average end area within each set of contours by the difference in elevation. To illustrate, the volume between contours 71 and 72 would be:

(2500 sf)(1 ft) = 2500 cf

Similarly,

Area 72-73 = 6550 cf
Area 73-74 = 10,050 cf
Area 74-75 = 12,950 cf
Area 75-76 = 16,750 cf

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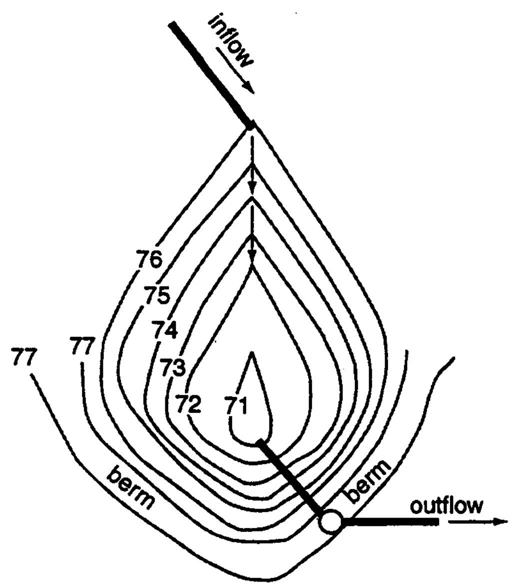
4. Define the total storage below each contour. This is just the sum of the volumes computed in the previous step up to the contour in question. For example, there is no storage below contour 71, 2500 cf below contour 72, and (6550 + 2500) = 9050 cf below contour 73.

In summary,

Contours	Stage	Sum of Volumes				Total Volume
Contours 71-72	1	0	+	2500	=	2500 cf
Contours 72-73	2	2500	+	6500	=	9050 cf
Contours 73-74	3	9050	+	10,050	=	19,100 cf
Contours 74-75	4	19,100	+	12,950	=	32,050 cf
Contours 75-76	5	32,050	+	16,750	=	48,800 cf

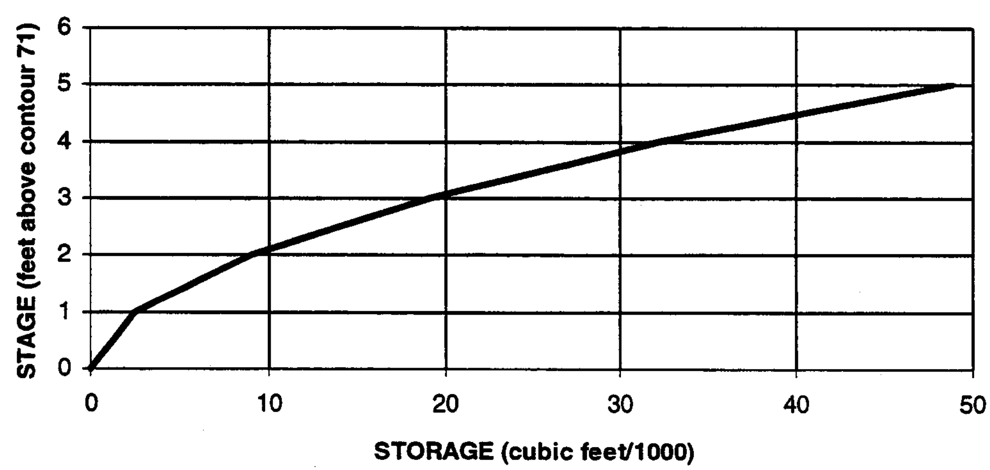
Figure 3.2.4.B below is a plot of the stage-storage relationship for this example.

FIGURE 3.2.4.A STORAGE SITE CONTOURS AT ONE-FOOT INTERVALS



Area within each contour	
71	600 sq. ft.
72	4400 sq. ft.
73	8700 sq. ft.
74	11,400 sq. ft.
75	14,500 sq. ft.
76	19,000 sq. ft.

FIGURE 3.2.4.B STAGE-STORAGE RELATIONSHIP



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Developing the Stage-Discharge Relationship

The stage-discharge relationship is determined by computing the peak discharge rate for each stage height used in the stage-storage relationship. Peak discharge rates are computed using the appropriate flow equation(s) or headwater data corresponding to the type of outlet present or proposed.

❑ LEVEL POOL ROUTING USING KCRTS

KCRTS supports level pool routing of time series as described in the preceding pages. To analyze an existing storage facility, the stage-storage and stage-discharge relationships are defined as explained above and input into KCRTS as "routing data." When sizing a new facility, KCRTS will automatically define these relationships. In addition to surface discharges, the user may define a stage variable permeable area and a constant infiltration rate for a storage feature. Infiltrated runoff is not saved to an outflow time series. Infiltration rates for most soils in King County under saturated conditions are slow, and permeable areas and infiltration rates are usually set to zero for simplicity. See Section 5.4 for considerations on the use of infiltration.

Routing is performed with the **Route-1 Outlet (single discharge), Route-2 Outlet (dual discharge-"flow splitter"), and Facility routines of KCRTS** as described in the program documentation. Whenever a time series is routed through a storage feature, KCRTS automatically generates an outflow time series containing both flow and stage records. In addition to normal applications as a flow time series, the time series can be analyzed for water levels in the storage feature.

❑ ASSESSING WATER LEVEL STATISTICS WITH KCRTS

KCRTS allows analysis of time series for water level statistics in the same manner as with flow statistics. Using the outflow time series, KCRTS can plot stages over a one-month time period, estimate return frequencies for various stages, plot a **stage-frequency curve**, and conduct **stage duration analysis**. The only water level analysis specifically required by this manual is **stage frequency analysis**. Other water level analysis capabilities are supported by KCRTS, but are not required anywhere in this manual.

Stage frequency analysis consists of estimating and plotting recurrence estimates for water levels within a storage feature in the same manner as flow frequency analysis is conducted for discharges. Stage frequency analysis is required for assessing runoff impacts to offsite closed depressions and ponding areas as required under Core Requirements 2 and 3, and as discussed Section 3.3.6, "Point of Compliance Analysis" (p. 3-51).

❑ ASSESSING ANNUAL AVERAGE RUNOFF VOLUMES WITH KCRTS

The Compute Volume routine, in the KCRTS Analysis Tools menu, can be used to compute the volume of runoff (surface + interflow) of a time series. For the reduced runoff files, the analysis is performed over the first 7 years (10/01/00 - 09/30/07); for the historical runoff files, the entire period of record is used. The total volume is divided by the number of full water years being analyzed to determine the annual average runoff volume.

3.3 HYDROLOGIC DESIGN PROCEDURES AND CONSIDERATIONS

This section presents the design procedures and considerations for sizing flow control facilities to meet the required hydrologic performance specified in Core Requirement #3, Section 1.2.3. It includes the following procedures and special considerations for proper hydrologic design:

- "General Hydrologic Design Process," Section 3.3.1
- "Flow Control Design with KCRTS," Section 3.3.2 (p. 3-43)
- "Conveyance System Design with KCRTS," Section 3.3.3 (p. 3-46)
- "Safety Factors in Hydrologic Design," Section 3.3.4 (p. 3-47)
- "Design Options for Addressing Downstream Problems," Section 3.3.5 (p. 3-48)
- "Point of Compliance Analysis," Section 3.3.6 (p. 3-51)
- "Onsite Closed Depressions and Ponding Areas," Section 3.3.7 (p. 3-54).

3.3.1 GENERAL HYDROLOGIC DESIGN PROCESS

This section presents the general process involved in conducting a hydrologic analysis using the runoff computation and analysis methods in Section 3.2 to design flow control facilities for a project. The process is described as follows:

1. Review the **core and special requirements** in Chapter 1 to determine all requirements that will apply to the proposed project.
   a) Determine the applicable flow control standard (basic outflow performance criteria).
   b) If downstream problems are identified through offsite analysis per Core Requirement #2, determine if they will necessitate additional onsite flow control or other measures as described in Section 3.3.5 (p. 3-48).
2. Determine and demonstrate in the Technical Information Report (see Section 2.3) the **existing site conditions** per Core Requirement #3, Flow Control (see Section 1.2.3).
3. Identify and delineate the drainage basin for each natural discharge location[2] from the project site.
   a) Identify **existing drainage features** such as streams, conveyance systems, detention facilities, ponding areas, depressions, wetlands, etc.
   b) Identify existing land uses.
   c) Identify soil types using SCS soil survey or onsite evaluation.
   d) Convert SCS soil types to KCRTS soil classifications.
4. Select and delineate **appropriate subbasins**, including subbasins tributary to major drainage features and important conveyance points, and subbasins for separate computation of onsite flows and offsite flows.
5. Determine **hydrologic parameters** for each subbasin under existing conditions.
   a) Determine appropriate rainfall region and regional scale factor.
   b) Categorize soil types and land cover per Table 3.2.2.B (p. 3-25) and Table 3.2.2.C (p. 3-26).
   c) Determine total impervious areas and effective impervious areas within each subbasin.

[2] The *natural discharge location* is the location where runoff leaves the project site under existing site conditions.

   d) Determine areas for each soil/cover type in each subbasin.

6. Determine the **runoff time series** for existing site conditions at each natural discharge location.
   a) Compute the existing site condition runoff time series for each subbasin using hourly time steps.
   b) **For subbasins that drain to a drainage feature with significant detention storage** (e.g., existing detention facilities, ponding areas, closed depressions), route the runoff time series through the feature per the storage routing methods in Section 3.2.4 (p. 3-36). This will yield an attenuated flow series, which becomes the effective runoff time series for that subbasin.
   c) Sum the appropriate subbasin runoff time series to obtain the total runoff time series for each natural discharge location.
   d) Determine the 100-year peak flow for each natural discharge location.
7. Repeat Steps 4 through 6 for the proposed post-development site condition.
8. Compare the **100-year peak flows** for existing and post-development site conditions at each natural discharge location.
   a) Check the "**Discharge Requirements**" criteria in Core Requirement #1 to determine the acceptable manner of discharge from the project site.
   b) Check the **flow control exemptions** in Core Requirement #3 to determine if a flow control facility is required.
   c) Check the requirement for **offsite bypass** in Core Requirement #3 to determine if offsite flows entering the project site must be conveyed around onsite flow control facilities.
9. If flow control facilities are required, determine their location and make any necessary adjustments to the developed condition subbasins.
10. **Design and size each flow control facility** using the methods described in Section 3.2 and the KCRTS design procedure in Section 3.3.2.
    a) Analyze the appropriate existing site condition runoff time series to determine target release rates for the proposed facility. *Note: If the target release rates are zero, an infiltration facility will be required.*
    b) Compute the post-development runoff time series for the proposed facility.
    c) Use the post-development runoff time series and an iterative process to size the facility to meet the required level of performance set forth in Core Requirement #3. See the *KCRTS User's Guide* for procedures in sizing flow control facilities using continuous flow series.
11. **Design required onsite conveyance systems** using the appropriate runoff computation method (either the Rational method or KCRTS/Runoff Files method with 15-minute time steps) as specified in Section 3.2 (p. 3-9).

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3.3.2 FLOW CONTROL DESIGN WITH KCRTS

Flow control facility design using the KCRTS *Size a R/D Facility* routine involves four basic steps:

1. Determining the statistical characteristics (peaks or durations) of predevelopment hourly flows which set the targets for the facility release rates,
2. Developing preliminary facility volume and orifice configuration using the Test Inflow Hydrograph List,
3. Routing post-development flow time series through the preliminary facility to check performance, and
4. Iteratively revising the facility and checking performance until the target flow conditions are achieved.

Instead of using individual design rainfall events as in an event model, the design of the facility is based on simulation of the facility's performance using the 8-year time series record of simulated post-development flows, and on comparison of the outflow record to characteristics of the predevelopment flow record. The design engineer uses several month-long test hydrographs for preliminary facility sizing and orifice adjustment, but final design is not achieved until the full 8-year outflow time series meets the target flow specifications.

Detention facility design with a continuous model is based on aggregate flow statistics, not upon individual storms. **When designing detention facilities with a continuous model like KCRTS, the return period of the peak flow leaving the facility for a particular event may not have the same return period as the peak flow entering the facility during the same event.** Unlike event models, continuous models have natural variability in the ratio of storm peak and volume. This lack of correspondence in the return periods of peak inflows and outflows in continuous models means that facility design using KCRTS is more complicated than with an event method and in general has to be done on an iterative trial-and-error basis to obtain an optimal (i.e., least volume) design.

The effect of detention facilities in controlling peak flows is dependent on both the volume and peak of the inflowing hydrograph. **Generally, it is high volume storms rather than high intensity storms that cause detention facilities to fill and overtop.** KCRTS-produced hydrographs, based on historical rainfall data, show considerable variability in the relationships between peak flows and storm volumes. For example, one event produced by high rainfall intensities in a relatively short duration storm may produce high peak flows with a relatively small hydrograph volume. By contrast, a second rainfall event may have relatively low intensities but long duration, producing a runoff hydrograph with large volumes and relatively small peak. Due to this natural variability, the peak annual outflows from a detention facility may not correspond in time to the annual peaks of the inflow record.

Similarly, **the predevelopment peak annual flows may not occur during the same storm as the peak annual flows for the post-development flow series.** This is because the types of storms that produce high flows from undeveloped land covers are different from those that produce high flows from impervious surfaces. Forests generate high streamflows in response to long-duration, high-volume rainfall events that soak the soil profile, whereas impervious surfaces produce the highest flow rates in response to high precipitation intensity. This is another reason why detention facility design with a continuous flow model is based on aggregate flow statistics, not upon individual storm hydrographs.

The following is a recommended procedure for hydrologic design of detention/infiltration facilities using KCRTS. Specific guidance for conducting hydrologic analysis and design with KCRTS is provided in the *KCRTS Computer Software Reference Manual.*

1. **Create time series** of flows from the predevelopment site (assuming existing site conditions), the post-development area tributary to the facility, any onsite post-development bypass area, and any offsite flow-through areas.
2. **Add any offsite flow-through time series** to the predevelopment flow time series to produce a time series of total predevelopment outflows from the site. Similarly, add the same offsite flow-through

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time series to the time series of post-development site flows tributary to the facility to produce a time series of total post-development inflows to the facility.

3. Generate **peak annual flow estimates** and **flow frequency curves** for pre- and post-development time series. If applicable, generate flow duration curves for predevelopment time series.
4. Enter the **Size a Facility routine** in KCRTS and specify initial facility specifications for the type of facility proposed. Use of two orifices is usually sufficient for most designs. If designing an infiltration facility, the bottom orifice may be elevated or zero orifices may be specified. Set the Test Inflow Hydrograph list using the post-development inflow time series.
5. Specify the **Primary Design Hydrograph (PDH).** The event specified as the PDH must have a target release rate specified. **Usually, control of only one test hydrograph in addition to the PDH is necessary for either flow frequency or flow duration control.** These test hydrographs are used as design storms to develop a preliminary facility design and simplify the revision process. The hydrographs and flow targets listed in Table 3.3.2.A below are suggested for preliminary pond and orifice sizing.

TABLE 3.3.2.A
HYDROGRAPHS AND FLOW TARGETS FOR PRELIMINARY POND & ORIFICE SIZING

	Flow Frequency Control		Flow Duration Control	
	Outflow Recurrence Interval	Target Pre-Development Flow Rate	Outflow Recurrence Interval	Target Pre-Development Flow Rate
Primary Design Hydrograph	10-year	10-year	100-year	100-year
Test Hydrograph Rank	3	--	1	
Additional Test Hydrograph	2-year	2-year	2-year	one-half the 2-year
Test Hydrograph Rank	6	--	6	

The initial **Test Inflow Hydrograph** list setup will include the storm events generating the highest annual peaks from the inflow time series. The final design is accomplished by controlling the events generating the annual peak flows from the outflow time series. It is recommended that the automatic **Event Date Notification/Update option** be used, which will notify the user of needed updates to the hydrograph event dates when the full time series is routed; see the *KCRTS Computer Software Reference Manual* for further information.

6. **Iterate the PDH** and save the designed facility.
7. Set up the **Auto-Analysis options** to execute the analysis tools needed to assess facility performance. To evaluate flow frequencies for application of the Level 1 flow control standard, the Compute Peaks and the Event Date Notification options should be turned on.
8. **Route** the complete pond inflow time series through the facility. The outflow time series is automatically saved and the analysis tools performed. Frequent routing of the full time series is necessary while adjusting the facility in order to keep the hydrograph list consistent with the events generating the highest outflows. *Note: In KCRTS version 4.0 and later, this process has been automated when using the Automatic Iteration function.*
9. **Adjust orifice configuration and iterate the PDH until desired performance is achieved.** The calculated outflow peaks for the test hydrograph list should remain in descending order. Repeat Step 8 if the relative rank of the test hydrographs changes.

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c) Conduct a **flow frequency analysis** on the total runoff time series. From this analysis the 10-year, 25-year, and 100-year peak flows can be determined. These design flows can then be used to size or assess the capacity of pipe systems, culverts, channels, spillways, and overflow structures.

3.3.4 SAFETY FACTORS IN HYDROLOGIC DESIGN

It is often appropriate to apply safety factors to detention volumes or conveyance design flows. This manual does not require safety factors for detention or conveyance design, but it does recommend the use of safety factors when the designer believes the results of KCRTS are not sufficiently conservative given local site conditions. **The KCRTS methodology does not include inherent safety factors as it is meant to account for "average" site conditions. On a particular site, KCRTS may overestimate or underestimate flow rates and detention volumes.**

Within any soil/cover group, there is a range of hydrologic response dependent on local soil and geologic conditions for which the KCRTS methodology does not account. The USGS regional parameters for HSPF that were used to create the runoff files produce "average" runoff time series that overestimate peak flows in some basins and underestimate them in others. Similarly, the detention volumes designed with KCRTS for a given conversion type are in the middle of the range of volumes that would be created if exact local hydrologic conditions were known for every project of that type. Therefore, some of the detention facilities designed with KCRTS are oversized and some are undersized, depending on variable site conditions.

Because of the uncertainty in local hydrologic response, King County recommends, but does not require, that a volume safety factor of 10% be applied to all detention facilities. If downstream resources are especially sensitive, or if the designer believes that KCRTS significantly overestimates predevelopment flows or underestimates post-development flows, a volume safety factor of up to 20% may be appropriate. If a volume safety factor is applied to a detention facility, the volume should be increased by the given percentage at each one-foot stage increment. Safety factors for conveyance systems should be evaluated with respect to the potential damages and costs of failures due to backwatering, overtopping, etc. Applications of safety factors fall strictly within a professional engineer's judgment and accountability for design. Section 4 of the Technical Information Report should state what safety factor was applied to the design of the flow control facility.

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3.3.5 DESIGN OPTIONS FOR ADDRESSING DOWNSTREAM PROBLEMS

This section explains the rationale behind the problem-specific mitigation criteria summarized in Chapter 1, Table 1.2.3.A, and it presents acceptable options for addressing the three primary types of downstream problems defined in Core Requirement #2.

1. Conveyance system nuisance problems
2. Severe erosion problems
3. Severe flooding problems.

If one or more of these problems is identified through offsite analysis per Core Requirement #2, the applicant must demonstrate that the proposed project will not create or significantly aggravate the problem. This may require additional analysis, onsite flow control, and/or offsite improvements sufficient to ensure no aggravation of these problems. To reduce the need for extra analysis and to aid in the selection of measures to prevent aggravation, a set of options corresponding to each of the three types of downstream problems is explained in this section. Each option details the extent to which additional measures are needed to prevent aggravation based on the flow control standard being applied to the project site.

❑ OPTIONS FOR ADDRESSING CONVEYANCE SYSTEM NUISANCE PROBLEMS

Problem Description: Overflow from a downstream conveyance system has or is predicted to cause nuisance flooding/erosion of a yard, a pasture, or one side of a roadway for runoff events less than or equal to the 10-year event.

The two options detailed below are acceptable measures for preventing the creation or aggravation of this problem. A combination of these two options may also be used if demonstrated to meet the same performance goals. Other options may be possible through a more rigorous design procedure using the **point of compliance analysis** technique described in Section 3.3.6 (p. 3-51).

The extent of additional onsite flow control or offsite improvements needed depends on the basic area-specific flow control standard already being applied to the proposed project per Section 1.2.3.1.

Option 1—Additional Onsite Flow Control

- **If Level 1 is the area-specific flow control standard** per Section 1.2.3.1, then expand its performance criteria to match the post-development discharge rate for the 10-year return period to the existing site conditions discharge rate for the return period T_r at which the conveyance system overflows. *Note: Determining T_r requires a minimum Level 2 downstream analysis as detailed in Chapter 2. To avoid this analysis, a T_r of 2 years may be assumed.*

  Intent: This criteria is intended to prevent creation or aggravation of the problem for runoff events less than or equal to the 10-year event by eliminating the project site's contribution to conveyance system overflows during these events.

- **If the Level 2 or Level 3 flow control standard** is being applied onsite, no additional flow control is needed. The duration-matching criteria of these standards already prevent aggravating increases in overflow volume by maintaining the discharge volumes of existing site conditions for peak flows greater than 50% of the 2-year peak flow.

Option 2—Offsite Improvements

- **If the Level 1 flow control standard** is being applied onsite, then make improvements to the existing conveyance system per Core Requirement #4 (see Section 1.2.4).

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10. **Verify the pond performance** by routing the complete time series of inflows and checking the post-development peak flows and/or durations at the site boundary against the target flows and/or durations (see the criteria for "Evaluating Flow Control Performance" provided below). Update the test inflow hydrograph dates as needed to keep the test hydrographs event dates current with the annual peaks of the post-development time series at the site boundary. Repeat Steps 8-10 as necessary to achieve the desired performance and to produce an optimal design.

Evaluating Flow Control Performance

Evaluating the performance of facility designs intended to provide **flow frequency control** is comparatively straightforward: the post-development facility annual peak flows should be strictly less than or equal to predevelopment annual peak flows at each of the specified return periods.

Evaluating the design performance of detention facilities providing **flow duration control**, however, generally requires several iterations. In fact, considerable time could be spent attempting to match predevelopment and post-development duration curves. Some flexibility in assessing the adequacy of fit is clearly needed to expedite both design and review. Therefore, flow duration designs will be accepted as meeting performance standards when the following conditions are met:

1. The post-development **flow duration curve** lies strictly on or below the predevelopment curve at the **lower limit of the range of control.**[3]
2. **At any duration within the range of control**, the post-development flow is less than 1.1 times the predevelopment flow.
3. The **target duration curve** may not be exceeded along more than 50% of the range of control.
4. The **peak flow at the upper end of the range of control** (reduced, 25-year; historical, 50-year) may not exceed predeveloped levels by more than 10%.

[3] For small projects, the lower limit of the range of control is considered met with a minimum diameter (0.5 inches) lower orifice in a low head facility (maximum effective storage depth of 3 feet) where full duration control cannot be achieved at the lower limit. Predeveloped flow durations, within allowed tolerances, must be met for all flows above the best achievable lower limit.

3.3.3 CONVEYANCE SYSTEM DESIGN WITH KCRTS

This section provides guidance for use of the KCRTS/Runoff Files method in determining peak flows for the design and analysis of conveyance elements, overflow structures, and other peak flow sensitive drainage features. KCRTS should not be used to determine peak flows for areas less than 10 acres in size unless there are significant storage features (see Section 3.2).

Rainfall events which create the highest rates of runoff from developed areas are typically shorter in duration and are characterized by brief periods of high intensity rainfall. To simulate the runoff from higher intensity, shorter duration rainfall events, **a 15-minute time series is used** and **flowpath adjustments** are made to the time series to account for the specific hydrologic response of the catchment.

To make flowpath adjustments to a time series, the user specifies the length and slope of the longest unconcentrated drainage pathway for the impervious and grass land cover types. Runoff is unconcentrated until collected into a drainage facility such as an open channel, catch basin, pond, depression, etc. Drainage pathways are measured from the farthest point in the catchment to the collection point and are aligned perpendicular to topographic contours.

The flowpath adjustments of 15-minute time series are accomplished by accessing a different set of runoff files containing the rainfall excess values for the impervious and grass land cover types. The *rainfall excess* is the portion of the total rainfall which is available as surface runoff but has not been routed across the landscape to the collection point of the drainage system. KCRTS utilizes standard routing equations to perform the surface routing along the user-defined flowpath.

The following is a recommended **procedure for hydrologic design and analysis of conveyance facilities using KCRTS:**

1. Select and delineate **appropriate subbasins.**
   a) Select separate subbasins for major drainage features and important conveyance points.
   b) Identify existing land covers offsite and post-development land covers onsite.
   c) Identify soil types by using the SCS soil survey or by directly evaluating the site.
   d) Convert SCS soil types to KCRTS soil classifications.
2. Determine **hydrologic parameters** for each subbasin.
   a) Determine appropriate rainfall region and regional scale factor.
   b) Categorize soil types and land cover per Table 3.2.2.B (p. 3-25) and Table 3.2.2.C (p. 3-26).
   c) Determine total impervious areas and effective impervious areas within each subbasin.
   d) Determine areas for each soil/cover type in each subbasin.
   e) Identify the longest flowpath for each land cover type.
   f) **Determine the length and slope of the longest unconcentrated flowpath for each post-development land-use type.** *Note: The forest, pasture, and wetlands land covers are not as sensitive to variations in surface flowpath. Therefore, KCRTS will not prompt for lengths and slopes from these land covers, and will access the normal (regionally calibrated) runoff files without site-specific calibration to surface flowpaths.*
3. Determine **peak flows** for the conveyance element being analyzed.
   a) Compute the runoff time series for each subbasin, using 15-minute time steps and specifying the flowpath data for the post-development land covers.
   b) Sum the appropriate subbasin runoff time series, accounting for travel time lags, to obtain the total runoff time series tributary to the drainage feature being analyzed.

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- **If the Level 2 or Level 3 flow control standard** is being applied onsite, no offsite improvements are necessary.

❑ OPTIONS FOR ADDRESSING SEVERE EROSION PROBLEMS

Problem Description: A downstream channel, ravine, or slope area has or is predicted to experience severe erosion and/or incision that poses a sedimentation hazard to downstream conveyance systems or poses a landslide hazard by undercutting a steep slope.

The two options detailed below are considered acceptable measures for preventing aggravation of this problem.

The extent of additional onsite flow control or offsite improvements needed depends on the basic area-specific flow control standard already being applied to the proposed project per Section 1.2.3.1.

Option 1—Additional Onsite Flow Control

- **If Level 1 is the area-specific flow control standard**, then **apply Level 2 instead**. This standard prevents aggravating increases in the durations of flow exceedance that contribute to erosion.
- **If the Level 2 or Level 3 flow control standard** is being applied onsite, no additional flow control is needed. The duration-matching criteria of these standards prevent aggravating increases in the durations of flow exceedance that contribute to erosion.

Note: If the proposed project's discharge is such that previously unconcentrated flows will be concentrated onto a highly erodible area, DDES may require a tightline system through the area regardless of the level of onsite flow control being provided. This should be addressed with DDES in a predesign meeting.

Option 2—Offsite Improvements

- **If the Level 1 flow control standard** is being applied onsite, then make tightline, channel armoring, or bioengineered improvements to safely convey discharge from the project site through the severely eroded area.
- **If Level 2 is the required area-specific flow control standard**, offsite tightline or channel armoring improvements may, in some cases, be used to reduce this standard if the project is not within a Basin Plan or Rural Stream Protection Area. In some cases, DDES may require a tightline if the risk of damage is high.
- **If Level 3 is the required area-specific flow control standard**, offsite tightline or channel armoring improvements may, in some cases, be required by DDES where the risk of damage is high.

❑ OPTIONS FOR ADDRESSING SEVERE FLOODING PROBLEMS

Problem Description: Overflow from a downstream conveyance system, or the elevated water surface of a downstream pond, lake, wetland, or closed depression, has or is predicted to cause a "severe building flooding problem" or a "severe roadway flooding problem." Such problems, by definition, occur during runoff events less than or equal to the 100-year event. See Section 1.2.2.1 for a more detailed description of severe building and roadway flooding problems.

The two options detailed below are acceptable measures for preventing the creation or significant aggravation of this problem. A combination of these two options may also be used if demonstrated to meet the same performance goals. Other options may be possible through a more rigorous design procedure using the **point of compliance analysis** technique described in Section 3.3.6 (p. 3-51).

The extent of additional onsite flow control or offsite improvements needed depends on the basic area-specific flow control standard already being applied to the proposed project per Section 1.2.3.1.

Option 1—Additional Onsite Flow Control

- **If Level 1 is the area-specific flow control standard**, then **apply Level 3 instead** AND comply with the special provision for closed depressions stated below, if applicable. Also, if the problem is caused by conveyance system overflows, the duration-matching criteria of **Level 3 may be modified** to match post-development discharge durations to predevelopment discharge durations for the range of predevelopment discharge rates between that which corresponds to the return period T_r of conveyance system overflow and the 50-year peak flow, assuming existing site conditions for the predevelopment condition. *Note: Determining T_r requires a minimum Level 2 downstream analysis as detailed in Chapter 2. To avoid this analysis, a T_r of 2 years may be assumed.*

  Intent: The intent behind Level 3 flow control is described in Section 1.2.3.1. The modified version of Level 3 is intended to prevent aggravating increases in overflow volume, duration, and peak flow for runoff events less than or equal to the 100-year event.

- **If Level 2 is the area-specific flow control standard**, then **apply Level 3 instead** AND comply with the special provision for closed depressions stated below, if applicable.

- **If Level 3 is the area-specific flow control standard**, then comply with the special provision for closed depressions stated below, if applicable.

  Special Provision for Closed Depressions

  If the amount of impervious surface area proposed by the project is greater than or equal to 10% of the 100-year water surface area of the closed depression, then use the **point of compliance analysis** technique described in Section 3.3.6 (p. 3-51) to verify that water surface levels are not increasing for the return frequencies at which flooding occurs, up to and including the 100-year frequency. If necessary, iteratively adjust onsite flow control performance to prevent increases.

  Intent: This provision is intended to be applied to those developments that are large enough to have a significant impact on the water surface levels of a closed depression. For such developments, the provision is intended to more closely examine the hydrologic characteristics of the depression to ensure no significant aggravation of the flooding problem. Characteristics such as the infiltration rate or the influence of groundwater fluctuations can be highly variable and difficult to measure, which may entail wet season monitoring for proper analysis.

Option 2—Offsite Improvements

- **If the Level 1 or Level 2 flow control standard** is being applied onsite, and the problem is caused by conveyance system overflows, then make improvements to the existing conveyance system sufficient to prevent the severe flooding problem. If the problem is caused by the elevated water surface of a pond, lake, wetland, or closed depression, then make improvements to the live storage volume or discharge characteristics of the water body in question such that water surface levels for the frequencies at which flooding occurs are not increased, OR make improvements to elevate the flooding building or roadway above the 100-year water surface.

- **If the Level 3 flow control standard** is being applied onsite, and the special provision for closed depressions is applicable, then make improvements as described above for the Level 1 and Level 2 flow control standards. Otherwise, offsite improvements are not required.

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3.3.6 POINT OF COMPLIANCE ANALYSIS

The *point of compliance* is the location where flow control performance standards are evaluated. In most cases, the point of compliance is the outlet of a proposed detention facility where, for example, 2- and 10-year discharges must match predevelopment 2- and 10-year peak flow rates.

The point of compliance for hydrologic control moves downstream of the detention facility outlet or the property boundary under the following circumstances:

1. The proposed project discharges to an **offsite closed depression with a "severe flooding problem"** per Section 1.2.2, and the project adds impervious surface greater than or equal to 10% of the 100-year water surface area of the closed depression (see Table 1.2.3.A). In these cases, the closed depression becomes the point of compliance, and the engineer must ensure that site runoff does not aggravate the flooding problem (or create a new flooding problem).
2. The proposed project includes an **onsite runoff bypass,** a small developed area which bypasses the flow control facility (see Section 1.2.3.2). In such cases, runoff from the remainder of the site is overdetained so that the sum of the detained and undetained flows meets the required flow control performance standard. The point of compliance for such projects is where the onsite bypass flows join the detained flows.
3. The proposed project **bypasses offsite flows** around an onsite closed depression, ponding area, or wetland (see Section 3.3.7, p. 3-54). As with onsite bypasses, the point of compliance in this case is where detained flows converge with the bypassed flows.

The **Facility Sizing routine within KCRTS** allows the user to analyze the facility performance at a downstream point of compliance through the Automatic Analysis routine.

*Note: When controlling flow durations at a downstream point of compliance to demonstrate no adverse impact, the 10% tolerance specified for Level 2 performance (p. 3-32) may **not** be used. Existing condition flow durations should be matched to the extent feasible, for all flows above the level of concern. The resultant facility should also be checked to verify that the minimum onsite performance standard (e.g., Level 1, Level 2 or Level 3; see Section 1.2.3) has also been met.*

❑ OFFSITE CLOSED DEPRESSIONS

If a project drains to an offsite closed depression with existing or potential flooding problems, then the water surface levels of the closed depression must not be allowed to increase for return frequencies at which flooding occurs, up to and including the 100-year frequency. This section describes the point of compliance analysis necessary to size detention facilities discharging to such a closed depression.

The closed depression is first modeled (using the predevelopment site) to determine the return frequency at which flooding currently occurs and the water levels associated with return frequencies in excess of this frequency. These flooding levels and their probabilities dictate the detention performance for the proposed development. The proposed detention facility is then iteratively sized such that discharge from the post-development site does not increase water surface levels for the frequencies at which flooding occurs—that is, after development, water level frequency curves must match for all frequencies equal to or greater than the frequency at which flooding occurs (up to the 100-year water level).

The infiltration rate must be determined in order to accurately model the closed depression. **In the case of a closed depression with an existing flooding problem, the infiltration rate is most realistically depicted by calibrating the model to known flooding events.** This should be done using the full historical runoff files (available on request from DNR) and setting the closed depression outflow (infiltration) such that recorded or anecdotal levels of flooding occur during the same storm events in the historical record.

Where a flooding problem might be created by discharge of post-development flows to a closed depression, and **in the absence of information on dates and water surface levels in the closed**

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depression during past runoff events, infiltration rates must be determined through testing as follows:

- For a closed depression without standing water, two or more **test pits** should be dug in the bottom of the closed depression to a depth of 10 feet or to the water table, whichever is reached first. The test pits shall be dug under the supervision of a geotechnical engineer, and a test pit log shall be kept. Evidence of high water table shall be noted.
- If the test pit reveals deep homogeneous permeable material with no evidence of a high water table, then infiltration tests shall be performed in the bottom of the closed depression at locations of similar elevation and on opposite sides of the bottom area (as feasible). **Surface infiltration rates** shall be determined using the methods for assessing measured infiltration rates included in Section 5.4. The measured rates should be used directly, without applying correction factors.
- If the closed depression has standing water or is a SAO-defined wetland, or if test pits show evidence of a high water table or underlying impermeable material, then procedures for determining infiltration rates will be established on a case-by-case basis in coordination with DDES geologists.
- In the event that a closed depression with a documented severe flooding problem is located on private property and all reasonable attempts to gain **access to the closed depression** have been **denied**, the Level 3 flow control standard shall be applied with a 20% factor of safety on the storage volume.

❑ ONSITE RUNOFF BYPASS

It is sometimes impractical to collect and detain runoff from an entire project area, so provisions are made to allow undetained discharge from onsite bypass areas (see Section 1.2.3.2) while overdetaining the remainder of the runoff to compensate for unmitigated flows. A schematic of an onsite runoff bypass is shown in Figure 3.3.6.A (next page).

For sites employing onsite runoff bypass, flow control performance standards are evaluated at the point of compliance, the point where detained and undetained flows from the site are combined.

Point of Compliance Analysis for Onsite Bypass Areas

1. Create an **existing condition runoff time series** for the entire project area including the predevelopment detained area and the predevelopment bypass area. Determine **flow targets** (either flow frequencies or durations, depending on the applicable design standard) from the existing condition runoff time series.
2. Create separate **developed condition runoff time series** for the detained area and the bypass area.
3. Ensure that the flow characteristics of the developed runoff time series for the bypass area do not exceed the targets determined in Step 1 or the 0.4 cfs threshold in Core Requirement #3. If the bypass area flows exceed the targets or threshold, then the bypass is not feasible.
4. Estimate **allowable release rates** from the detention facility for each return period of interest with the following equation:

$$\text{Allowable release} = (\text{Total Project Area Flow})_{\text{existing cond.}} - (\text{Bypass Area Flow})_{\text{developed cond.}}$$

Note: KCRTS version 4.0 and later supports the direct sizing of onsite detention facilities based on the results at a downstream point-of-compliance. See the KCRTS Software Documentation for further details.

5. Develop a **preliminary design of the flow control facility** based on the estimated release rate.
6. **Route** post-development flows from the detained area through the detention facility, and create a detention facility outflow time series.
7. Determine the **total project post-development outflow** by adding the detention facility outflow runoff time series to the post-development runoff time series from the bypass area.

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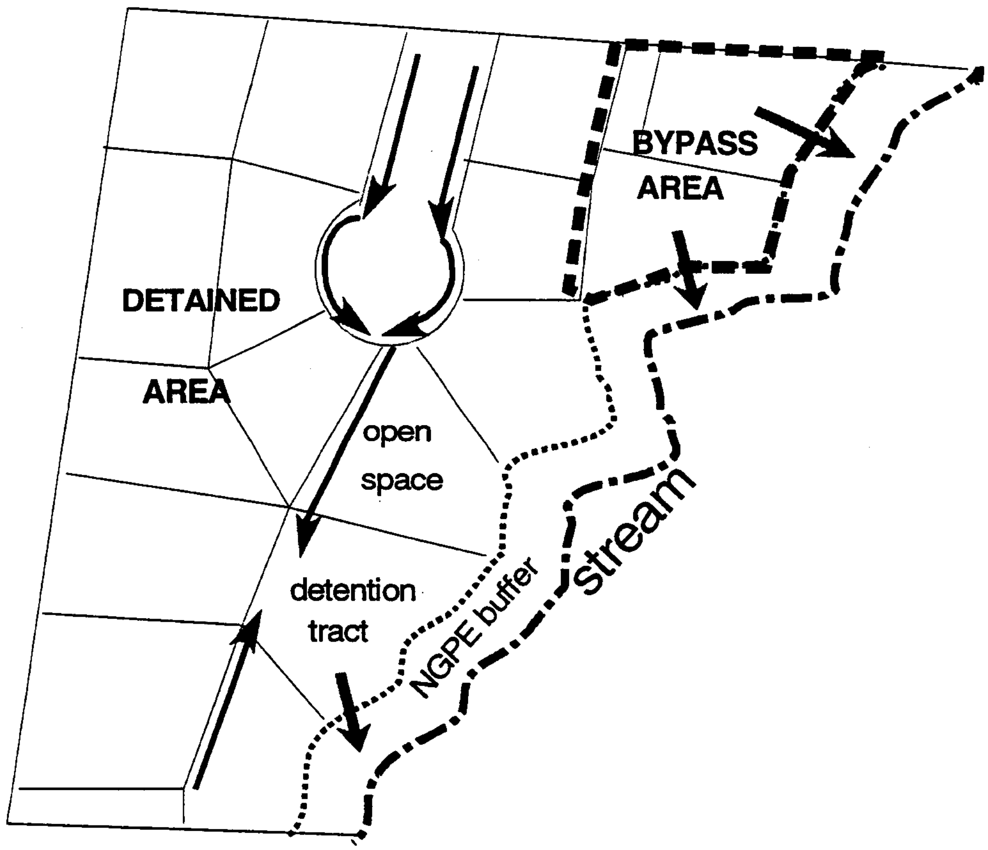
8. Check characteristics of the total project post-development outflow against the targets determined in Step 1.
9. If compliance is not achieved (e.g., 2- and 10-year post-development flows exceed 2- and 10-year predevelopment flows), repeat Steps 6 through 8. **Steps 6 through 8 have been automated for facility sizing by using the point of compliance option of the KCRTS (version 4.0 and later) Automatic Iteration and Automatic Analysis routines.**

FIGURE 3.3.6.A SCHEMATIC OF AN ONSITE RUNOFF BYPASS



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3.3.7 ONSITE CLOSED DEPRESSIONS AND PONDING AREAS

Onsite closed depressions, ponding areas, and wetlands require special consideration when determining detention performance targets; if altered, they can shift the point of compliance downstream. However, the SAO regulates wetlands (note that most closed depressions and ponding areas are wetlands by definition) and generally does not permit alteration through either filling or gross hydrologic changes such as bypassing offsite flows. *Note: Post-development discharges to offsite closed depressions, ponding areas, or wetlands (with the exception of Level 3 Flow Control Areas on the Flow Control Applications Map, or as discussed in Section 3.3.6) are normally not required to meet special performance standards, unless there is a severe flooding problem as defined in Section 1.2.2.*

❑ GENERAL REQUIREMENTS

The following general requirements apply to **onsite closed depressions, ponding areas, and wetlands** (referred to below as "features"):

1. **Flow attenuation** provided by onsite wetlands and ponding areas, and storage provided by onsite closed depressions must be accounted for when computing both existing onsite and offsite flows.
   - **Existing onsite flows** must be routed through onsite wetlands and ponding areas to provide accurate target release rates for the developed site. *Note: Closed depressions will have no outflow for some portions of the site for some events, although overflow may occur during extreme events.*
   - **Existing offsite flows** will increase at the project boundary if the feature is filled or if the offsite flows are bypassed around the feature. To compensate, post-development onsite flows must be overdetained, and the point of compliance will shift downstream to where the detained flows converge with the bypassed offsite flows.
2. **If the onsite feature is used for detention,** the 100-year floodplain must be delineated considering developed onsite and existing offsite flows to the feature. *Note: Additional storage volume may be necessary within the feature, and the point of compliance is the discharge point from the feature.*
3. **If the detention facility for the proposed project discharges to an onsite wetland, ponding area, or closed depression that is not altered[4] by the proposed project, AND Level 2 or Level 3 flow control is provided,** the point of compliance is the discharge point of the detention facility, not the outlet of the onsite feature. If Level 1 flow control is being provided, the point of compliance is the outlet of the onsite feature.

❑ FLOODPLAIN DELINEATION FOR LAKES, WETLANDS, CLOSED DEPRESSIONS, AND PONDING AREAS

A minor floodplain analysis is required for onsite or adjacent lakes, wetlands, and closed depressions that do not have an approved floodplain or flood hazard study (see Section 4.4.2; note the exceptions). Minor floodplain studies establish an assumed base flood elevation below which development is not allowed.

The following are guidelines for minor floodplain analysis of volume sensitive water bodies:

1. **Create time series** representing tributary flows to the feature from the entire tributary area. Where the feature is contained entirely onsite and where no offsite flows exist, use the tributary area for the proposed developed condition.
2. **Use the full historical runoff files** (available from DNR) to create the runoff time series.
3. Where the feature is only partially onsite, or where there are offsite flows to the feature, **assume the entire tributary area is fully built out under current zoning,** accounting for required open space and protected sensitive areas in the basin as well as impervious surfaces and grass.

[4] *Not altered* means existing on- and offsite flows to the feature will remain unchanged and the feature will not be excavated or filled.

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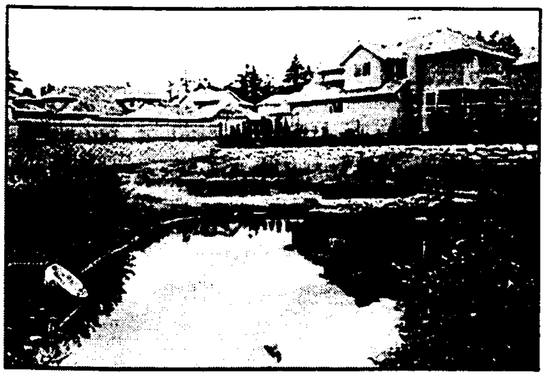
4. **For potential future development, assume detention standards per the Flow Control Applications Map. For simplicity the proposed detention may be simulated with a single assumed detention pond just upstream of the feature.** This pond should be sized to the appropriate detention standard as noted on the Flow Control Applications Map and will require generating a predevelopment time series based on existing conditions in the basin. Large water bodies may provide significant floodwater storage and may also be included in the analysis. Most existing detention in the basin, with exception of that providing duration control, will have little effect on the analysis and should be discounted.
5. Sum all subbasin time series to create a **single composite time series** for the drainage feature.
6. Develop **routing curves** for the feature. As appropriate, consider infiltration as an outflow for closed depressions.
7. **Route the time series** through the storage feature, generate water surface frequency curves, and note the 100-year water surface elevation.

Chapter 4

CHAPTER 4

CONVEYANCE SYSTEM ANALYSIS & DESIGN



KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

CHAPTER 4
CONVEYANCE SYSTEM ANALYSIS & DESIGN

This chapter presents King County approved methods for the hydraulic analysis and design of conveyance systems. A *conveyance system* includes all portions of the surface water system, either natural or man-made, that transports surface and storm water runoff. The purpose of the conveyance system is to drain surface water, up to a specific design flow, from properties so as to provide protection to property and the environment.

This chapter contains the detailed design criteria, methods of analysis, and standard details for all components of the conveyance system. In some cases, reference is made to other adopted or accepted design standards and criteria such as the *King County Road Standards (KCRS)*, the *Washington State Department of Transportation/APWA (WSDOT/APWA) Standard Specifications for Road, Bridge, and Municipal Construction* (most recent edition), and a King County supplement to the WSDOT/APWA standards called the *General Special Provisions.*

Chapter Organization

The information presented in this chapter is organized into four main sections:

These sections begin on odd pages so that tabs can be inserted by the user if desired for quicker reference.

Required vs. Recommended Design Criteria

Both required and recommended design criteria are presented in this chapter. Criteria stated using **"shall"** or **"must"** are mandatory, to be followed unless there is a good reason to deviate as allowed by the adjustment process (see Section 1.4). These criteria are **required design criteria** and generally affect facility performance or critical maintenance factors.

Sometimes options are stated as part of the required design criteria using the language **"should"** or **"may."** These criteria are really **recommended design criteria**, but are so closely related to the required criteria that they are placed with it.

4.1 ROUTE DESIGN AND EASEMENT REQUIREMENTS

This section presents the general requirements for aligning conveyance systems and providing easements and setbacks to allow for proper maintenance and inspection of all conveyance system elements.

❑ ROUTE DESIGN

The most efficient route selected for new conveyance systems will result from careful consideration of the topography of the area to be traversed, the legal property boundaries, and access for inspection and maintenance. The general requirements for route design are as follows:

1. Proposed new conveyance systems should be aligned to emulate the natural conveyance system to the extent feasible. Inflow to the system and discharge from the system should occur at the natural drainage points as determined by topography and existing drainage patterns.
2. **New conveyance system alignments in residential subdivisions** should be located **adjacent and parallel to property lines** so that required drainage easements can be situated along property lines. Drainage easements should be located entirely on one property and not split between adjacent properties.

   Exception: Streams and natural drainage channels shall not be relocated to meet this requirement.
3. Aesthetic considerations and traffic routes may dictate the placement and alignment of open channels. Appropriate vehicular and pedestrian traffic crossings must be provided in the design.

❑ EASEMENT AND SETBACK REQUIREMENTS

1. All **County-maintained conveyance systems** shall be located in drainage easements, tracts, or right-of-way granted to King County. **Privately maintained conveyance systems** must be located in covenants per Reference 8-F.

   Exception: Roof downspout, minor yard, and footing drains are not County-maintained and do not require easements. If easements are provided for these minor drains (or for other utilities such as power, gas, or telephone), they need not comply with the requirements of this section.
2. Table 4.1 (p. 4-4) lists the required widths and building setback lines for drainage easements. For all pipes or any channels or constructed swales greater than 30 feet wide, facilities must be placed in the center of the easement. For channels or constructed swales less than or equal to 30 feet wide, the easement extends to only one side of the facility.
3. Any portion of a conveyance system drainage easement (shown in Table 4.1) shall not be located within an **adjacent property or right-of-way**. Building setback lines may cross into adjacent property.
4. The distance between the easement line (BSBL) and building or other structure footings shall be no less than the building setback line distance shown in Table 4.1.

   Exception: The BSBL may be measured from the edge of a pipe in the easement plus 2 feet if all of the following conditions are met:

   a) As-builts showing the location of the pipe are submitted

   b) A geotechnical/structure analysis demonstrates stability of the proposed structure

   c) Access for maintenance/replacement remains unobstructed.

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TABLE 4.1 EASEMENT WIDTHS AND BUILDING SETBACK LINES

For Pipes:[1] **Inside Diameter (ID)**	**Easement Width**	**BSBL (From Easement)**
ID ≤ 36"	depth to invert < 8': 10 feet[2] depth to invert > 8': 15 feet	5 feet
36" < ID ≤ 60"	depth to invert < 8': 10 feet[2] depth to invert > 8': 15 feet	7.5 feet
ID > 60"	ID plus 10 feet	10 feet
For Channels and Swales: **Top Width of Channel (W)**	**Easement Width**	**BSBL (From Easement)**
W ≤ 10 feet	W plus 10 feet on one side W if no access required[3]	5 feet
10 feet < W ≤ 30 feet	W plus 15 feet on one side	5 feet
W > 30 feet	W plus 15 feet on both sides	5 feet

Notes:

(1) Pipes installed deeper than 10 feet require one of the following actions:

- Increase the BSBL such that the distance from the BSBL to the centerline of the pipe is at least 1.5 times the depth to pipe invert, or
- Place a restriction on adjacent lots that the footings be placed at a specific elevation, deep enough that the closest horizontal distance from the footing to the pipe centerline is 1.5 times the difference in elevation of the footing and pipe invert, or
- Place a restriction on adjacent lots that the footings be designed by a geotechnical engineer, such that excavation of the pipe may be performed without necessitating shoring of adjacent structures.

(2) Fifteen-foot easement width is required for maintenance access to all manholes, inlets, and culverts.

(3) Access is not required for small channels if the channel gradient is greater than 5% (assumes steep channels will be self-cleaning).

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4.2 PIPES, OUTFALLS, AND PUMPS

This section presents the methods, criteria, and details for analysis and design of pipe systems, outfalls, and pump-dependent conveyance systems. The information presented is organized as follows:

4.2.1 PIPE SYSTEMS

Pipe systems are networks of storm drain pipes, catch basins, manholes, inlets, and outfalls designed and constructed to convey surface water. The hydraulic analysis of flow in storm drain pipes typically is limited to gravity flow; however, in analyzing existing systems it may be necessary to address pressurized conditions. A properly designed pipe system will maximize hydraulic efficiency by utilizing proper material, slope, and pipe size.

4.2.1.1 DESIGN CRITERIA

General

All pipe material, joints, and protective treatment shall be in accordance with Section 9.05 of the *WSDOT/APWA Standard Specifications* as modified by the *King County Road Standards* and AASHTO and ASTM treatment as noted below under "Allowable Pipe Materials."

Note: The pipe materials and specifications included in this section are for conveyance systems installed according to engineering plans required for King County permits/approvals. Other pipe materials and specifications may be used by private property owners for drainage systems they construct and maintain when such systems are not required by or granted to King County.

Acceptable Pipe Sizes

The following pipe sizes shall be used for **pipe systems to be maintained by King County**: 8-inch (generally for use only in privately maintained systems or in special cases within road right-of-way; see *KCRS*), 12-inch, 15-inch, 18-inch, 21-inch, 24-inch, and 30-inch. For pipes larger than 30-inch diameter, increasing increments of 6-inch intervals shall be used (36-inch, 42-inch, 48-inch, etc.).

Allowable Pipe Materials

The following pipe materials are allowed for use in meeting the requirements of this manual. Refer to the *King County Road Standards (KCRS)* for pipe materials allowed in King County road right-of-way.

1. Plain concrete pipe (12-inch diameter only, and only as driveway culvert)
2. Reinforced concrete pipe
3. Corrugated aluminum pipe

4. Aluminum spiral rib pipe
5. Aluminized Type 2 corrugated steel (meets AASHTO treatments M274 and M56)
6. Galvanized[1] corrugated iron or steel pipe, Treatments 1 through 6
7. Galvanized[1] steel spiral rib pipe, Treatments 1 through 6
8. Ductile iron (water supply, Class 50 or 52)
9. Lined corrugated polyethylene pipe (LCPE)[2]
10. Corrugated polyethylene pipe (CPE)[3] that is single wall and fully corrugated
11. Polyvinyl chloride (PVC)[4] sewer pipe
12. Solid wall polyethylene pipe (SWPE; also known as HDPE pipe or HDPP)[5]

Allowable Pipe Joints

1. Concrete pipe shall be rubber gasketed.
2. CMP shall be rubber gasketed and securely banded.
3. Spiral rib pipe shall be "hat-banded" with neoprene gaskets.
4. Ductile pipe joints shall be flanged, bell and spigot, or restrained mechanical joints.
5. LCPE pipe shall be joined by split corrugated couplings, with gasket, which are at least 4 corrugations wide and exceed the soil tightness requirements of the *AASHTO Standard Specifications for Highway Bridges*, Section 23 (2.23.3).
6. CPE single wall, fully corrugated pipe shall be joined by split or snap-on couplings for 3- through 10-inch diameter pipe, and by split corrugated couplings with gasket for 12- through 24-inch diameter pipe. Couplings for 12- through 24-inch diameter pipe shall be at least 7 corrugations wide and shall exceed the soil tightness requirements of the *AASHTO Standard Specifications for Highway Bridges*, Section 23 (2.23.3).
7. PVC pipe shall be installed following procedures outlined in ASTM D2321; joints shall conform to ASTM D3212, and gaskets shall conform to ASTM F477.
8. SWPE pipe shall be jointed by butt fusion methods or flanged according to the *KCRS*.

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[1] Galvanized metals leach zinc into the environment, especially in standing water situations. High zinc concentrations, sometimes in the range that can be toxic to aquatic life, have been observed in the region. Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other materials or treatments are available, such as aluminized or stainless steel, aluminum, or polyethylenes, they should be used.

[2] LCPE pipe and fittings shall be manufactured from high density polyethylene resin which shall meet or exceed the requirements of Type 111, Category 3, 4 or 5, Grade P23, P33 or P34, Class C per ASTM D1248. In addition, the pipe shall comply with all material and stiffness requirements of AASHTO M294.

[3] CPE pipe (single wall, fully corrugated) is allowed only for use in temporary storm sewer systems such as downspout, footing, or yard drain collectors on private property (smooth interior required in road right-of-way for drainage stub-outs or perforated as subgrade drain per *KCRS*). Pipe and fittings shall comply with all of the requirements of AASHTO M252 for 3" through 10" diameter, and AASHTO M294 for 12" through 24" diameter.

[4] PVC pipe is allowed only for use in privately maintained drainage systems or as allowed in road right-of-way per *KCRS*. PVC pipe must be SDR 35 or thicker and meet the requirements of ASTM D3034.

[5] SWPE pipe is normally used outside of King County right-of-way, such as on steep slope installations (see Section 4.2.2, p. 4-27). Connections to King County road drainage systems are allowed for pipe diameters of 12" or greater. SWPE pipe shall comply with the requirements of Type III C5P34 as tabulated in ASTM D1248, shall have the PPI recommended designation of PE3408, and shall have an ASTM D3350 cell classification of 345534C. The pipe shall have a manufacturer's recommended hydrostatic design stress rating of 800 psi based on a material with a 1600 psi design basis determined in accordance with ASTM D2837-69. The pipe shall have a suggested design working pressure of 50 psi at 73.4° F and SDR of 32.5.

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Pipe Alignment

1. Pipes must be laid true to line and grade with no curves, bends, or deflections in any direction.

   Exception: Vertical deflections in SWPE and ductile iron pipe with flanged restrained mechanical joint bends (not greater than 30°) on steep slopes, provided the pipe drains.

2. A **break in grade** or alignment, or changes in pipe material shall occur only at catch basins or manholes.

Maximum Pipe Slopes and Velocities

Table 4.2.1.A presents maximum pipe slopes and velocities by pipe material.

TABLE 4.2.1.A MAXIMUM PIPE SLOPES AND VELOCITIES

Pipe Material	Pipe Slope above which Pipe Anchors Required and Minimum Anchor Spacing	Maximum Slope Allowed	Maximum Velocity at Full Flow
CMP, Spiral Rib, PVC, CPE(1)	20% (1 anchor per 100 LF of pipe)	30%(3)	30 fps
Concrete or LCPE(1)	10% (1 anchor per 50 LF of pipe)	20%(3)	30 fps
Ductile Iron(2)	20% (1 anchor per pipe section)	None	None
SWPE(2)	20% (1 anchor per 100 LF of pipe, cross-slope installations only)	None	None

Notes:

(1) These materials are not allowed in landslide hazard areas.

(2) Butt-fused or flanged pipe joints are required; above ground installation is recommended on slopes greater than 40%.

(3) A maximum slope of 200% is allowed for these pipe materials with no joints (one section), with structures at each end, and with proper grouting.

Changes in Pipe Size

1. Increase or decreases in pipe size are **allowed only at junctions and structures.** *Exceptions may be allowed per Section 7.04C of the KCRS.*

2. When **connecting pipes at structures,** match any of the following (in descending order of preference): crowns, 80% diameters,[6] or inverts of pipes (or use drop manholes per *KCRS*). Side lateral connections, 12 inches and smaller, are exempt from this requirement.

3. **Downsizing** pipes larger than 12 inches may be allowed provided pipe capacity is adequate for design flows.

Note: The above criteria do not apply to detention tanks.

[6] Match point is at 80% of the pipe diameter, measured from the invert of the respective pipes.

Structures

Table 4.2.1.B below lists typical drainage structures with corresponding maximum allowable pipe sizes.

1. Catch basin (or manhole) diameter shall be determined by pipe orientation at the junction structure. A **plan view of the junction structure**, drawn to scale, will be required when more than four pipes enter the structure on the same plane, or if angles of approach and clearance between pipes is of concern. The plan view (and sections if necessary) must ensure a minimum distance (of solid concrete wall) between pipe openings of 8 inches for 48-inch and 54-inch catch basins, and 12 inches for 72-inch and 96-inch catch basins.
2. Evaluation of the structural integrity for **H-20 loading,** or as required by the *King County Road Standards*, may be required for multiple junction catch basins and other structures.
3. Catch basins shall be provided within 50 feet of the **entrance to a pipe system** to provide for silt and debris removal.
4. **All SWPE pipe systems** (including buried SWPE pipe) must be secured at the upstream end. The downstream end shall be placed in a 4-foot section of the next larger pipe size. This sliding sleeve connection allows for the high thermal expansion/contraction coefficient of this pipe material.
5. The **maximum slope of the ground surface** for a radius of 5 feet around a catch basin grate or solid lid should be 5:1 to facilitate maintenance access. Where not physically feasible, such as at control structures in ponds, a maximum slope of 3:1 (H:V) shall be provided around at least 50% of the catch basin circumference.

TABLE 4.2.1.B ALLOWABLE STRUCTURES AND PIPE SIZES

	Maximum Pipe Diameter	
Catch Basin Type[1]	**CMP, Spiral Rib, CPE, SWPE, PVC, and Ductile Iron[2]**	**Concrete LCPE**
Inlet[4]	12"	12"
Type 1[3]	18"	12"
Type 1L[3]	24"	18"
Type 2 - 48-inch dia.	30"	24"
Type 2 - 54-inch dia.	36"	30"
Type 2 - 72-inch dia.	54"	48"
Type 2 - 96-inch dia.	72"	72"

Notes:

[1] Catch basins (including manhole steps, ladder, and handholds) shall conform to *King County Road Standards.*

[2] Generally these pipe materials will be one size larger than concrete due to smaller wall thickness. However, for angled connections or those with several pipes on the same plane, this will not apply.

[3] A maximum of 5 vertical feet is allowed between finished grade and invert elevation.

[4] Inlets are normally allowed only for use in privately maintained drainage systems and must discharge to a catch basin immediately downstream.

Pipe Design Between Structures

The following requirements are for privately maintained or County maintained off-road right-of-way pipe systems. See *KCRS* for pipe design between structures in County road right-of-way.

1. Minimum velocity at full flow should be 3.0 feet per second. **If site constraints result in velocities less than 3 feet per second at full flow**, impacts from sedimentation in the pipe system shall be addressed with larger pipes, closer spacing of structures, sediment basins, or other similar measures.
2. Minimum slope for 8-inch pipes shall be 0.5%; minimum slope for 12-inch or larger pipes shall be 0.2%.
3. Maximum lengths between structures shall be 300 feet (for design flows greater than 3 fps). Tightlines down steep slopes are self cleaning and do not require structures for maintenance.

Pipe Cover

1. **Pipe cover,** measured from the finished grade elevation to the top of the outside surface of the pipe, shall be **2 feet minimum** unless otherwise specified or allowed below. Under drainage easements, driveways, parking stalls, or other areas subject to light vehicular loading, pipe cover may be reduced to 1 foot minimum if the design considers expected vehicular loading and the cover is consistent with pipe manufacturer's recommendations. Pipe cover in areas not subject to vehicular loads, such as landscape planters and yards, may be reduced to 1 foot minimum.
2. Pipe cover over storm **pipes in King County road right-of-way** shall comply with the *KCRS*. Pipe **cover over concrete pipe** shall comply with Table 4.2.1.C (p. 4-9). For other pipe types, the manufacturer's specifications or other documentation shall be provided for proposed cover in excess of 30 feet. *Caution: Additional precautions to protect against crushing during construction may be needed under roadways if the road bed is included to meet minimum cover requirements. Damaged pipe shall be replaced.*
3. For proposed **pipe arches**, the manufacturer's specifications or other documentation shall be provided for proposed cover in excess of 8 feet.
4. Pipe cover over **PVC SDR 35** shall be 3 feet minimum and 30 feet maximum.

TABLE 4.2.1.C MAXIMUM COVER (FEET) FOR CONCRETE PIPE COMPACTION DESIGN A

Pipe Diameter (inches)	Plain	Class II	Class III	Class IV	Class V
12	18	10	14	21	26
18	18	11	14	22	28
24	16	11	15	22	28
30		11	15	23	29
36		11	15	23	29
48		12	15	23	29
60		12	16	24	30
72		12	16	24	30
84		12	16	24	30
96		12	16	24	30
108		12	16	24	30

Note: Compaction Design A refer to Figure 4.2.1.A (p. 4-12).

Pipe Clearances

A minimum of 6 inches vertical and 3 feet horizontal clearance (outside surfaces) shall be provided between storm drain pipes and other utility pipes and conduits. **Clearances** within King County right-of-way shall comply with the *KCRS*. When crossing sanitary sewer lines, the Washington Department of Ecology criteria shall apply. When crossing swale easements, minimum specified cover shall be increased by 6 inches.

Pipe Compaction and Backfill

Pipe compaction and backfill shall be in accordance with Figure 4.2.1.A (p. 4-12).

Pipe System Connections

Connections to a pipe system shall be made only at catch basins or manholes. No wyes or tees are allowed except on roof/footing/yard drain systems on pipes 8 inches in diameter or less, with clean-outs upstream of each wye or tee. Additional exceptions may be made in accordance with Section 7.03D of the *KCRS* and for steep slope applications of SWPE pipe, as deemed prudent by geotechnical review.

Pipe Anchors

Table 4.2.1.A (p. 4-7) presents the requirements, by pipe material, for anchoring pipe systems. Figure 4.2.1.B (p. 4-13) and Figure 4.2.1.C (p. 4-14) show typical details of pipe anchors.

Spill Control

Spill control is required for projects constructing or replacing onsite pipe systems that receive runoff from pollution-generating surfaces such as roads or parking lots. Spill control measures are intended to temporarily detain oil or other floatable pollutants and prevent them from entering the downstream conveyance system, water quality facility, or flow control facility in the event of an accidental spill or illegal dumping. Allowable options for providing spill control include the following:

a) A **tee section** in one of the lowest manholes or catch basins in the system (see Figure 5.3.4.A)

b) An **API or coalescing plate oil/water separator**

c) A **tee section in a wet vault, or detention tank or vault** (provided water quality facilities are downstream of the detention tank or vault)

d) An **active spill control plan.** To use this option, the spill control plan and summary of an existing or proposed training schedule must be submitted as part of the drainage review submittal. At a minimum, such plans must include the following:

   - Instructions for isolating the site to prevent spills from moving downstream (shutoff valves, blocking catch basins, etc.)
   - Onsite location of spill clean-up materials
   - Phone numbers to call for emergency response
   - Phone numbers of company officials to notify
   - Special safety precautions, if applicable.

Debris Barriers

Debris barriers (trash racks) are required on all pipes 18 to 36 inches in diameter entering a closed pipe system. See Figure 4.2.1.D (p. 4-15) for required debris barriers on pipe ends outside of roadways. See Figure 4.2.1.E (p. 4-16) and Section 4.3 (p. 4-35) for requirements on pipe ends (culverts) projecting from driveway or roadway side slopes.

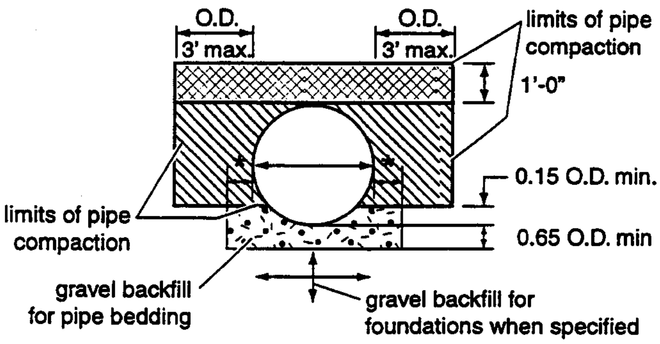
Outfalls

Outfalls shall be designed as detailed in Section 4.2.2 (p. 4-27).

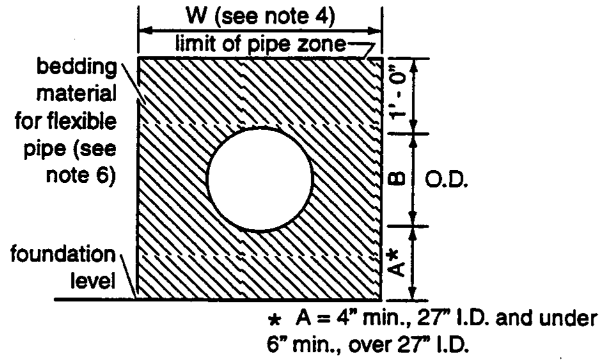
Other Details

In addition to the details shown in Figure 4.2.1.A (p. 4-12) through Figure 4.2.1.E (p. 4-16), Standard Construction Details are available in the *King County Road Standards* and *APWA/WSDOT Standard Plans for Road, Bridge and Municipal Construction.* Commonly used details include field tapping of concrete pipe, catch basins and catch basin details, manholes and manhole details, curb inlets, frames, grates, and covers.

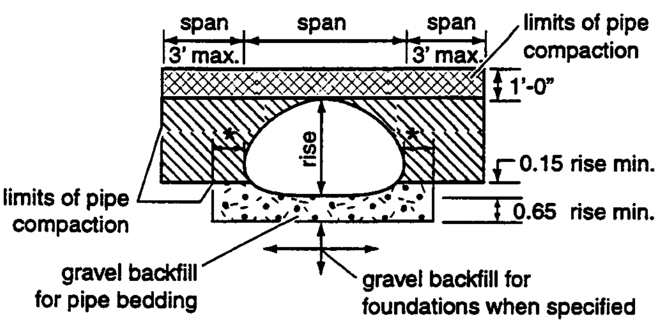
FIGURE 4.2.1.A PIPE COMPACTION DESIGNS AND BACKFILL



A. Metal and Concrete Pipe



Bedding for Flexible Pipe



B. Pipe - Arch Installation

Rigid Pipe NOTES:

1. Pipe compaction limits shown on this plan are for pipe construction in an embankment. For pipe construction in a trench, the horizontal limits of the pipe compaction zone shall be the walls of the trench.
2. All steel and aluminum pipe and pipe-arches shall be installed in accordance with design A.
3. Concrete pipe with elliptical reinforcement shall be installed in accordance with design A.
4. Concrete pipe, plain or with circular reinforcement, shall be installed with design A.
5. O.D. is equal to the outside diameter of a pipe or the outside span of pipe-arch. The dimensions shown as O.D. with 3' maximum shall be O.D. until O.D. equals 3', at which point 3' shall be used.

* 1'-0" for diameters 12" through 42" and spans through 50". 2'-0" for diameters greater than 42" and spans greater than 50".

Flexible Pipe NOTES:

1. Provide uniform support under barrels.
2. Hand tamp under haunches.
3. Compact bedding material to 95% max. density; directly over pipe, hand tamp only.
4. See "Excavation and Preparation of Trench" in sanitary sewers section of the standard WSDOT/APWA specifications for trench width "W" and trenching options. The pipe zone will be the actual trench width. The minimum concrete width shall be 1 1/2 I.D. + 18".
5. Trench backfill shall conform to "Backfilling Sewer Trenches" in the sanitary sewers section of the WSDOT/APWA standard specifications, except that rocks or lumps larger than 1" per foot of pipe diameter shall not be used in the backfill material.
6. See "Bedding Material for Flexible Pipe" in aggregates section of the WSDOT/APWA standard specification for the material specifications.

Backfill material placed in 0.5' loose layers and compacted to 95% maximum density.

Method B or C compaction (WSDOT/APWA standard specifications.)

Pipe	Size	Min. dist. between barrels
circular pipe conc., LCPE, CMP (diameter)	12" to 24"	12"
	30" to 96"	diam. ÷ 2
	102" to 180"	48"
pipe - arch metal only (span)	18" to 36"	12"
	43" to 142"	span. ÷ 3
	148" to 199"	48"

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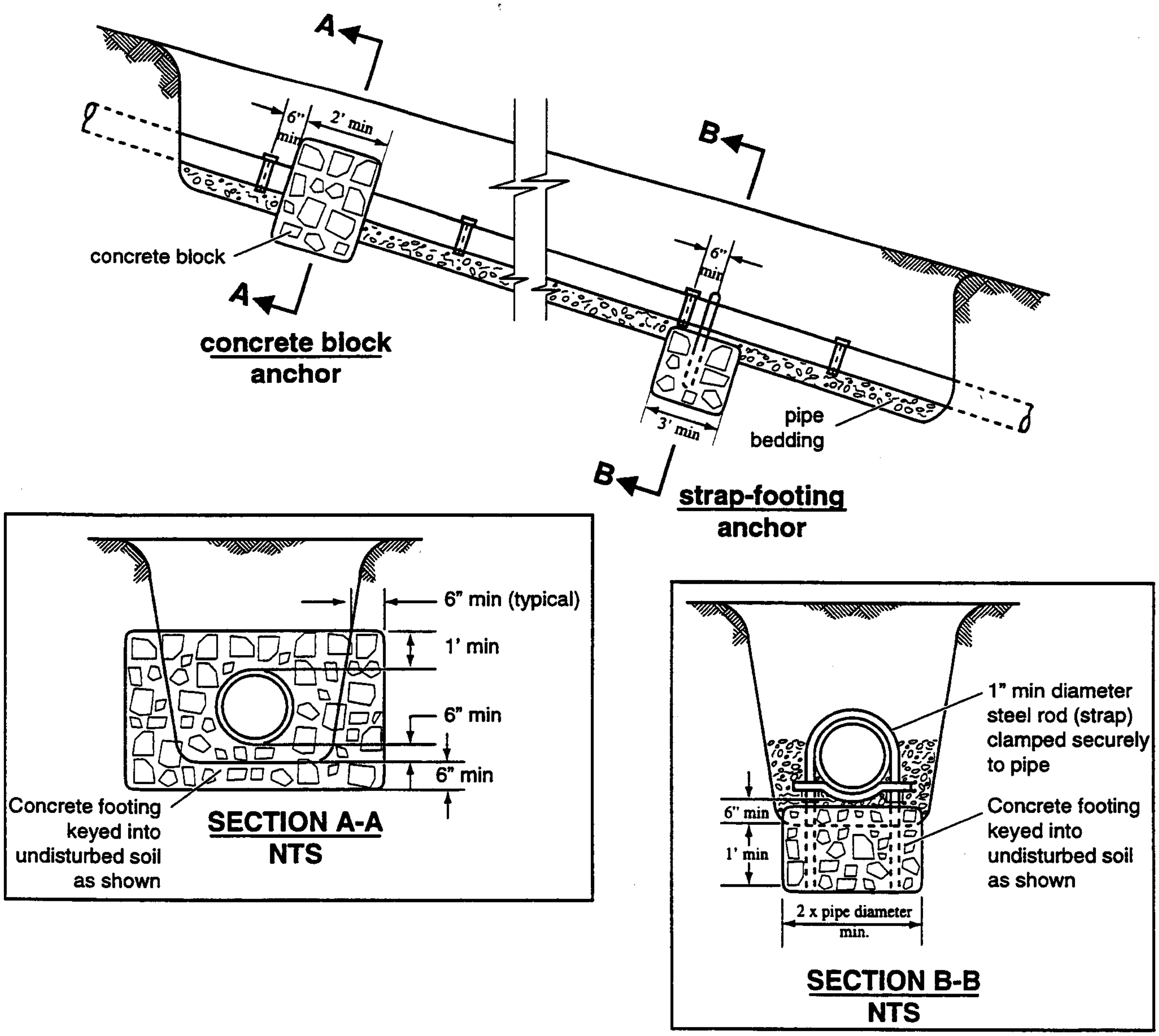
FIGURE 4.2.1.B PIPE ANCHOR DETAIL



NOTE: For SWPE, pipe must be free to slide inside a 4' long section of pipe one size diameter larger.

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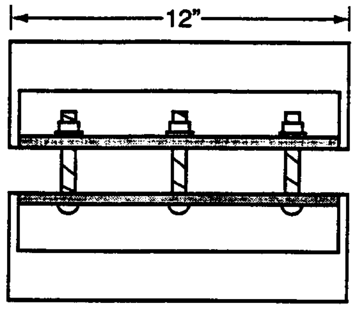
FIGURE 4.2.1.C CORRUGATED METAL PIPE COUPLING AND/OR GENERAL PIPE ANCHOR ASSEMBLY



Smooth Coupling Band for Smooth Pipe

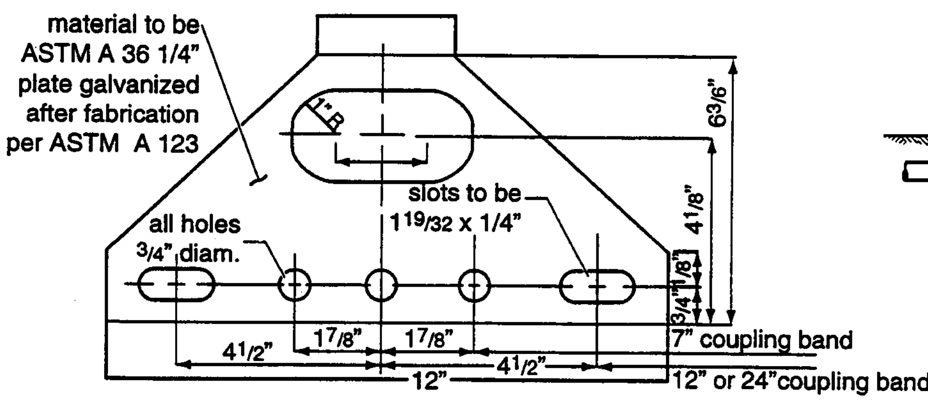
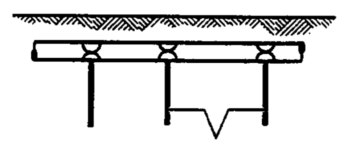
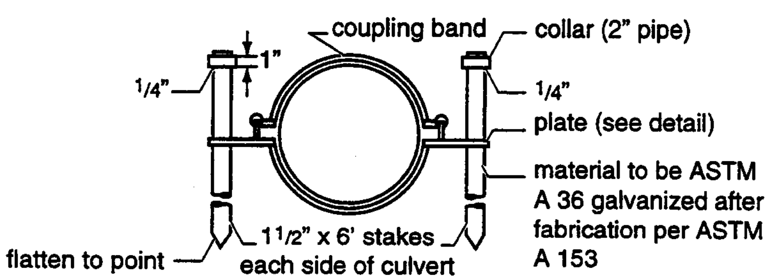


Plate Detail



pipe stakes



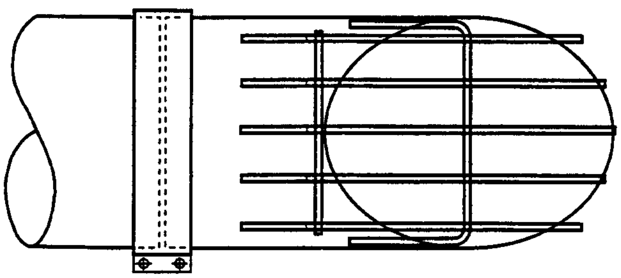
Anchor Assembly - Corrugated Metal Pipe

NOTES:

1. The smooth coupling band shall be used in combination with concrete pipe.
2. Concrete pipe without ball and spigot shall not be installed on grades in excess of 20%.
3. The first anchor shall be installed on the first section of the lower end of the pipe and remaining anchors evenly spaced throughout the installation.
4. If the pipe being installed has a manhole or catch basin on the lower end of the pipe, the first pipe anchor may be eliminated.
5. When CMP is used, the anchors may be attached to the coupling bands used to join the pipe as long as the specified spacing is not exceeded.
6. All pipe anchors shall be securely installed before backfilling around the pipe.

FIGURE 4.2.1.D DEBRIS BARRIER (OFF-ROAD RIGHT-OF-WAY)

NOTE:
1. This debris barrier is for use outside roadways on pipes 36" dia. and smaller. See Figure 4.2.1.E. for debris barriers on pipes projecting from driveway or roadway sideslopes.
2. All steel parts must be galvanized and asphalt coated (treatment 1 or better).
3. LCPE pipe requires bolts to secure debris barrier to pipe.



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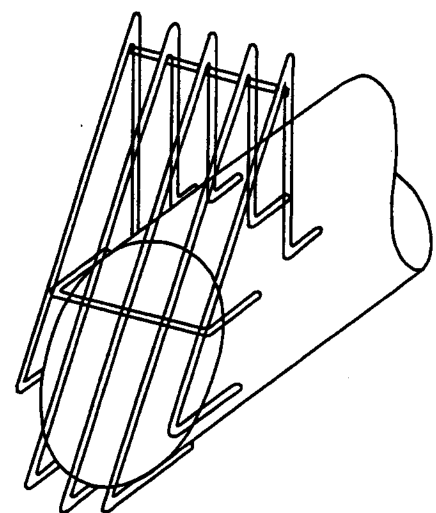

ISOMETRIC
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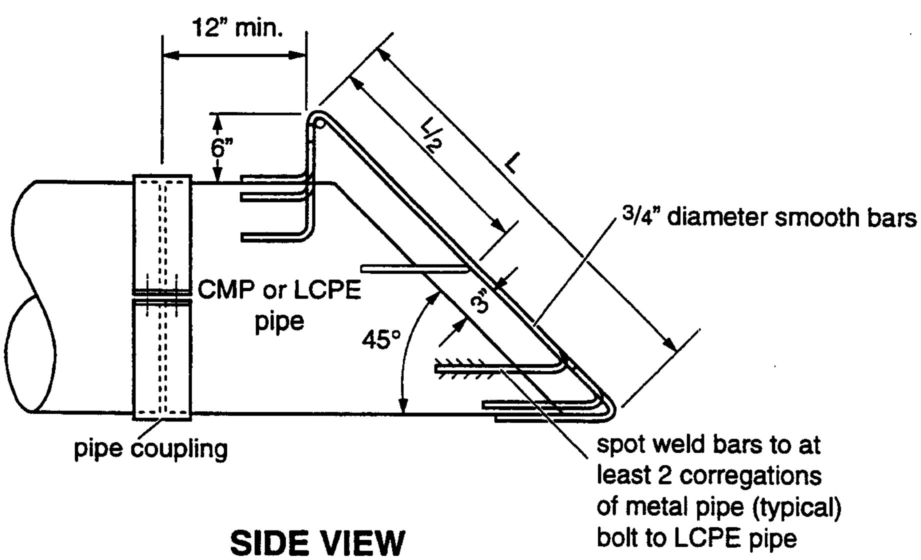

SIDE VIEW
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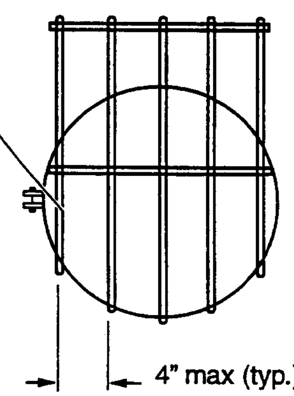

END VIEW
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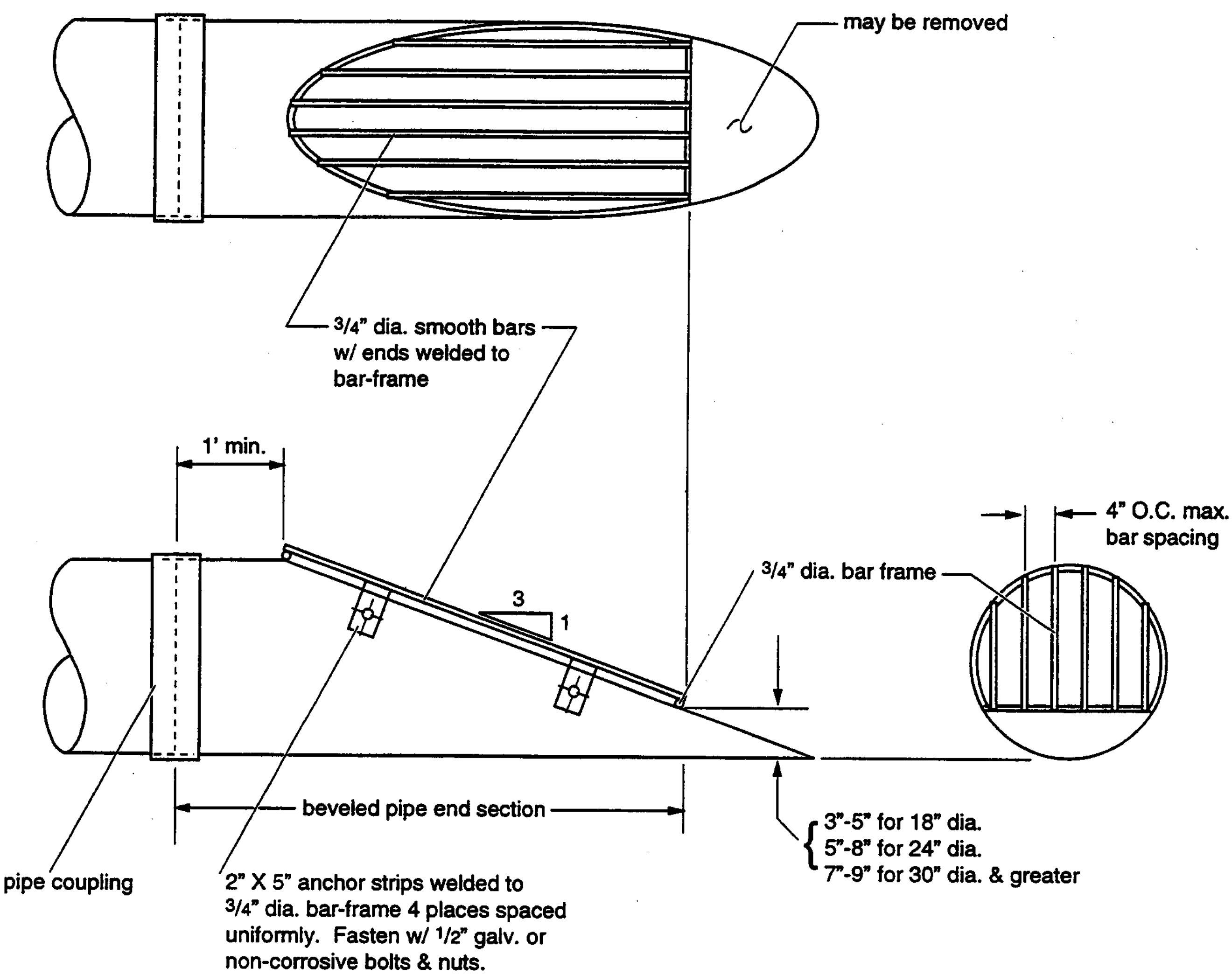
FIGURE 4.2.1.E DEBRIS BARRIER (IN ROAD RIGHT-OF-WAY)

NOTES:
1. CMP or LCPE pipe end-section shown; for concrete pipe beveled end section, see KCRS drawing No. 2-001.
2. All steel parts must be galvanized and asphalt coated (treatment 1 or better).



AR 031921

4.2.1.2 METHODS OF ANALYSIS

This section presents the methods of analysis for designing new or evaluating existing **pipe systems** for compliance with the conveyance capacity requirements set forth in Section 1.2.4, "Core Requirement #4: Conveyance System."

❑ DESIGN FLOWS

Design flows for sizing or assessing the capacity of pipe systems shall be determined using the hydrologic analysis methods described in Chapter 3.

❑ INLET GRATE CAPACITY

The methods described in Chapter 5, Sections 4 and 5, of the *Washington State Department of Transportation (WSDOT) Hydraulics Manual* can be used in determining the capacity of inlet grates when capacity is of concern, with the following exceptions:

1. Use design flows as required in Section 1.2.4 of this manual.
2. Assume grate areas on slopes are 80% free of debris; "vaned" grates, 95% free.
3. Assume grate areas in sags or low spots are 50% free of debris; "vaned" grates, 75% free.

❑ CONVEYANCE CAPACITY

Two methods of hydraulic analysis using Manning's equation are used sequentially for the design and analysis of pipe systems. First, the **Uniform Flow Analysis method** is used for the preliminary design of new pipe systems. Second, the **Backwater Analysis method** is used to analyze both proposed and existing pipe systems to verify adequate capacity. See Core Requirement #4, Section 1.2.4, for sizing requirements of pipe systems.

Note: Use of the Uniform Flow Analysis method to determine preliminary pipe sizes is only suggested as a first step in the design process and is not required. Results of the Backwater Analysis method determine final pipe sizes in all cases.

Uniform Flow Analysis Method

This method is used for **preliminary sizing** of new pipe systems to convey the *design flow* (i.e., the 10-year or 25-year peak flow rate as specified in Core Requirement #4, Section 1.2.4).

Assumptions:

- Flow is uniform in each pipe (i.e., depth and velocity remain constant throughout the pipe for a given flow).
- Friction head loss in the pipe barrel alone controls capacity. Other head losses (e.g., entrance, exit, junction, etc.) and any backwater effects or inlet control conditions are not specifically addressed.

Each pipe within the system is sized and sloped such that its **barrel capacity at normal full flow** (computed by Manning's equation) is equal to or greater than the design flow. The nomograph in Figure 4.2.1.F (p. 4-20) can be used for an approximate solution of Manning's equation. For more precise results, or for partial pipe full conditions, solve Manning's equation directly:

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$$V = \frac{1.49}{n} R^{2/3} S^{1/2} \tag{4-1}$$

or use the continuity equation, $Q = AV$, such that:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2} \tag{4-2}$$

where Q = discharge (cfs)
V = velocity (fps)
A = area (sf)
n = Manning's roughness coefficient; see Table 4.2.1.D below
R = hydraulic radius = area/wetted perimeter (ft)
S = slope of the energy grade line (ft/ft)

For **pipes flowing partially full**, the actual velocity may be estimated from the hydraulic properties shown in Figure 4.2.1.G by calculating Q_{full} and V_{full} and using the ratio Q_{design}/Q_{full} to find V and d (depth of flow).

Table 4.2.1.D provides the recommended **Manning's "n" values for preliminary design** using the Uniform Flow Analysis method for pipe systems. *Note: The "n" values for this method are 15% higher in order to account for entrance, exit, junction, and bend head losses.*

TABLE 4.2.1.D MANNING'S "*n*" VALUES FOR PIPES

Type of Pipe Material	Analysis Method	
	Uniform Flow (Preliminary design)	Backwater Flow (Capacity Verification)
A. Concrete pipe and LCPE pipe	0.014	0.012
B. Annular Corrugated Metal Pipe or Pipe Arch:		
1. 2-2/3" x 1/2" corrugation (riveted):		
a. plain or fully coated	0.028	0.024
b. paved invert (40% of circumference paved):		
1) flow at full depth	0.021	0.018
2) flow at 80% full depth	0.018	0.016
3) flow at 60% full depth	0.015	0.013
c. treatment 5	0.015	0.013
2. 3" x 1" corrugation	0.031	0.027
3. 6" x 2" corrugation (field bolted)	0.035	0.030
C. Helical 2-2/3" x 1/2" corrugation and CPE pipe	0.028	0.024
D. Spiral rib metal pipe and PVC pipe	0.013	0.011
E. Ductile iron pipe cement lined	0.014	0.012
F. SWPE pipe (butt fused only)	0.009	0.009

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Backwater Analysis Method

This method is used to analyze the capacity of both new and existing pipe systems to convey the required design flow (i.e., either the 10-year or 25-year peak flow, whichever is specified in Core Requirement #4, Section 1.2.4). In either case, pipe system structures must be demonstrated to contain the **headwater surface** (hydraulic grade line) for the specified peak flow rate. Structures may overtop for the 100-year peak flow as allowed by Core Requirement #4. When this occurs, the additional flow over the ground surface is analyzed using the methods for open channels described in Section 4.4.1.2 (p. 4-59) and added to the flow capacity of the pipe system.

This method is used to compute a **simple backwater profile** (hydraulic grade line) through a proposed or existing pipe system for the purposes of verifying adequate capacity. It incorporates a re-arranged form of Manning's equation expressed in terms of *friction slope* (slope of the energy grade line in ft/ft). The friction slope is used to determine the head loss in each pipe segment due to barrel friction, which can then be combined with other head losses to obtain water surface elevations at all structures along the pipe system.

The backwater analysis begins at the downstream end of the pipe system and is computed back through each pipe segment and structure upstream. The friction, entrance, and exit head losses computed for each pipe segment are added to that segment's tailwater elevation (the water surface elevation at the pipe's outlet) to obtain its **outlet control** headwater elevation. This elevation is then compared with the **inlet control** headwater elevation, computed assuming the pipe's inlet alone is controlling capacity using the methods for inlet control presented in Section 4.3.1.2 (p. 4-37). The condition that creates the highest headwater elevation determines the pipe's capacity. The approach velocity head is then subtracted from the controlling headwater elevation, and the junction and bend head losses are added to compute the total headwater elevation, which is then used as the tailwater elevation for the upstream pipe segment.

The **Backwater Calculation Sheet** in Figure 4.2.1.H (p. 4-22) can be used to compile the head losses and headwater elevations for each pipe segment. The numbered columns on this sheet are described in Figure 4.2.1.I (p. 4-23). An example calculation is performed in Figure 4.2.1.J (p. 4-24).

*Note: **This method should not be used to compute stage/discharge curves for level pool routing purposes**. Instead, a more sophisticated backwater analysis using the computer software provided with this manual is recommended as described below.*

Computer Applications

The **King County Backwater (KCBW) computer program** includes a subroutine **BWPIPE** which can be used to quickly compute a family of backwater profiles for a given range of flows through a proposed or existing pipe system. A schematic description of the nomenclature used in this program is provided in Figure 4.3.1.G (p. 4-48). Program documentation providing instructions on the use of this and the other KCBW subroutines is available from DNR.

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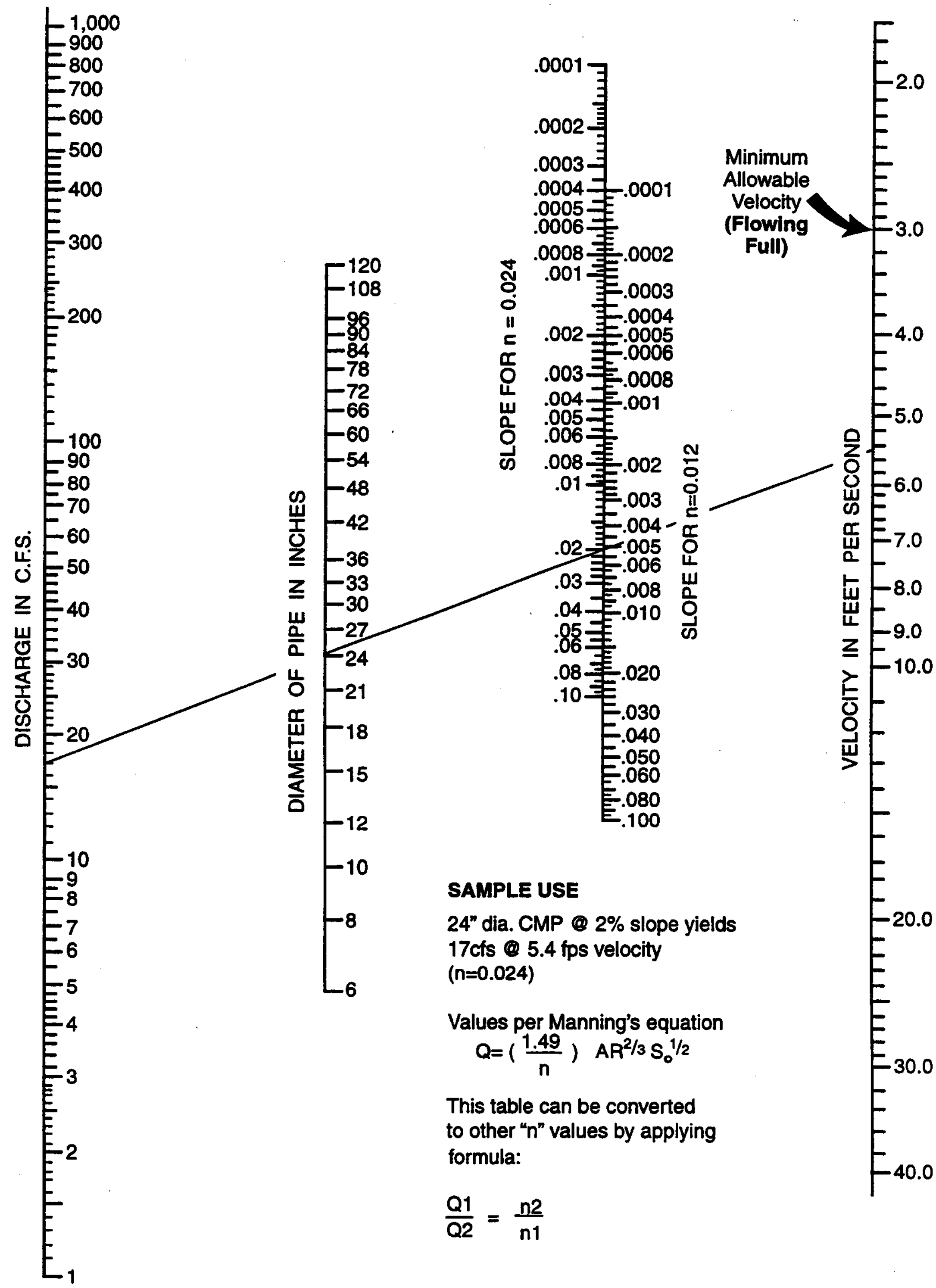
FIGURE 4.2.1.F NOMOGRAPH FOR SIZING CIRCULAR DRAINS FLOWING FULL



SAMPLE USE

24" dia. CMP @ 2% slope yields 17cfs @ 5.4 fps velocity (n=0.024)

Values per Manning's equation

$$Q = \left(\frac{1.49}{n}\right) AR^{2/3} S_o^{1/2}$$

This table can be converted to other "n" values by applying formula:

$$\frac{Q1}{Q2} = \frac{n2}{n1}$$

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FIGURE 4.2.1.G CIRCULAR CHANNEL RATIOS

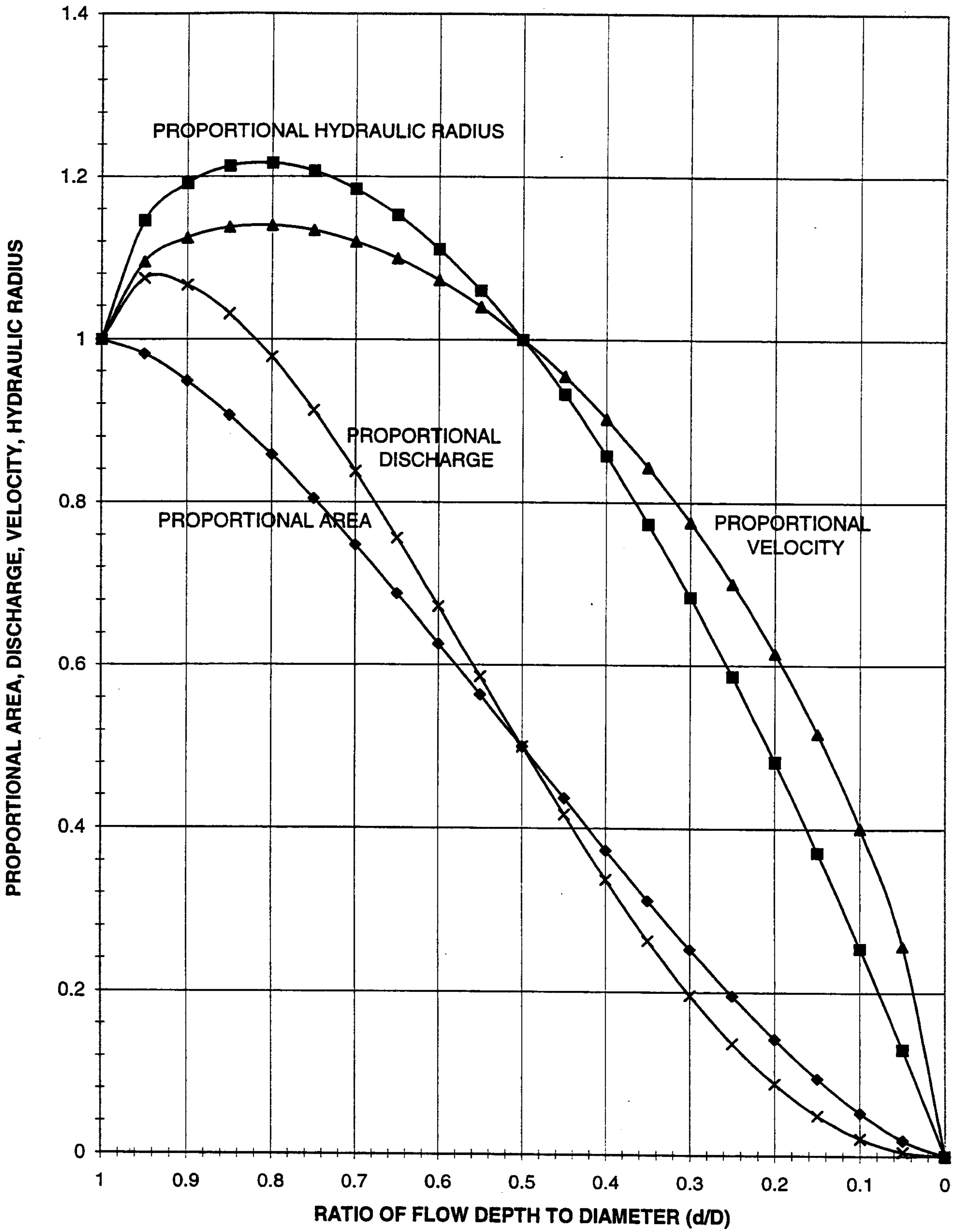

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FIGURE 4.2.1.H BACKWATER CALCULATION SHEET

Pipe Segment CB to CB		(1) Q (cfs)	(2) Lngth (ft)	(3) Pipe Size	(4) "n" Value	(5) Outlet Elev (ft)	(6) Inlet Elev (ft)	(7) Barrel Area (sq. ft)	(8) Barrel Vel (fps)	(9) Barrel Vel Head (ft)	(10) TW Elev (ft)	(11) Fric-tion Loss (ft)	(12) Entr HGL Elev (ft)	(13) Entr Head Loss (ft)	(14) Exit Head Loss (ft)	(15) Outlt Cntrl Elev (ft)	(16) Inlet Cntrl Elev (ft)	(17) Appr Vel Head (ft)	(18) Bend Head Loss (ft)	(19) Junc Head Loss (ft)	(20) HW Elev (ft)

FIGURE 4.2.1.I BACKWATER CALCULATION SHEET NOTES

Column (1) - Design flow to be conveyed by pipe segment.

Column (2) - Length of pipe segment.

Column (3) - Pipe Size; indicate pipe diameter or span x rise.

Column (4) - Manning's "n" value.

Column (5) - Outlet Elevation of pipe segment.

Column (6) - Inlet Elevation of pipe segment.

Column (7) - Barrel Area; this is the full cross-sectional area of the pipe.

Column (8) - Barrel Velocity; this is the full velocity in the pipe as determined by:

$V = Q/A$ or Col.(8) = Col.(1) / Col.(7)

Column (9) - Barrel Velocity Head = $V^2/2g$ or $(\text{Col.}(8))^2/2g$

where $g = 32.2$ ft/sec^2 (acceleration due to gravity)

Column (10) - Tailwater (TW) Elevation; this is the water surface elevation at the outlet of the pipe segment. If the pipe's outlet is not submerged by the TW and the TW depth is less than $(D+d_c)/2$, set TW equal to $(D+d_c)/2$ to keep the analysis simple and still obtain reasonable results (D = pipe barrel height and d_c = critical depth, both in feet. See Figure 4.3.1.F (p. 4-47) for determination of d_c).

Column (11) - Friction Loss = $S_f \times L$ [or $S_f \times$ Col.(2)]
where S_f is the friction slope or head loss per linear foot of pipe as determined by Manning's equation expressed in the form:

$S_f = (nV)^2/2.22\,R^{1.33}$

Column (12) - Hydraulic Grade Line (HGL) Elevation just inside the entrance of the pipe barrel; this is determined by adding the friction loss to the TW elevation:

Col.(12) = Col.(11) + Col.(10)

If this elevation falls below the pipe's inlet crown, it no longer represents the true HGL when computed in this manner. The true HGL will fall somewhere between the pipe's crown and either normal flow depth or critical flow depth, whichever is greater. To keep the analysis simple and still obtain reasonable results (i.e., erring on the conservative side), set the HGL elevation equal to the crown elevation.

Column (13) - Entrance Head Loss = $K_e \times V^2/2g$ [or $K_e \times$ Col.(9)]
where K_e = Entrance Loss Coefficient (from Table 4.3.1.B, p. 4-40). This is the head lost due to flow contractions at the pipe entrance.

Column (14) - Exit Head Loss = $1.0 \times V^2/2g$ or $1.0 \times$ Col.(9)

This is the velocity head lost or transferred downstream.

Column (15) - Outlet Control Elevation = Col.(12) + Col.(13) + Col.(14)

This is the maximum headwater elevation assuming the pipe's barrel and inlet/outlet characteristics are controlling capacity. It does not include structure losses or approach velocity considerations.

Column (16) - Inlet Control Elevation (see Section 4.3.1.2, page 4-37, for computation of inlet control on culverts); this is the maximum headwater elevation assuming the pipe's inlet is controlling capacity. It does not include structure losses or approach velocity considerations.

Column (17) - Approach Velocity Head; this is the amount of head/energy being supplied by the discharge from an upstream pipe or channel section, which serves to reduce the headwater elevation. If the discharge is from a pipe, the approach velocity head is equal to the barrel velocity head computed for the upstream pipe. If the upstream pipe outlet is significantly higher in elevation (as in a drop manhole) or lower in elevation such that its discharge energy would be dissipated, an approach velocity head of zero should be assumed.

Column (18) - Bend Head Loss = $K_b \times V^2/2g$ [or $K_b \times$ Col.(17)]
where K_b = Bend Loss Coefficient (from Figure 4.2.1.K, p. 4-25). This is the loss of head/energy required to change direction of flow in an access structure.

Column (19) - Junction Head Loss. This is the loss in head/energy which results from the turbulence created when two or more streams are merged into one within the access structure. Figure 4.2.1.L (p. 4-26) can be used to determine this loss, or it can be computed using the following equations derived from Figure 4.2.1.L:

Junction Head Loss = $K_j \times V^2/2g$ [or $K_j \times$ Col.(17)]

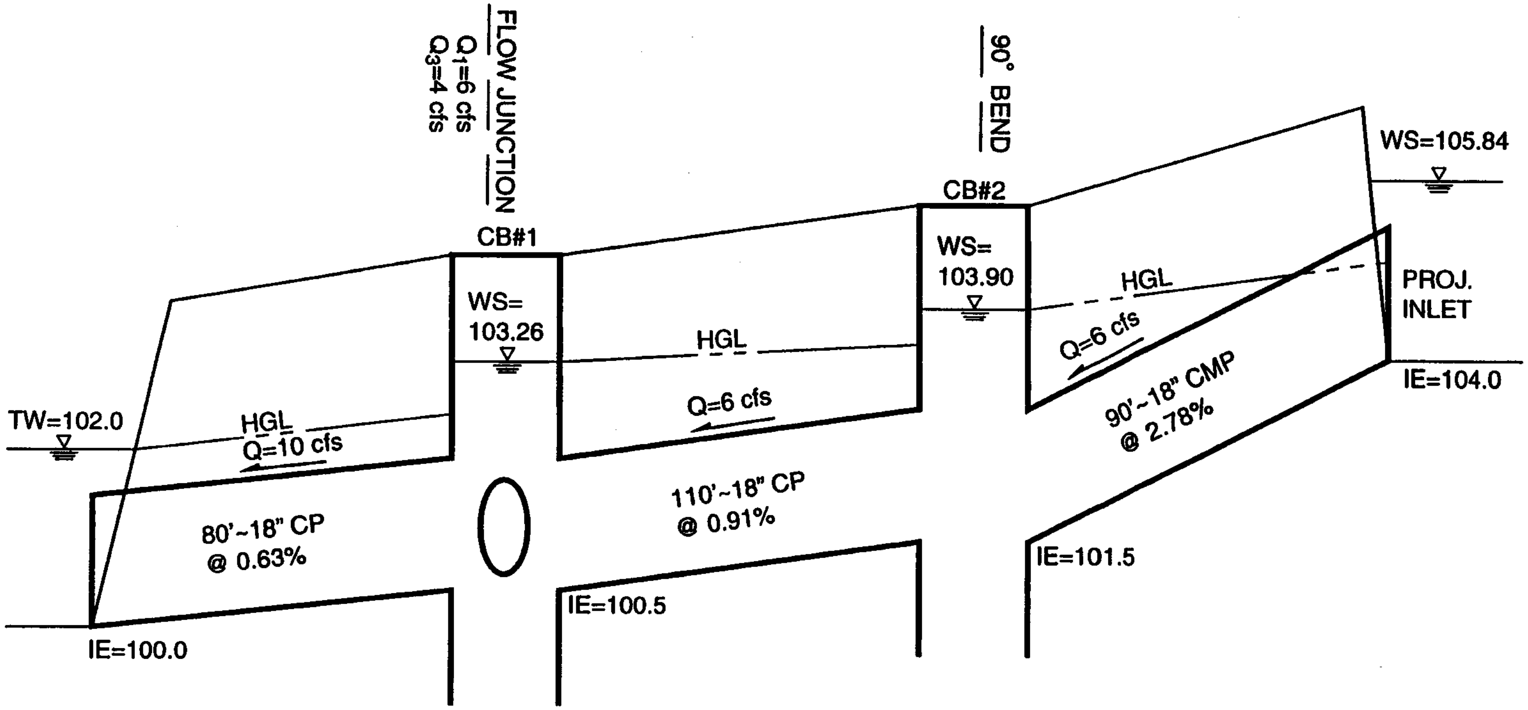
where K_j is the Junction Loss Coefficient determined by:

$K_j = (Q_3/Q_1)/(1.18 + 0.63(Q_3/Q_1))$

Column (20) - Headwater (HW) Elevation; this is determined by combining the energy heads in Columns 17, 18, and 19 with the highest control elevation in either Column 15 or 16, as follows:

Col.(20) = Col.(15 or 16) - Col.(17) + Col.(18) + Col.(19)

FIGURE 4.2.1.J BACKWATER PIPE CALCULATION EXAMPLE



BACKWATER CALCULATION SHEET

Select the greater elevation: (15), (16)

Pipe Segment CB to CB		(1) Q (cfs)	(2) Length (ft)	(3) Pipe Size	(4) "n" Value	(5) Outlet Elev (ft)	(6) Inlet Elev (ft)	(7) Barrel Area (sqft)	(8) Barrel Vel (fps)	(9) Barrel Vel Head (ft)	(10) TW Elev (ft)	(11) Friction Loss (ft)	(12) Entr HGL Elev (ft)	(13) Entr Head Loss (ft)	(14) Exit Head Loss (ft)	(15) Outlt Contr Elev (ft)	(16) Inlet Contr Elev (ft)	(17) Appr Vel Head (ft)	(18) Bend Head Loss (ft)	(19) Junc Head Loss (ft)	(20) HW Elev (ft)
Out fall	1	10	80	18"	0.012	100.00	100.50	1.77	5.65	0.50	102.00	0.62	102.62	0.25	0.50	103.37	102.75	-0.18	0.002	0.07	103.26
1	2	6	110	18"	0.012	100.50	101.50	1.77	3.39	0.18	103.26	0.31	103.57	0.09	0.18	103.84	102.95	-0.18	0.24	0.0	103.90
2	Inlet	6	90	18"	0.024	101.50	104.00	1.77	3.39	0.18	103.90	1.00	(104.9) 105.5	0.16	0.18	105.84	105.80	-0.0	0.0	0.0	105.84

FIGURE 4.2.1.K BEND HEAD LOSSES IN STRUCTURES

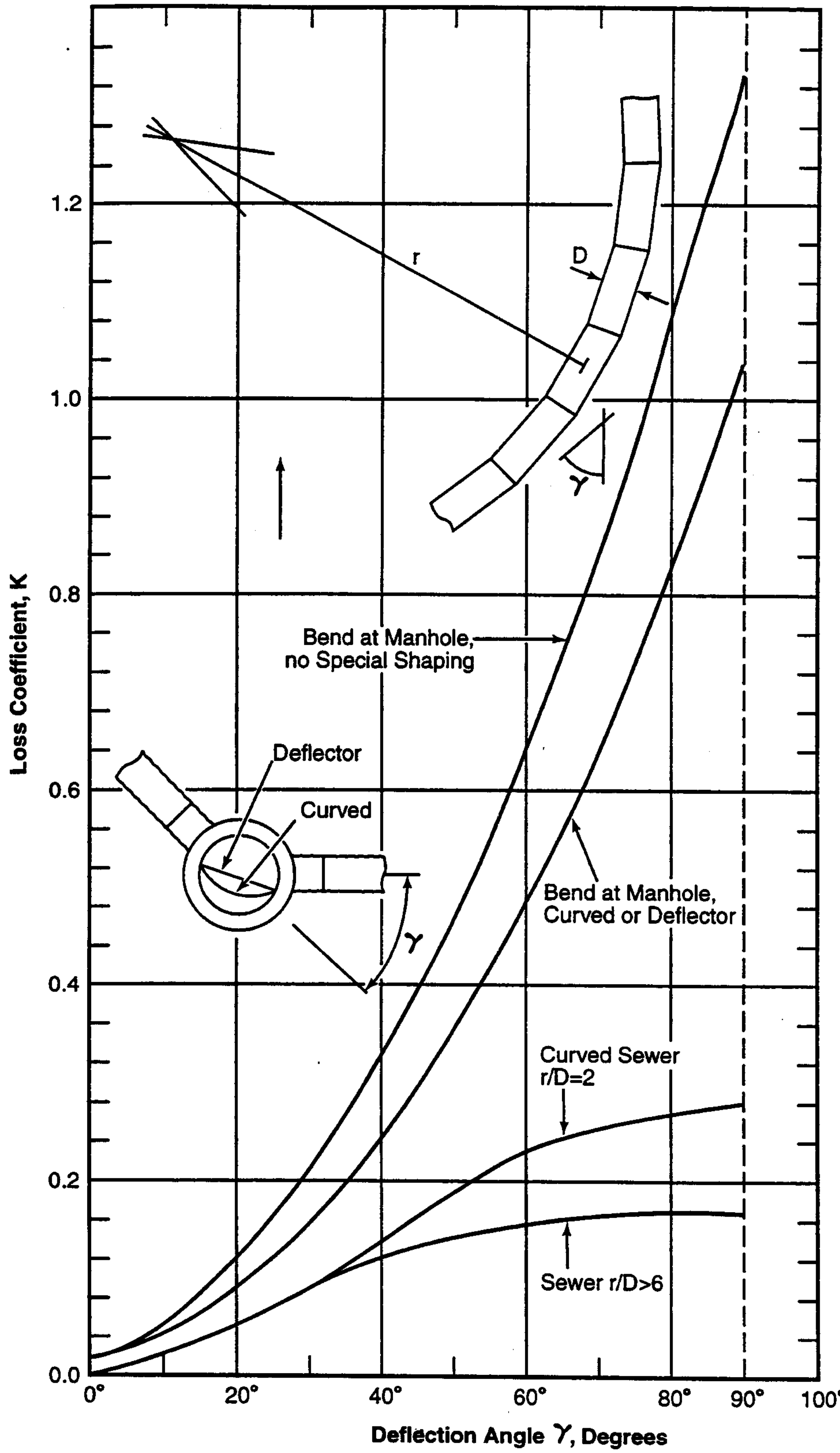


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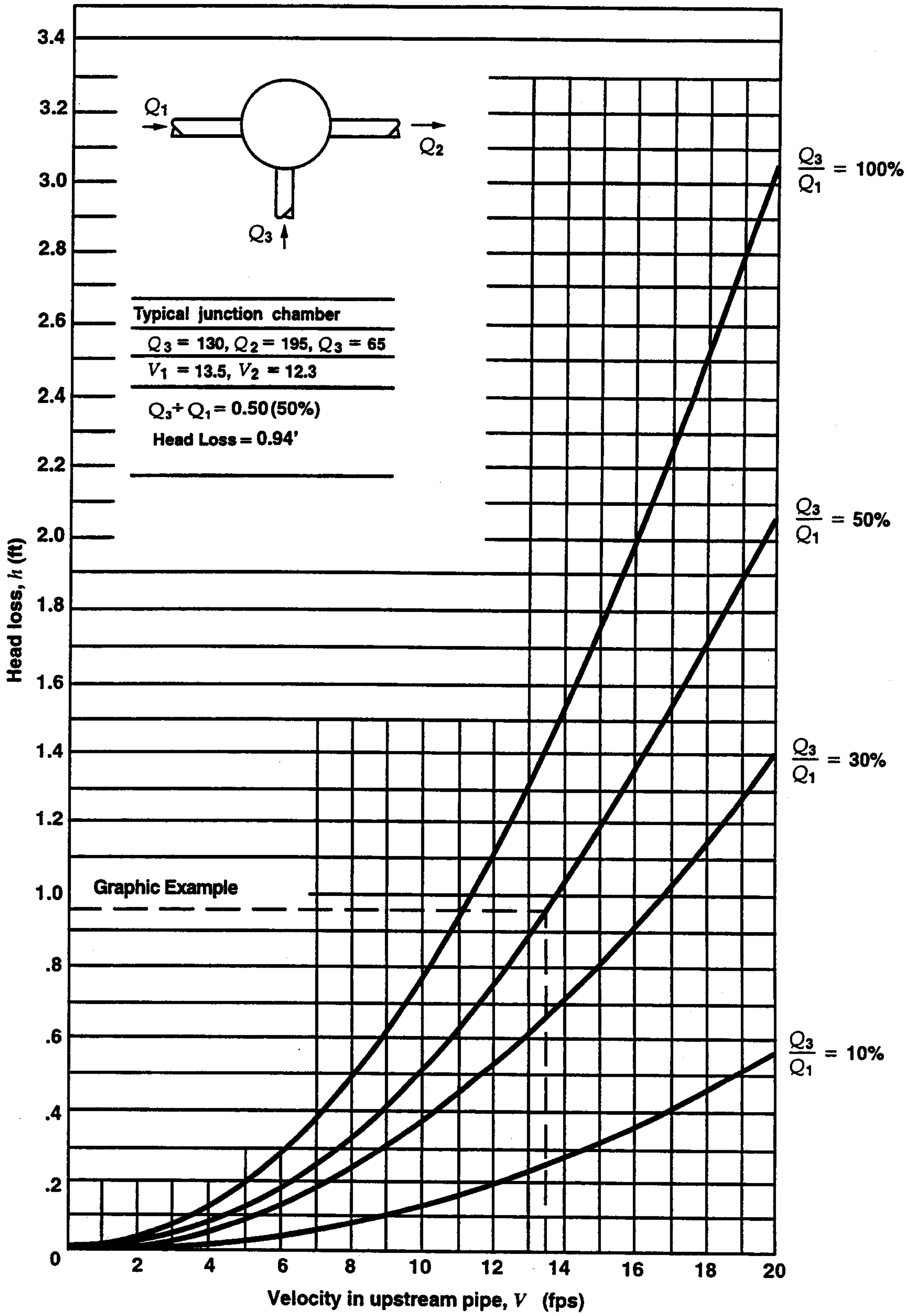
FIGURE 4.2.1.L JUNCTION HEAD LOSS IN STRUCTURES



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4.2.2 OUTFALL SYSTEMS

Properly designed outfalls are critical to ensuring no adverse impacts occur as the result of concentrated discharges from pipe systems and culverts, both onsite and downstream. *Outfall systems* include rock splash pads, flow dispersal trenches, gabion or other energy dissipaters, and tightline systems. A *tightline system* is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

4.2.2.1 DESIGN CRITERIA

General

At a minimum, all outfalls shall be provided with a **rock splash pad** (see Figure 4.2.2.B, p. 4-30) except as specified below and in Table 4.2.2.A (p. 4-28):

1. The **flow dispersal trench** shown in Figure 4.2.2.C (p. 4-31) shall only be used as an outfall as described in Core Requirement #1, Section 1.2.1.
2. For outfalls with a velocity at design flow greater than 10 fps, a **gabion dissipater** or **engineered energy dissipater** shall be required. Note the gabion outfall detail shown in Figure 4.2.2.E (p. 4-33) is illustrative only; a design engineered to specific site conditions is required.
3. **Engineered energy dissipaters**, including stilling basins, drop pools, hydraulic jump basins, baffled aprons, and bucket aprons, are required for outfalls with velocity at design flow greater than 20 fps. These should be designed using published or commonly known techniques found in such references as *Hydraulic Design of Energy Dissipaters for Culverts and Channels*, published by the Federal Highway Administration of the United States Department of Transportation; *Open Channel Flow*, by V.T. Chow; *Hydraulic Design of Stilling Basins and Energy Dissipaters*, EM 25, Bureau of Reclamation (1978); and other publications, such as those prepared by the Soil Conservation Service (now Natural Resource Conservation Service). **Alternate mechanisms,** such as bubble-up structures (which will eventually drain) and structures fitted with reinforced concrete posts, may require an approved adjustment and must be designed using sound hydraulic principles and considering constructability and ease of maintenance.
4. **Tightline systems** shall be used when required by the discharge requirements of Core Requirement #1 or the outfall requirements of Core Requirement #4. Tightline systems may also be used to prevent aggravation or creation of a downstream erosion problem.

Tightline Systems

1. Outfall tightlines may be installed in trenches with standard bedding on slopes up to 40%. In order to minimize disturbance to slopes greater than 40%, it is recommended that tightlines be placed at grade with proper pipe anchorage and support.
2. SWPE tightlines must be designed to address the material limitations, particularly **thermal expansion and contraction** and pressure design, as specified by the manufacturer. The coefficient of thermal expansion and contraction for SWPE is on the order of 0.001 inch per foot per Fahrenheit degree. **Sliding sleeve connections** shall be used to address this thermal expansion and contraction. These sleeve connections consist of a section of the appropriate length of the next larger size diameter of pipe into which the outfall pipe is fitted. These sleeve connections must be located as close to the discharge end of the outfall system as is practical.
3. SWPE tightlines shall be designed and sized using the applicable design criteria and methods of analysis specified for pipe systems in Section 4.2.1, beginning on page 4-5.
4. Due to the ability of SWPE tightlines to transmit flows of very high energy, special consideration for energy dissipation must be made. Details of a sample gabion mattress energy dissipater have been

provided as Figure 4.2.2.E (p. 4-33). Flows of very high energy will require a specifically engineered energy dissipater structure, as described above in General Criterion #3.

TABLE 4.2.2.A ROCK PROTECTION AT OUTFALLS

Discharge Velocity at Design Flow (fps)		REQUIRED PROTECTION				
Greater than	Less than or equal to	Minimum Dimensions				
		Type	Thickness	Width	Length	Height
0	5	Rock lining[1]	1 foot	Diameter + 6 feet	8 feet or 4 x diameter, whichever is greater	Crown + 1 foot
5	10	Riprap[2]	2 feet	Diameter + 6 feet or 3 x diameter, whichever is greater	12 feet or 4 x diameter, whichever is greater	Crown + 1 foot
10	20	Gabion outfall	As required	As required	As required	Crown + 1 foot
20	N/A	Engineered energy dissipater required				

(1) **Rock lining** shall be quarry spalls with gradation as follows:

Passing 8-inch square sieve:	100%
Passing 3-inch square sieve:	40 to 60% maximum
Passing 3/4-inch square sieve:	0 to 10% maximum

(2) **Riprap** shall be reasonably well graded with gradation as follows:

Maximum stone size:	24 inches (nominal diameter)
Median stone size:	16 inches
Minimum stone size:	4 inches

Note: Riprap sizing governed by side slopes on outlet channel is assumed to be approximately 3:1.

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Other Recommended Outfall Features

- Mechanisms which reduce velocity prior to discharge from an outfall are encouraged. Some of these are **drop manholes** and **rapid expansion** into pipes of much larger size.
- New pipe outfalls can provide an opportunity for **low-cost fish habitat improvements**. For example, an alcove of low-velocity water can be created by constructing the pipe outfall and associated energy dissipater back from the stream edge and digging a channel, over widened to the upstream side, from the outfall to the stream (see Figure 4.2.2.A below). Overwintering juvenile and migrating adult salmonids may use the alcove as shelter during high flows.

Note: A Hydraulic Project Approval (R.C.W. 75.20) may be required for any work within the ordinary high water marks of a stream.

FIGURE 4.2.2.A FISH HABITAT IMPROVEMENT AT NEW OUTFALLS

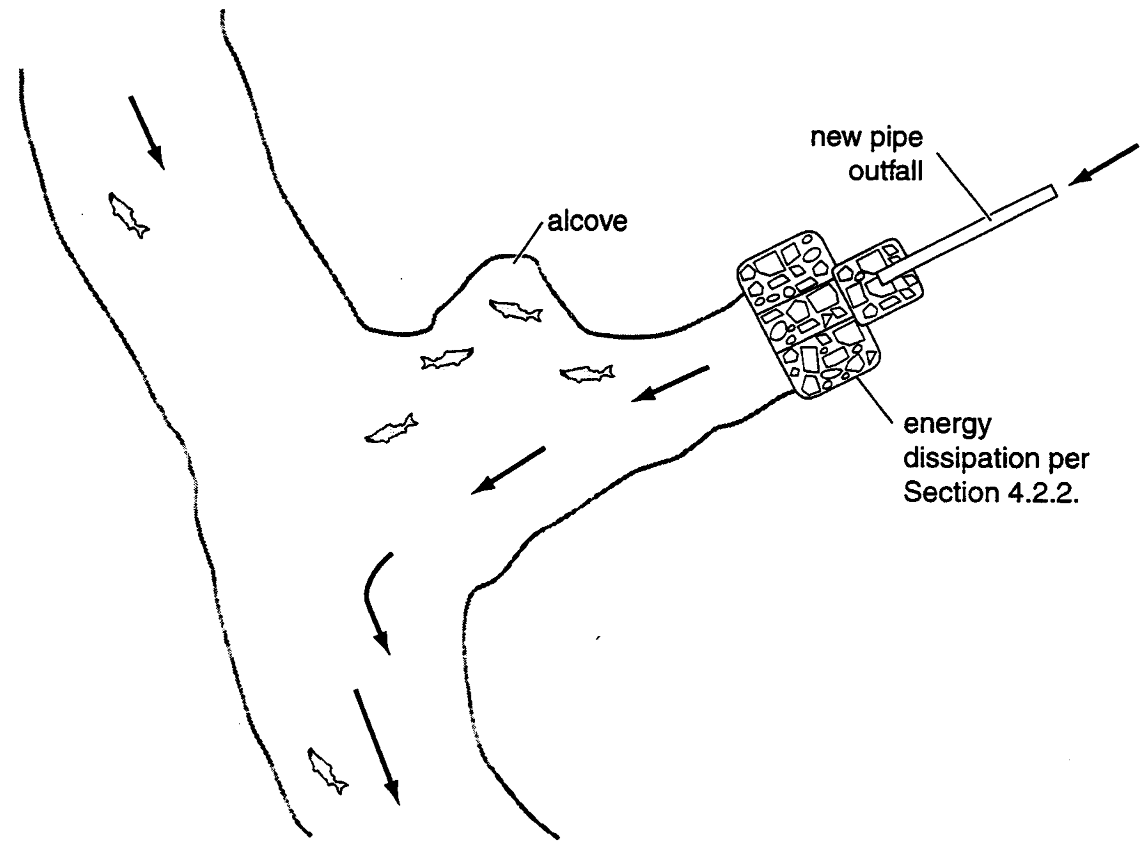

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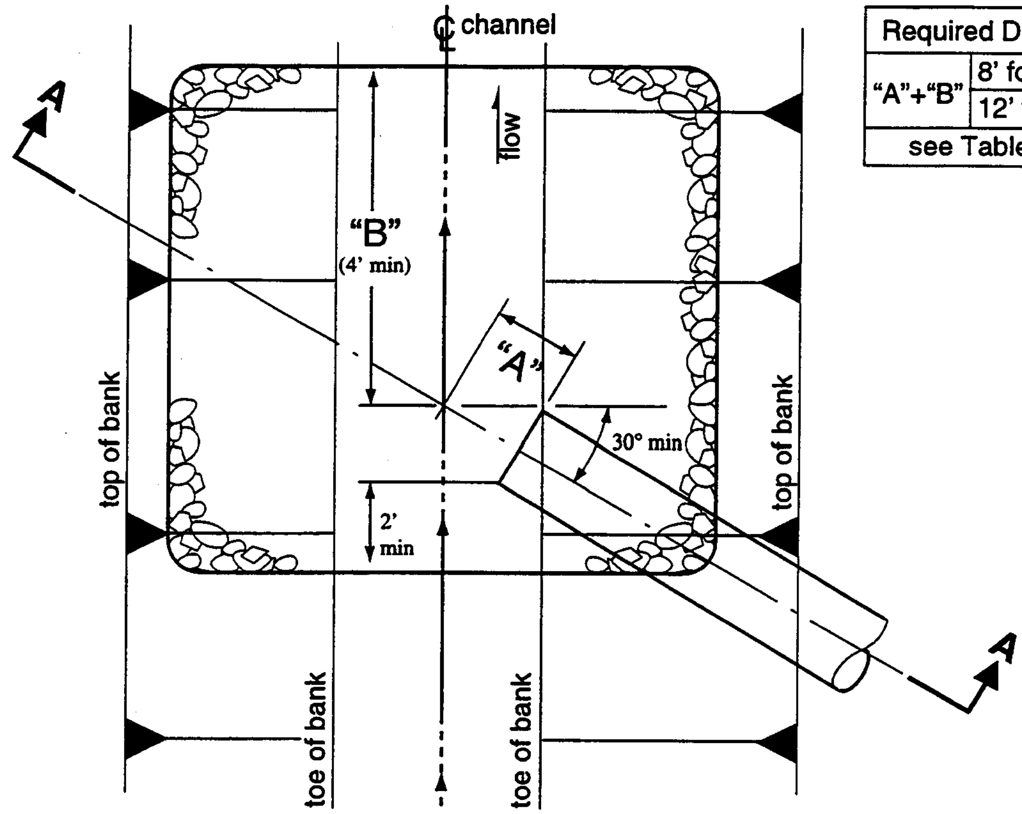
FIGURE 4.2.2.B PIPE/CULVERT DISCHARGE PROTECTION



Required Dimensions	
"A"+"B"	8' for rock lining
	12' for rip rap
see Table 4.2.2.A.	

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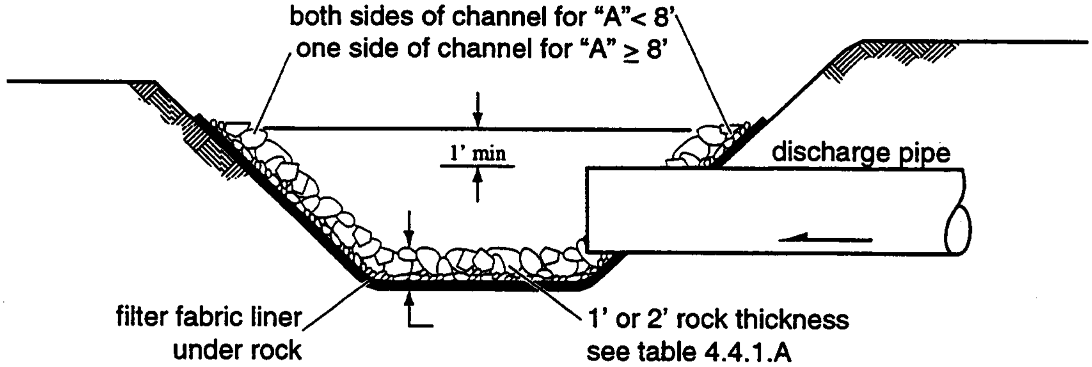

SECTION A-A
NTS

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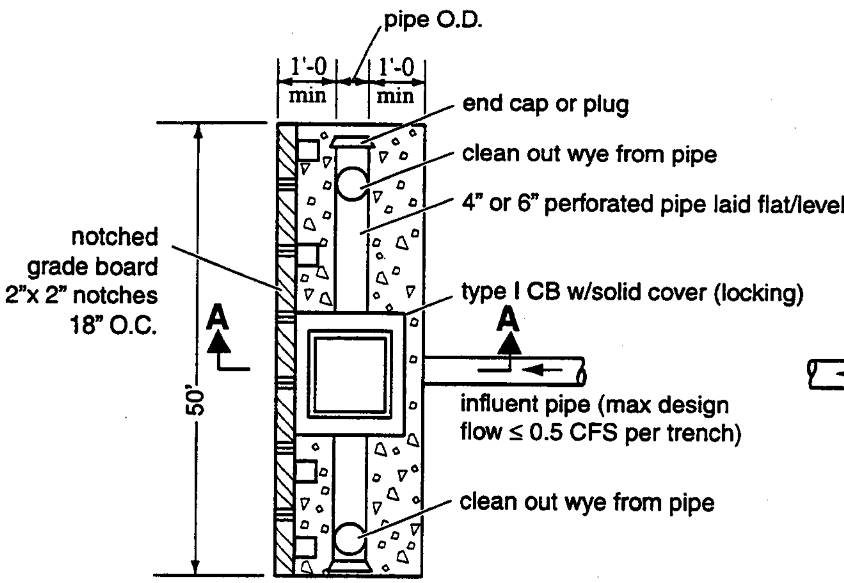
FIGURE 4.2.2.C FLOW DISPERSAL TRENCH



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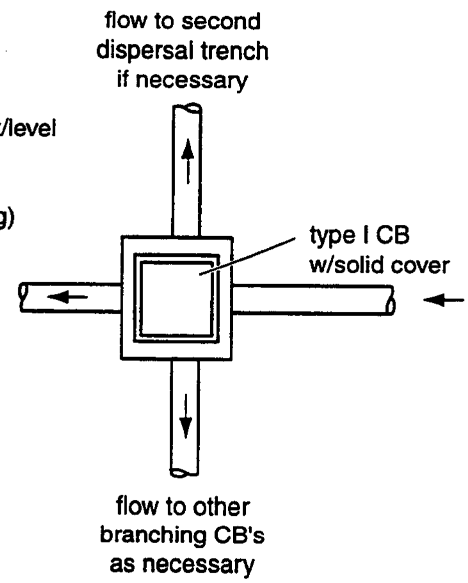

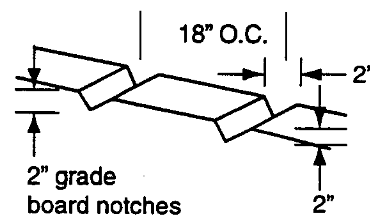

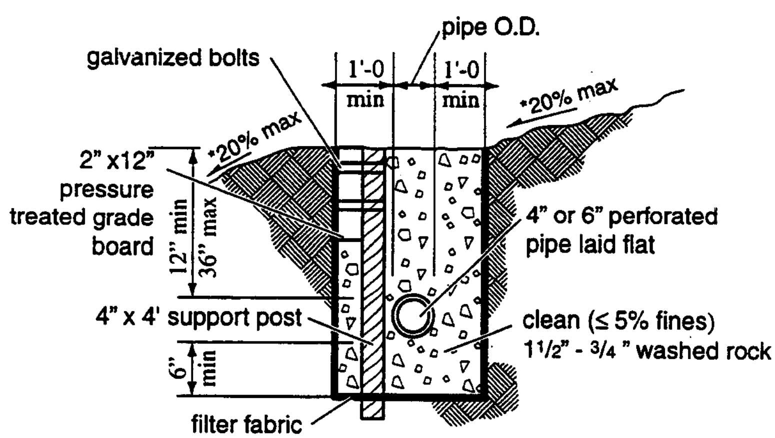

*15% max for flow control/water quality treatment in rural areas.

SECTION A-A
NTS

NOTES:

1. This trench shall be constructed so as to prevent point discharge and/or erosion.
2. Trenches may be placed no closer than 50 feet to one another. (100 feet along flowline)
3. Trench and grade board must be level. Align to follow contours of site.
4. Support post spacing as required by soil conditions to ensure grade board remains level.

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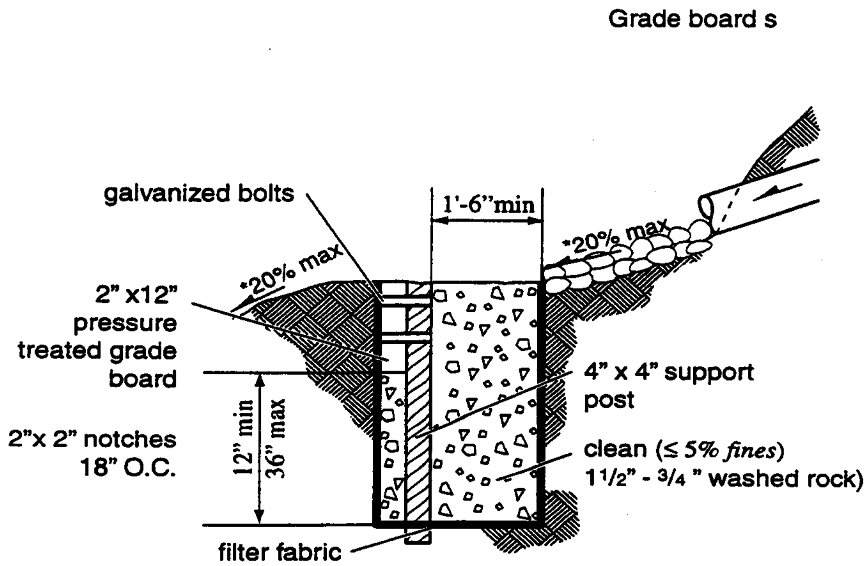
FIGURE 4.2.2.D ALTERNATIVE FLOW DISPERSAL TRENCH



*15% max for flow control/water quality treatment in rural areas

SECTION A-A
NTS

NOTES:

1. This trench shall be constructed so as to prevent point discharge and/or erosion.
2. Trenches may be placed no closer than 50 feet to one another. (100 feet along flowline)
3. Trench and grade board must be level. Align to follow contours of site.
4. Support post spacing as required by soil conditions to ensure grade board remains level.

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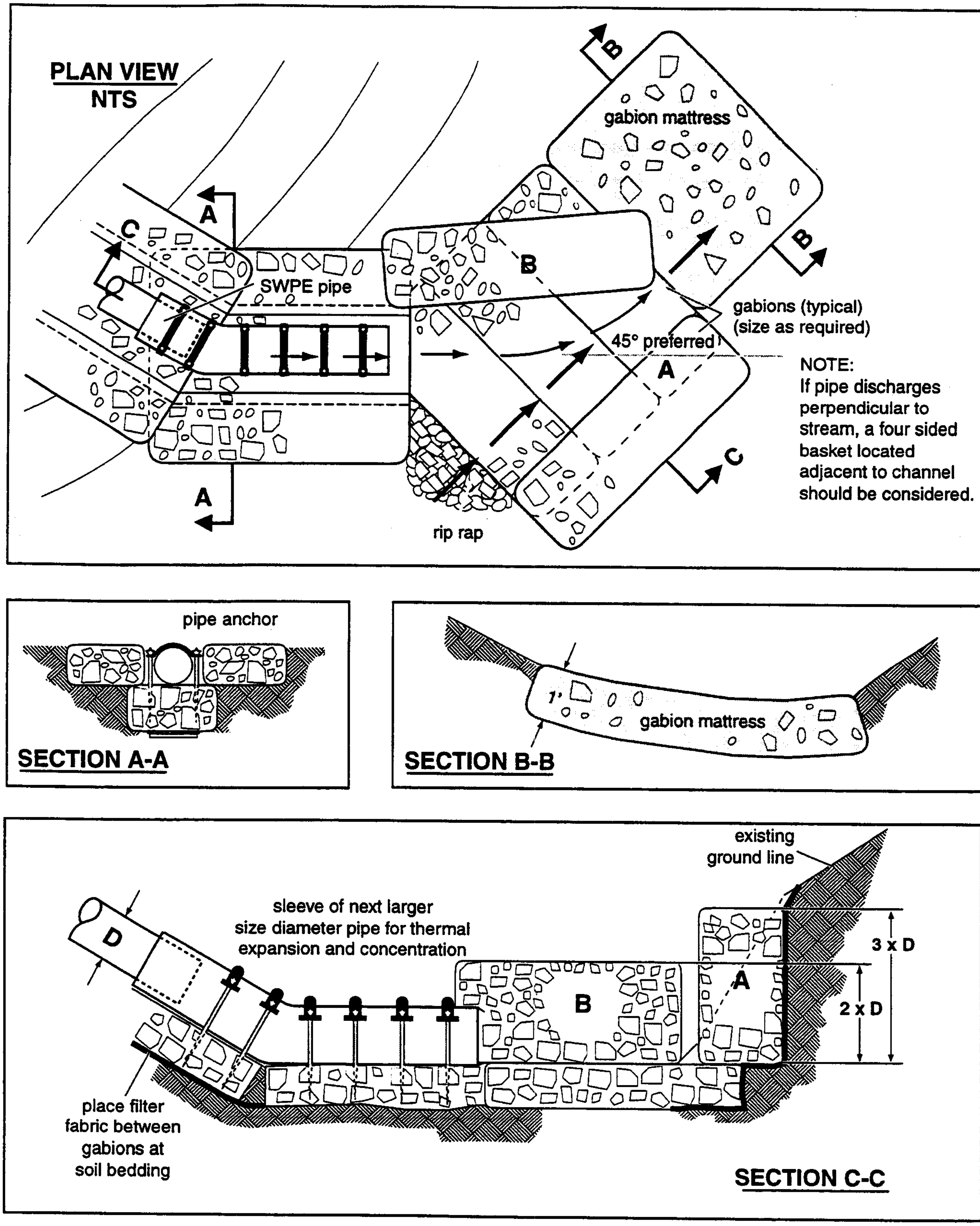
FIGURE 4.2.2.E GABION OUTFALL DETAIL



4.2.3 PUMP SYSTEMS

As allowed in Core Requirement #4, Section 1.2.4.3, pump systems may be used for conveyance of flows internal to a project site if located on private property and privately maintained.

4.2.3.1 DESIGN CRITERIA

Proposed pump systems must meet the following minimum requirements:

1. The pump system must be **privately owned and maintained.**
2. The pump system shall be used to convey water from one location or elevation to another within the project site.
3. The pump system must have a dual pump (alternating) equipped with an external alarm system.
4. The pump system shall not be used to circumvent any other King County drainage requirements, and construction and operation of the pump system shall not violate any other King County requirements.
5. The gravity-flow components of the drainage system to and from the pump system must be designed so that pump failure does not result in flooding of a building or emergency access, or overflow to a location other than the natural discharge point for the project site.

4.2.3.2 METHODS OF ANALYSIS

Pump systems must be sized in accordance with the conveyance capacity requirements for pipe systems set forth in Section 1.2.4, "Core Requirement #4: Conveyance System."

4.3 CULVERTS AND BRIDGES

This section presents the methods, criteria, and details for hydraulic analysis and design of culverts and bridges. The information presented is organized as follows:

4.3.1 CULVERTS

Culverts are relatively short segments of pipe of circular, elliptical, rectangular, or arch cross section. They are usually placed under road embankments or driveways to convey surface water flow safely under the embankment. They may be used to convey flow from constructed or natural channels including streams. The Sensitive Areas Ordinance and Rules contain the definitions of streams and requirements for crossing of streams. In addition to those requirements and the design criteria described below, other agencies such as the Washington State Department of Fish and Wildlife (WDFW) may have additional requirements which will affect the design of proposed culverts.

4.3.1.1 DESIGN CRITERIA

General

1. All **circular pipe culverts** shall conform to any applicable design criteria specified for pipe systems in Section 4.2.1.
2. All other types of culverts shall conform to manufacturer's specifications. See the *King County Road Standards* and *General Special Provisions* for types of culverts allowed in King County right-of-way.

Headwater

1. For **culverts 18-inch diameter or less**, the maximum allowable headwater elevation (measured from the inlet invert) shall not exceed 2 times the pipe diameter or arch-culvert-rise at *design flow* (i.e., the 10-year or 25-year peak flow rate as specified in Core Requirement #4, Section 1.2.4).
2. For **culverts larger than 18-inch diameter,** the maximum allowable design flow headwater elevation (measured from the inlet invert) shall not exceed 1.5 times the pipe diameter or arch-culvert-rise at design flow.
3. The **maximum headwater elevation** at design flow shall be below any road or parking lot subgrade.

Inlets and Outlets

1. All inlets and outlets in or near roadway embankments must be flush with and conforming to the slope of the embankment.
2. For culverts 18-inch diameter and larger, the embankment around the culvert inlet shall be protected from erosion by **rock lining or riprap** as specified in Table 4.2.2.A (p. 4-28), except the length shall extend at least 5 feet upstream of the culvert, and the height shall be at or above the design headwater elevation.

   Inlet structures, such as concrete headwalls, may provide a more economical design by allowing the use of smaller entrance coefficients and, hence, smaller diameter culverts. When properly designed, they will also protect the embankment from erosion and eliminate the need for rock lining.
3. In order to maintain the stability of roadway embankments, concrete headwalls, wingwalls, or tapered inlets and outlets may be required if **right-of-way or easement constraints** prohibit the culvert from extending to the toe of the embankment slopes. All inlet structures or headwalls installed in or near roadway embankments must be flush with and conforming to the slope of the embankment.
4. **Debris barriers (trash racks)** are required on the inlets of all culverts that are over 60 feet in length and are 18 to 36 inches in diameter. This requirement also applies to the inlets of pipe systems. See Figure 4.2.1.D (p. 4-15) and Figure 4.2.1.E (p. 4-16) for debris barrier details. Exceptions are culverts on Type 1 or 2 streams.
5. For culverts 18-inch diameter and larger, the receiving channel of the outlet shall be protected from erosion by **rock lining** specified in Table 4.2.2.A (p. 4-28), except the height shall be one foot above maximum tailwater elevation or one foot above the crown, whichever is higher (See Figure 4.2.2.B, p. 4-30).

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4.3.1.2 METHODS OF ANALYSIS

This section presents the methods of analysis for designing new or evaluating existing **culverts** for compliance with the conveyance capacity requirements set forth in Section 1.2.4, "Core Requirement #4: Conveyance System."

☐ DESIGN FLOWS

Design flows for sizing or assessing the capacity of culverts shall be determined using the hydrologic analysis methods described in Chapter 3.

☐ CONVEYANCE CAPACITY

The theoretical analysis of culvert capacity can be extremely complex because of the wide range of possible flow conditions that can occur due to various combinations of inlet and outlet submergence and flow regime within the culvert barrel. An exact analysis usually involves detailed backwater calculations, energy and momentum balance, and application of the results of hydraulic model studies.

However, simple procedures have been developed where the various flow conditions are classified and analyzed on the basis of a control section. A *control section* is a location where there is a unique relationship between the flow rate and the upstream water surface elevation. Many different flow conditions exist over time, but at any given time the flow is either governed by the culvert's inlet geometry (*inlet control*) or by a combination of inlet geometry, barrel characteristics, and tailwater elevation (*outlet control*). Figure 4.3.1.A (p. 4-42) illustrates typical conditions of inlet and outlet control. The procedures presented in this section provide for the analysis of both inlet and outlet control conditions to determine which governs.

Inlet Control Analysis

Nomographs such as those provided in Figure 4.3.1.B (p. 4-43) and Figure 4.3.1.C (p. 4-44) can be used to determine the **inlet control headwater depth** at design flow for various types of culverts and inlet configurations. These nomographs were originally developed by the Bureau of Public Roads—now the Federal Highway Administration (FHWA)—based on their studies of culvert hydraulics. These and other nomographs can be found in the FHWA publication *Hydraulic Design of Highway Culverts, HDS No. #5 (Report No. FHWA-IP-85-15),* September 1985; or the *WSDOT Hydraulic Manual.*

Also available in the FHWA publication are the design equations used to develop the inlet control nomographs. These equations are presented below.

For **unsubmerged** inlet conditions (defined by $Q/AD^{0.5} \leq 3.5$);

Form 1*: $$HW/D = H_c/D + K(Q/AD^{0.5})^M - 0.5S^{**} \quad (4\text{-}3)$$

Form 2*: $$HW/D = K(Q/AD^{0.5})^M \quad (4\text{-}4)$$

For **submerged** inlet conditions (defined by $Q/AD^{0.5} \geq 4.0$);

$$HW/D = c(Q/AD^{0.5})^2 + Y - 0.5S^{**} \quad (4\text{-}5)$$

where
HW = headwater depth above inlet invert (ft)
D = interior height of culvert barrel (ft)
H_c = specific head (ft) at critical depth ($dc + Vc^2/2g$)
Q = flow (cfs)
A = full cross-sectional area of culvert barrel (sf)

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S = culvert barrel slope (ft/ft)
K, M, c, Y = constants from Table 4.3.1.A.

The specified head H_c is determined by the following equation:

$$H_c = dc + V_c^2/2g \tag{4-6}$$

where dc = critical depth (ft); see Figure 4.3.1.F (p. 4-47)
Vc = flow velocity at critical depth (fps)
g = acceleration due to gravity (32.2 ft/sec^2).

* The appropriate equation form for various inlet types is specified in Table 4.3.1.A (p. 4-38

** For mitered inlets, use $+0.7S$ instead of $-0.5S$.

Note: Between the unsubmerged and submerged conditions, there is a transition zone (3.5 < $Q/AD^{0.5}$ < 4.0) for which there is only limited hydraulic study information. The transition zone is defined empirically by drawing a curve between and tangent to the curves defined by the unsubmerged and submerged equations. In most cases, the transition zone is short and the curve is easily constructed.

TABLE 4.3.1.A CONSTANTS FOR INLET CONTROL EQUATIONS*

Shape and Material	Inlet Edge Description	Unsubmerged			Submerged	
		Equation Form	K	M	c	Y
Circular Concrete	Square edge with headwall	1	0.0098	2.0	0.0398	0.67
	Groove end with headwall		0.0078	2.0	0.0292	0.74
	Groove end projecting		0.0045	2.0	0.0317	0.69
Circular CMP	Headwall	1	0.0078	2.0	0.0379	0.69
	Mitered to slope		0.0210	1.33	0.0463	0.75
	Projecting		0.0340	1.50	0.0553	0.54
Rectangular Box	30° to 75° wingwall flares	1	0.026	1.0	0.0385	0.81
	90° and 15° wingwall flares		0.061	0.75	0.0400	0.80
	0° wingwall flares		0.061	0.75	0.0423	0.82
CM Boxes	90° headwall	1	0.0083	2.0	0.0379	0.69
	Thick wall projecting		0.0145	1.75	0.0419	0.64
	Thin wall projecting		0.0340	1.5	0.0496	0.57
Arch CMP	90° headwall	1	0.0083	2.0	0.0496	0.57
	Mitered to slope		0.0300	1.0	0.0463	0.75
	Projecting		0.0340	1.5	0.0496	0.53
Bottomless Arch CMP	90° headwall	1	0.0083	2.0	0.0379	0.69
	Mitered to slope		0.0300	2.0	0.0463	0.75
	Thin wall projecting		0.0340	1.5	0.0496	0.57
Circular with Tapered Inlet	Smooth tapered inlet throat	2	0.534	0.333	0.0196	0.89
	Rough tapered inlet throat		0.519	0.64	0.0289	0.90

* Source: *FHWA HDS No. 5*

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Outlet Control Analysis

Nomographs such as those provided in Figure 4.3.1.D (p. 4-45) and Figure 4.3.1.E (p. 4-46) can be used to determine the **outlet control headwater depth** at design flow for various types of culverts and inlets. Outlet control nomographs other than those provided can be found in *FHWA HDS No.5* or the *WSDOT Hydraulic Manual.*

The outlet control headwater depth can also be determined using the simple Backwater Analysis method presented in Section 4.2.1.2 (p. 4-19) for analyzing pipe system capacity. This procedure is summarized as follows for culverts:

$$HW = H + TW - LS \tag{4-7}$$

where
- H = $Hf + He + Hex$
- Hf = friction loss (ft) = $(V^2n^2L)/(2.22R^{1.33})$
  Note: If (Hf+TW-LS) < D, adjust Hf such that (Hf+TW-LS) = D. This will keep the analysis simple and still yield reasonable results (erring on the conservative side).
- He = entrance head loss (ft) = $Ke(V^2/2g)$
- Hex = exit head loss (ft) = $V^2/2g$
- TW = tailwater depth above invert of culvert outlet (ft)
  Note: If TW < (D+dc)/2, set TW = (D+dc)/2. This will keep the analysis simple and still yield reasonable results.
- L = length of culvert (ft)
- S = slope of culvert barrel (ft/ft)
- D = interior height of culvert barrel (ft)
- V = barrel velocity (fps)
- n = Manning's roughness coefficient from Table 4.2.1.D (p. 4-18)
- R = hydraulic radius (ft)
- Ke = entrance loss coefficient (from Table 4.3.1.B, p. 4-40)
- g = acceleration due to gravity (32.2 ft/sec^2)
- dc = critical depth (ft); see Figure 4.3.1.F (p. 4-47)

Note: The above procedure should not be used to develop stage/discharge curves for level pool routing purposes because its results are not precise for flow conditions where the hydraulic grade line falls significantly below the culvert crown (i.e., less than full flow conditions).

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TABLE 4.3.1.B ENTRANCE LOSS COEFFICIENTS

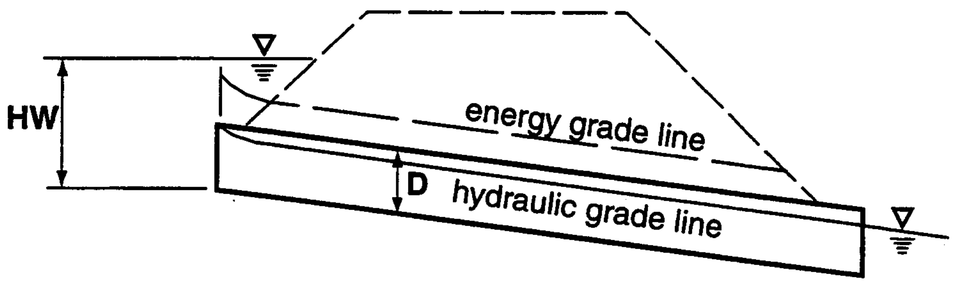
Type of Structure and Design Entrance	Coefficient, K_e
<u>Pipe, Concrete, PVC, Spiral Rib, DI, and LCPE</u>	
Projecting from fill, socket (bell) end	0.2
Projecting from fill, square cut end	0.5
Headwall, or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = $^1/_{12}$D)	0.2
Mitered to conform to fill slope	0.7
End section conforming to fill slope*	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
<u>Pipe, or Pipe-Arch, Corrugated Metal and Other Non-Concrete or D.I.</u>	
Projecting from fill (no headwall)	0.9
Headwall, or headwall and wingwalls (square-edge)	0.5
Mitered to conform to fill slope (paved or unpaved slope)	0.7
End section conforming to fill slope*	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
<u>Box, Reinforced Concrete</u>	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of $^1/_{12}$ barrel dimension or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of $^1/_{12}$ barrel dimension or beveled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

* *Note: "End section conforming to fill slope" are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both **inlet and outlet control**. Some end sections incorporating a **closed taper** in their design have a superior hydraulic performance.*

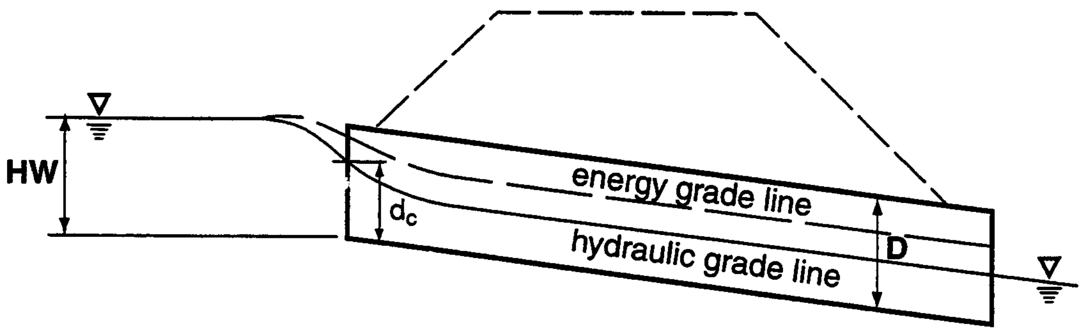
Computer Applications

The **King County Backwater (KCBW) computer program** available with this manual contains two subroutines which can be used to analyze culvert capacity and develop stage/discharge curves for level pool routing purposes. These areBackwater computer programBackwater computer program **BWPIPE** and **BWCULV**. A schematic description of the nomenclature used in these programs is provided in Figure 4.3.1.G (p. 4-48). The KCBW program documentation available from DNR includes more detailed descriptions of program features.

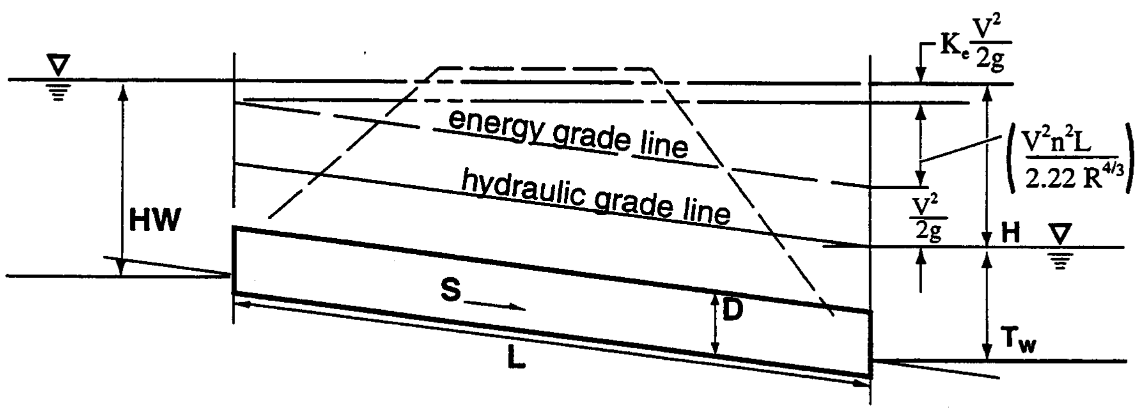
FIGURE 4.3.1.A INLET/OUTLET CONTROL CONDITIONS



Inlet Control - Submerged Inlet



Inlet Control - Unsubmerged Inlet



Outlet Control - Submerged Inlet and Outlet

NOTE: See FHWA no. 5 for other possible conditions

FIGURE 4.3.1.B
HEADWATER DEPTH FOR SMOOTH INTERIOR PIPE CULVERTS WITH INLET CONTROL

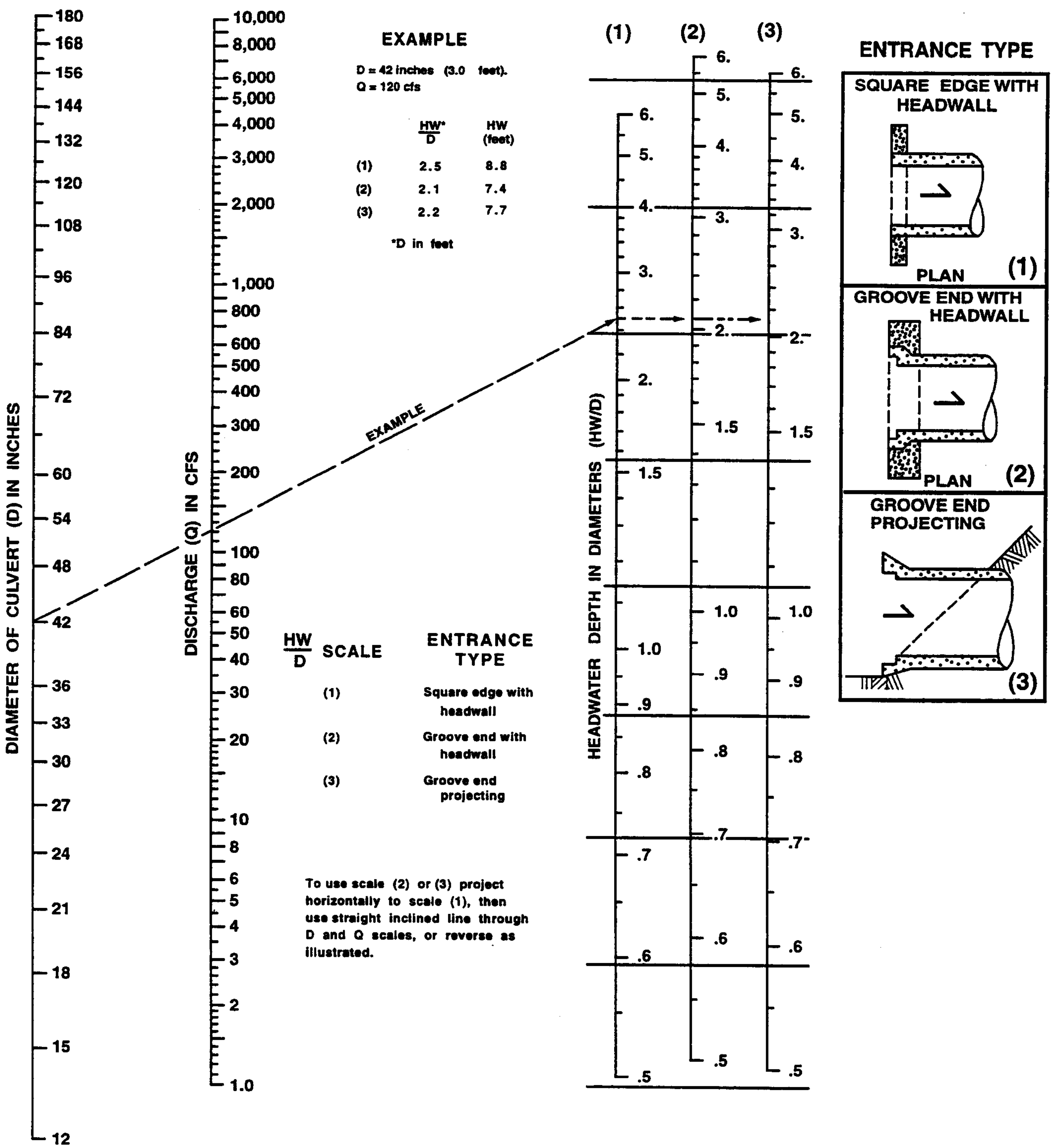


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FIGURE 4.3.1.C HEADWATER DEPTH FOR CORRUGATED PIPE CULVERTS WITH INLET CONTROL

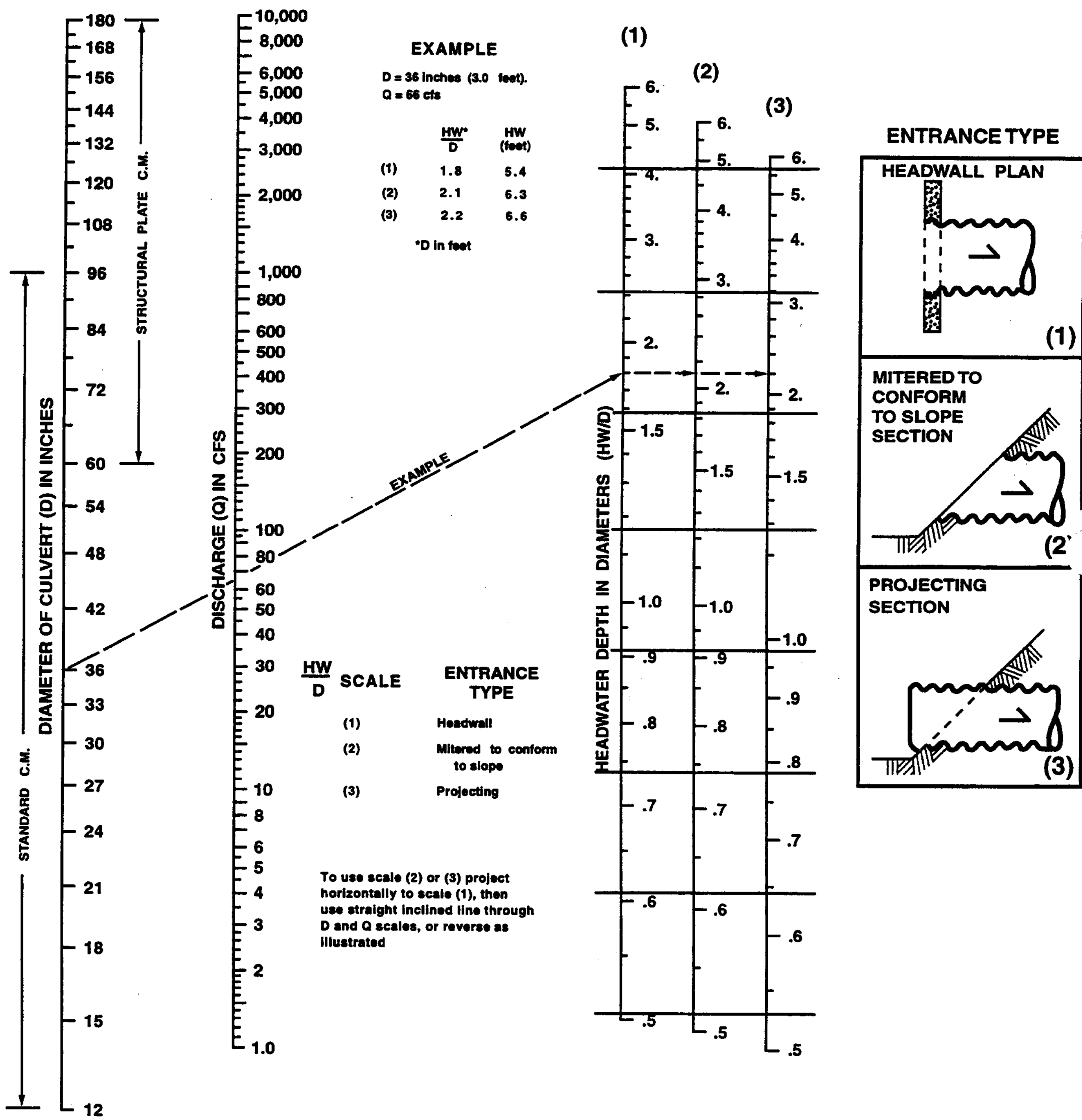

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FIGURE 4.3.1.D HEAD FOR CULVERTS (PIPE W/"*n*"= 0.012) FLOWING FULL WITH OUTLET CONTROL

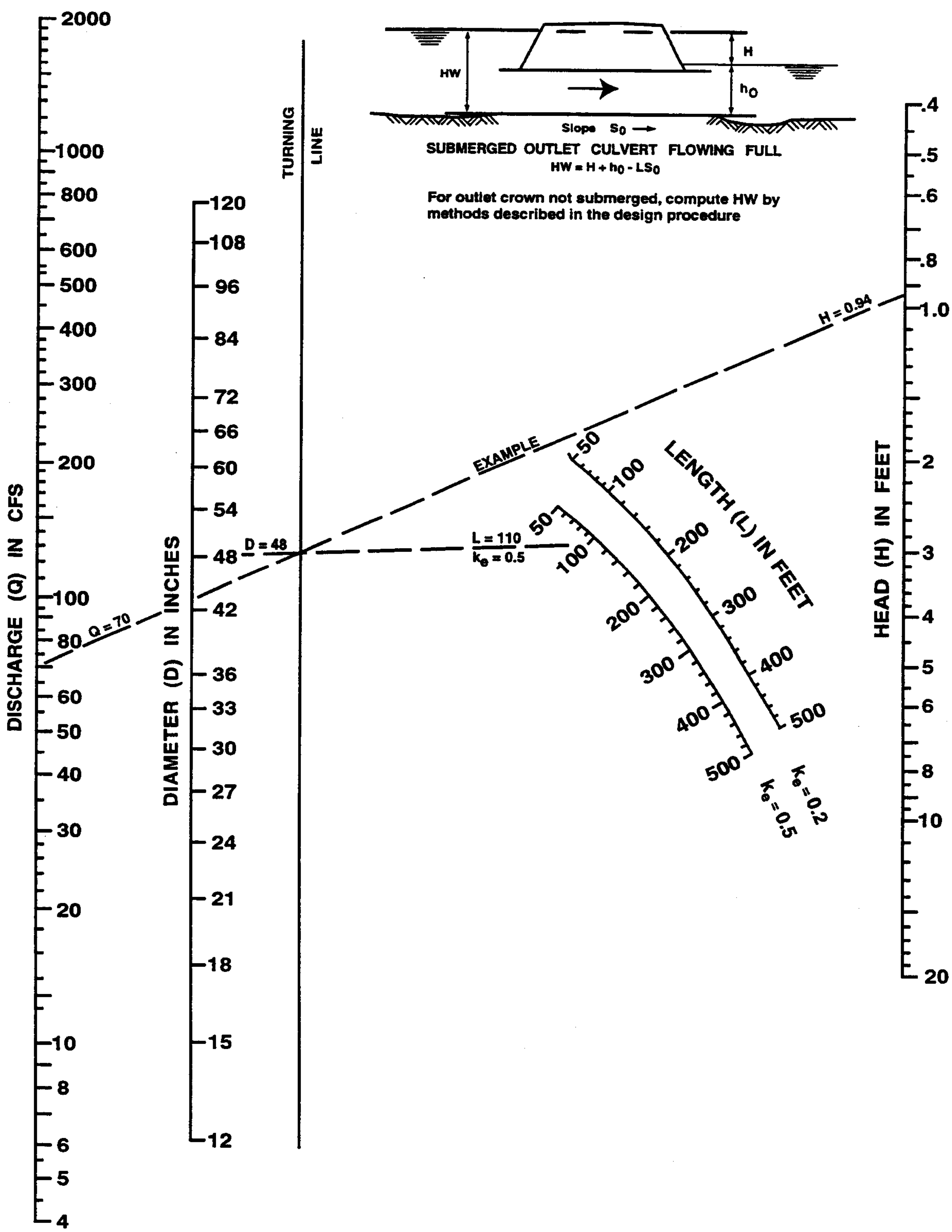

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FIGURE 4.3.1.E HEAD FOR CULVERTS (PIPE W/"n"= 0.024) FLOWING FULL WITH OUTLET CONTROL

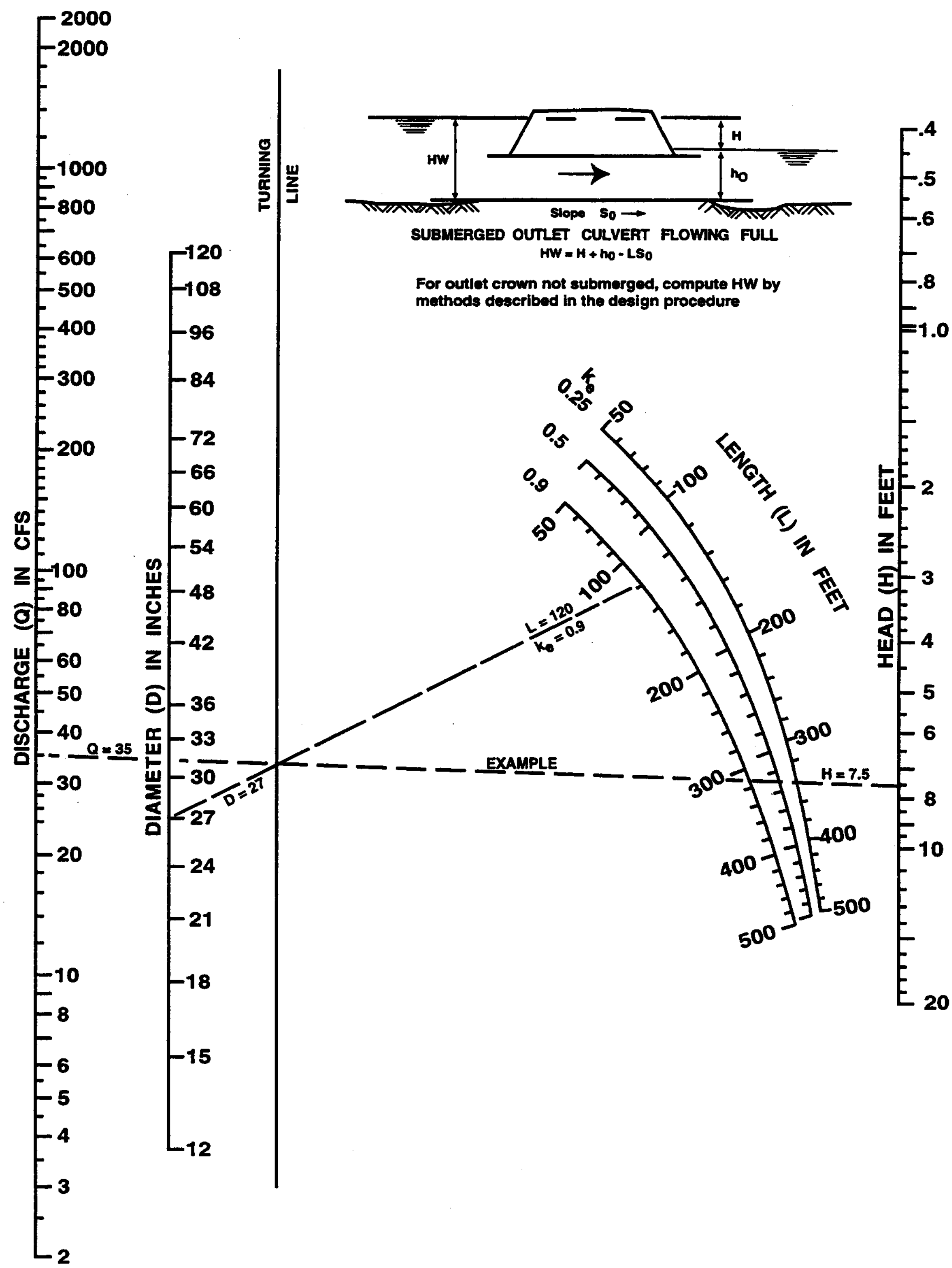

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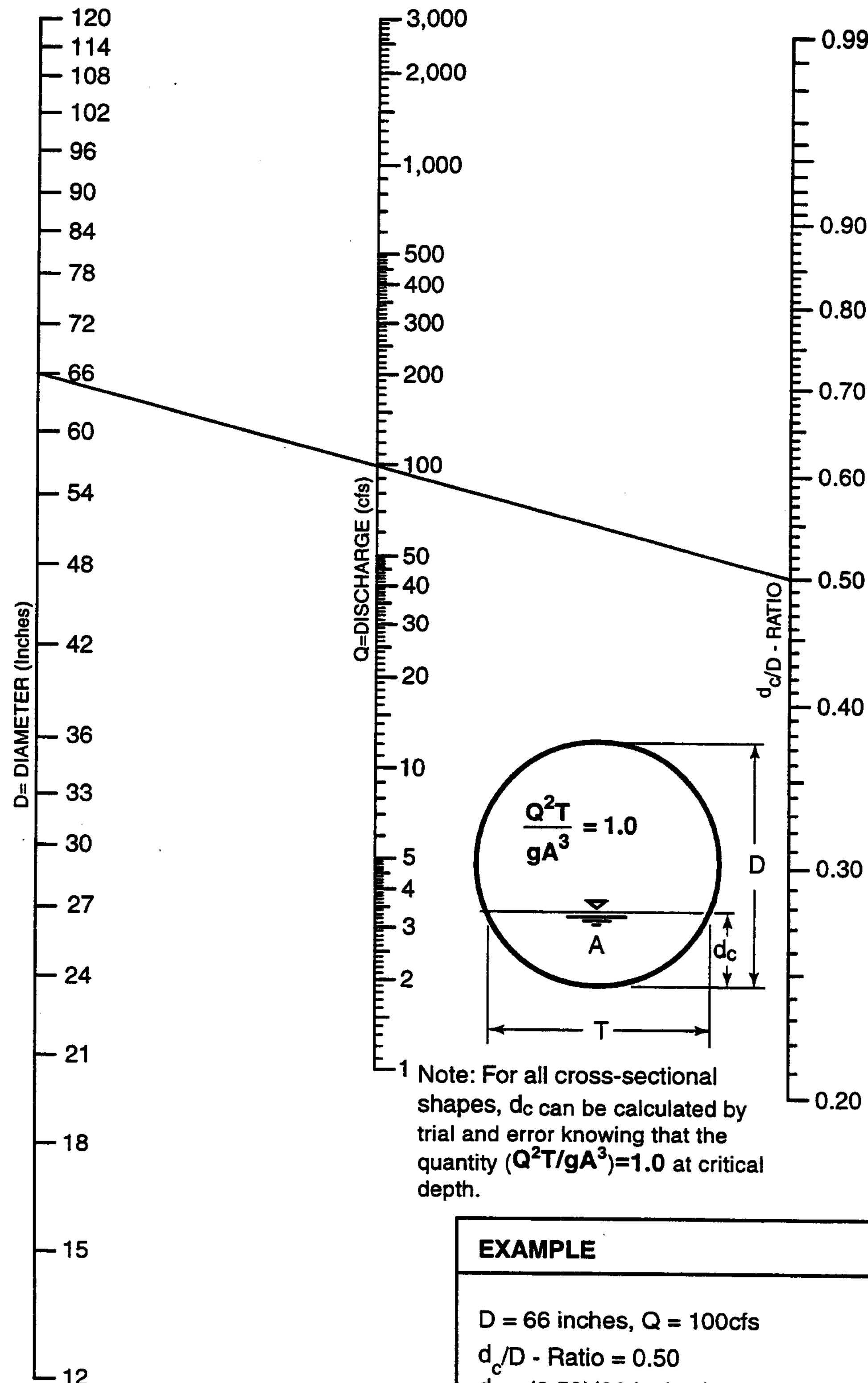
FIGURE 4.3.1.F CRITICAL DEPTH OF FLOW FOR CIRCULAR CULVERTS



Note: For all cross-sectional shapes, d_c can be calculated by trial and error knowing that the quantity **(Q^2T/gA^3)=1.0** at critical depth.

EXAMPLE
D = 66 inches, Q = 100cfs d_c/D - Ratio = 0.50 d_c = (0.50)(66 inches)= 33 inches ÷ (12 inches/ft) d_c= 2.75 feet

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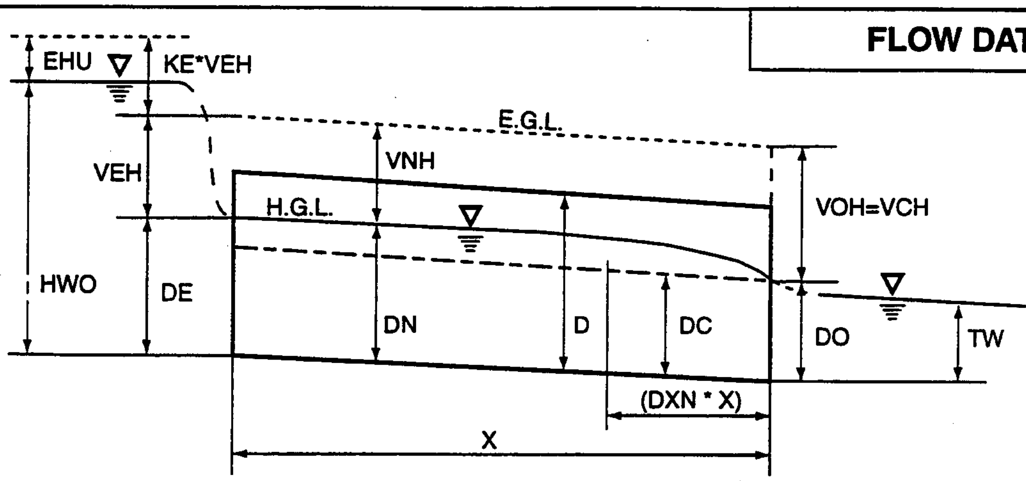
FIGURE 4.3.1.G COMPUTER SUBROUTINES BWPIPE AND BWCULV: VARIABLE DEFINITIONS



FLOW DATA	COEFFICIENTS/INLET DATA
DC -Critical Depth (ft)	**KE -Entrance Coefficient under Outlet Control**
DN -Normal Depth (ft)	**KB -Bend Loss Coefficient**
TW -Tailwater Depth (ft)	**KJ -Junction Loss Coefficient**
DO -Outlet Depth (ft)	**K -Inlet Control Equation parameter** (See Table 4.3.1.A)
DE -Entrance Depth (ft)	**M -Inlet Control Equation parameter** (See Table 4.3.1.A)
HWO -Headwater (ft) assuming Outlet Control	**C -Inlet Control Equation parameter** (See Table 4.3.1.A)
HWI -Headwater (ft) assuming Inlet Control	**Y -Inlet Control Equation parameter** (See Table 4.3.1.A)
DXN -Distance (expressed as a fraction of the pipe length) from the outlet to where the flow profile intersects with normal depth. DXN will equal one under full-flow conditions and will equal zero when a hydraulic jump occurs at the outlet or when normal depth equals zero (normal depth will equal zero when the pipe grade is flat or reversed).	**Q-Ratio Ratio of tributary flow to main upstream flow of Q3/Q1** 
VBH -Barrel Velocity Head (ft) based on the average velocity determined by V=Q/Afull	
VUH -Upstream Velocity Head (ft) based on an inputted velocity.	
EHU -Upstream Energy Head (ft) available after bend losses and junction losses have been subtracted from VUH.	
VCH -Critical Depth Velocity Head (ft)	
VNH -Normal Depth Velocity Head (ft)	
VEH -Entrance Depth Velocity Head (ft)	
VOH -Outlet Depth Velocity Head (ft)	

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4.3.2 CULVERTS PROVIDING FOR FISH PASSAGE/MIGRATION

In fish-bearing waters, water-crossing structures must usually provide for fish passage as required for Washington State Department of Fish and Wildlife (WDFW) Hydraulic Project Approval or as a condition of permitting under the Sensitive Areas Ordinance. Culverts designed for fish passage must also meet the requirements of Section 1.2.4, "Core Requirement #4: Conveyance System."

Fish passage can generally be ensured by providing structures that do not confine the streambed—that is, a structure wide enough so that the stream can maintain its natural channel within the culvert. Bridges, bottomless arch culverts, arch culverts, and rectangular box culverts ("utility vaults") can often be used to accommodate stream channels.

Where it is unfeasible to construct these types of structures, round pipe culverts may be used if high flow velocities are minimized and low flow depths are maximized. The Hydraulic Code Rules (Title 220 WAC) detail requirements for WDFW Hydraulic Project Approval.

4.3.2.1 DESIGN CRITERIA

Table 4.3.2.A (from Title 220 WAC) lists allowable velocities, flow depths, and hydraulic drops for culverts in fish-bearing streams. Velocities are for the **high flow design discharge**; water depths are for the **low flow design discharge.** The *hydraulic drop* (a vertical drop in the water surface profile at any point within culvert influence) is for all flows between the high and low flow design discharges.

TABLE 4.3.2.A FISH PASSAGE DESIGN CRITERIA

	Adult Trout	Adult Pink, Chum Salmon	Adult Chinook, Coho, Sockeye, Steelhead
1. Max Velocity (fps)			
Culvert Length:			
10-60 ft	4.0	5.0	6.0
60-100 ft	4.0	4.0	5.0
100-200 ft	3.0	3.0	4.0
2. Min Flow Depth (ft)	0.8	0.8	1.0
3. Max Hydraulic Drop (ft)	0.8	0.8	1.0

4.3.2.2 METHODS OF ANALYSIS

High Flow Design Discharge

For **gaged streams**, the high flow design discharge shall be estimated by the 10% exceedance flow for October through April inclusive, proportioned by tributary area to the culvert using the technique described in Section 4.4.2.2 under "Flood Flows from Stream Gage Data" (p. 4-71).

For **ungaged streams,** the high flow design discharge shall be estimated by one of the following:

- The 10% exceedance flow for October through April inclusive for the nearest hydrologically similar gaged stream, proportioned by tributary area
- The 5% exceedance flow determined through duration analysis with the KCRTS model

- The 10% exceedance flow for October through April inclusive determined with the HSPF model or the KCRTS model using the full historical record.

Low Flow Design Discharge

For **gaged streams**, the low flow design discharge shall be estimated by the 95% exceedance flow for October through April inclusive, proportioned by tributary area.

For **ungaged streams**, the low flow design discharge shall be estimated by one of the following:

- The 95% exceedance flow for October through April inclusive for the nearest hydrologically similar gaged stream, proportioned by tributary area
- The 95% exceedance flow for October through April inclusive, determined by the HSPF model or the KCRTS model using the full historical record
- One of the following equations, using KCRTS input data:

For the Sea-Tac rainfall region:

$$Q_l = f_r(0.46A_{tf} + 0.56A_{tp} + 0.46A_{tg} + 0.72A_{of} + 0.96A_{op} + 1.10A_{og}) / 1000 \qquad (4\text{-}8)$$

For the Landsburg rainfall region:

$$Q_l = f_r(0.65A_{tf} + 0.90A_{tp} + 0.70A_{tg} + 1.10A_{of} + 1.45A_{op} + 1.70A_{og} + 0.25A_{wl}) / 1000 \qquad (4\text{-}9)$$

where
Q_l = low flow design discharge (cfs)
f_r = regional rainfall scale factor from Figure 3.2.2.A
A_{tf} = area of till forest (acres)
A_{tp} = area of till pasture (acres)
A_{tg} = area of till grass (acres)
A_{of} = area of outwash forest (acres)
A_{op} = area of outwash pasture (acres)
A_{og} = area of outwash grass (acres)

Note: Minimum depths may also be met by providing an "installed no-flow depth," per Title 220 WAC, where the static water surface level meets minimum flow depth criteria.

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4.3.3 BRIDGES

Bridges are structures constructed over an obstacle (such as a waterway) to allow the continuation of a thoroughfare (such as a road). They generally consist of foundation abutments and/or piers which support a deck spanning the obstacle. In addition to the design criteria described below, bridge designs must reflect the requirements of the Sensitive Areas Ordinance and Rules and those of other agencies such as the Washington State Department of Fish and Wildlife (WDFW).

4.3.3.1 DESIGN CRITERIA

Bridge Clearance Requirements

Bridges shall be designed to convey flows for runoff events up to and including the 100-year event in a manner that does not increase the potential for flooding in the surrounding community or cause bridge failure. To assure this goal, the bridge must provide sufficient clearance (vertical distance between the 100-year water surface and the low chord of the bridge) to allow for **passage of debris** and uncertainties in hydraulic calculations, such as bed aggradation and flows exceeding 100-year rates.

Clearance requirements differ with the size (mean annual flow) of the stream as described below. The mean annual flow can be determined using the methods described in Section 4.3.3.2 (p. 4-52).

1. For **streams with mean annual flows greater than or equal to 40 cfs**, design clearance shall be at least 6 feet. This may be reduced to a minimum of 3 feet through an analysis addressing the following considerations:

    a) **Debris passage:** Required clearance for debris should be based on the expected height of material above the water surface, considering the maximum material size available, the ability of the stream to transport it, and the proximity of debris sources. Clearance for debris passage should be applied for the width of the channel where debris flow is expected. At a minimum, the width shall be between ordinary high water marks or the tops of defined banks, whichever is greater.

    b) **Bed aggradation:** Where bed aggradation is probable, a hydraulic analysis shall be submitted with the bed raised by an amount expected during a suitable design life (40 years minimum). Aggradation estimates shall be based on a sediment transport analysis that, where possible, is calibrated to direct cross-section comparisons over time.

    c) **Safety margin:** The safety margin should account for uncertainties in flow rates, water surface elevations, and aggradation over time. In addition, the safety margin should be increased when the surrounding community is especially susceptible to flood damages that could be exacerbated by a debris jam at the bridge.

    Note: Justification for the clearance values determined above can include historical data, field observations, and comparisons to similar bridge sites as well as quantitative analysis. Extensive analysis may not be required; if the reviewing County engineer agrees on clearance parameters based on review of existing data or site review, only a simple statement of the agreement and information leading to it are needed.

2. For **streams with mean annual flows greater than or equal to 20 cfs but less than 40 cfs,** minimum design clearance within the debris path shall be 3 feet. Design clearances less than 3 feet are allowed if supported by an analysis as outlined above.

3. For **streams with mean annual flows greater than or equal to 5 cfs but less than 20 cfs,** minimum design clearance within the debris path shall be 2 feet.

4. For **streams with mean annual flows less than 5 cfs,** there are no minimum clearance requirements. However, for salmonid streams, headwater depths for the 25-year peak flow must be no higher than the low chord of the bridge, assuming inlet control.

AR 031956

5. For **lakes, wetlands, closed depressions, and streams with mean annual flows greater than or equal to 5 cfs** (applies outside of debris path only), minimum design clearance shall be 1 foot.

Bridge Approach Slopes

On streams with levees, the portion of the approach slopes subject to floodwaters must be connected to the existing levees, and the approach slopes must be designed to meet Federal Emergency Management Administration (FEMA) levee construction and stability standards.

Bridge Piers and Abutments

Bridge pier and abutment locations are governed by provisions of the King County Sensitive Areas Ordinance codified in KCC 21A.24.

4.3.3.2 METHODS OF ANALYSIS

Estimation of Mean Annual Flows

Mean annual flow can be estimated from measurements of normal winter flow or may be made from gage records, continuous hydrological modeling, or regression methods as described in the *Washington State Department of Transportation Hydraulics Manual*, Section 2.7.

For gaged streams, mean annual flows can be obtained from the U.S. Geologic Survey Water Resources Data Annual Reports for Washington State.

For ungaged streams in the Puget Sound Region, the mean annual flow may be estimated with the following regression equation:

$$Q_b = 0.00808\,A^{0.933}P^{1.48} \qquad (4\text{-}10)$$

where Q_b = mean annual flow (cfs)
A = basin area (square miles)
P = mean annual precipitation (inches)

Hydraulic Analysis

The following methods are acceptable for hydraulic analysis of **bridges:**

1. The **Direct Step backwater method** described on page 4-60 shall be used to analyze the hydraulic impacts of bridge piers and abutments to the water surface profile.
2. The Army Corps of Engineers Hydraulic Engineering Center publishes technical papers on methods used to address the hydraulic effects of bridge piers and abutments. The book *Open Channel Hydraulics* by V.T. Chow also contains techniques for analyzing these hydraulic effects.

4.4 OPEN CHANNELS, FLOODPLAINS, AND FLOODWAYS

This section presents the methods, criteria, and details for hydraulic analysis and design of open channels, and the determination and analysis of floodplains and floodways. The information presented is organized as follows:

4.4.1 OPEN CHANNELS

Open channels can be classified as either natural or constructed. Natural channels are generally referred to as streams, creeks, or swales, while constructed channels are most often called ditches, or simply channels. The Sensitive Areas Ordinance and Rules and Chapter 1 of this manual should be reviewed for requirements related to streams.

Natural Channels

Natural channels are defined as those that have occurred naturally due to the flow of surface waters, or those that, although originally constructed by human activity, have taken on the appearance of a natural channel including a stable route and biological community. They may vary hydraulically along each channel reach and should be left in their natural condition, wherever feasible or required, in order to maintain natural hydrologic functions and wildlife habitat benefits from established vegetation.

Constructed Channels

Constructed channels are those constructed or maintained by human activity and include bank stabilization of natural channels. Constructed channels shall be either vegetation-lined, rock-lined, or lined with appropriately bioengineered vegetation.

- **Vegetation-lined channels** are the most desirable of the constructed channels when properly designed and constructed. The vegetation stabilizes the slopes of the channel, controls erosion of the channel surface, and removes pollutants. The channel storage, low velocities, water quality benefits, and greenbelt multiple-use benefits create significant advantages over other constructed channels. The presence of vegetation in channels creates turbulence which results in loss of energy and increased flow retardation; therefore, the design engineer must consider sediment deposition and scour, as well as flow capacity, when designing the channel.
- **Rock-lined channels** are necessary where a vegetative lining will not provide adequate protection from erosive velocities. They may be constructed with riprap, gabions, or slope mattress linings. The rock lining increases the turbulence, resulting in a loss of energy and increased flow retardation. Rock lining also permits a higher design velocity and therefore a steeper design slope than in grass-lined channels. Rock linings are also used for erosion control at culvert and storm drain outlets, sharp channel bends, channel confluences, and locally steepened channel sections.
- **Bioengineered vegetation lining** is a desirable alternative to the conventional methods of rock armoring. *Soil bioengineering* is a highly specialized science that uses living plants and plant parts to stabilize eroded or damaged land. Properly bioengineered systems are capable of providing a measure of immediate soil protection and mechanical reinforcement. As the plants grow they produce a

vegetative protective cover and a root reinforcing matrix in the soil mantle. This root reinforcement serves several purposes:

a) The developed anchor roots provide both shear and tensile strength to the soil, thereby providing protection from the frictional shear and tensile velocity components to the soil mantle during the time when flows are receding and pore pressure is high in the saturated bank.

b) The root mat provides a living filter in the soil mantle that allows for the natural release of water after the high flows have receded.

c) The combined root system exhibits active friction transfer along the length of the living roots. This consolidates soil particles in the bank and serves to protect the soil structure from collapsing and the stabilization measures from failing.

The vegetative cover of bioengineered systems provides immediate protection during high flows by laying flat against the bank and covering the soil like a blanket. It also reduces pore pressure in saturated banks through transpiration by acting as a natural "pump" to "pull" the water out of the banks after flows have receded.

The King County publication *Guidelines for Bank Stabilization Projects* primarily focuses on projects on larger rivers and streams, but the concepts it contains can be used in conjunction with other natural resource information for stabilization projects on smaller systems.

4.4.1.1 DESIGN CRITERIA

General

1. **Open channels** shall be designed to provide required conveyance capacity while minimizing erosion and allowing for aesthetics, habitat preservation, and enhancement.

2. An **access easement for maintenance** is required along all constructed channels located on private property. Required easement widths and building setback lines vary with channel top width as shown in Table 4.1 (p. 4-4).

3. **Channel cross-section geometry** shall be trapezoidal, triangular, parabolic, or segmental as shown in Figure 4.4.1.C (p. 4-63) through Figure 4.4.1.E (p. 4-65). **Side slopes** shall be no steeper than 3:1 for vegetation-lined channels and 2:1 for rock-lined channels. *Note: Roadside ditches shall comply with King County Road Standards.*

4. **Vegetation-lined channels** shall have **bottom slope gradients** of 6% or less and a **maximum velocity** at design flow of 5 fps (see Table 4.4.1.A, p. 4-55).

5. **Rock-lined channels or bank stabilization of natural channels** shall be used when design flow velocities exceed 5 feet per second. Rock stabilization shall be in accordance with Table 4.4.1.A (p. 4-55) or stabilized with bioengineering methods as described above in "Constructed Channels (p. 4-53).

AR 031959

TABLE 4.4.1.A CHANNEL PROTECTION				
Velocity at Design Flow (fps)		**REQUIRED PROTECTION**		
Greater than	**Less than or equal to**	**Type of Protection**	**Thickness**	**Minimum Height Above Design Water Surface**
0	5	Grass lining or bioengineered lining	N/A	
5	8	Rock lining[1] or bioengineered lining	1 foot	1 foot
8	12	Riprap[2]	2 feet	2 feet
12	20	Slope mattress gabion, etc.	Varies	2 feet

[1] Rock Lining shall be reasonably well graded as follows:

Maximum stone size: 12 inches
Median stone size: 8 inches
Minimum stone size: 2 inches

[2] Riprap shall be reasonably well graded as follows:

Maximum stone size: 24 inches
Median stone size: 16 inches
Minimum stone size: 4 inches

Note: Riprap sizing is governed by side slopes on channel, assumed to be approximately 3:1.

Riprap Design[7]

When riprap is set, stones are placed on the channel sides and bottom to protect the underlying material from being eroded. Proper riprap design requires the determination of the median size of stone, the thickness of the riprap layer, the gradation of stone sizes, and the selection of angular stones which will interlock when placed. Research by the U.S. Army Corps of Engineers has provided criteria for selecting the **median stone weight, W_{50}** (Figure 4.4.1.A, p. 4-57). If the riprap is to be used in a highly turbulent zone (such as at a culvert outfall, downstream of a stilling basin, at sharp changes in channel geometry, etc.), the median stone W_{50} should be increased from 200% to 600% depending on the severity of the locally high turbulence. The thickness of the riprap layer should generally be twice the **median stone diameter (D_{50})** or at least that of the maximum stone. The riprap should have a reasonably well graded assortment of stone sizes within the following gradation:

$$1.25 \leq D_{max}/D_{50} \leq 1.50$$

$$D_{15}/D_{50} = 0.50$$

$$D_{min}/D_{50} = 0.25$$

For a more detailed analysis and design procedure for riprap requiring water surface profiles and estimates of tractive force, refer to the paper by Maynord et al in *Journal of Hydraulic Engineering (A.S.C.E.)*, July 1989.

[7] From a paper prepared by M. Schaefer, Dam Safety Section, Washington State Department of Ecology.

AR 031960

Riprap Filter Design

Riprap should be underlain by a sand and gravel filter (or filter fabric) to keep the fine materials in the underlying channel bed from being washed through the voids in the riprap. Likewise, the filter material must be selected so that it is not washed through the voids in the riprap. Adequate filters can usually be provided by a reasonably well graded sand and gravel material where:

$D_{15} < 5d_{85}$

The variable d_{85} refers to the sieve opening through which 85% of the material being protected will pass, and D_{15} has the same interpretation for the filter material. A filter material with a D_{50} of 0.5 mm will protect any finer material including clay. Where very large riprap is used, it is sometimes necessary to use two filter layers between the material being protected and the riprap.

Example:

What embedded riprap design should be used to protect a streambank at a level culvert outfall where the outfall velocities in the vicinity of the downstream toe are expected to be about 8 fps?

From Figure 4.4.1.A (p. 4-57), $W_{50} = 6.5$ lbs, but since the downstream area below the outfall will be subjected to severe turbulence, increase W_{50} by 400% so that:

$W_{50} = 26$ lbs, $D_{50} = 8.0$ inches

The gradation of the riprap is shown in Figure 4.4.1.B (p. 4-58), and the minimum thickness would be 1 foot (from Table 4.4.1.A, p. 4-55); however, 16 inches to 24 inches of riprap thickness would provide some additional insurance that the riprap will function properly in this highly turbulent area.

Figure 4.4.1.B (p. 4-58) shows that the gradation curve for ASTM C33, size number 57 coarse aggregate (used in concrete mixes), would meet the filter criteria. Applying the filter criteria to the coarse aggregate demonstrates that any underlying material whose gradation was coarser than that of a concrete sand would be protected.

For additional information and procedures for specifying filters for riprap, refer to the *Army Corps of Engineers Manual EM 1110-2-1601 (1970), Hydraulic Design of Flood Control Channels,* Paragraph 14, "Riprap Protection."

AR 031961

FIGURE 4.4.1.A
MEAN CHANNEL VELOCITY VS. MEDIUM STONE WEIGHT (W_{50}) AND EQUIVALENT STONE DIAMETER

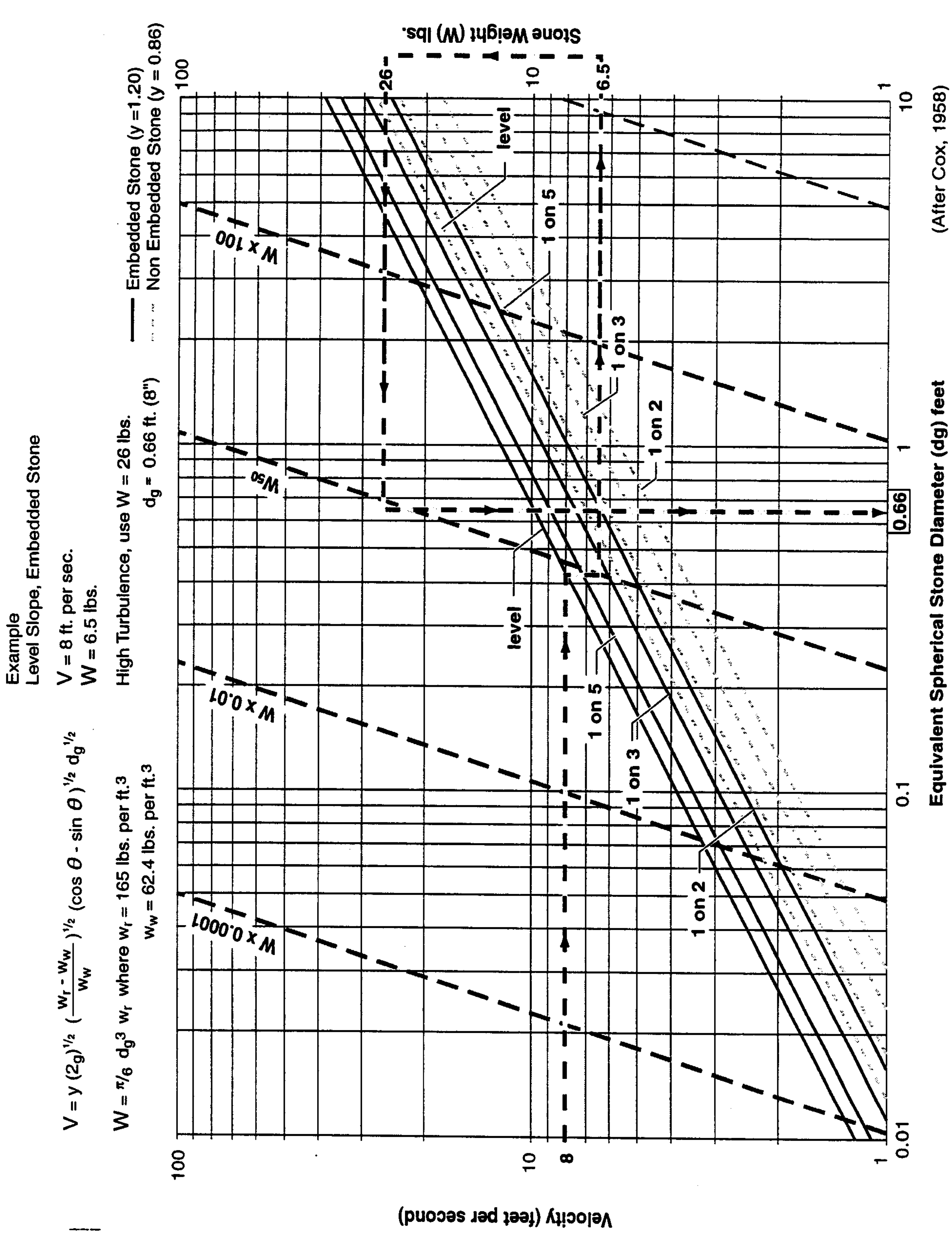

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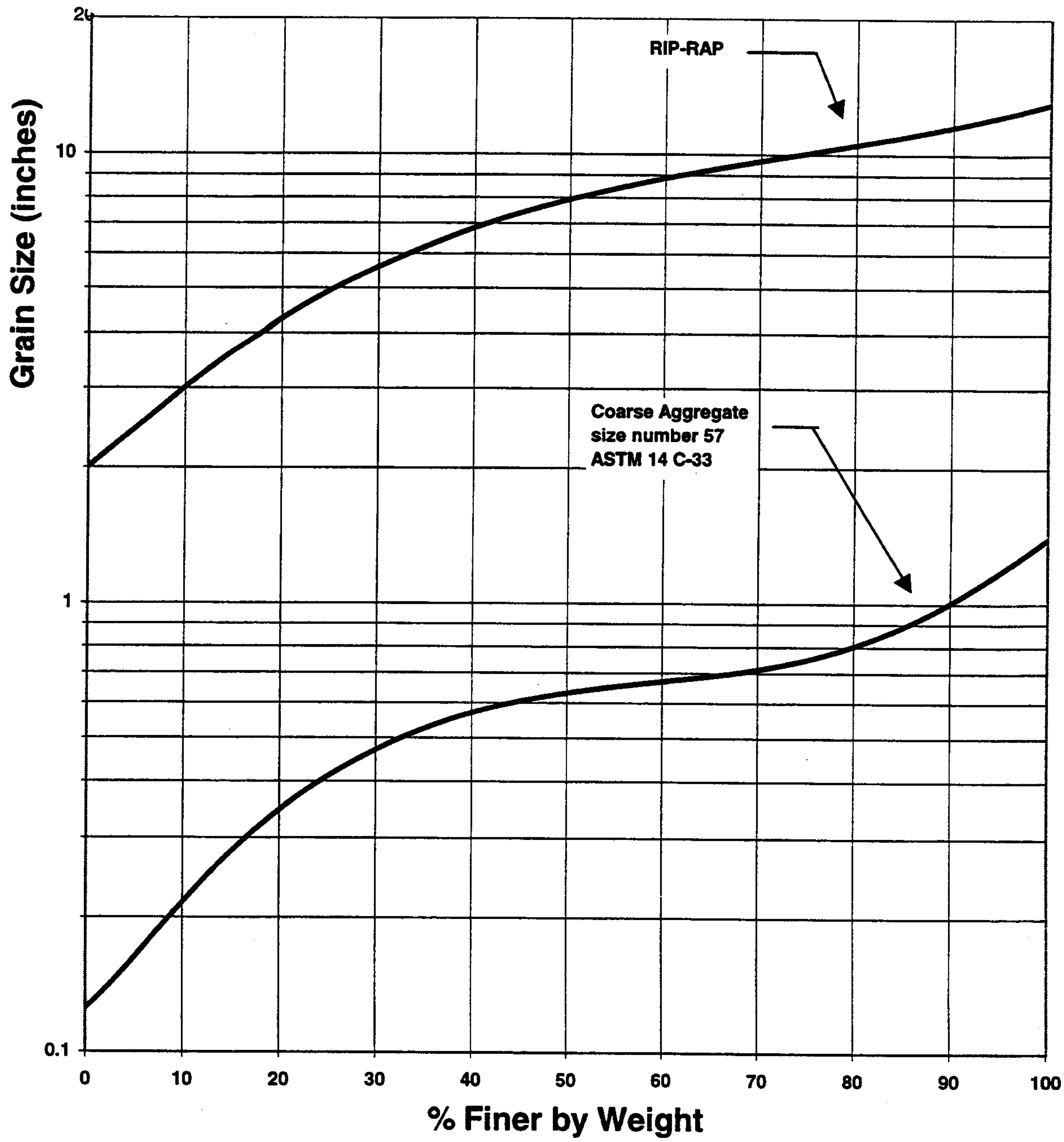
FIGURE 4.4.1.B RIPRAP GRADATION CURVE



AR 031963

4.4.1.2 METHODS OF ANALYSIS

This section presents the methods of analysis **for designing new or evaluating existing open channels** for compliance with the conveyance capacity requirements set forth in Section 1.2.4, "Core Requirement #4: Conveyance System."

❑ DESIGN FLOWS

Design flows for sizing and assessing the capacity of open channels shall be determined using the hydrologic analysis methods described in Chapter 3.

❑ CONVEYANCE CAPACITY

There are three acceptable methods of analysis for sizing and analyzing the capacity of open channels:

1. Manning's equation for preliminary sizing
2. Direct Step backwater method
3. Standard Step backwater method.

Manning's Equation for Preliminary Sizing

Manning's equation is used for preliminary sizing of open channel reaches of uniform cross section and slope (i.e., prismatic channels) and uniform roughness. This method assumes the flow depth (or normal depth) and flow velocity remain constant throughout the channel reach for a given flow.

The charts in Figure 4.4.1.C (p. 4-63) and Figure 4.4.1.D (p. 4-64) can be used to obtain graphic solutions of Manning's equation for common ditch sections. For conditions outside the range of these charts or for more precise results, Manning's equation can be solved directly from its classic forms shown in Equations (4-1) and (4-2) on page 4-18.

Table 4.4.1.B (p. 4-60) provides a reference for selecting the appropriate "*n*" values for open channels. A number of engineering reference books, such as *Open-Channel Hydraulics* by V.T. Chow (Table 5-6 and Figure 5-5), may also be used as guides to select "*n*" values. Figure 4.4.1.E (p. 4-65) contains the geometric elements of common channel sections useful in determining area *A*, wetted perimeter *WP*, and hydraulic radius (*R= A/WP*).

If flow restrictions occur which raise the water level above normal depth within a given channel reach, a *backwater condition* (or non-uniform flow) is said to exist. This condition can result from flow restrictions created by a downstream culvert, bridge, dam, pond, lake, etc., and even a downstream channel reach having a higher normal flow depth. If backwater conditions are found to exist for the design flow, a backwater profile must be computed to verify that the channel's capacity is still adequate as designed. The Direct Step or Standard Step backwater methods presented in this section can be used for this purpose.

AR 031964

TABLE 4.4.1.B VALUES OF ROUGHNESS COEFFICIENT "*n*" FOR OPEN CHANNELS

Type of Channel and Description	Manning's "*n*"* (Normal)
A. Constructed Channels	
a. Earth, straight and uniform	
1. Clean, recently completed	0.018
2. Gravel, uniform section, clean	0.025
3. With short grass, few weeds	0.027
b. Earth, winding and sluggish	
1. No vegetation	0.025
2. Grass, some weeds	0.030
3. Dense weeds or aquatic plants in deep channels	0.035
4. Earth bottom and rubble sides	0.030
5. Stony bottom and weedy banks	0.035
6. Cobble bottom and clean sides	0.040
c. Rock lined	
1. Smooth and uniform	0.035
2. Jagged and irregular	0.040
d. Channels not maintained, weeds and brush uncut	
1. Dense weeds, high as flow depth	0.080
2. Clean bottom, brush on sides	0.050
3. Same as #2, highest stage of flow	0.070
4. Dense brush, high stage	0.100
B. Natural Streams	
B-1 Minor streams (top width at flood stage < 100 ft.)	
a. Streams on plain	0.030
1. Clean, straight, full stage no rifts or deep pools	0.035
2. Same as #1, but more stones and weeds	0.040
3. Clean, winding, some pools and shoals	0.040
4. Same as #3, but some weeds	0.050
5. Same as #4, but more stones	
6. Sluggish reaches, weedy deep pools	0.070
7. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.100
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages	
1. Bottom: gravel, cobbles, and few boulders	0.040
2. Bottom: cobbles with large boulders	0.050
B-2 Floodplains	
a. Pasture, no brush	
1. Short grass	0.030
2. High grass	0.035
b. Cultivated areas	
1. No crop	0.030
2. Mature row crops	0.035
3. Mature field crops	0.040
c. Brush	
1. Scattered brush, heavy weeds	0.050
2. Light brush and trees	0.060
3. Medium to dense brush	0.070
4. Heavy, dense brush	0.100
d. Trees	
1. Dense willows, straight	0.150
2. Cleared land with tree stumps, no sprouts	0.040
3. Same as #2, but with heavy growth of sprouts	0.060
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.100
5. Same as #4, but with flood stage reaching branches	0.120

* *Note: These "n" values are "normal" values for use in analysis of channels. For conservative design for channel capacity, the maximum values listed in other references should be considered. For channel bank stability, the minimum values should be considered.*

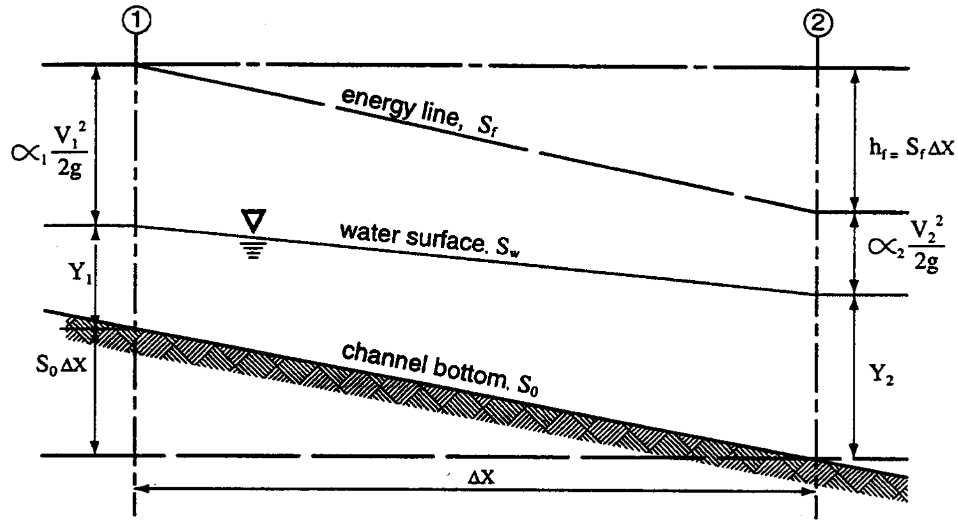
Direct Step Backwater Method

The Direct Step backwater method can be used to compute backwater profiles on prismatic channel reaches (i.e., reaches having uniform cross section and slope) where a backwater condition or restriction to normal flow is known to exist. The method can be applied to a series of prismatic channel reaches in secession beginning at the downstream end of the channel and computing the profile upstream.

AR 031965

Calculating the coordinates of the water surface profile using this method is an iterative process achieved by choosing a range of flow depths, beginning at the downstream end, and proceeding incrementally up to the point of interest or to the point of normal flow depth. This is best accomplished by the use of a table (see Figure 4.4.1.G, p. 4-67) or computer programs (as discussed on page 4-62, "Computer Applications").

To illustrate analysis of a single reach, consider the following diagram:



Equating the total head at cross sections 1 and 2, the following equation may be written:

$$S_o\Delta x + y_1 + \alpha_1 \frac{V_1^2}{2g} = y_2 + \alpha_2 \frac{V_2^2}{2g} + S_f\Delta x \qquad (4\text{-}11)$$

where,
- Δx = distance between cross sections (ft)
- y_1, y_2 = depth of flow (ft) at cross sections 1 and 2
- V_1, V_2 = velocity (fps) at cross sections 1 and 2
- α_1, α_2 = energy coefficient at cross sections 1 and 2
- S_o = bottom slope (ft/ft)
- S_f = friction slope = $(n^2V^2)/(2.21R^{1.33})$
- g = acceleration due to gravity, (32.2 ft/sec^2)

If the specific energy E at any one cross section is defined as follows:

$$E = y + \alpha \frac{V^2}{2g} \qquad (4\text{-}12)$$

and assuming $\alpha = \alpha_1 = \alpha_2$ where α is the energy coefficient which corrects for the non-uniform distribution of velocity over the channel cross section, Equations (4-11) and (4-12) can be combined and rearranged to solve for Δx as follows:

$$\Delta x = (E_2 - E_1)/(S_o - S_f) = \Delta E/(S_o - S_f) \qquad (4\text{-}13)$$

AR 031966

Typical values of the energy coefficient α are as follows:

Channels, regular section	1.15
Natural streams	1.3
Shallow vegetated flood fringes (includes channel)	1.75

For a given flow, channel slope, Manning's "n," and energy coefficient α, together with a beginning water surface elevation y_2, the values of Δx may be calculated for arbitrarily chosen values of y_1. The coordinates defining the water surface profile are obtained from the cumulative sum of Δx and corresponding values of y.

The **normal flow depth y_n** should first be calculated from Manning's equation to establish the upper limit of the backwater effect.

Standard Step Backwater Method

The Standard Step Backwater Method is a variation of the Direct Step Backwater Method and can be used to compute backwater profiles on both prismatic and non-prismatic channels. In this method, stations are established along the channel where cross section data is known or has been determined through field survey. The computation is carried out in steps from station to station rather than throughout a given channel reach as is done in the Direct Step method. As a result, the analysis involves significantly more trial-and-error calculation in order to determine the flow depth at each station.

Computer Applications

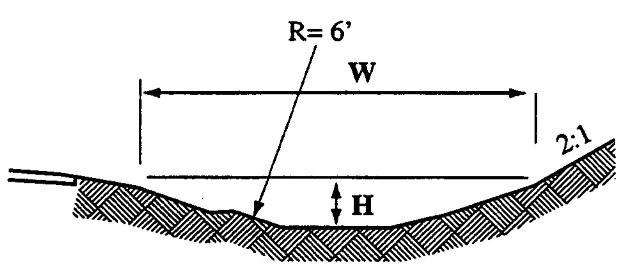
Because of the iterative calculations involved, use of a computer to perform the analysis is recommended. The **King County Backwater (KCBW) computer program** included in the software package available with this manual, includes a subroutine, **BWCHAN**, based on the Standard Step backwater method, which can be used for all channel capacity analysis. It can also be combined with the **BWPIPE** and **BWCULV** subroutinesBackwater computer programBackwater computer program, to analyze an entire drainage conveyance system. A schematic description of the nomenclature used in the **BWCHAN** subroutine is provided in Figure 4.4.1.H (p. 4-68). See the KCBW program documentation for further information.

AR 031967

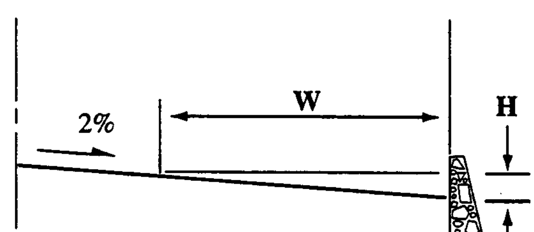
FIGURE 4.4.1.C DITCHES — COMMON SECTIONS

PROPERTIES OF DITCHES

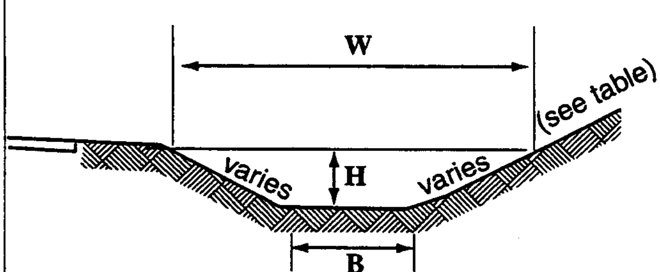
	DIMENSIONS				HYDRAULICS			
NO.	Side Slopes	B	H	W	a	p	R	$R^{(2/3)}$
D-1	--	--	6.5"	5'-0"	1.84	5.16	0.356	0.502
D-1C	--	--	6"	25'-0"	6.25	25.50	0.245	0.392
D-2A	1.5:1	2'-0"	1'-0"	5'-0"	3.50	5.61	0.624	0.731
B	2:1	2'-0"	1'-0"	6'-0"	4.00	6.47	0.618	0.726
C	3:1	2'-0"	1'-0"	8'-0"	5.00	8.32	0.601	0.712
D-3A	1.5:1	3'-0"	1'-6"	7'-6"	7.88	8.41	0.937	0.957
B	2:1	3'-0"	1'-6"	9'-0"	9.00	9.71	0.927	0.951
C	3:1	3'-0"	1'-6"	12'-0"	11.25	12.49	0.901	0.933
D-4A	1.5:1	3'-0"	2'-0"	9'-0"	12.00	10.21	1.175	1.114
B	2:1	3'-0"	2'-0"	11'-0"	14.00	11.94	1.172	1.112
C	3:1	3'-0"	2'-0"	15'-0"	18.00	15.65	1.150	1.098
D-5A	1.5:1	4'-0"	3'-0"	13'-0"	25.50	13.82	1.846	1.505
B	2:1	4'-0"	3'-0"	16'-0"	30.00	16.42	1.827	1.495
C	3:1	4'-0"	3'-0"	22'-0"	39.00	21.97	1.775	1.466
D-6A	2:1	--	1'-0"	4'-0"	2.00	4.47	0.447	0.585
B	3:1	--	1'-0"	6'-0"	3.00	6.32	0.474	0.608
D-7A	2:1	--	2'-0"	8'-0"	8.00	8.94	0.894	0.928
B	3:1	--	2'-0"	12'-0"	12.00	12.65	0.949	0.965
D-8A	2:1	--	3'-0"	12'-0"	18.00	13.42	1.342	1.216
B	3:1	--	3'-0"	18'-0"	27.00	18.97	1.423	1.265
D-9	7:1	--	1'-0"	14'-0"	7.00	14.14	0.495	0.626
D-10	7:1	--	2'-0"	28'-0"	28.00	28.28	0.990	0.993
D-11	7:1	--	3'-0"	42'-0"	63.00	42.43	1.485	1.302



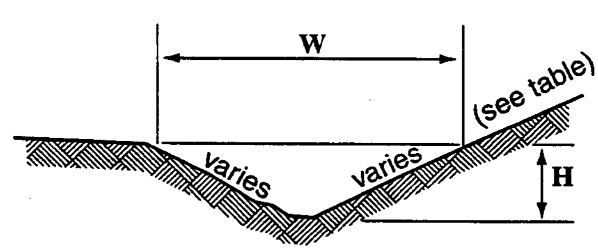
D-1 Segmental (parabolic)



D-1c Curbed crowned street



D-2, D-3, D-4, D-5 Trapezoidal



Isosceles triangular D-6 through D-11

AR 031968

FIGURE 4.4.1.D DRAINAGE DITCHES — COMMON SECTIONS

NOTE: A) Chart based on Manning formula Q=1.49/n*A*R2/3*S1/2 with n=0.030, except D-1C which is based on n=0.015. For other values of n, multiply discharge by 0.030/n

B) 1 indicates a velocity of 1 ft. per sec.

Example: Given- Slope=3.3' per 1000', discharge=6.3 c.f.s., n=0.025. Required- Size of ditch and velocity. Solution- To use chart, multiply discharge, 6.3 by (.03/.025) = 7.56 c.f.s. Point satisfying given conditions lies between lines for D-2A and D-2B. Select larger of the two ditches, in this case D-2B. Velocity approx. 2.1 ft. per sec.

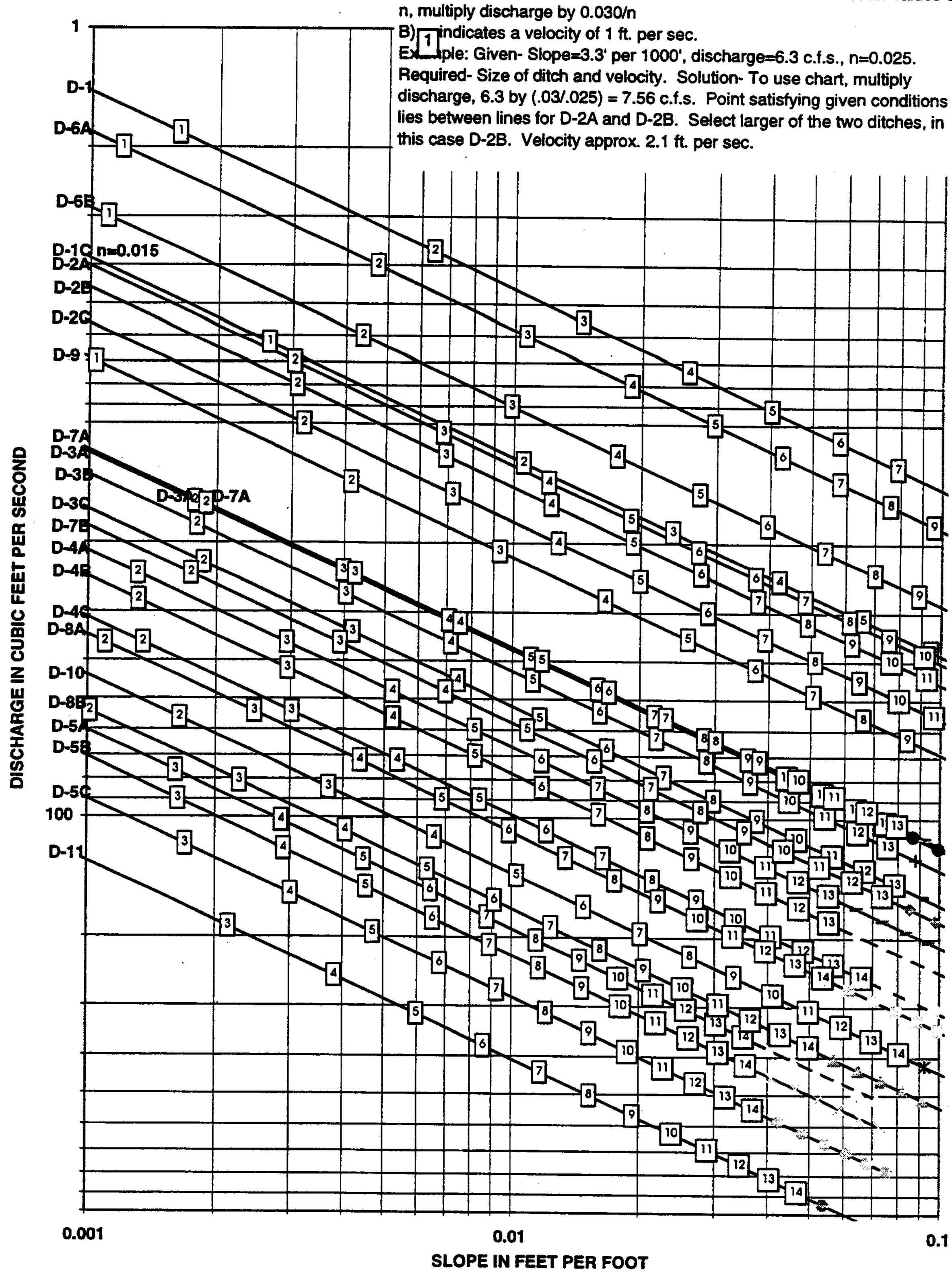


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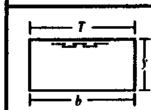
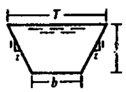
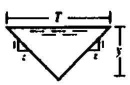
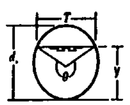
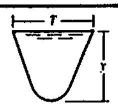
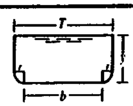
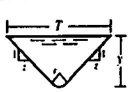
FIGURE 4.4.1.E GEOMETRIC ELEMENTS OF COMMON SECTIONS

Section	Area A	Wetted perimeter P	Hydraulic radius R	Top width W	Hydraulic depth D	Section factor Z
 Rectangle	by	$b + 2y$	$\frac{by}{b + 2y}$	b	y	$by^{1.5}$
 Trapezoid	$(b + zy)y$	$b + 2y\sqrt{1 + z^2}$	$\frac{(b + zy)y}{b + 2y\sqrt{1 + z^2}}$	$b + 2zy$	$\frac{(b + zy)y}{b + 2zy}$	$\frac{[(b + zy)y]^{1.5}}{\sqrt{b + 2zy}}$
 Triangle	zy^2	$2y\sqrt{1 + z^2}$	$\frac{zy}{2\sqrt{1 + z^2}}$	$2zy$	${}^1/_2 y$	$\frac{\sqrt{2}}{2} zy^{2.5}$
 Circle	${}^1/_8(\theta - \sin\theta)d_o^2$	${}^1/_2 \theta d_o$	${}^1/_4(1 - \frac{\sin\theta}{\theta})d_o$	$(\sin({}^1/_2\theta)d_o)$ *or* $2\sqrt{y(d_o - y)}$	${}^1/_8\left(\frac{\theta - \sin\theta}{\sin{}^1/_2\theta}\right)d_o$	$\frac{\sqrt{2}}{32}\frac{(\theta - \sin\theta)^{1.5}}{(\sin{}^1/_2\theta)^{0.5}}d_o^{2.5}$
 Parabola	${}^2/_3 Ty$	$T + \frac{8y^2}{3T}$ *	$\frac{2T^2 y}{3T^2 + 8y^2}$ *	$\frac{3A}{2y}$	${}^2/_3 y$	${}^2/_9\sqrt{6}Ty^{1.5}$
 Round-cornered Rectangle (y>r)	$(\frac{\pi}{2} - 2)r^2 + (b + 2r)y$	$(\pi - 2)r + b + 2y$	$\frac{(\frac{\pi}{2} - 2)r^2 + (b + 2r)y}{(\pi - 2)r + b + 2y}$	$b + 2r$	$\frac{(\frac{\pi}{2} - 2)r^2}{(b + 2r)} + y$	$\frac{[(\frac{\pi}{2} - 2)r^2 + (b + 2r)y]^{1.5}}{\sqrt{b + 2y}}$
 Round-bottomed Triangle	$\frac{T^2}{4z} - \frac{r^2}{z}(1 - z\cot^{-1}z)$	$\frac{T}{z}\sqrt{1 + z^2} - \frac{2r}{z}(1 - z\cot^{-1}z)$	$\frac{A}{P}$	$2[z(y - r) + r\sqrt{1 + z^2}]$	$\frac{A}{T}$	$A\sqrt{\frac{A}{T}}$

*Satisfactory approximation for the interval 0<x≤1, where x=4y/T. When x>1, use the exact expression $P = ({}^T/_2)\left[\sqrt{1 + x^2} + {}^1/_x \ln\left(x + \sqrt{1 + x^2}\right)\right]$

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FIGURE 4.4.1.F OPEN CHANNEL FLOW PROFILE COMPUTATION

Q = ________ n = ________ S_o = ________ α = ________ Y_n = ________

y (1)	A (2)	R (3)	$R^{4/3}$ (4)	V (5)	$\alpha V^2/2g$ (6)	E (7)	ΔE (8)	S_f (9)	$\bar{S}_f$ (10)	$S_o - \bar{S}_f$ (11)	Δx (12)	x (13)

FIGURE 4.4.1.G DIRECT STEP BACKWATER METHOD - EXAMPLE

y (1)	A (2)	R (3)	$R^{4/3}$ (4)	V (5)	$\alpha V^2/2g$ (6)	E (7)	ΔE (8)	S_f (9)	$\bar{S}_f$ (10)	$S_o - \bar{S}_f$ (11)	Δx (12)	x (13)
6.0	72.0	2.68	3.72	0.42	0.0031	6.0031	-	0.00002	-	-	-	-
5.5	60.5	2.46	3.31	0.50	0.0040	5.5040	0.4990	0.00003	0.000025	0.00698	71.50	71.5
5.0	50.0	2.24	2.92	0.60	0.0064	5.0064	0.4976	0.00005	0.000040	0.00696	71.49	142.99
4.5	40.5	2.01	2.54	0.74	0.0098	4.5098	0.4966	0.00009	0.000070	0.00693	71.64	214.63
4.0	32.0	1.79	2.17	0.94	0.0157	4.0157	0.4941	0.00016	0.000127	0.00687	71.89	286.52
3.5	24.5	1.57	1.82	1.22	0.0268	3.5268	0.4889	0.00033	0.000246	0.00675	72.38	358.90
3.0	18.0	1.34	1.48	1.67	0.0496	3.0496	0.4772	0.00076	0.000547	0.00645	73.95	432.85
2.5	12.5	1.12	1.16	2.40	0.1029	2.6029	0.4467	0.00201	0.001387	0.00561	79.58	512.43
2.0	8.0	0.89	0.86	3.75	0.2511	2.2511	0.3518	0.00663	0.004320	0.00268	131.27	643.70

The step computations are carried out as shown in the above table. The values in each column of the table are explained as follows:

Col. 1. Depth of flow (ft) assigned from 6 to 2 feet

Col. 2. Water area (ft^2) corresponding to depth y in Col. 1

Col. 3 Hydraulic radius (ft) corresponding to y in Col. 1

Col. 4. Four-thirds power of the hydraulic radius

Col. 5. Mean velocity (fps) obtained by dividing Q (30 cfs) by the water area in Col. 2

Col. 6. Velocity head (ft)

Col. 7. Specific energy (ft) obtained by adding the velocity head in Col. 6 to depth of flow in Col. 1

Col. 8. Change of specific energy (ft) equal to the difference between the E value in Col. 7 and that of the previous step.

Col. 9. Friction slope S_f, computed from V as given in Col. 5 and $R^{4/3}$ in Col. 4

Col.10. Average friction slope between the steps, equal to the arithmetic mean of the friction slope just computed in Col. 9 and that of the previous step

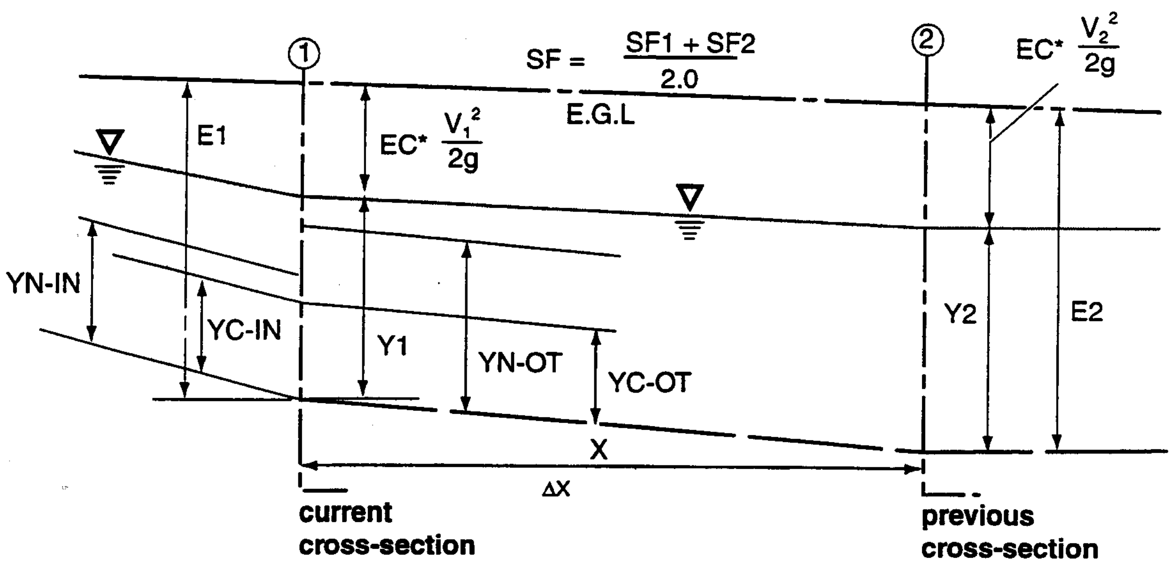
Col.11. Difference between the bottom slope, S_o, and the average friction slope, $\bar{S}_f$

Col.12. Length of the reach (ft) between the consecutive steps;
Computed by $\Delta x = \Delta E/(S_o - \bar{S}_f)$ or by dividing the value in Col. 8 by the value in Col. 11

Col.13. Distance from the beginning point to the section under consideration. This is equal to the cumulative sum of the values in Col. 12 computed for previous steps.

There are a number of commercial software programs for use on personal computers that use variations of the Standard Step backwater method for determining water surface profiles. The most common and widely accepted program is called HEC-2, published and supported by the United States Army Corps of Engineers Hydraulic Engineering Center. It is the model required by FEMA for use in performing flood hazard studies for preparing flood insurance maps. Other programs include WSP-2, published by the SCS, and WSPRO or E-431, published by USGS.

FIGURE 4.4.1.H BWCHAN COMPUTER SUBROUTINE - VARIABLE DEFINITIONS



	BWCHAN – VARIABLE DEFINITIONS
YC-IN	Critical Depth (ft) at current section based on ***incoming*** flow rate.
YC-OUT	Critical Depth (ft) at current section based on ***outgoing*** flow rate.
YN-IN	Normal Depth (ft) at current section based on ***incoming*** flow rate/channel grade.
YN-OUT	Normal Depth (ft) at current section based on ***outgoing*** flow rate/channel grade.
Y1	Final Water Depth (ft) at current cross section
N-Y1	Composite n-factor of current section for final depth, Y1.
A-Y1	Cross-sectional Area of current section for final depth, Y1.
WP-Y1	Wetted Perimeter (ft) of current section for final depth, Y1.
V-Y1	Average Velocity (fps) of current section for final depth, Y1.
E1	Total Energy Head (ft) at current section $\left(Y1+EC*V_1^2/2g\right)$
E2	Total Energy Head (ft) at pervious or downstream section.
SF1	Friction Slope of current section.
SF2	Friction Slope of previous or downstream section.
DXY	Distance (expressed as a fraction of the current reach length) from the previous or downstream section to where the flow profile would intersect the final water depth, Y1, assuming Y1 were to remain constant
EC	Energy Coefficient "α"
Q-TW	The flow rate used to determine Tailwater Height from an inputted HW/TW Data File.
TW-HT	Tailwater Height.
Q-Y1	Flow rate (cfs) in channel at current section, for depth, Y1
VU-Y1	Upstream Velocity (fps) at current section for depth, Y1 ("Adjust" option).
V1-HD	Channel Velocity Head (ft) at current section.
VU-HD	Upstream Velocity Head (ft) at current section.

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4.4.2 FLOODPLAIN/FLOODWAY ANALYSIS

This section describes the flood hazard studies required by Special Requirement #2, Floodplain/Floodway Delineation, in Section 1.3.2. Flood hazard studies establish base flood elevations and delineate floodplains and/or floodways when a proposed project contains or is adjacent to a stream, lake, wetland, or closed depression. Furthermore, when development is proposed within the floodplain, the flood hazard study is used to show compliance with Sensitive Areas Ordinance (SAO) flood hazard area regulations. *Note that flood hazard studies are generally not required when an approved flood hazard study, such as shown on a Federal Emergency Management Administration (FEMA) Flood Insurance Rate Map (FIRM), exists for the site.*

There are two types of flood hazard studies:

1. **Minor floodplain studies** are acceptable where development is not proposed within a floodplain. In some instances, minor floodplain studies may also be required to evaluate floodplains associated with existing drainage channels or culvert headwaters. Minor floodplain studies determine an **assumed base flood elevation**, and the entire site below this elevation (i.e., within the floodplain) is assumed to be floodway. The portion of the site below the base flood elevation must be designated as a floodplain and a Sensitive Area Notice on Title recorded for the site.

   An exception to minor floodplain studies is provided for proposals where topographical relief is sufficient to clearly preclude the possibility of flooding (see Section 4.4.2.1 below). Application of the exception also establishes an assumed base flood elevation and requires a Notice on Title.

2. **Major flood hazard studies** are required only if development is proposed within the floodplain. The SAO applies different regulations to development within the flood fringe and the floodway. Therefore, if development is proposed within the floodplain, a major flood hazard study is required to both **establish the base flood elevation and delineate the floodway**. Since major flood hazard studies must comply with FEMA regulations, these studies may also be used in support of a FEMA Letter of Map Revision or Letter of Map Amendment.

4.4.2.1 MINOR FLOODPLAIN STUDIES

For streams without an approved floodplain or flood hazard study, or **for drainage ditches or culvert headwaters**, the floodplain shall be determined using the Direct Step backwater method, Standard Step backwater method, or the King County Backwater computer program.

For lakes, wetlands, and closed depressions without an approved floodplain or flood hazard study, the floodplain shall be determined using the point of compliance technique described in Section 3.3.6.

Exception: In lieu of a minor floodplain study, the applicant may submit an engineering plan[8] showing the proposed building site located at an elevation at least 10 feet above the ordinary high water mark of a stream, lake, or wetland, or 2 feet above the downstream overflow elevation of a conveyance system, stream, lake, wetland, or closed depression, whichever is less, subject to the following conditions:

1. The design engineer preparing the engineering plan shall provide a narrative describing his/her level of confidence in the assumed base flood elevation. The narrative must include, but is not limited to, an assessment of potential backwater effects (such as might result from nearby river flooding, for example); observations and/or anecdotal information on water surface elevations during previous flood events; and an assessment of potential for significantly higher future flows at basin buildout. (*Note: Many of these issues will have been addressed in a Level 1 downstream analysis, if required.*) Where there is any doubt, expressed by either the engineer or DDES staff, that the actual base flood elevation may be higher than the assumed base flood elevation, this exception shall not apply.

[8] In some instances, DDES engineering review staff may determine that the proposed project is sufficiently above the clearances specified in this exception and may not require an engineering plan. Typically, this is done for projects in Small Site Drainage Review that clearly exceed minimum clearances and otherwise would not require engineering design.

2. The area of the proposed project site that is at or below the assumed base flood elevation must be delineated and designated as a floodplain, and a Sensitive Area Notice on Title must be recorded for the site. For single family residential permits, the assumed floodplain need not be delineated, but a Notice on Title must be recorded stating that a floodplain exists, and the assumed base flood elevation must be noted if determined.

The **intent of this exception** is to reduce required analysis in those situations where proposals may be adjacent to or contain a flood hazard area, but by virtue of significant topographical relief are clearly in no danger of flooding. The minimum 10 feet of separation from ordinary high water reduces analysis for those proposals adjacent to streams confined to deep channels or ravines, or near lakes or wetlands.

The 2 feet above downstream overflow elevation is intended to protect projects located upstream of drainage systems that may become plugged, such as roadway culverts, or for projects near lakes, wetlands, or closed depressions.

4.4.2.2 MAJOR FLOOD HAZARD STUDIES

Major flood hazard studies must conform to FEMA regulations described in Part 65 of 44 Code of Federal Regulations (CFR). In addition, the following information must be provided and procedures performed for major flood hazard studies used under the SAO to examine development proposals or improvements within a floodplain.

❑ INFORMATION REQUIRED

The following information is required for review of a floodplain/floodway analysis in addition to that required for the drainage plan of a proposed project.

Floodplain/Floodway Map

A major flood hazard study requires submittal of five copies of a separate floodplain/floodway map stamped by a licensed civil engineer and a professional land surveyor registered in the State of Washington (for the base survey). The map must accurately locate any proposed development with respect to the floodplain and floodway, the channel of the stream, and existing development in the floodplain; it must also supply all pertinent information such as the nature of any proposed project, legal description of the property on which the project would be located, fill quantity, limits and elevation, the building floor elevations, flood-proofing measures, and any use of compensatory storage.

The map must show elevation contours at a minimum of 2-foot vertical intervals and shall comply with survey and map guidelines published in the FEMA publication *Guidelines and Specifications for Study Contractors*. The map must show the following:

- elevations and ground contours;
- elevations and dimensions of existing structures, fill, and compensatory storage areas;
- size, location, elevation, and spatial arrangement of all proposed structures on the site;
- location and elevations of roadways, water supply lines, and sanitary sewer facilities.

Study Report

A major flood hazard study also requires submittal of two copies of a study report, stamped by a licensed civil engineer, which must include calculations or any computer analysis input and output information as well as the following additional information:

1. Valley **cross sections** showing the channel of the stream, the floodplain adjoining each side of the channel, the computed floodway, the cross-sectional area to be occupied by any proposed development, and all historic high water information.

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2. **Profiles** showing the bottom of the channel, the top of both left and right banks, and existing and proposed base flood water surfaces.
3. Plans and specifications for **flood-proofing** any structures, construction areas, filling, dredging, channel improvement, storage of materials, water supply, and sanitary facilities within the floodplain.
4. Complete **printout of input and output for HEC-2**. Liberal use of comments will assist in understanding model logic and prevent review delays.
5. One ready-to-run **digital copy of each HEC-2 input file** used in the study. Data shall be submitted on a disk in standard ASCII format, ready for use on an IBM-compatible PC.

❑ DETERMINING FLOOD FLOWS

The **three techniques** used to determine the flows used in the analysis depend on whether gage data is available or whether a basin plan has been adopted. The first technique is for basins in adopted basin plan areas. The second technique is used if a gaging station exists on the stream. The third technique is used on ungaged catchments or those with an insufficient length of record. In all cases, the engineer shall be responsible for assuring that the hydrologic methods used are technically reasonable and conservative, conform to the *Guidelines and Specifications for Study Contractors*, and are acceptable by FEMA.

Flood Flows from Adopted Basin Plan Information

For those areas where King County has adopted a basin plan since 1986, flood flows may be determined using information from the adopted basin plan. The hydrologic model used in the basin plan shall be updated to include the latest changes in zoning, or any additional information regarding the basin which has been acquired since the adoption of the basin plan.

Flood Flows from Stream Gage Data

Determining flood flows from stream gage data uses the Log-Pearson Type III distribution method as described in *Guidelines for Determining Flood Flow Frequency*, Bulletin 17B of the Hydrology Committee, United States Water Resources Council, (revised September 1981). Contact FEMA to verify use of this technique.

1. This technique may only be used if data from a gaging station in the basin is available for a period of at least ten years.
2. If the difference in the drainage area on the stream at the study site and the drainage area to a gaging station on the stream at a different location in the same basin is less than or equal to 50 percent, the flow at the study site shall be determined by transferring the calculated flow at the gage to the study site using a drainage area ratio raised to the 0.86 power, as in the following equation:

$$Q_{SS} = Q_G (A_{SS}/A_G)^{0.86} \tag{4-14}$$

where Q_{SS} = estimated flow for the given return frequency on the stream at the study site
Q_G = flow for the given return frequency on the stream at the gage site
A_{SS} = drainage area tributary to the stream at the study site
A_G = drainage area tributary to the stream at the gage site

3. If the difference in the drainage area at the study site and the drainage area at a gaging station in the basin is more than 50 percent and a basin plan has not been prepared, a continuous model shall be used as described below to determine flood flows at the study site.
4. In all cases where dams or reservoirs, floodplain development, or land use upstream may have altered the storage capacity or runoff characteristics of the basin so as to affect the validity of this technique, a continuous model shall be used to determine flood flows at the study site.

Flood Flows from a Calibrated Continuous Model

Flood flows may be determined by utilizing a continuous flow simulation model such as HSPF. Where flood elevations or stream gaging data are available, the model shall be calibrated; otherwise, regional parameters[9] may be used.

❑ DETERMINING FLOOD ELEVATIONS, PROFILES, AND FLOODWAYS

Reconnaissance

The applicant's design engineer is responsible for the collection of all existing data with regard to flooding in the study area. This shall include a literature search of all published reports in the study area and adjacent communities, and an information search to obtain all unpublished information on flooding in the immediate and adjacent areas from federal, state, and local units of government. This search shall include specific information on past flooding in the area, drainage structures such as bridges and culverts that affect flooding in the area, available topographic maps, available community maps, photographs of past flood events, and general flooding problems within the community. A field reconnaissance shall be made by the applicant's design engineer to determine hydraulic conditions of the study area, including type and number of structures, locations of cross sections, and other parameters, including the roughness values necessary for the hydraulic analysis.

Base Data

Cross sections used in the hydraulic analysis shall be obtained by surveying. Topographic information obtained from aerial photographs may be used in combination with surveyed cross sections in the hydraulic analysis. The **elevation datum** of all information used in the hydraulic analysis shall be verified. All information shall be referenced directly to **NAVD 1988** (and include local correlation to NGVD) unless otherwise approved by King County. See Table 4.4.2.C (p. 4-75) for correlations of other datum to NAVD 1988.

Methodology

Flood profiles and floodway studies shall be calculated using the U.S. Army Corps of Engineers' HEC-2 computer model (or subsequent revisions).

Floodway Determination

King County recognizes two distinct floodway definitions. The *FEMA floodway* describes the limit to which encroachment into the natural conveyance channel can cause one foot or less rise in water surface elevation. The *zero-rise floodway* is based upon the limit to which encroachment can occur without detectable water surface elevation or energy grade line changes.

1. **FEMA floodways** are determined through the procedures outlined in the FEMA publication *Guidelines and Specifications for Study Contractors* using the 1-foot maximum allowable rise criteria.
2. **Transitions** shall take into account obstructions to flow such as road approach grades, bridges, piers, or other restrictions. General guidelines for transitions may be found in *HEC-2, Water Surface Profiles-Users Manual, Appendix IV, Application of HEC-2 Bridge Routines*, published by the Hydrologic Engineering Center, Davis, California.
3. **Zero-rise floodways** are assumed to include the entire 100-year floodplain until King County approves a detailed study which defines a zero-rise floodway.
4. **Zero-rise means no detectable change in water surface elevation or energy grade line.** For changes between the unencroached condition and encroachment to the zero-rise floodway, HEC-2 must report 0.00 as both the change in water surface elevation (DIFWSP) and the change in energy

[9] Dinacola, 1990. U.S.G.S., Charaterization and Simulation of Rainfall-Runoff Relations for Headwater Basins in Western King and Snohomish Counties, Washington.

grade (DIFEG). HEC-2 must further report the exact same elevations for both the computed water surface (CWSEL) and energy grade (EG).

5. Floodway studies must reflect the transitions mentioned in Requirement 2 above. **Floodway boundaries** are to follow stream lines, and should reasonably balance the rights of property owners on either side of the floodway. Use of the automatic equal conveyance encroachment options in the HEC-2 program will be considered equitable. For zero-rise floodway studies, or where HEC-2 automatic options are otherwise not appropriate, the floodway must be placed to minimize the top width of the floodway.

6. Floodway studies submitted for King County review must include the **HEC-2 output summary tables** called by:

   J3 38 43 1 3 50 61 53 27 21 22

   J3 28 54 110 150

   The J3 output variables include the following:

   38 SECND: Cross section identification number which identifies the location of all other data in the table row

   43 Q: Steady-state flow past cross section in cubic feet per second

   1 CWSEL: Computed water surface elevation at cross section

   3 EG: Energy grade at cross section

   50 DIFWSP: Difference between two profiles' water surface elevation at one cross section (e.g., difference between natural and encroached water surface)

   61 DIFEG: Difference between two profiles' energy grade at one cross section

   53 SSTA: Starting station where water surface intersects the ground (leftmost edge of floodplain)

   27 STENCL: Station of encroachment left of the channel

   21 STCHL: Station of channel's left bank

   22 STCHR: Station of channel's right bank

   28 STENCR: Station of encroachment right of the channel

   54 ENDST: Ending station where the water surface intersects the ground (rightmost edge of floodplain)

   110 HEC-2 standard encroachment data table

   150 HEC-2 standard summary (two tables).

Previous Floodplain Studies

If differences exist between a study previously approved by the County and the applicant's design engineer's calculated hydraulic floodways or flood profiles, the design engineer shall provide justification and obtain County approval for these differences.

Calculation of Flow Profile

For zero-rise analysis, the flow profile shall be computed and reported to the nearest 0.01 foot. While absolute water surfaces cannot be predicted with such accuracy on dynamic river and stream systems, zero-rise analysis requires only comparisons of modeled hydraulics for the existing and proposed conditions. Such comparisons are independent of natural dynamics and are not limited by the accuracy of the model's absolute water surface predictions.

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Adequacy of Hydraulic Model

The County considers the following factors when determining the adequacy of the hydraulic model and flow profiles for use in floodway analysis:

1. Cross section spacing
2. Differences in energy grade

   Note: Significant differences in the energy grade from cross section to cross section are an indication that cross sections should be more closely spaced or that other inaccuracies exist in the hydraulic model.

3. Methods for analyzing the hydraulics of structures such as bridges and culverts
4. Lack of flow continuity
5. Use of a gradually-varied flow model

   Note: In certain circumstances (such as weir flow over a levee or dike, flow through the spillway of a dam, or special applications of bridge flow), rapidly-varied flow techniques shall be used in combination with a gradually-varied flow model.

6. Manning's "*n*" values
7. Calibration of the hydraulic model with past flood events
8. Special applications. In some cases, HEC-2 alone may not be sufficient for preparing the floodplain/floodway analysis. This may occur where sediment transport, two-dimensional flow, or other unique hydraulic circumstances affect the accuracy of the HEC-2 hydraulic model. In these cases, the applicant shall obtain County approval of other methods proposed for establishing the water surface profiles.

TABLE 4.4.2.C DATUM CORRELATIONS

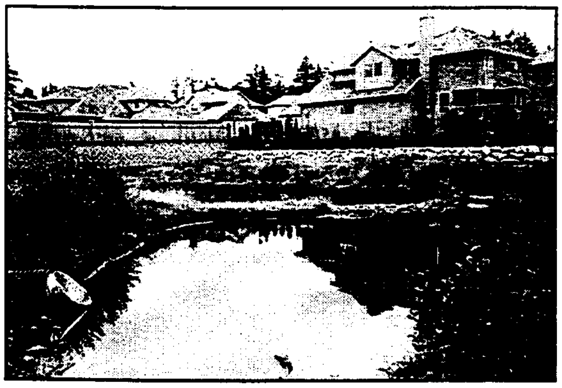
Correlation From ⟶ To	(Snoq. Valley) NAVD 1988*	KCAS	U.S. Engineers	City of Seattle	NGVD, USGS & USC & GS 1947	Seattle Area Tide Tables & Navigation Charts 1954 & Later
NAVD 1988* (Snoqualmie Valley)	--	-3.58	3.44	-9.54	-3.49	2.98
KCAS	3.58	--	7.02	-5.96	0.09	6.56
U.S. Engineers	-3.44	-7.02	--	-12.98	-6.93	-0.46
City of Seattle	9.54	5.96	12.98	--	6.05	12.52
NGVD, USGS & USC& GS 1947 (adjusted to the 1929 datum)	3.49	-0.09	6.93	-6.05	--	6.47
Seattle Area Tide Tables & Navigation Charts 1954 & Later (based on epoch 1924-1942)	-2.98	-6.56	0.46	-12.52	-6.47	--
Design Tidal Tailwater Elevation	12.08	8.50	15.52	2.54	8.59	15.06
Mean Higher High Water (MHHW)	8.34	4.76	11.78	-1.20	4.85	11.32
Mean High Water (MHW)	7.49	3.91	10.93	-2.05	4.00	10.47
Mean Low Water (MLW)	-0.16	-3.74	3.28	-9.70	-3.65	2.82
Mean Lower Low Water (MLLW)	-2.98	-6.56	0.46	-12.52	-6.47	0.00

*Varies, correlation is for Snoqualmie Valley.
Note: Contact King County Department of Transportation (KC-DOT) Survey Division for datum correlation for other areas.

Chapter 5

CHAPTER 5

FLOW CONTROL DESIGN



KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

CHAPTER 5

FLOW CONTROL DESIGN

This chapter presents the King County approved methods, criteria, and details for hydraulic analysis and design of flow control facilities, roof downspout controls, and flow control Best Management Practices (BMPs) pursuant to Core Requirement #3, "Flow Control" (see Section 1.2.3). *Flow control facilities*, as described in this manual, are detention or infiltration facilities engineered to meet a specified discharge performance. *Roof downspout controls* are infiltration or dispersion systems required on all lots of proposed plats and short plats in conjunction with, and in addition to, required flow control facilities.

Flow control BMPs are simple methods and designs for dispersing and reducing runoff from developed areas.

Four terms are commonly used to describe flow control facilities in King County: detention facilities, retention facilities, infiltration facilities, and R/D (Retention/Detention) facilities. A *detention facility*, by definition, temporarily stores surface water runoff and discharges it at a reduced rate. A *retention facility* stores water longer and effectively has no surface outflow (outflow occurs by evaporation or soaking into the ground). *Infiltration facilities* are retention facilities that rely entirely on the soaking of collected surface water into the ground. The term *R/D facility* has been used in previous versions of this manual to generally refer to all flow control facilities.

Chapter Organization

The information in this chapter is organized into the following four main sections:

- Section 5.1, "Roof Downspout Controls" (p. 5-3)
- Section 5.2, "Flow Control BMPs" (p. 5-13)
- Section 5.3, "Detention Facilities" (p. 5-19)
- Section 5.4, "Infiltration Facilities" (p. 5-53).

These sections begin on odd pages so that tabs can be inserted by the user if desired for quicker reference.

Required vs. Recommended Design Criteria

Both required and recommended design criteria are presented in this chapter. Criteria stated using **"shall"** or **"must"** are mandatory, to be followed unless there is a good reason to deviate as allowed by the adjustment process (see Section 1.4). These criteria are **required design criteria** and generally affect facility performance or critical maintenance factors.

Sometimes options are stated as part of the required design criteria using the language **"should"** or **"may."** These criteria are really **recommended design criteria**, but are so closely related to the required criteria that they are placed with it.

5.1 ROOF DOWNSPOUT CONTROLS

This section presents the criteria for design and implementation of roof downspout controls. *Roof downspout controls* are simple designs for infiltrating and/or dispersing runoff from roof areas for the purposes of increasing opportunities for groundwater recharge and reduction of runoff volumes from new developments. These controls are a mandatory requirement for all single family subdivision projects subject to Core Requirement #3 (see Section 1.2.3). They are also applied as flow control BMPs as detailed in Section 5.2 (p. 5-13).

When roof downspout controls are required, one of the following three types must be selected in descending order of preference as specified in this section:

- Downspout infiltration systems (Section 5.1.1, p. 5-5)
- Downspout dispersion systems (Section 5.1.2, p. 5-9)
- Downspout perforated stub-out connections (Section 5.1.3, p. 5-11).

Note: Other innovative downspout control BMPs such as rain barrels or ornamental ponds may also be proposed through an approved "adjustment" (see Section 1.4).

Selection of Roof Downspout Controls in Subdivisions

King County zoning creates high density residential development in urban areas and low density development in rural areas. Lots created in rural areas will typically be very large (5 acres or greater); dispersion or infiltration is required for these lots. Lots created in urban areas will typically be smaller than about 8,000 square feet. Since these lots have a limited amount of area in which to site trenches, downspout infiltration is required only in those soils which readily infiltrate (coarse sands and cobbles to medium sands). For urban lots located in less permeable soils, dispersion is required. Connection to the street storm drain system is only allowed where dispersion is not feasible because of very small lot size or where there is a potential for creating drainage problems on adjacent lots (see Section 5.1.2, p. 5-9).

The evaluation and selection of roof downspout controls shall be done at the platting stage. Roof downspout controls shall be shown on engineering plans, and a note conditioning single family residential permit approval on compliance with approved downspout controls shall be recorded with the plat.

Figure 5.1 (p. 5-4) illustrates how roof downspout controls are selected and applied in single family subdivision projects. More detailed procedures for applying these controls to subdivisions are provided in the above-referenced sections.

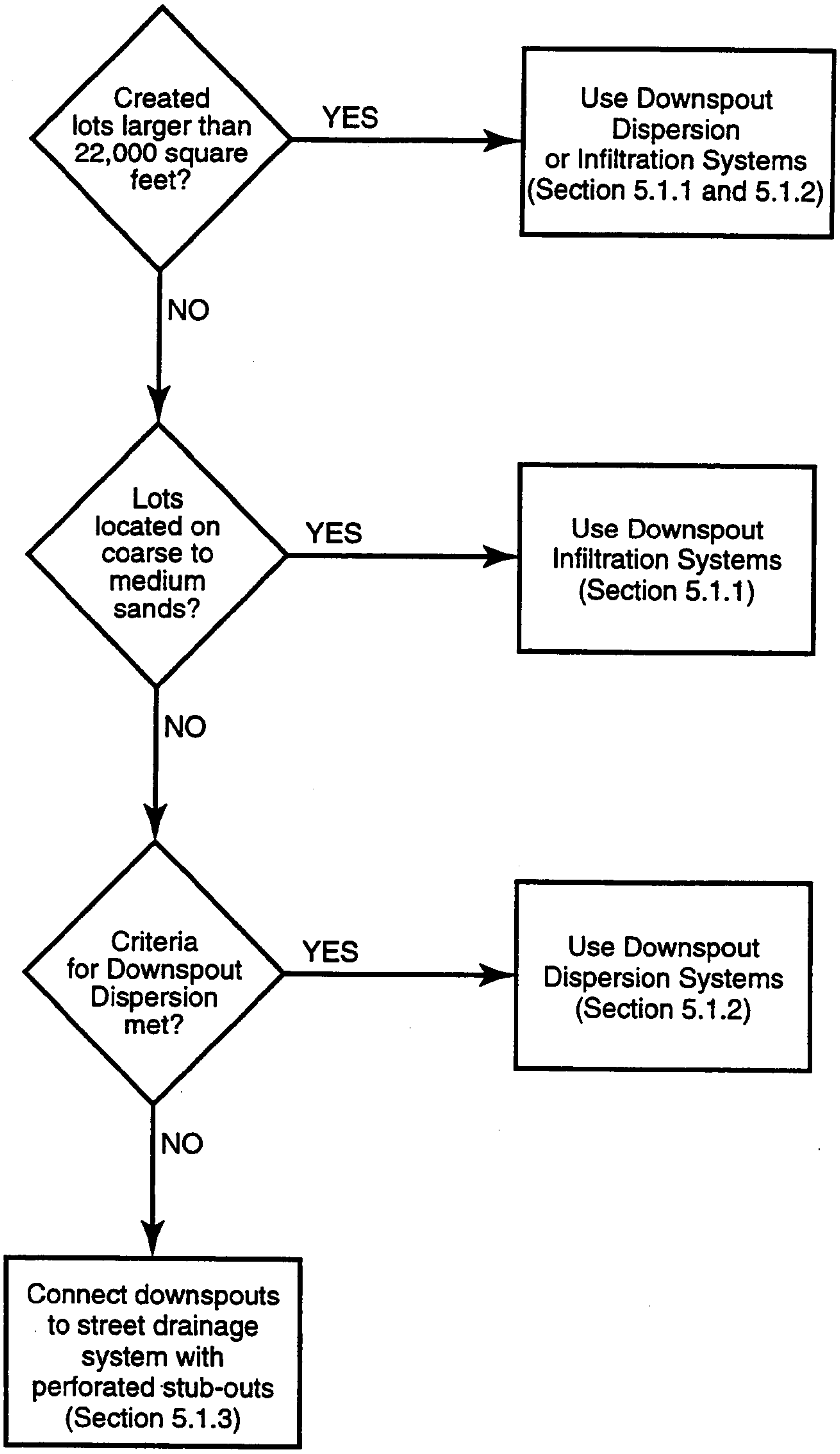
Roof Downspout Controls Applied as Flow Control BMPs

As with subdivisions, projects utilizing roof downspout controls to meet the flow control BMP requirements of Section 5.2 must apply these controls in the order of preference specified above. Essentially, roof downspout infiltration is required unless determined to be not feasible or not applicable using the evaluation procedure in Section 5.1.1 (p. 5-5). If infiltration is not feasible, then downspout dispersion is required. If downspout infiltration is not implementable as detailed in Section 5.1.2 (p. 5-9), then a perforated stub-out connection to the local drainage system may be allowed in some cases.

Roof Downspout Controls in Landslide Hazard Drainage Areas

Individual lot downspout infiltration or dispersion systems may be considered in the design of residential subdivisions upslope of landslide hazard areas. If scattered across the landscape, these systems may better replicate existing runoff conditions than would collecting all runoff in a single large facility. Even if served by a tightline, lots not adjacent to the hazard area should be considered for individual lot systems. Lots immediately adjacent to the hazard area should be collected in the tightline system, if provided.

FIGURE 5.1 SELECTION OF ROOF DOWNSPOUT CONTROLS IN SUBDIVISIONS



Note:
If connection to the street system is not feasible, an acceptable discharge must be determined by the design engineer.

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5.1.1 DOWNSPOUT INFILTRATION SYSTEMS

Downspout infiltration systems are trench systems intended only for use in infiltrating runoff from roof downspout drains. They are not designed to directly infiltrate surface water that could transport sediment or pollutants, such as from paved areas.

❑ BASIC REQUIREMENTS

1. Single family subdivision projects subject to Core Requirement #3 must provide for individual downspout infiltration systems on all lots smaller than 22,000 square feet if feasible.
2. The feasibility or applicability of downspout infiltration must be evaluated for all subdivision single family lots smaller than 22,000 square feet. The evaluation procedure detailed below shall be used to determine if downspout infiltration is feasible or whether downspout dispersion can be used in lieu of infiltration. This procedure shall also be used to evaluate all projects proposing to apply roof downspout controls as flow control BMPs per Section 5.2.
3. For subdivision single family lots greater than or equal to 22,000 square feet, downspout infiltration is optional, and the evaluation procedure detailed below is only required if downspout infiltration is being proposed voluntarily. *Note: If downspout infiltration is not required or provided on these lots, then a downspout dispersion system must be provided per Section 5.1.2 (p. 5-9).*

❑ PROCEDURE FOR EVALUATING FEASIBILITY

1. A **soils report** must be prepared by a geotechnical engineer. The report must reference a sufficient number of soils logs to establish the type and limits of soils on the project site. The report should at a minimum identify the limits of any *outwash type soils* (i.e., those meeting USDA soil texture classes ranging from coarse sand and cobbles to medium sand) versus other soil types.
2. On lots or sites with **no outwash** type soils, a **downspout dispersion system** per Section 5.1.2 (p. 5-9) may be used in lieu of infiltration. If downspout infiltration is still desired to qualify for flow control sizing credits, it must be shown to be feasible as described below.
3. On lots or sites containing **outwash** type soils (coarse to medium sand), additional site-specific testing must be done. **Individual lot or site tests** shall consist of at least one soils log, a minimum of 4 feet in depth (from proposed grade), identifying the SCS series of the soil and the USDA textural class of the soil horizon through the depth of the log, and noting any evidence of high groundwater level, such as mottling. *Note: This testing is also required on lots or sites where downspout infiltration is being proposed in soils other than outwash.*
4. If site-specific tests indicate **less than 3 feet of permeable soil** to the seasonal high groundwater table, then a downspout dispersion system per Section 5.1.2 may be used in lieu of infiltration. If downspout infiltration is still desired to qualify for flow control sizing credits, the minimum 3-foot depth to groundwater may be met by using fill material as allowed in the design criteria below.
5. On lots or sites with **more than 3 feet of permeable soil** to the seasonal high groundwater table, downspout infiltration is considered feasible and mandatory if the soils are outwash type soils and the infiltration trench can be designed to meet the minimum design criteria specified below. Voluntary provision of downspout infiltration must also meet these design criteria in order to be approved as feasible.

❑ DESIGN CRITERIA

Figure 5.1.1.A (p. 5-7) shows a typical **downspout infiltration system**, and Figure 5.1.1.B (p. 5-8) presents an alternative infiltration system for sites with coarse sand and cobble soils. These systems shall be designed as specified below.

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General

1. Downspout infiltration trenches shall be the following **minimum lengths** (linear feet) per 1,000 square feet of roof area based on soil type:

Coarse sands and cobbles:	20 LF
Medium sand:	30 LF
Fine sand, loamy sand	75 LF
Sandy loam	125 LF
Loam	190 LF

2. **Maximum length** of trench shall not exceed 100 feet from the inlet sump.
3. **Minimum spacing** between trench center lines shall be 6 feet.
4. **Filter fabric** shall be placed over the drain rock prior to backfilling.
5. Infiltration trenches may be **placed in fill material** if the fill is placed and compacted under the supervision of a geotechnical engineer, and if the measured infiltration rate is at least 8 inches per hour. Trench length in fill shall be 60 linear feet per 1,000 square feet of roof area. Infiltration rates shall be tested using the methods described in Section 5.4.1 (p. 5-53).
6. Infiltration trenches are **not allowed on slopes steeper than 25%** (4:1). A geotechnical analysis and report may be required on slopes over 15% or if located within 200 feet of the top of steep slope or landslide hazard area.
7. Trenches may be **located under pavement** if a small yard drain or catch basin with grate cover is placed at the end of the trench pipe such that overflow would occur out of the catch basin at an elevation at least one foot below that of the pavement, and in a location which can accommodate the overflow without creating a significant adverse impact per Core Requirement #1 (see Section 1.2.1).

   Intent: To prevent saturation of the pavement subgrade in the event of system failure.

Setbacks

1. All trenches must be at least 5 feet from any **structure, property line, or sensitive area** (except steep slopes).
2. All trenches must be at least 50 feet from any **sensitive area steep slope**. This setback may be reduced to 15 feet based on a geotechnical evaluation, but in no instances may it be less than the buffer width.
3. For sites with **septic systems**, infiltration trenches must be downgradient of the drainfield. This requirement may be waived if site topography clearly prohibits subsurface flows from intersecting the drainfield.

Documentation Requirements

1. The **approved plans for single family subdivision projects** must show infiltration trench details and the approximate location and size of each proposed downspout infiltration system and septic system (if applicable). Alternatively, details of representative lots may be provided to depict approximate locations of downspout infiltration systems and septic systems (if applicable).
2. If the proposed project is a subdivision, the following **note** conditioning single family residential building permits on compliance with the approved infiltration systems shall be recorded with the plat or short plat:

   "Single family residences constructed on lots created by this subdivision must provide downspout infiltration systems according to the details shown on the approved plans."

FIGURE 5.1.1.A TYPICAL DOWNSPOUT INFILTRATION SYSTEM

PLAN VIEW
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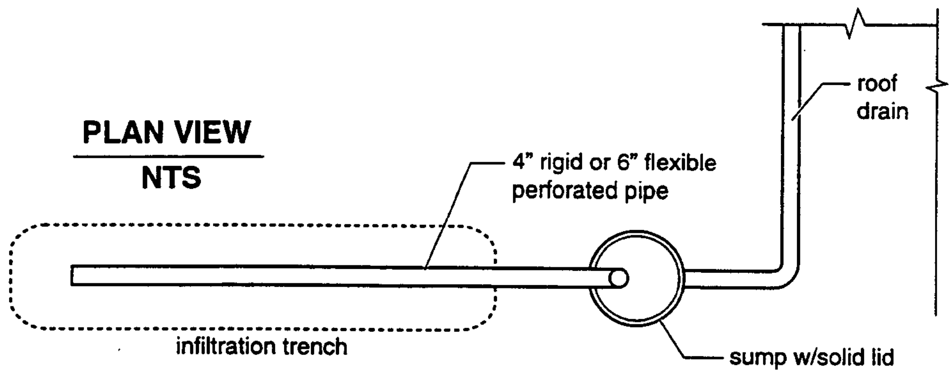

PLAN VIEW
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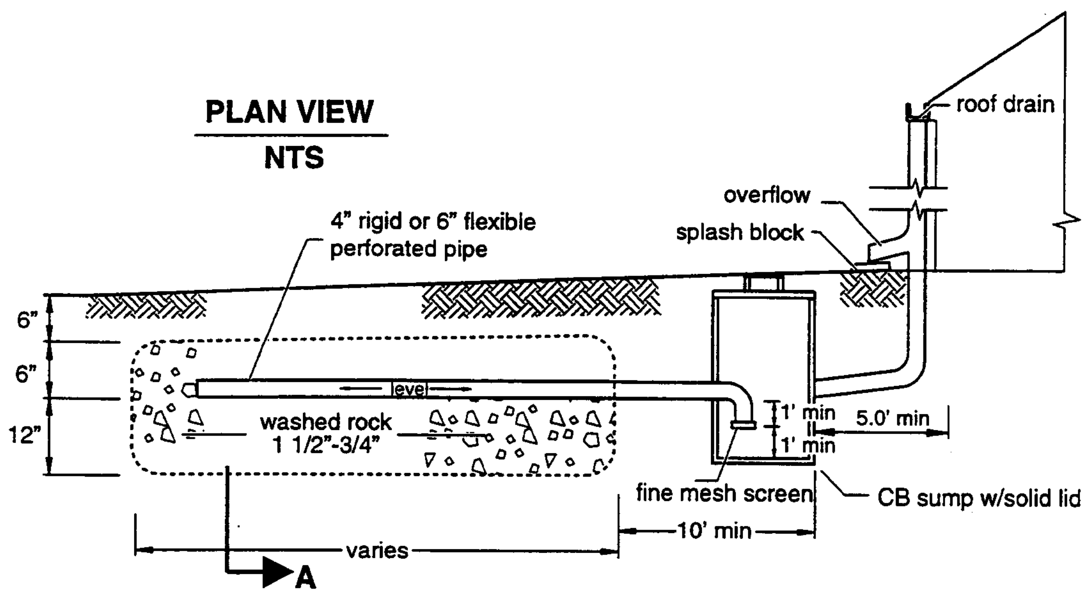

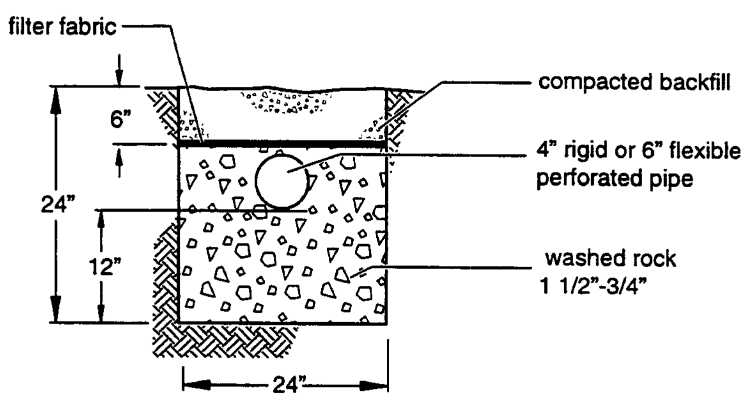

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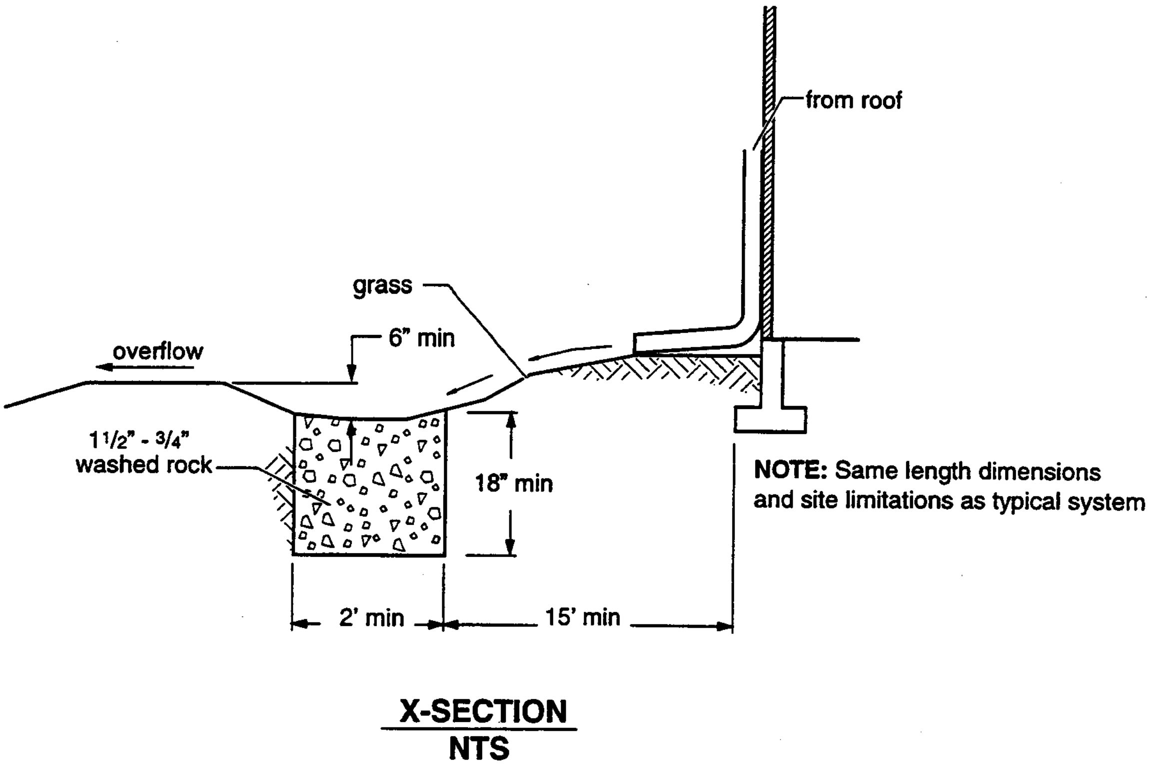
FIGURE 5.1.1.B
ALTERNATIVE DOWNSPOUT INFILTRATION SYSTEM FOR COARSE SAND AND GRAVEL



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5.1.2 DOWNSPOUT DISPERSION SYSTEMS

Downspout dispersion systems are splash blocks or gravel-filled trenches which serve to spread roof runoff over vegetated pervious areas. Dispersion attenuates peak flows by slowing entry of the runoff into the conveyance system, allows for some infiltration, and provides some water quality benefits.

❑ BASIC REQUIREMENTS

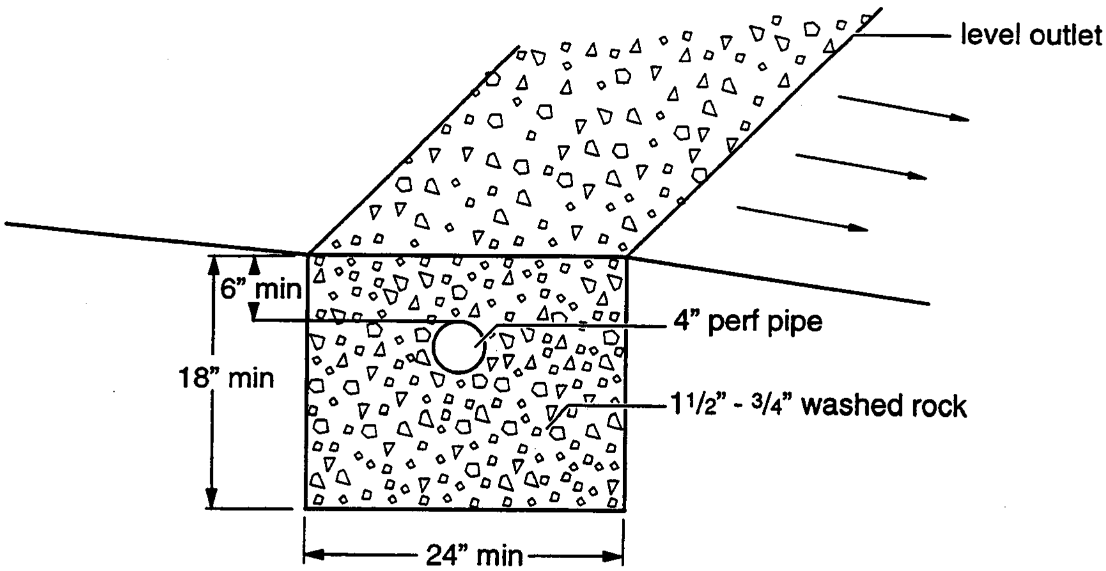
1. Downspout dispersion is required on all subdivision single family lots which meet one of the following criteria:
   - Lots greater than or equal to 22,000 square feet where downspout infiltration is not being provided according to the requirements in Section 5.1.1 (p. 5-5).
   - Lots smaller than 22,000 square feet where soils are not suitable for downspout infiltration as determined in Section 5.1.1, and where the design criteria below can be met.
2. Projects utilizing roof downspout controls as flow control BMPs per Section 5.2 (p. 5-13) are required to provide downspout dispersion if downspout infiltration is not feasible or applicable as determined in Section 5.1.1, and if the design criteria below can be met.

❑ DESIGN CRITERIA

1. **Downspout trenches** designed as shown in Figure 5.1.2.A, (p. 5-10) shall be used for all downspout dispersion applications except where splash blocks are allowed below.
2. **Splash blocks** may be used for downspouts discharging to a *vegetated flowpath* at least 50 feet in length as measured from the downspout to the downstream property line, structure, SAO steep slope, stream, wetland, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
3. If the **vegetated flowpath** (measured as defined above) is less than 25 feet on a subdivision single family lot, a perforated stub-out connection per Section 5.1.3 (p. 5-11) may be used in lieu of downspout dispersion. A perforated stub-out may also be used where implementation of downspout dispersion might cause **erosion or flooding problems**, either on site or on adjacent lots. This provision might be appropriate, for example, for lots constructed on steep hills where downspout discharge could be cumulative and might pose a potential hazard for lower lying lots, or where dispersed flows could create problems for adjacent offsite lots. This provision does not apply to situations where lots are flat and onsite downspout dispersal would result in saturated yards. *Note: For all other types of projects, the use of a perforated stub-out in lieu of downspout dispersion shall be as specified in Section 5.2 (p. 5-13) for implementation of flow control BMPs.*
4. For **sites with septic systems**, the discharge point of all dispersion systems must be downgradient of the drainfield. This requirement may be waived if site topography clearly prohibits flows from intersecting the drainfield.
5. **The approved plans for single family subdivision projects** must show dispersion trench details and which lots they apply. If a facility sizing credit is being claimed, the approximate location of the house and associated flowpaths must be shown for each lot proposed for credit. Alternatively, details of typical lots may be provided to depict approximate locations of flowpaths and septic systems (if applicable).
6. If the project is a subdivision, the following **note** conditioning single family residential building permits on compliance with the approved dispersion systems shall be recorded with the plat or short plat:

   "Single family residences constructed on lots created by this subdivision must provide downspout dispersion systems according to the details shown on the approved plans."

FIGURE 5.1.2.A TYPICAL DOWNSPOUT DISPERSION TRENCH



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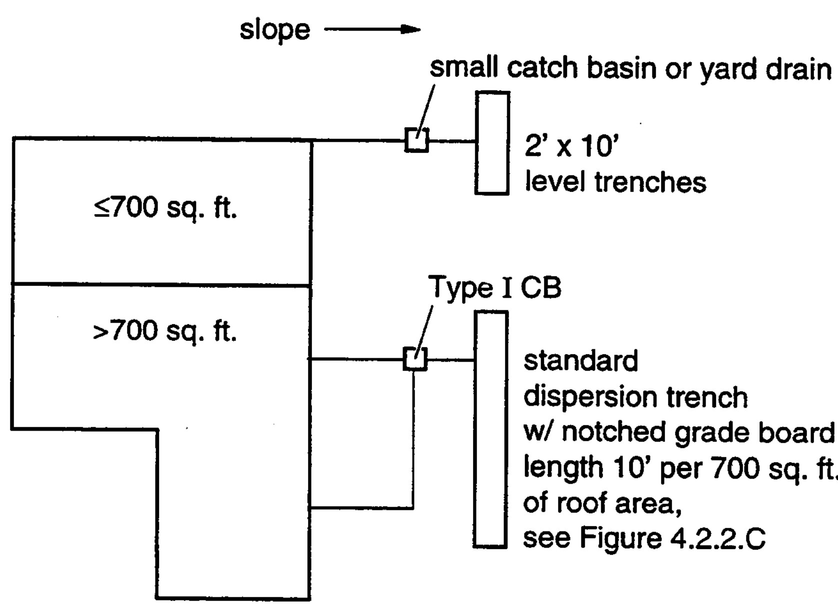

PLAN VIEW OF ROOF
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5.1.3 PERFORATED STUB-OUT CONNECTIONS

A *perforated stub-out connection* is a length of perforated pipe within a gravel-filled trench that is placed between roof downspouts and a stub-out to the local drainage system. Figure 5.1.3.A (p. 5-12) details a perforated stub-out connection. These systems are intended to provide some infiltration during drier months; during the wet winter months, they may provide little or no flow control, and hence no reduction in a flow control facility is allowed when perforated stub-outs are used.

In **single family subdivision projects** subject to Core Requirement #3 (see Section 1.2.3), perforated stub-out connections are allowed only when downspout infiltration or dispersion is not feasible per the criteria in Sections 5.1.1 and 5.1.2. For projects proposing to apply roof downspout controls as flow control BMPs, a perforated stub-out connection is allowed only as specified in Section 5.2 (p. 5-13).

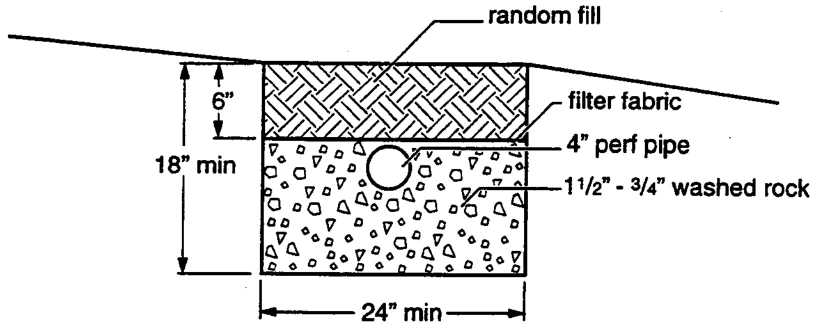
Location of the connection should be selected to allow a maximum amount of runoff to infiltrate into the ground (ideally a dry location on the site that is relatively well drained). Perforated stub-out connections shall consist of **at least 10 feet of perforated pipe** laid in a level, 2-foot wide trench backfilled with washed drain rock. The drain rock shall extend to a depth of at least 8 inches below the bottom of the pipe and shall cover the pipe. The pipe shall be laid level, and the rock trench shall be covered with filter fabric and 6 inches of random fill (see Figure 5.1.3.A). **Setbacks** shall be the same as for infiltration trenches.

The **approved plans for single family subdivision projects** shall include perforated stub-out details (if applicable) and details of "typical" lots depicting the approximate locations of perforated stub-out connections.

If the project is a subdivision, the following **note** conditioning single family residential building permits on compliance with the approved stub-out systems shall be recorded with the plat or short plat:

> "Single family residences constructed on lots created by this subdivision must provide perforated stub-out connections according to the details shown on the approved plans."

FIGURE 5.1.3.A PERFORATED STUB-OUT CONNECTION



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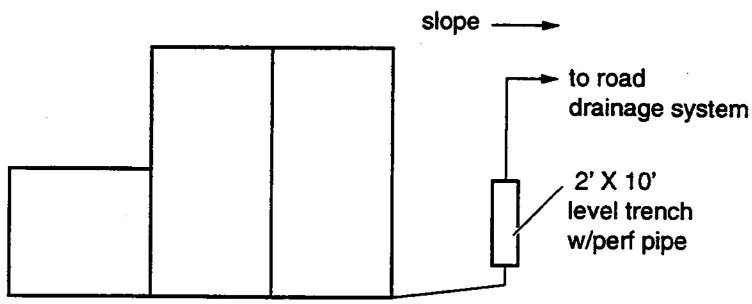

PLAN VIEW OF ROOF
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5.2 FLOW CONTROL BMPs

Flow control Best Management Practices (BMPs) are simple methods and designs for infiltrating, dispersing, and reducing increased runoff from development sites. This section presents the design criteria and requirements for use of flow control BMPs in lieu of, or to reduce the required size of, a formal flow control facility. The BMPs applied in this section include the following:

- **Roof downspout controls**, as described in Section 5.1
- **Roof and driveway dispersion BMPs**, as described in the *Small Site Drainage Requirements* booklet adopted as Appendix C to this manual
- **Native growth open space**, as described in the *Small Site Drainage Requirements* booklet
- **Forested open space**, as described on page 5-14
- **Roadway dispersion BMPs**, as described on page 5-15.
- **Modular Grid Pavement**, as described on page 5-17.

The information presented in this section is organized as follows:

- Section 5.2.1, "BMPs in Lieu of Facilities," describes how flow control BMPs are to be applied to specific project types in order to qualify for facility Exemptions 2, 3, 4, and 5 in Section 1.2.3.
- Section 5.2.2, "BMPs for Reducing Facility Size" (p. 5-17), describes how flow control BMPs can be used to reduce the size of a required flow control facility.

5.2.1 BMPs IN LIEU OF FACILITIES

In Core Requirement #3 (see Section 1.2.3), there are several exemptions from the requirement to provide **a formal flow control facility** which are contingent on the applicability of flow control BMPs as detailed in this section. The intent of these exemptions is to provide for situations where a facility may not be practical or needed, where other alternatives to a facility can be just as effective, or where it makes sense to provide incentives for retaining native vegetation or for maximizing use of existing developed areas.

The facility exemptions requiring BMPs are as follows:

- **Exemption 2, "Impervious Surface Exemption Using Flow Control BMPs."** Flow control BMPs must be provided as described below in order for a project to qualify for this exemption.
- **Exemption 3, "Peak Flow Exemption Using Flow Control BMPs."** Flow control BMPs as described below must be provided to the extent feasible in order for a threshold discharge area within the project to qualify for this exemption.
- **Exemption 4, "Peak Flow Exemption for Urban Redevelopment Projects."** Flow control BMPs as described below must be provided to the extent feasible in order for a natural discharge area within a redevelopment project to qualify for this exemption.
- **Exemption 5, "Forested Open Space Exemption for Rural Residential Projects."** Flow control BMPs meeting the criteria specified below must be provided in order for a natural discharge area within a rural residential project (zoned RA-2.5, RA-5, RA-10, or RA-20) to qualify for this exemption.
- **Exemption 7, "Peak Flow Exemption for Urban Residential Infill Projects."** Flow control BMPs as described below must be provided to the extent feasible in order for the project to qualify for this exemption.

Because the above exemptions include various project-specific incentives and protection goals, the flow control BMPs required to qualify for them are applied by project type. The three types of projects

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presented in this section include (1) commercial and redevelopment projects, (2) single family residential projects, and (3) rural residential projects.

❑ COMMERCIAL AND REDEVELOPMENT PROJECTS

Commercial or redevelopment projects utilizing **Exemptions 2, 3, or 4** must infiltrate the runoff from **new roof areas** if feasible according to the requirements in Section 5.1.1. If downspout infiltration is not feasible, then the runoff from roofs shall be dispersed using dispersion trenches with vegetated flowpath lengths of at least 25 feet as detailed in Section 5.1.2. If this dispersion requirement can not be met, then a perforated stub-out connection as detailed in Section 5.1.3 may be used only if the project is a redevelopment project; all other projects with new roof areas would not qualify for these exemptions.

For redevelopment projects utilizing **Exemptions 3 or 4**, infiltration or dispersion of runoff from **parking lots and roads** is usually not possible or effective due to lack of space and vegetation. Therefore, infiltration or dispersion of runoff from these areas is not strictly required. However, if these areas are subject to Core Requirement #8, "Water Quality," the runoff generated from them shall be treated using water quality facilities that provide some opportunity for infiltration or dispersion prior to discharge from the project site (e.g., biofiltration swales or filter strips).

❑ SINGLE FAMILY RESIDENTIAL PROJECTS

Single family residential projects in Full Drainage Review qualifying for **Exemptions 2, 3, and 7** must comply with the flow control BMPs detailed in the *Small Site Drainage Requirements* booklet adopted as Appendix C to this manual. These include roof downspout control and driveway dispersion BMPs, and native growth open space designations to limit onsite clearing.

❑ RURAL RESIDENTIAL PROJECTS

Rural residential projects (i.e., projects located on properties zoned RA-2.5, RA-5, RA-10, or RA-20) may qualify for **Exemption 5** through designation of 65% of any natural drainage area (excluding areas submerged by streams, lakes, and wetlands) as **forested[1] open space**. To qualify for Exemption 5, a proposed project must comply with the open space requirements described below, and the runoff from new impervious surfaces must be dispersed according to the requirements for "Roof Downspout Dispersion" and "Roadway Dispersion BMPs" specified on page 5-15.

Forested Open Space

The following criteria and conditions apply to forested open space designated to qualify for Exemption 5:

1. The forested open space **must be placed in a separate tract or protected through recorded easements** on individual lots. Open space on individual lots can be established through conservation easements, with tax benefits available through the *Public Benefit Rating System*[2] program.
2. Whether set aside in tracts or established as easements on individual lots, the forested open space must be shown on **drainage plans** and shown and described in **recorded documents** (including the final recording plan for plats and binding site plans) as "a forested native vegetation retention area established for purposes of dispersing and treating stormwater flows."
3. The **principle restriction** on open space areas is **removal of vegetation and trees**. Since flow control and water quality in these rural developments is provided largely by flow dispersion through duff, undisturbed soils and native vegetation, open space areas must be located downslope of roadways and building sites.

[1] Project sites which contain areas that are naturally non-forested (e.g., meadows) may include these areas in the open space tract provided the percentage of non-forested area within the tract is not greater than for the entire project site.

[2] The *Public Benefit Rating System* provides tax credit for properties which preserve 4 acres or more of contiguous open space in rural areas. Additional credits are granted under the forested open space category, provided a Forest Management Plan is developed which, for the purpose of these requirements, shall maintain the open space in a fully forested condition.

4. The **open space may include onsite SAO sensitive areas** and should be contiguous with sensitive areas, as feasible. However, only the *unsubmerged portion*[3] of these sensitive areas may be counted towards meeting minimum open space requirements. For sensitive areas designated under KCC Title 21A, allowable uses shall be limited to those specified in KCC 21A.24 which are also consistent with Item 7 below.

5. **All trees** within the forested open space **at the time of permit application shall be retained**, aside from approved timber harvest activities and the removal of dangerous or diseased trees. If the site is located within an area of mandatory clearing limits and has been illegally cleared, a restoration plan may be required. Additionally, projects may choose to develop a long-term Forest Management Plan which may qualify for additional tax relief under the Public Benefit Rating System, described below. The Forest Management Plan should require reforestation of any open space areas which had been previously cleared.

6. The forested open space **shall be shown on all property maps**, shall be clearly marked during clearing and construction on the site, and shall be permanently marked with at least one sign per buildable lot adjoining the tract indicating that the tract is dedicated as permanent forested open space.

7. The forested open space **may be used for passive recreation** and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the area of the open space tract.

8. The forested open space **may contain utilities and utility easements**, including flow control BMPs.

Roof Downspout Dispersion

Rural residential projects setting aside open space pursuant to Exemption 5 in Section 1.2.3 must provide roof downspout dispersion as described in the *Small Site Drainage Requirements* booklet adopted as Appendix C to this manual. For rural subdivisions, a note conditioning single family residential building permits on compliance with small site requirements shall be recorded with the plat or short plat. The note shall also stipulate that proposed single family residences within a plat or short plat must submit for Small Site Drainage Review at the time of building permit application to document compliance.

Roadway Dispersion BMPs

Roads and driveways in rural residential projects setting aside open space areas per Exemption 5, must meet the following dispersion requirements:

1. Roadway runoff dispersion is **allowed only on rural neighborhood collectors and local access streets** in accordance with the *King County Road Standards*. To the extent feasible, driveways should be dispersed to the same standards as roadways to ensure adequate water quality protection of downstream resources. *Note: Driveway dispersion through lawn areas (as allowed under Small Site Drainage Review) generally does not provide adequate water quality treatment due to the wash off of fertilizers, pesticides, and other common contaminants.*

2. The road section shall be designed to **minimize collection and concentration of roadway runoff.** Sheet flow over roadway fill slopes (i.e., where roadway subgrade is above adjacent right-of-way) should be used wherever possible to avoid concentration.

3. When it is necessary to collect and concentrate runoff from the roadway and adjacent upstream areas (e.g., in a ditch on a cut slope), concentrated flows shall be **incrementally discharged** from the ditch via cross culverts or at the ends of cut sections. These incremental discharges of newly concentrated flows **shall not exceed 0.5 cfs at any one discharge point from a ditch** for the 100-year runoff event. Where flows at a particular ditch discharge point were already concentrated under existing site

[3] *Unsubmerged portion* means the portion outside the ordinary high water line of streams, lakes, and wetlands.

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conditions (e.g., in a natural channel that crosses the roadway alignment), the 0.5 cfs limit would be in addition to the existing concentrated peak flows.

4. Ditch discharge points with up to 0.2 cfs discharge for the peak 100-year flow shall use **rock pads** or dispersion trenches to disperse flows. Ditch discharge points with between 0.2 and 0.5 cfs discharge for the 100-year peak flow shall use only **dispersion trenches** to disperse flows.

5. **Dispersion trenches** shall be designed to accept surface flows (free discharge) from a pipe, culvert, or ditch end, shall be aligned perpendicular to the flowpath, and shall be minimum 2 feet by 2 feet in section, 50 feet in length, filled with $1^1/_2$" - $^3/_4$" washed rock, and provided with a level notched grade board per Figure 4.2.2.C. Manifolds may be used to split flows up to 2 cfs discharge for the 100-year peak flow between up to 4 trenches. Dispersion trenches shall have a minimum spacing of 50 feet.

6. After being dispersed with rock pads or trenches, **flows from ditch discharge points must traverse a minimum of 100 feet** of undisturbed native vegetation before leaving the project site, or entering an existing onsite channel carrying existing concentrated flows across the road alignment. *Note: In order to provide the 100-foot flowpath length to an existing channel, some roadway runoff may unavoidably enter the channel undispersed. Also note that **water quality treatment may be waived** for roadway runoff dispersed through 100 feet of undisturbed native vegetation (see Exemption 3, Section 1.2.8).*

7. **Flowpaths from adjacent discharge points must not intersect within the 100-foot flowpath lengths**, and dispersed flow from a discharge point must not be intercepted by another discharge point. To enhance the flow control and water quality effects of dispersion, the flowpath shall not exceed 15% slope, and shall be located within designated open space. *Note: Runoff may be conveyed to an area meeting these flowpath criteria.*

8. Ditch discharge points shall be located a minimum of **100 feet upgradient of SAO steep slopes**, wetlands, and streams.

9. Where DDES determines there is a potential for **significant adverse impacts downstream** (e.g., erosive steep slopes or existing downstream drainage problems), dispersion of roadway runoff may not be allowed, or other measures may be required.

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5.2.2 BMPs FOR REDUCING FACILITY SIZE

The flow control BMPs presented in this section may be used to reduce the size of required flow control facilities if implemented as described below.

Roof Downspout Infiltration and Dispersion

1. If roof runoff is infiltrated according to the requirements of Section 5.1.1 (p. 5-5), the **roof area may be discounted** from the net impervious area used for sizing the required flow control facility.
2. If roof runoff is dispersed according to the requirements of Section 5.1.2 (p. 5-9) on single family lots greater than or equal to 22,000 square feet, and the *vegetated flowpath*[4] of the roof runoff is 50 feet or longer, the **roof area may be modeled as grassed surface rather than impervious surface** when sizing the required flow control facility.

Open Space Designation

The "Land Cover Assumptions" in Core Requirement #3 (see Section 1.2.3.2) require that flow control facilities be sized assuming the entire site will be cleared unless uncleared areas are protected by an open space tract or covenant. If uncleared areas are proposed to be designated as open space in order to reduce facility size, the **native growth open space** provisions described in the *Small Site Drainage Requirements* booklet (see detached Appendix C) may be used.

Modular Grid Pavement

Modular grid pavement may be used for low traffic driveways, overflow parking areas, maintenance access roads, etc., to reduce the size of required detention facilities as well as infiltration facilities. Where modular grid pavement is used, the **area it covers may be considered a grassed pervious surface** rather than an impervious surface when the site is modeled. Modular grid pavement consists of a lattice of concrete, plastic, or other load bearing material over a permeable base course such as gravel or sand. The actual pavement design should be prepared by the design engineer, but a minimum of 6 inches of permeable base should be placed under the pavement. Grass may be grown in the interstices of the grid.

Modular grid pavement may be used off right-of-way in low-traffic or infrequently used areas such as residential driveways. Provisions for the removal of oil and grease contaminated soils should be included in the maintenance plan for modular grid pavements. The finished grade of the soil surface within the pavers should be about 0.75 inch below the top of the pavers. Smooth surfaced walkways may be run across modular grid pavements, but impervious surfaced walkways should not exceed 10 percent of the total paved surface.

[4] *Vegetated flowpath* is measured from the downspout or dispersion system discharge point to the downstream property line, structure, SAO steep slope, stream, wetland, or other impervious surface.

5.3 DETENTION FACILITIES

This section presents the methods, criteria, and details for design and analysis of detention facilities. These facilities provide for the temporary storage of increased surface water runoff resulting from development pursuant to the performance standards set forth in Core Requirement #3, "Flow Control" (see Section 1.2.3).

There are three primary types of detention facilities described in this section: detention ponds, tanks, and vaults. The information presented in this section is organized as follows:

5.3.1 DETENTION PONDS

Open ponds are the most desirable detention facilities for controlling runoff from developed areas. The design criteria in Section 5.3.1.1 are for detention ponds. However, many of the criteria also apply to infiltration ponds (Section 5.4.2), and water quality wetponds and combined detention/wetponds (Section 6.4).

Dam Safety Compliance

Detention ponds and other open impoundment facilities must comply with requirements for dam safety (WAC 173-175). Under current regulations (as of September 1998), if the impoundment has a storage capacity (including both water and sediment storage volumes) greater than 10 acre-feet above natural ground level and a dam height of more than 6 feet, then dam safety design and review are required by the Washington State Department of Ecology (WDOE). If the storage capacity is less than 10 acre-feet above natural ground level, then the facility is exempt from WDOE review. If the dam height is less than 6 feet but capacity is greater than 10 acre-feet, then WDOE reviews on a case-by-case-basis to determine the hazard potential downstream in the event of a failure.

5.3.1.1 DESIGN CRITERIA

Standard details for **detention ponds** are shown in Figure 5.3.1.A (p. 5-28) through Figure 5.3.1.D (p. 5-31). Control structure details are shown in Section 5.3.4 beginning on page 5-42.

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General

1. Ponds **must be designed as flow-through systems** (however, parking lot storage may be utilized through a back-up system; see Section 5.3.5, p. 5-51). Developed flows must enter through a conveyance system separate from the control structure and outflow conveyance system. Maximizing distance between the inlet and outlet is encouraged to promote sedimentation.
2. **Pond bottoms shall be level** and be located a minimum of 0.5 feet below the inlet and outlet to provide sediment storage.
3. Outflow **control structures** shall be designed as specified in Section 5.3.4 (p. 5-40).
4. A **geotechnical analysis** and report may be required on slopes over 15%, or if located within 200 feet of the top of a steep slope or landslide hazard area.

Side Slopes

1. For facilities to be maintained by King County, **interior side slopes** up to the emergency overflow water surface shall be no steeper than 3H:1V unless a fence is provided (see "Fencing," p. 5-22). See Section 6.4.4 for side slope requirements for internal berms in combined ponds and wetponds.
2. **Exterior side slopes** shall be no steeper than 2H:1V unless analyzed for stability by a geotechnical engineer.
3. **Pond walls** may be vertical retaining walls, provided: (a) they are constructed of reinforced concrete per Section 5.3.3 (p. 5-37); (b) a fence is provided along the top of the wall; (c) at least 25% of the pond perimeter will be a vegetated soil slope not steeper than 3H:1V; and (d) the design is stamped by a licensed structural civil engineer.
4. For **privately owned and maintained facilities**, the entire pond perimeter may be retaining walls, and building foundations may serve as one or more of the pond walls.

Embankments

1. Pond berm embankments higher than 6 feet shall require **design by a geotechnical engineer.**
2. For berm embankments 6 feet or less, the **minimum top width** shall be 6 feet, or as recommended by a geotechnical engineer.
3. Pond berm embankments must be **constructed on native consolidated soil** (or adequately compacted and stable fill soils analyzed by a geotechnical engineer) free of loose surface soil materials, roots, and other organic debris.
4. Pond berm embankments greater than 4 feet in height must be **constructed by excavating a key** equal to 50% of the berm embankment cross-sectional height and width. This requirement may be waived if specifically recommended by a geotechnical engineer.
5. The berm embankment shall be **constructed of compacted soil** (95% minimum dry density, modified proctor method per ASTM D1557), placed in 6-inch lifts, with the following soil characteristics per the United States Department of Agriculture's Textural Triangle: a minimum of 20% silt and clay, a maximum of 60% sand, a maximum of 60% silt, with nominal gravel and cobble content. *Note: In general, excavated glacial till is well suited for berm embankment material.*
6. **Anti-seepage collars** must be placed on outflow pipes in berm embankments impounding water greater than 8 feet in depth at the design water surface.

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Overflow

1. In all ponds, tanks, and vaults, a **primary overflow** (usually a riser pipe within the control structure; see Section 5.3.4.2, p. 5-45) must be provided to bypass the 100-year developed peak flow over or around the restrictor system. This assumes the facility will be full due to plugged orifices or high inflows; the primary overflow is intended to protect against breaching of a pond embankment (or

overflows of the upstream conveyance system, in the case of a detention tank or vault). The design must provide controlled discharge directly into the downstream conveyance system or another acceptable discharge point.

2. A **secondary inlet** to the control structure must be provided in ponds as additional protection against overtopping should the inlet pipe to the control structure become plugged. A grated opening ("jailhouse window") in the control structure manhole functions as a weir (see Figure 5.3.1.B, p. 5-29) when used as a secondary inlet. *Note: The maximum circumferential length of this opening shall not exceed one-half the control structure circumference.* The "birdcage" overflow structure as shown in Figure 5.3.1.C (p. 5-30) may also be used as a secondary inlet.

Emergency Overflow Spillway

1. In addition to the above overflow requirements, ponds must have an emergency overflow spillway **sized to pass the 100-year developed peak flow** in the event of total control structure failure (e.g., blockage of the control structure outlet pipe) or extreme inflows. Emergency overflow spillways are intended to control the location of pond overtopping and direct overflows back into the downstream conveyance system or other acceptable discharge point.

2. Emergency overflow spillways must be provided for **ponds with constructed berms over 2 feet in height,** or for **ponds located on grades in excess of 5%.** As an option for ponds with berms less than 2 feet in height and located at grades less than 5%, emergency overflow may be provided by an **emergency overflow structure**, such as a Type II manhole fitted with a birdcage as shown in Figure 5.3.1.C (p. 5-30). The emergency overflow structure must be designed to pass the 100-year developed peak flow, with a minimum 6 inches of freeboard, directly to the downstream conveyance system or another acceptable discharge point. Where an emergency overflow spillway would discharge to a steep slope, consideration should be given to providing an emergency overflow structure *in addition to* the spillway.

3. The emergency overflow spillway shall be **armored with riprap** in conformance with Table 4.2.2.A. The spillway shall be armored full width, beginning at a point midway across the berm embankment and extending downstream to where emergency overflows re-enter the conveyance system (see Figure 5.3.1.B, p. 5-29).

4. Design of emergency overflow spillways requires the analysis of a broad-crested trapezoidal weir as described in Section 5.3.1.2 (p. 5-32). Either one of the weir sections shown in Figure 5.3.1.B (p. 5-29) may be used.

Access Requirements

1. **Maintenance access road(s)** shall be provided to the control structure and other drainage structures associated with the pond (e.g., inlet or bypass structures). Manhole and catch basin lids must be in or at the edge of the access road and at least three feet from a property line.

2. An **access ramp** is required for removal of sediment with a trackhoe and truck. The ramp must extend to the pond bottom if the pond bottom is greater than 1500 square feet (measured without the ramp) and it may end at an elevation 4 feet above the pond bottom, if the pond bottom is less than 1,500 square feet (measured without the ramp).

   Intent: On large, deep ponds, truck access to the pond bottom via an access ramp is necessary so loading can be done in the pond bottom. On small deep ponds, the truck can remain on the ramp for loading. On small shallow ponds, a ramp to the bottom may not be required if the trackhoe can load a truck parked at the pond edge or on the internal berm of a wetpond or combined pond (trackhoes can negotiate interior pond side slopes).

3. The **internal berm** of a wetpond or combined detention and wetpond may be used for access if it is no more than 4 feet above the first wetpool cell, if the first wetpool cell is less than 1500 square feet (measured without the ramp), and if it is designed to support a loaded truck, considering the berm is normally submerged and saturated.

4. **Access ramps** shall meet the requirements for design and construction of access roads specified below.
5. All control structures shall have round, solid **locking lids** with $^5/_8$-inch diameter allen head cap screws (see *KCRS* Drawing No. 2-022 and 2-023).
6. Access shall be limited by a double-posted gate if a fence is required, or by **bollards**—that is, two fixed bollards on each side of the access road and two removable bollards equally located between the fixed bollards.

Design of Access Roads

Access roads shall meet the following design criteria:

1. **Maximum grade** shall be 15%.
2. Outside **turning radius** shall be 40 feet, minimum.
3. **Fence gates** shall be located only on straight sections of road.
4. Access roads shall be 15 feet in **width** on curves and 12 feet on straight sections.
5. A **paved apron** shall be provided where access roads connect to paved public roadways. The apron shall be consistent with driveway details in *KCRS*.

Construction of Access Roads

Access roads shall be constructed with an asphalt or gravel surface, or modular grid pavement. Asphalt surfaces must conform to King County standards for residential minor access streets. Gravel surfaces must meet the *King County Road Standards* (*KCRS*) for crushed surfacing base course. Modular grid pavement shall meet manufacturer's specifications.

Fencing

1. A fence is **required** at the emergency overflow water surface elevation, or higher, **where a pond interior side slope is steeper than 3H:1V,** or where the impoundment is a wall greater than 24 inches in height. The fence need only be constructed for those slopes steeper than 3H:1V.

   Intent: To discourage access to portions of a pond where steep side slopes (steeper than 3:1) increase the potential for slipping into the pond, and to guide those who have fallen into a pond to side slopes that are flat enough (flatter than 3:1 and unfenced) to allow for easy escape.
2. For **privately owned and maintained facilities**, fences are recommended, but not required, for slopes steeper than 3:1. Note, however, that other regulations such as the Uniform Building Code may require fencing of vertical walls. Fence material and construction specifications outlined below do not apply to private facilities.
3. Fences shall be 6 feet in **height**. For example designs, see WSDOT Standard Plan L-2, Type 1 or Type 3 chain link fence.

   Exception: The fence may be a minimum of 4 feet in height if the depth of the impoundment (measured from the lowest elevation in the bottom of the impoundment, directly adjacent to the bottom of the fenced slope, up to the emergency overflow water surface) is 5 feet or less. For example designs, see WSDOT Standard Plan L-2, Type 4 or Type 6 chain link fence.
4. **Access road gates** shall be 16 feet in width consisting of two swinging sections 8 feet in width. Additional vehicular access gates may be required as needed to facilitate maintenance access.
5. **Pedestrian access gates** (if needed) shall be 4 feet in width.
6. For fences to be maintained by the County, **fence material** shall be vertical metal balusters or 9 gauge galvanized steel fabric with bonded vinyl coating. For steel fabric fences, the following apply:

a) **Vinyl coating** shall be compatible with the surrounding environment (e.g., green in open, grassy areas and black or brown in wooded areas). All posts, cross bars, and gates shall be painted or coated the same color as the vinyl clad fence fabric.

b) **Fence posts and rails** shall conform to WSDOT Standard Plan L-2 for Types 1, 3, or 4 chain link fence.

7. For **metal baluster fences**, Uniform Building Code standards shall apply.
8. **Wood fences are allowed** in subdivisions where the fence will be maintained by homeowners associations or adjacent lot owners. Fence maintenance requirements shall be a condition of subdivision approval, and a statement detailing maintenance responsibilities and requirements must be recorded with the plat.
9. Wood fences shall have **pressure treated posts** (ground contact rated) either set in 24-inch deep concrete footings or attached to footings by galvanized brackets. Rails and fence boards shall be cedar or pressure-treated fir or hemlock.
10. Where only **short stretches of the pond perimeter** (< 10%) have side slopes steeper than 3:1, split rail fences (3-foot minimum height) or densely planted thorned hedges (e.g., barberry, holly, etc.) may be used in place of a standard fence.

Signage

Detention ponds, infiltration ponds, wetponds, and combined ponds to be maintained by King County shall have a sign placed for maximum visibility from adjacent streets, sidewalks, and paths. The sign shall meet the design and installation requirements illustrated in Figure 5.3.1.D (p. 5-31).

Right-of-Way

1. Open detention ponds shall not be located in dedicated public road right-of-way.
2. Detention ponds to be maintained by King County shall be in a tract dedicated to King County (see Section 1.2.6). Any tract not abutting public right-of-way will require a 15-foot wide extension of the tract to an acceptable access location.

Setbacks

1. A setback of 5 feet from the **toe of the exterior slope** to the tract or property line is required for County-maintained ponds and recommended for privately maintained ponds.
2. The tract or property line on a detention pond cut slope shall be setback 5 feet from the **emergency overflow water surface**.
3. The detention pond water surface at the pond outlet invert elevation shall be setback 100 feet from **proposed or existing septic system drainfields**. This setback may be reduced with written approval of the Seattle-King County Department of Public Health.

Seeps and Springs

Intermittent seeps along cut slopes are typically fed by a shallow groundwater source (interflow) flowing along a relatively impermeable soil stratum. These flows are storm driven and should discontinue after a few weeks of dry weather. The KCRTS model accounts for this shallow groundwater component, and no special provisions are needed when directing these flows through the flow control facility. However, more continuous seeps and springs, which extend through longer dry periods, are likely from a deeper groundwater source. When continuous flows are intercepted and directed through flow control facilities, adjustments to the approved facility design may be required to account for the additional base flow (unless already considered in design). If uncertain at the time of construction, the situation may be monitored while the facility is under maintenance and defect financial guarantee. Adjustments to the facility may be required prior to the release of the financial guarantee.

Planting Requirements

Exposed earth on the pond bottom and interior side slopes shall be sodded or seeded with an appropriate seed mixture. All remaining areas of the tract must either be planted with grass or be landscaped and mulched with a 4-inch cover of hog fuel or shredded wood mulch.[5]

Landscaping

Landscaping is encouraged, but not required, for most stormwater tract areas (see below for areas not to be landscaped). However, if provided, landscaping must adhere to the criteria which follow so as not to hinder maintenance operations. Landscaped stormwater tracts may, in some instances, be used to satisfy requirements for recreational space. In other instances, "naturalistc" stormwater facilities may be placed in open space tracts. For more information, see page 5-26.

If landscaping is proposed, the following requirements shall apply:

1. **No trees or shrubs may be planted within 10 feet of inlet or outlet pipes** or manmade drainage structures such as spillways or flow spreaders. Species with roots that seek water, such as willow or poplar, should be avoided within 50 feet of pipes or manmade structures.

2. **Planting is restricted on berms that impound water** either permanently or temporarily during storms. *Note: This restriction does not apply to cut slopes that form pond banks, only to berms.*

   a) Trees or shrubs may not be planted on portions of water-impounding berms taller than four feet high. Only grasses may be planted on berms taller than four feet.

      Intent: Grasses allow unobstructed visibility of berm slopes for detecting potential dam safety problems such as animal burrows, slumping, or fractures in the berm.

   b) Trees planted on portions of water-impounding berms less than 4 feet high must be small, not higher than 20 feet mature height, and have a fibrous root system. Table 5.3.1.A gives some examples of trees with these characteristics.

      Intent: These trees reduce the likelihood of blow-down trees, or the possibility of channeling or piping of water through the root system, which may contribute to dam failure on berms that retain water.

   Note: The internal berm in a wetpond is not subject to this planting restriction since the failure of an internal berm would be unlikely to create a safety problem.

3. All landscape material, including grass, must be **planted in good topsoil**. Native underlying soils may be made suitable for planting if amended with 4 inches of well-rotted compost tilled into the subgrade. Compost used should meet Ecology publication 94-38 specifications for Grade A compost quality.

4. Soil in which **trees or shrubs** are planted may require additional enrichment or additional compost top-dressing. Consult a nurseryman, landscape professional, or arborist for site-specific recommendations.

5. For a naturalistic effect as well as ease of maintenance, trees or shrubs must be planted in clumps to form "*landscape islands*" rather than evenly spaced.

6. The **landscaped islands** must be a minimum of six feet apart, and if set back from fences or other barriers, the setback distance must also be a minimum of six feet. Where tree foliage extends low to the ground, the six feet of setback should be counted from the outer drip line of the trees (estimated at maturity).

   Intent: This setback allows a 6-foot wide mower to pass around and between clumps.

[5] Shredded wood mulch is made from shredded tree trimmings, usually from trees cleared on site. It must be free of garbage and weeds and may not contain excessive resin, tannin, or other material detrimental to plant growth.

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7. Evergreen trees and trees which produce relatively little leaf-fall (such as Oregon ash, mimosa, or locust) are preferred in areas draining to the pond.
8. Trees should be set back so that branches do not extend over the pond (to prevent leaf-drop into the water).
9. Drought tolerant species are recommended.

TABLE 5.3.1.A SMALL TREES AND SHRUBS WITH FIBROUS ROOTS

Small Trees / High Shrubs	Low Shrubs
*Red twig dogwood (*Cornus stolonifera*)	*Snowberry (*Symphoricarpus albus*)
*Serviceberry (*Amelanchier alnifolia*)	*Salmonberry (*Rubus spectabilis*)
Strawberry tree (*Arbutus unedo*)	*Rosa rugosa* (avoid spreading varieties)
Highbush cranberry (*Vaccinium opulus*)	Rock rose (*Cistus* spp.)
Blueberry (*Vaccinium* spp.)	Ceanothus spp. (choose hardier varieties)
*Filbert (*Corylus cornuta*, others)	New Zealand flax (*Phormium penax*)
Fruit trees on dwarf rootstock	
Rhododendron (native and ornamental varieties)	Ornamental grasses (e.g., *Miscanthis, Pennisetum)*

* *Native species*

Guidelines for Naturalistic Planting

Stormwater facilities may sometimes be located within open space tracts if "natural appearing" (see page 5-26 for details). Two generic kinds of naturalistic planting are outlined below, but other options are also possible. A booklet discussing stormwater ponds and landscaping possibilities is available at the Water and Land Resources Division; when completed, it should be consulted for additional ideas. Native vegetation is preferred in naturalistic plantings.

Note: These landscaping criteria must be followed unless a landscape professional judges that long-term quality of the open space would be improved by deviating from the criteria, AND that if the facility is maintained by the County, maintenance would not be made more difficult by the deviations.

Open Woodland

In addition to the general landscaping criteria above, the following requirements must be met:

1. Landscaped islands (when mature) should cover a minimum of 30% or more of the tract, exclusive of the pond area.
2. Tree clumps should be underplanted with shade-tolerant shrubs and groundcover plants. The goal is to provide a dense understory that need not be weeded or mowed.
3. Landscaped islands should be placed at several elevations rather than "ring" the pond, and the size of clumps should vary from small to large to create variety.
4. Not all islands need have trees. Shrub or groundcover clumps are acceptable, but lack of shade should be considered in selecting vegetation.

Note: Landscaped islands are best combined with the use of hog fuel or shredded wood mulch for erosion control (only for slopes above the flow control water surface). *It is often difficult to sustain a low-maintenance understory if the site was previously hydroseeded.*

Northwest Savannah or Meadow

In addition to the general landscape criteria above, the following requirements must be met:

1. Landscape islands (when mature) should cover 10% or more of the site, exclusive of the pond area.
2. Planting groundcovers and understory shrubs is encouraged to eliminate the need for mowing under the trees when they are young.
3. Landscape islands should be placed at several elevations rather than "ring" the pond.
4. The remaining site area should be planted with an appropriate grass seed mix which may include northwest meadow or wildflower species. Native or dwarf grass mixes are preferred. Table 5.3.1.B below gives one acceptable dwarf grass mix. Grass seed should be applied at 2.5 to 3 pounds per 1000 square feet. *Note: Amended soil or good topsoil is required for all plantings.*
5. Creation of areas of emergent vegetation in shallow areas of the pond is recommended. Native wetland plants, such as sedges (*Carex* sp.), bulrush (*Scirpus* sp.), water plantain (*Alisma* sp.), and burreed (*Sparganium sp.*) are recommended. If the pond does not hold standing water, a clump of wet-tolerant, non-invasive shrubs, such as salmonberry or snowberry, is recommended below the detention design water surface.

Note: This landscape style is best combined with the use of grass or sod for site stabilization and erosion control.

TABLE 5.3.1.B STORMWATER TRACT "LOW-GROW" SEED MIX

Seed Name	Percentage of Mix
Dwarf tall fescue	40%
Dwarf perennial rye "Barclay" *	30%
Red fescue	25%
Colonial bentgrass	5%

* If wildflowers are used and sowing is done before Labor Day, the amount of dwarf perennial rye can be reduced proportionately to the amount of wildflower seed used.

Detention Ponds in Recreational Tracts

Projects required to provide onsite recreational space per KCC 21A.14.180 may combine the detention pond tract with the recreation space tract to receive a 50% reduction in required onsite recreational space. To receive the 50% credit, the following criteria must be met as required by KCC 21A.14.180.D:

1. The proposed stormwater tract must be dedicated or reserved as a part of a recreational space tract.
2. The stormwater pond must be constructed to meet the following requirements:
   a) Side slopes shall not exceed 33 percent unless they are existing, natural, and covered with vegetation.
   b) A bypass system or an emergency overflow pathway shall be designed to handle flow exceeding the facility design and located so that it does not pass through active recreation areas or present a safety hazard.
   c) The stormwater pond shall be landscaped in a manner to enhance passive recreational opportunities such as trails and aesthetic viewing.

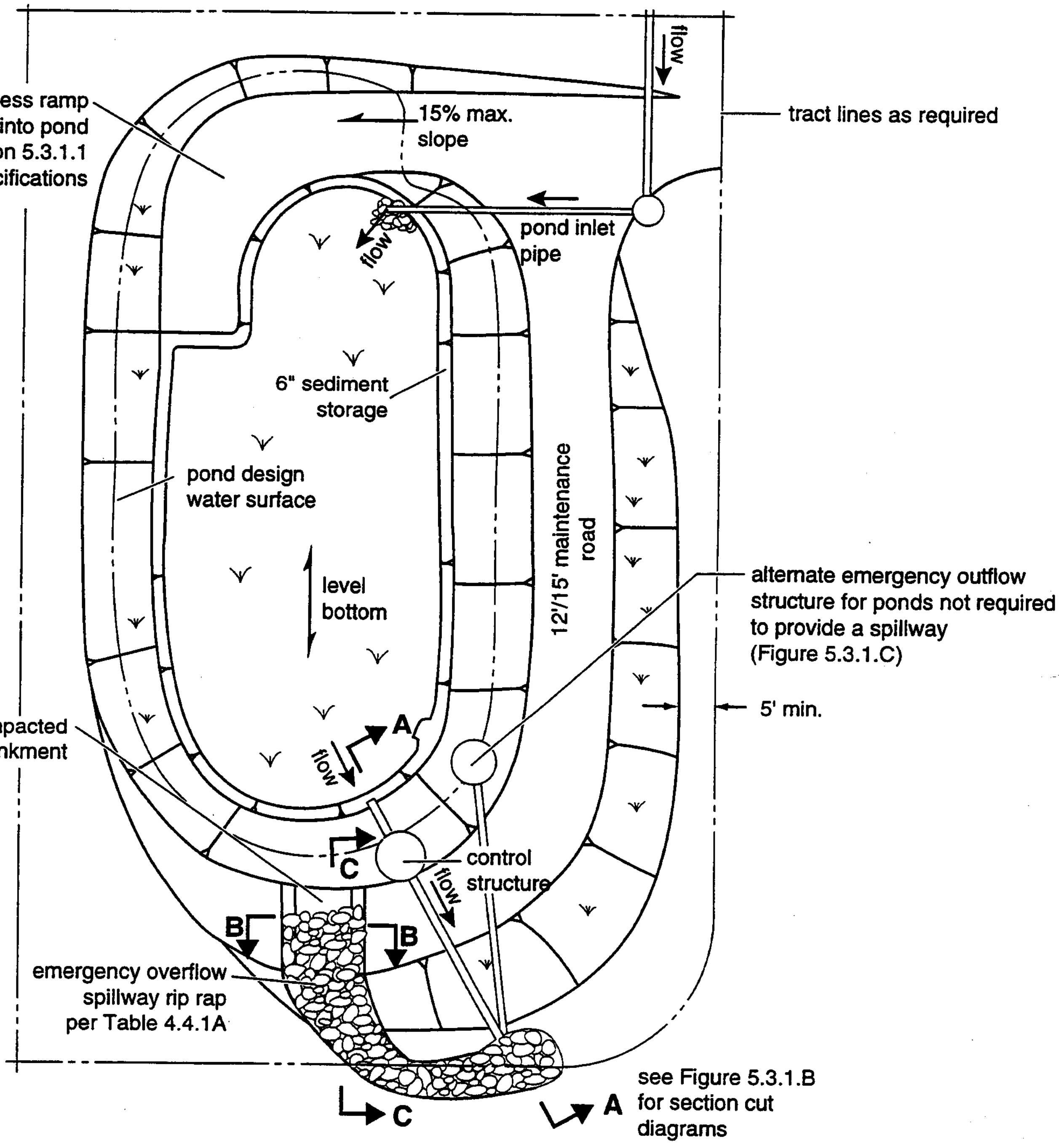
d) The stormwater pond shall be designed so that it does not require fencing per the fencing requirements on page 5-22.

3. Where a tract is jointly used for recreational space and King County maintained drainage facilities, the County is only responsible for maintenance of the drainage facilities, and an access easement shall be provided for that purpose.

Detention Ponds in Open Space

Open space areas reserved through the **four-to-one program** may be used to site "natural appearing" stormwater facilities if they are found to be compatible with the site open space value and functions, and if they are located on a "small portion of the open space" (Amended policy I-204, King County Comprehensive Plan). Conscientious application of the "Guidelines for Naturalistic Plantings" (p. 5-25) typically will produce natural-appearing stormwater facilities. A site-specific assessment is needed, however, to determine whether the stormwater tract would be compatible with the open space value and functions.

FIGURE 5.3.1.A TYPICAL DETENTION POND



NOTE:
This detail is a schematic representation only. Actual configuation will vary depending on specific site constraints and applicable design criteria.

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FIGURE 5.3.1.B TYPICAL DETENTION POND SECTIONS

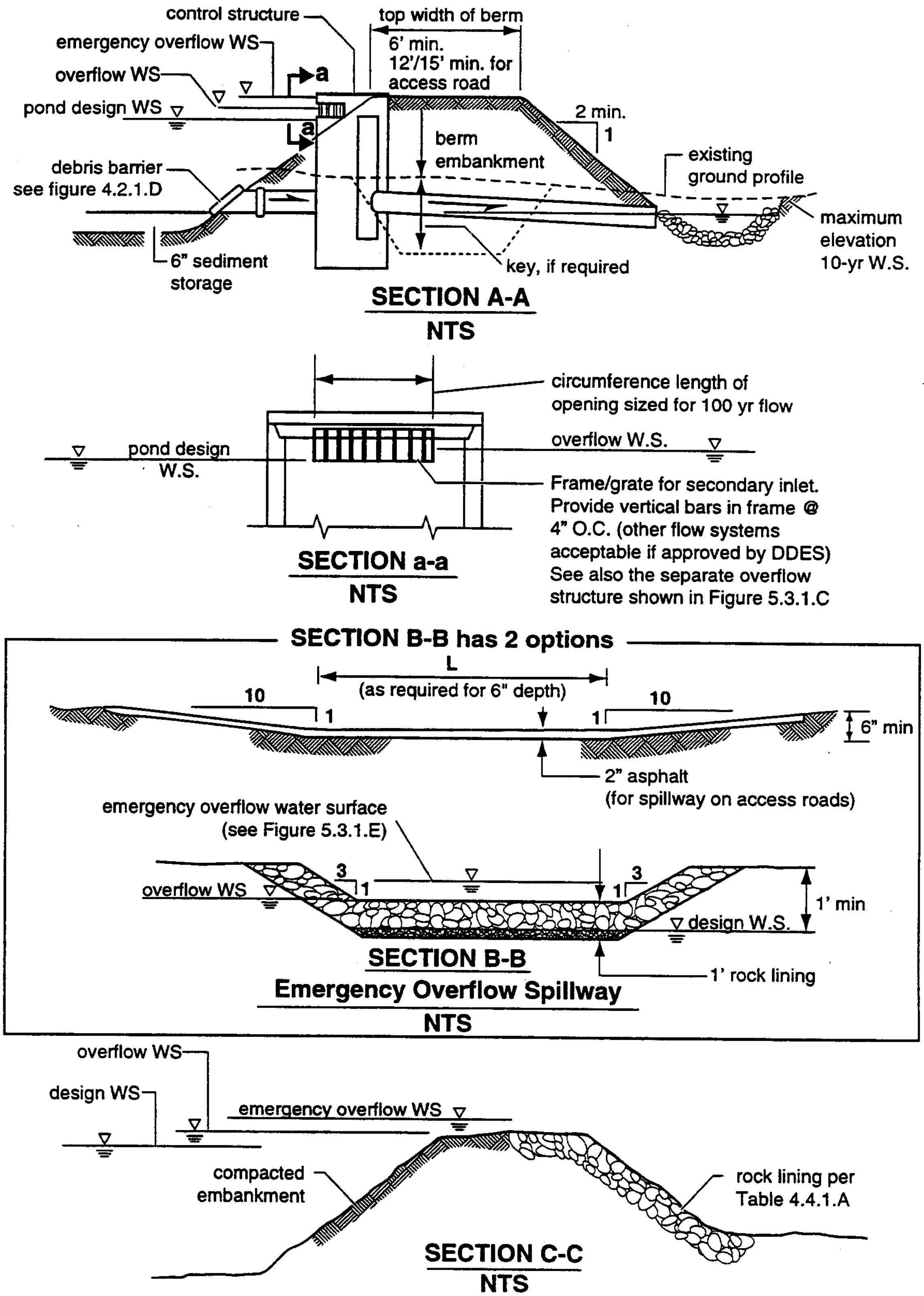
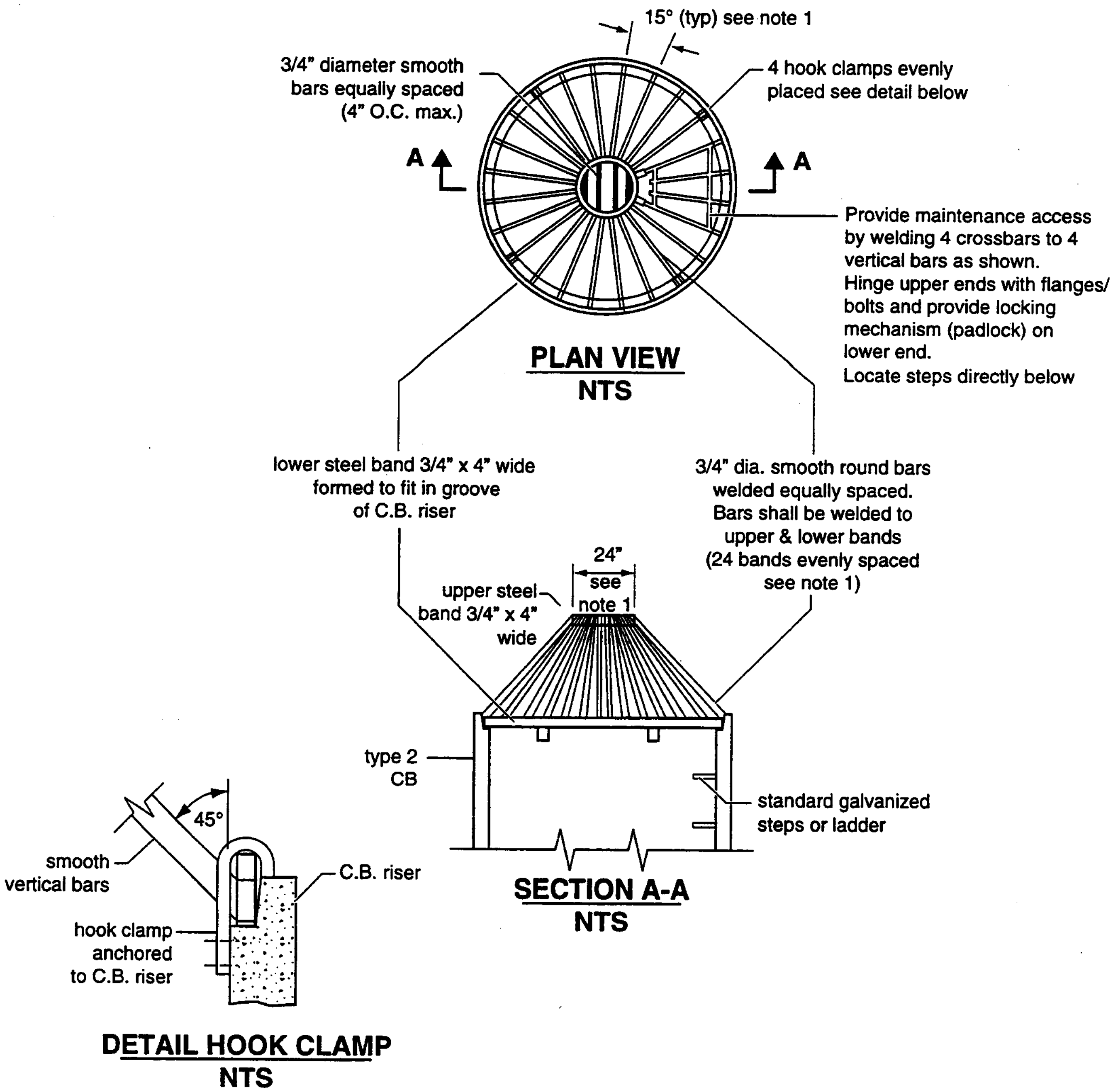


FIGURE 5.3.1.C OVERFLOW STRUCTURE



NOTES:

1. Dimensions are for illustration on 54" diameter CB For different diameter CB's adjust to maintain 45° angle on "vertical" bars and 7" o.c. maximum spacing of bars around lower steel band.
2. Metal parts must be corrosion resistant; steel bars must be galvanized.
3. This debris barrier is also recommended for use on the inlet to roadway cross-culverts with high potential for debris collection (except on type 2 streams)
4. This debris barrier is for use outside of road right-of-way only. For debris cages within road right-of-way, see Drawing 2-028 KCRS.

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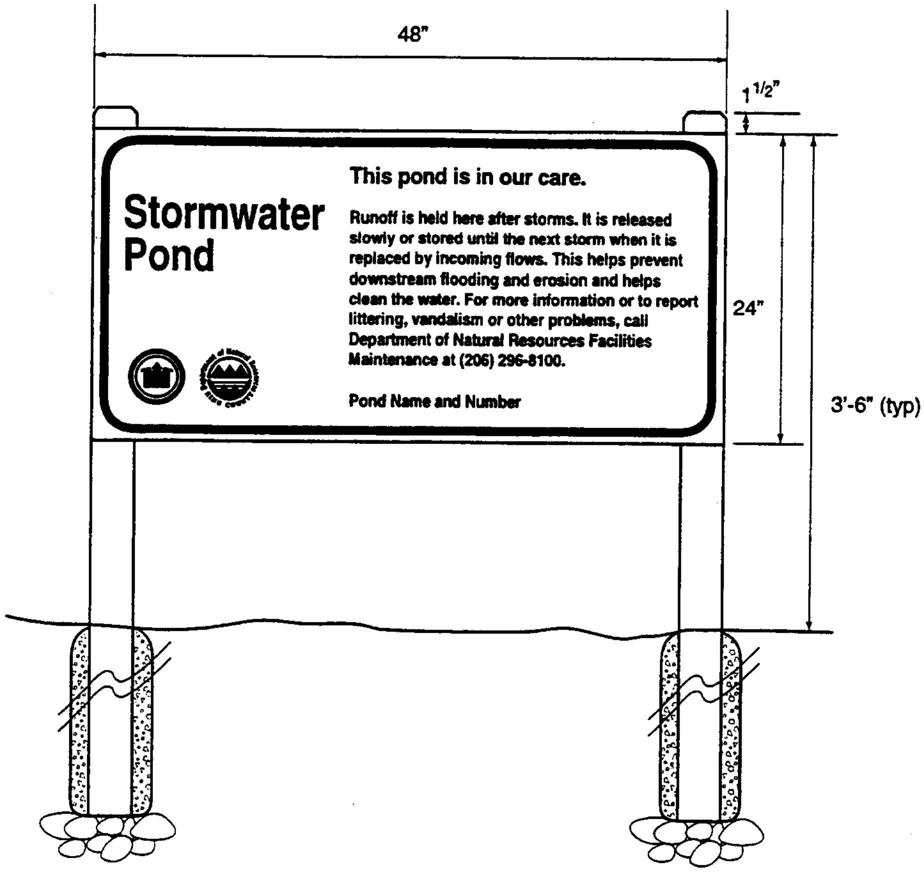
FIGURE 5.3.1.D PERMANENT SURFACE WATER CONTROL POND SIGN



SPECIFICATIONS:

Size: 48 inches by 24 inches

Material: 0.125-gauge aluminum

Face: Non-reflective vinyl or 3 coats outdoor enamel (sprayed).

Lettering: Silk screen enamel where possible, or vinyl letters.

Colors: Beige background, teal letters.

Type face: Helvetica condensed. Title: 3 inch; Sub-Title: $1^1/_2$ inch; Text: 1 inch; Outer border: $^1/_8$ inch border distance from edge: 1/4 inch; all text $1^3/_4$ inch from border.

Posts: Pressure treated, beveled tops, $1^1/_2$ inch higher than sign.

Installation: Secure to chain link fence if available. Otherwise install on two 4"x4" posts, pressure treated, mounted atop gravel bed, installed in 30-inch concrete filled post holes (8-inch minimum diameter). Top of sign no higher than 42 inches from ground surface.

Placement: Face sign in direction of primary visual or physical access. Do not block any access road. Do not place within 6 feet of structural facilities (e.g. manholes, spillways, pipe inlets).

Note: If the facility has a liner to restrict infiltration of stormwater, the following note must be added to the face of the sign: "This facility is lined to protect groundwater quality." In addition, specific information about the liner must be added to the back of the sign as specified in Section 6.2.4.

5.3.1.2 METHODS OF ANALYSIS

Detention Volume and Outflow

The volume and outflow design for detention ponds shall be in accordance with the performance requirements in Chapter 1 and the hydrologic analysis and design methods in Chapter 3. Restrictor orifice structure design shall comply with Section 5.3.4 (p. 5-40). *Note: The **design water surface elevation** is the highest elevation which occurs in order to meet the required outflow performance for the pond.*

Detention Ponds in Infiltrative Soils

Detention ponds may occasionally be sited on till soils that otherwise meet the basic criteria of "**sufficient permeable soil**" for a properly functioning infiltration system (see Section 5.4.1, p. 5-53). These detention ponds have a surface discharge and may also utilize infiltration as a second pond outflow. Detention ponds sized with infiltration as a second outflow must meet all the requirements of Section 5.4 for infiltration ponds, including a soils report, testing, groundwater protection, presettling, and construction techniques.

Emergency Overflow Spillway Capacity

The emergency overflow spillway weir section shall be designed to pass the 100-year runoff event for developed conditions assuming a broad-crested weir. The **broad-crested weir equation** for the spillway section in Figure 5.3.1.E, for example, would be:

$$Q_{100} = C\,(2g)^{1/2}\,[{}^{2}/_{3}\,LH^{3/2} + {}^{8}/_{15}\,(\text{Tan}\,\theta)\,H^{5/2}] \qquad (5\text{-}1)$$

where
Q_{100} = peak flow for the 100-year runoff event (fps)
C = discharge coefficient (0.6)
g = gravity (32.2 ft/sec^2)
L = length of weir (ft)
H = height of water over weir (ft)
θ = angle of side slopes

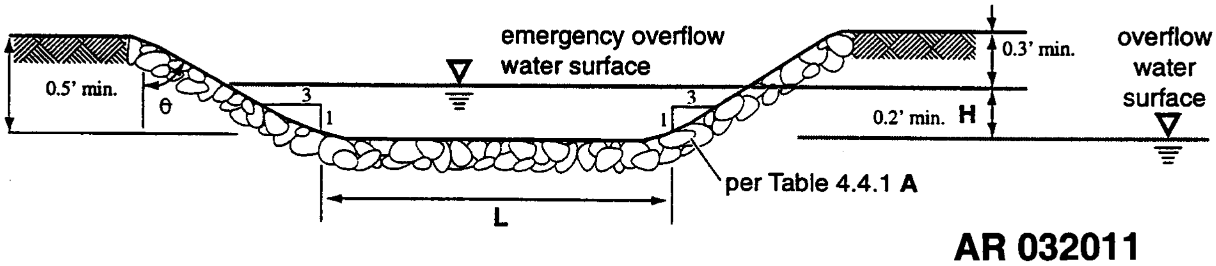
Assuming $C = 0.6$ and Tan $\theta = 3$ (for 3:1 slopes), the equation becomes:

$$Q_{100} = 3.21\,(LH^{3/2} + 2.4\,H^{5/2}) \qquad (5\text{-}2)$$

To find width L for the weir section, the equation is rearranged to use the computed Q_{100} and trial values of H (0.2 feet minimum):

$$L = [Q_{100}\,/\,(3.21\,H^{3/2})] - 2.4\,H \quad \text{or} \quad 6 \text{ feet minimum} \qquad (5\text{-}3)$$

FIGURE 5.3.1.E WEIR SECTION FOR EMERGENCY OVERFLOW SPILLWAY



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5.3.2 DETENTION TANKS

Detention tanks are underground storage facilities typically constructed with large diameter corrugated metal pipe. Standard detention tank details are shown in Figure 5.3.2.A (p. 5-35) and Figure 5.3.2.B (p. 5-36). Control structure details are shown in Section 5.3.4 beginning on page 5-40.

5.3.2.1 DESIGN CRITERIA

General

1. Tanks shall be designed as **flow-through systems with manholes in line** (see Figure 5.3.2.A, p. 5-35) to promote sediment removal and facilitate maintenance.

   Exception: Tanks may be designed as **back-up systems** if preceded by water quality facilities since little sediment should reach the inlet/control structure and low headlosses can be expected because of the proximity of the inlet/control structure to the tank.

2. The detention tank bottom shall be located 0.5 feet below the inlet and outlet to provide dead storage for sediment.
3. The **minimum pipe diameter** allowed for a detention tank is 36 inches.
4. Tanks larger than 36 inches may be connected to each adjoining structure with a short section (2-foot maximum length) of 36-inch minimum diameter pipe.
5. Outflow **control structures** shall be as detailed in Section 5.3.4 (p. 5-40). *Note: Control and access manholes shall have additional ladder rungs to allow ready access to all tank access pipes when the catch basin sump is filled with water (see Figure 5.3.4.A, plan view, p. 5-42).*

Materials

Galvanized metals leach zinc into the environment, especially in standing water situations. High zinc concentrations, sometimes in the range that can be toxic to aquatic life, have been observed in the region.[6] Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other metals, such as aluminum or stainless steel, or plastics are available, they should be used.

Pipe material, joints, and protective treatment for tanks shall be in accordance with Section 9.05 of the *WSDOT/APWA Standard Specification* as modified by the *King County Road Standards* and AASHTO designations. Such materials include the following:

- Lined corrugated polyethylene pipe (LCPE)
- Aluminized Type 2 corrugated steel pipe and pipe arch (meets AASHTO designations M274 and M36)
- Aluminum spiral rib pipe
- Corrugated aluminum pipe and pipe arch
- Reinforced concrete pipe
- Narrow concrete vaults (see Section 5.3.3, p. 5-37).
- Galvanized, corrugated iron or steel pipe and pipe arch, Treatments 1 through 6
- Galvanized steel spiral rib pipe, Treatments 1 through 6
- Galvanized structural plate pipe and pipe arch, Treatments 1 through 6

[6] Finlayson, 1990. Unpublished data from reconnaissance of Metro Park-and-Ride lot stormwater characteristics.

Structural Stability

Tanks shall meet structural requirements for overburden support and traffic loading if appropriate. H-20 live loads must be accommodated for tanks lying under parking areas and access roads. The *King County Roads Standards* may have different live load requirements for structures located under roadways. Metal tank end plates must be designed for structural stability at maximum hydrostatic loading conditions. Flat end plates generally require thicker gage material than the pipe and/or require reinforcing ribs. Tanks shall be placed on stable, well consolidated native material with a suitable bedding. Tanks shall not be allowed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Buoyancy

In moderately pervious soils where seasonal groundwater may induce flotation, buoyancy tendencies must be balanced either by ballasting with backfill or concrete backfill, providing concrete anchors, increasing the total weight, or providing subsurface drains to permanently lower the groundwater table. Calculations must be submitted which demonstrate stability.

Access Requirements

1. The **maximum depth** from finished grade to tank invert shall be 20 feet.
2. **Access openings** shall be positioned a maximum of 50 feet from any location within the tank.
3. All tank access openings shall have round, solid **locking lids** with $^5/_8$-inch diameter allen head cap screws (see *KCRS* Drawing No. 2-022 and 2-023).
4. Thirty-six-inch minimum diameter **CMP riser-type manholes** (Figure 5.3.2.B, p. 5-36) of the same gage as the tank material may be used for access along the length of the tank and at the upstream terminus of the tank if a backup system. The top slab is separated (1-inch minimum gap) from the top of the riser to allow for deflections from vehicle loadings without damaging the riser tank.
5. All tank access openings must be readily **accessible by maintenance vehicles.**
6. Tanks must comply with the **OSHA confined space requirements**, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Access Roads

Access roads are required to all detention tank control structures and risers. The access roads shall be designed and constructed **as specified for detention ponds** in Section 5.3.1 (p. 5-22).

Right-of-Way

Detention tanks to be maintained by King County but not located in King County right-of-way shall be in a tract dedicated to King County. Any tract not abutting public right-of-way will require a 15-foot wide extension of the tract to accommodate an access road to the facility.

Setbacks

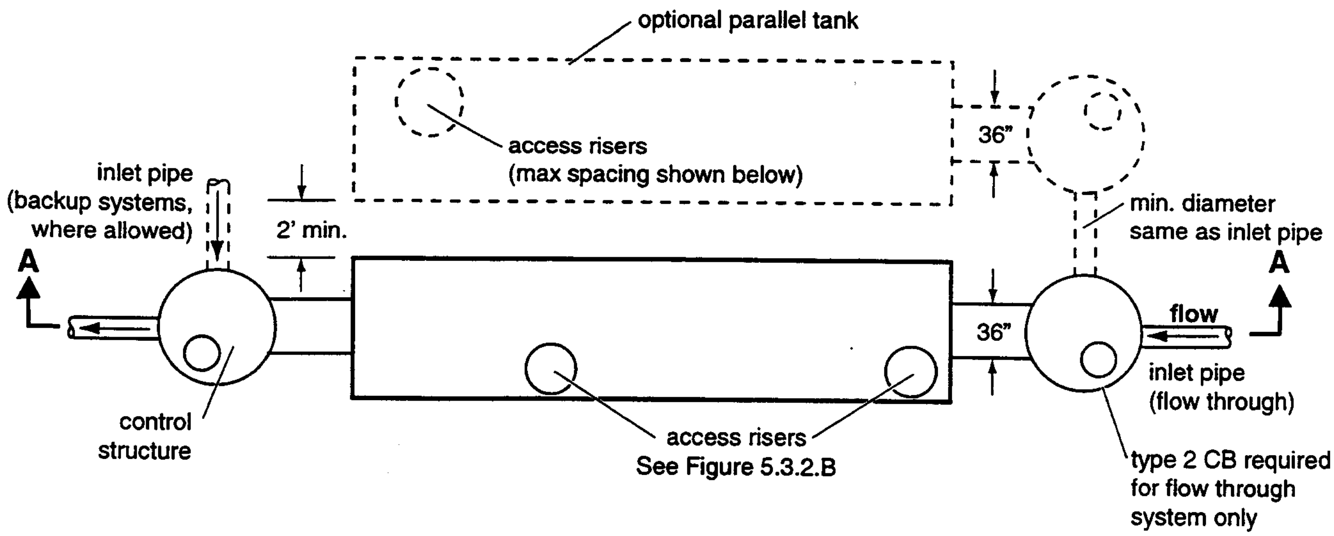
Setbacks (easement/tract width) and building setback lines (BSBLs) for tanks shall be the same as for pipes (see Section 4.1).

5.3.2.2 METHODS OF ANALYSIS

Detention Volume and Outflow

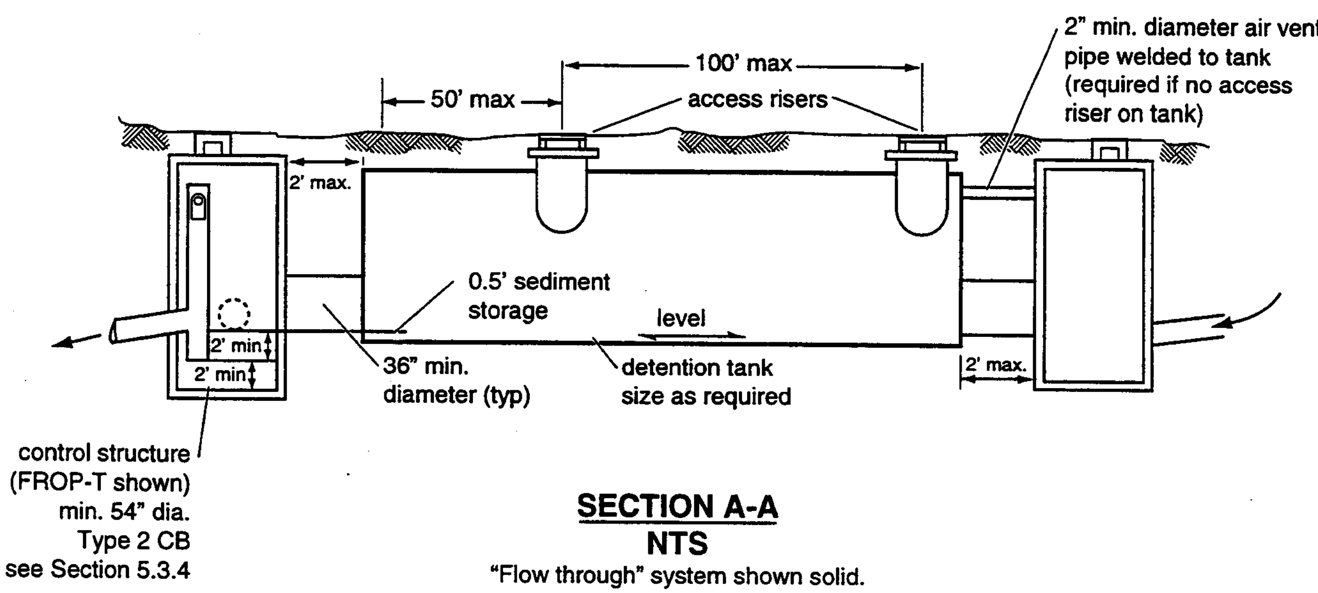
The volume and outflow design for **detention tanks** shall be in accordance with the performance requirements in Chapter 1 and the hydrologic analysis and design methods in Chapter 3. Restrictor and orifice design shall be according to Section 5.3.4 (p. 5-40).

FIGURE 5.3.2.A TYPICAL DETENTION TANK



PLAN VIEW
NTS

"Flow-through" system shown solid.
Designs for "flow backup" system and
parallel tanks shown dashed



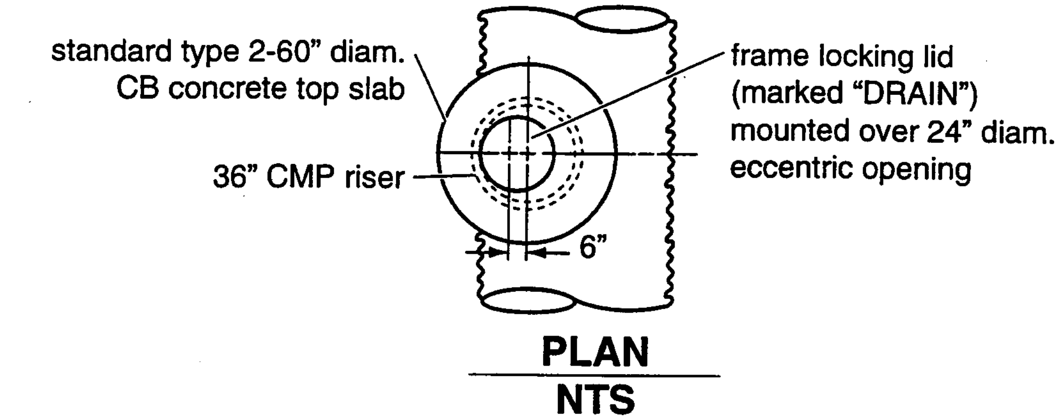
SECTION A-A
NTS

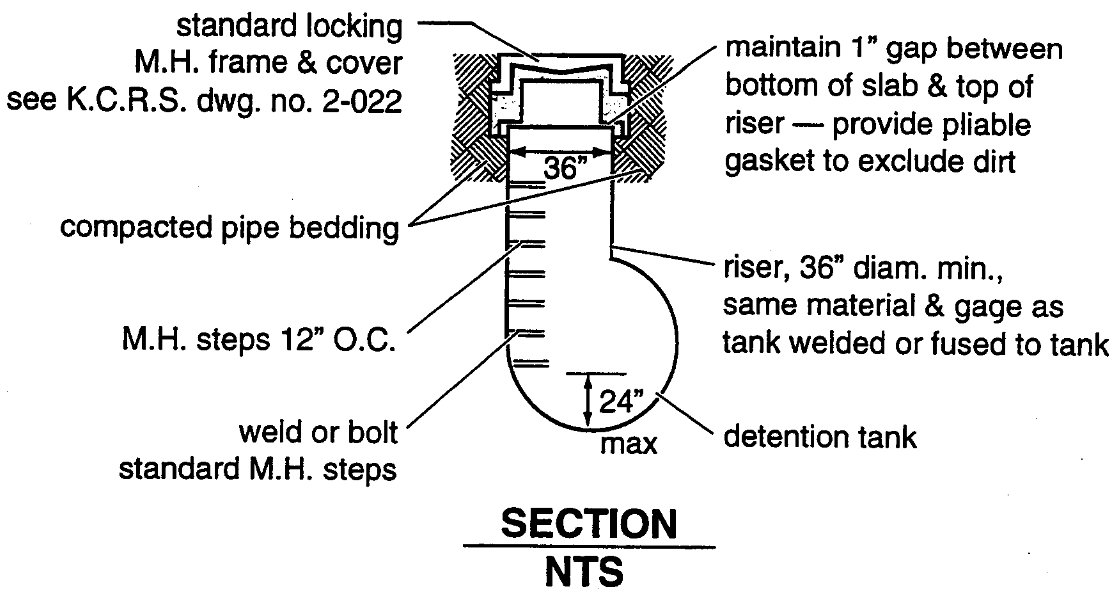
"Flow through" system shown solid.

NOTE:
All metal parts corrosion resistant.
Steel parts galvanized and asphalt
coated (Treatment 1 or better).

AR 032014

FIGURE 5.3.2.B DETENTION TANK ACCESS DETAIL





NOTES:

1. Use adjusting blocks as required to bring frame to grade.
2. All materials to be aluminum or galvanized and asphalt coated (Treatment 1 or better).
3. Must be located for access by maintenance vehicles.
4. May substitute WSDOT special Type IV manhole (RCP only).

AR 032015

5.3.3 DETENTION VAULTS

Detention vaults are box-shaped underground storage facilities typically constructed with reinforced concrete. A standard detention vault detail is shown in Figure 5.3.3.A (p. 5-39). Control structure details are shown in Section 5.3.4 beginning on page 5-40.

5.3.3.1 DESIGN CRITERIA

General

1. Detention vaults shall be designed as **flow-through systems** with bottoms level (longitudinally) or sloped toward the inlet to facilitate sediment removal. Distance between the inlet and outlet shall be maximized (as feasible).
2. The detention **vault bottom** shall slope at least 5% from each side towards the center, forming a broad "v" to facilitate sediment removal. *Note: More than one "v" may be used to minimize vault depth.*

   Exception: The vault bottom may be flat if **removable panels** are provided over the entire vault. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
3. The **invert elevation of the outlet** shall be elevated above the bottom of the vault to provide an average 6 inches of sediment storage over the entire bottom. The outlet must also be elevated a minimum of 2 feet above the orifice to retain oil within the vault.
4. The outflow system and restrictor device shall be designed according to the applicable requirements specified for **control structures** in Section 5.3.4 (p. 5-40).

Materials

Minimum 3,000 psi structural reinforced concrete must be used for all detention vaults. All construction joints must be provided with water stops.

Structural Stability

All vaults shall meet structural requirements for overburden support and H-20 traffic loading. Vaults located under roadways must meet the live load requirements of the *King County Road Standards*. Cast-in-place wall sections shall be designed as retaining walls. Structural designs for cast-in-place vaults require a separate commercial building permit issued by DDES, and must be stamped by a licensed structural civil engineer. Vaults shall be placed on stable, well-consolidated native material with suitable bedding. Vaults shall not be allowed in fill slopes, unless analyzed in a geotechnical report for stability and constructability.

Access Requirements

1. **Access** shall be provided over the inlet pipe and outlet structure. Access openings shall be positioned a maximum of 50 feet from any location within the tank; additional access points may be required on large vaults. If more than one "v" is provided in the vault floor, access to each "v" must be provided.
2. For vaults with **greater than 1250 square feet of floor area**, a 5' by 10' removable panel shall be provided over the inlet pipe (instead of a standard frame, grate and solid cover). Alternatively, a separate access vault may be provided as shown in Figure 5.3.3.A (p. 5-39).
3. For **vaults under roadways**, the removable panel must be located outside the travel lanes. Alternatively, multiple standard locking manhole covers (see KCRS Drawing No. 2-022 and 2-023) may be provided. Spacing of manhole covers shall be 12 feet, measured on center, to facilitate removal of sediment. Ladders and hand-holds need only be provided at the outlet pipe and inlet pipe,

and as needed to meet OSHA confined space requirements. Vaults providing manhole access at 12-foot spacing need not provide corner ventilation pipes as specified in Item 10 below.

4. All **access openings**, except those covered by removable panels, shall have round, solid **locking lids** (see *KCRS* Drawing No. 2-022 and 2-023), or 3-foot square, locking diamond plate covers.
5. Vaults with widths 10 feet or less must have **removable lids.**
6. The **maximum depth** from finished grade to the vault invert shall be 20 feet.
7. **Internal structural walls** of large vaults shall be provided with openings sufficient for maintenance access between cells. The openings shall be sized and situated to allow access to the maintenance "v" in the vault floor.
8. The **minimum internal height** shall be 7 feet from the highest point of the vault floor (not sump), and the **minimum width** shall be 4 feet.

   Exceptions:

   - Concrete vaults may be a minimum 3 feet in height and width **if used as tanks** with access manholes at each end, and if the width is no larger than the height.
   - The minimum internal height requirement may be waived for any areas covered by removable panels.
9. Vaults must comply with the **OSHA confined space requirements**, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.
10. **Ventilation pipes** (minimum 12-inch diameter or equivalent) shall be provided in all four corners of vaults to allow for artificial ventilation prior to entry of maintenance personnel into the vault. This requirement is waived if removable panels are provided over the entire vault.

Access Roads

Access roads are required to the access panel (if applicable), the control structure, and at least one access point per cell, and they shall be designed and constructed **as specified for detention ponds** in Section 5.3.1
(p. 5-22).

Right-of-Way

Detention vaults to be maintained by King County but not located in King County right-of-way shall be in a tract dedicated to King County. Any tract not abutting public right-of-way will require a 15-foot wide extension of the tract to accommodate an access road to the vault.

Setbacks

Setbacks to tract/easement lines for vaults shall be 5 feet; adjacent building setback lines shall be 10 feet. For privately owned and maintained vaults, building foundations may serve as one or more of the vault walls.

5.3.3.2 METHODS OF ANALYSIS

Detention Volume and Outflow

The volume and outflow design for detention vaults shall be in accordance with the performance requirements in Chapter 1 and the hydrologic analysis and routing/design methods in Chapter 3. Restrictor and orifice design shall be according to Section 5.3.4 (p. 5-40).

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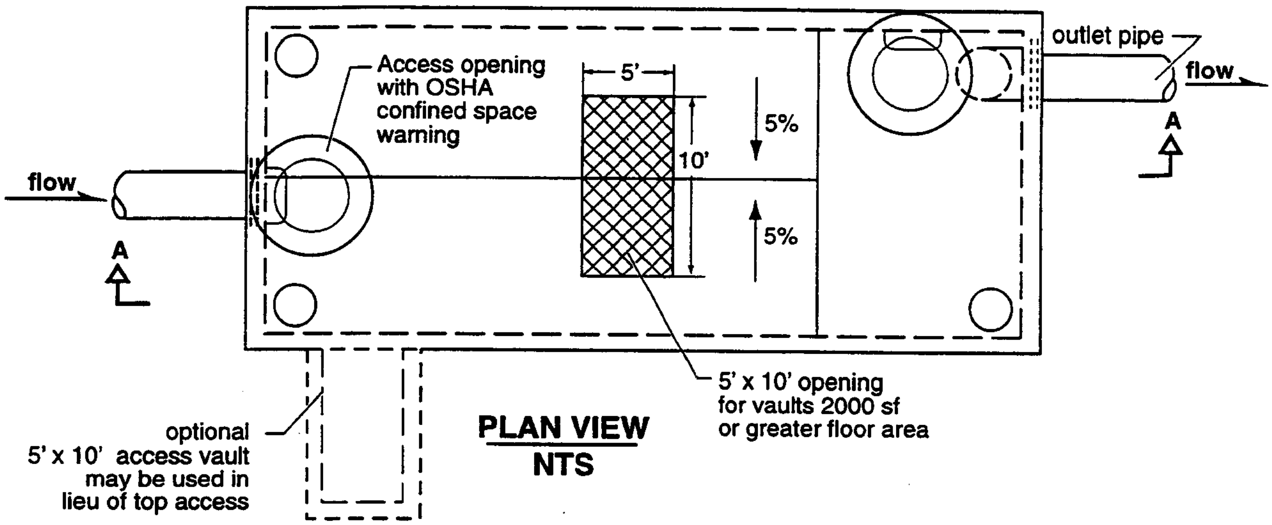
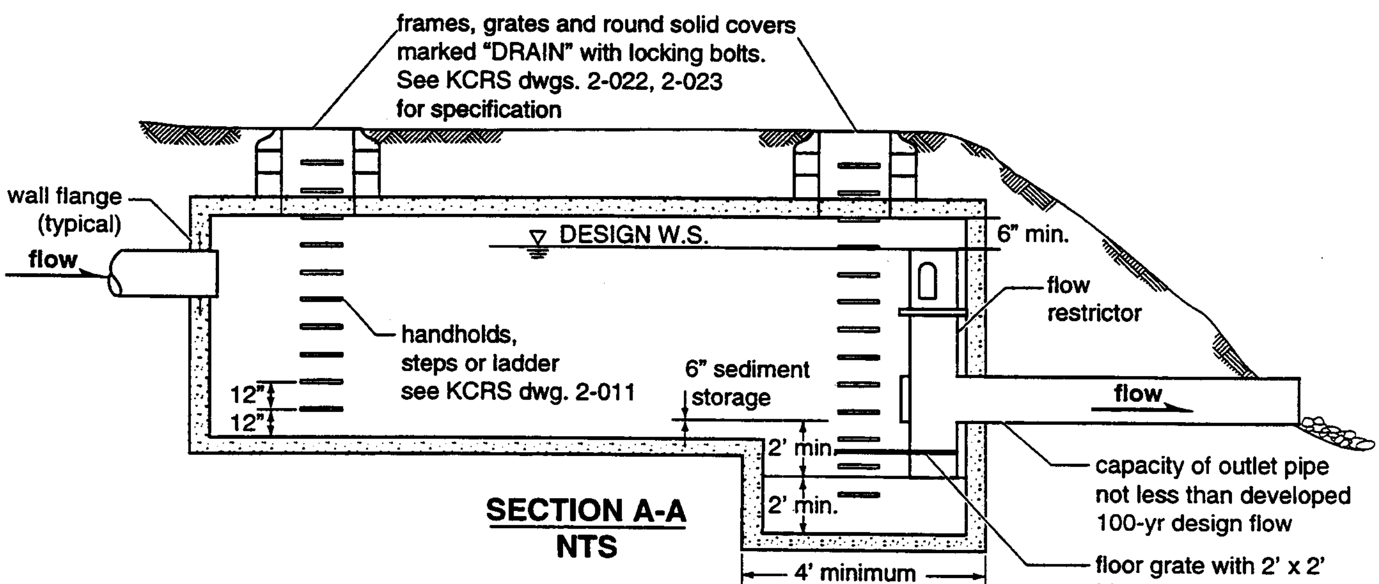
FIGURE 5.3.3.A TYPICAL DETENTION VAULT

NOTE: All vault areas must be within 50' of an access point





NOTES:

1. All metal parts must be corrosion resistant. Steel parts must be galvanized and asphalt coated (Treatment I or better).
2. Provide water stop at all cast-in-place construction joints. Precast vaults shall have approved rubber gasket system.
3. Vaults ≤ 10' wide must use removable lids.
4. Prefabricated vault sections may require structural modifications to support 5' x 10' opening over main vault. Alternatively, access can be provided via a side vestibule as shown.

5.3.4 CONTROL STRUCTURES

Control structures are catch basins or manholes with a restrictor device for controlling outflow from a facility to meet the desired performance. Riser type restrictor devices ("tees" or "FROP-Ts") also provide some incidental oil/water separation and fulfill the spill control requirements specified for pipe systems in Section 4.2 and as set forth in Core Requirement #4 (see Section 1.2.4).

The restrictor device is usually multiple orifice, consisting of two or more orifices and/or a weir section sized to meet performance requirements.

Standard control structure details are shown in Figure 5.3.4.A (p. 5-42) through Figure 5.3.4.C (p. 5-44).

5.3.4.1 DESIGN CRITERIA

Multiple Orifice Restrictor

In most cases, control structures need only two orifices: one at the bottom and one near the top of the riser, although additional orifices may best utilize detention storage volume. Several orifices may be located at the same elevation if necessary to meet performance requirements.

1. **Minimum orifice diameter is 0.5 inches.** *Note: In some instances, a 0.5-inch bottom orifice will be too large to meet target release rates, even with minimal head. In these cases, the live storage depth need not be reduced to less than 3 feet to meet performance.*
2. Orifices shall be constructed on a **tee section** as shown in Figure 5.3.4.A (p. 5-42) or on a baffle as shown in Figure 5.3.4.B (p. 5-43).
3. In some cases, performance requirements may require the **top orifice/elbow** to be located too high on the riser to be physically constructed (e.g., a 13-inch diameter orifice positioned 0.5 feet from the top of the riser). In these cases, a notch weir in the riser pipe may be used to meet performance requirements (see Figure 5.3.4.E, p. 5-46).
4. Consideration shall be given to the backwater effect of water surface elevations in the downstream conveyance system. **High tailwater elevations** may affect performance of the restrictor system and reduce live storage volumes. *Note: The KCRTS program, version 4.0 and later, supports the design of a partially tailwatered control structure by using a headwater/tailwater (HW/TW) data file generated using the KCBW program. The user can specify the use of a HW/TW file within the "Point of Compliance Setup," located within the "Edit Facility" menu screen.*

Riser and Weir Restrictor

1. Properly designed **weirs may be used as flow restrictors** (see Figure 5.3.4.C and Figure 5.3.4.E through Figure 5.3.4.F). However, they must be designed to provide for primary overflow of the developed 100-year peak flow discharging to the detention facility.
2. The combined orifice and riser (or weir) overflow may be used to meet performance requirements; however, the design must still provide for primary overflow of the developed 100-year peak flow assuming all orifices are plugged. Figure 5.3.4.H (p. 5-50) can be used to calculate the head in feet above a riser of given diameter and flow.

Access Requirements

1. An **access road** to the control structure is required for inspection and maintenance, and shall be designed and constructed **as specified for detention ponds** in Section 5.3.1 (p. 5-22).
2. **Manhole and catch basin lids** for control structures shall be **locking**, and rim elevations shall match proposed finish grade.

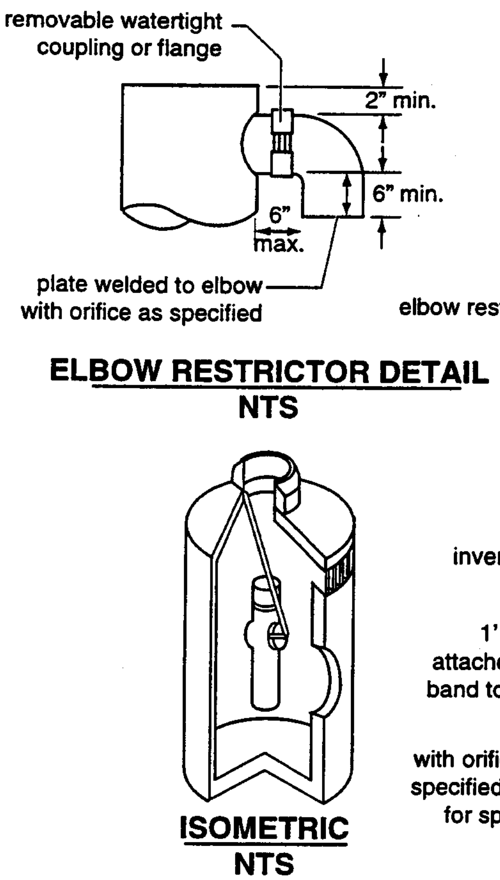
3. Manholes and catch-basins must meet the **OSHA confined space requirements**, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser, just under the access lid.

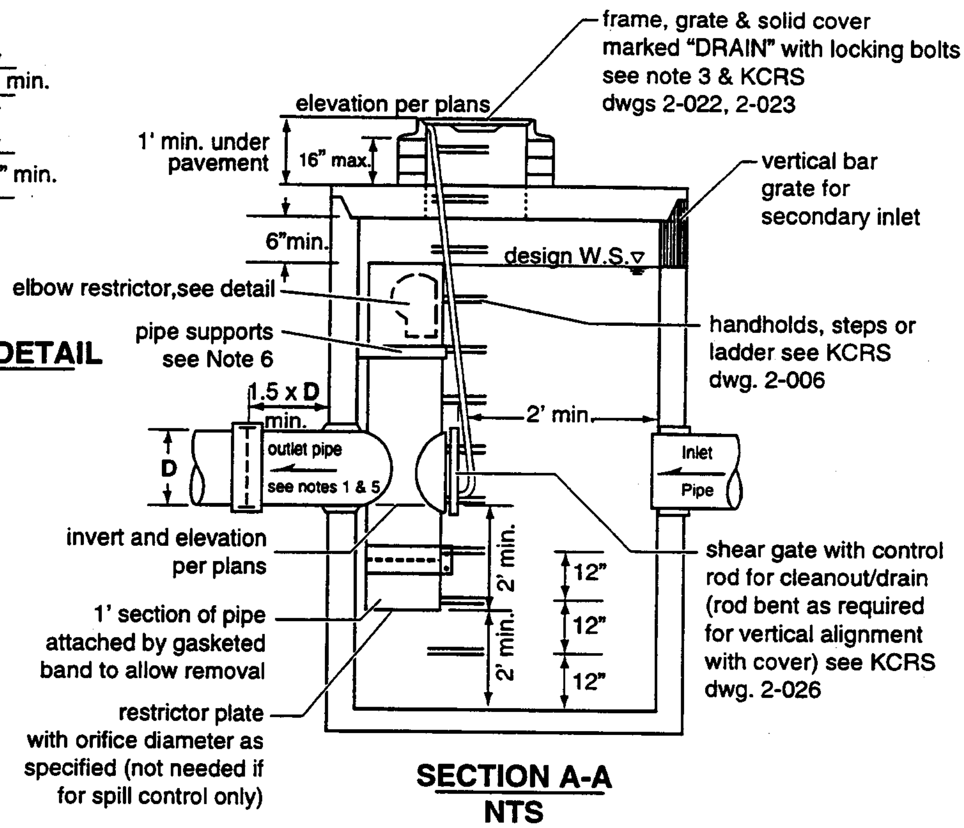
Information Plate

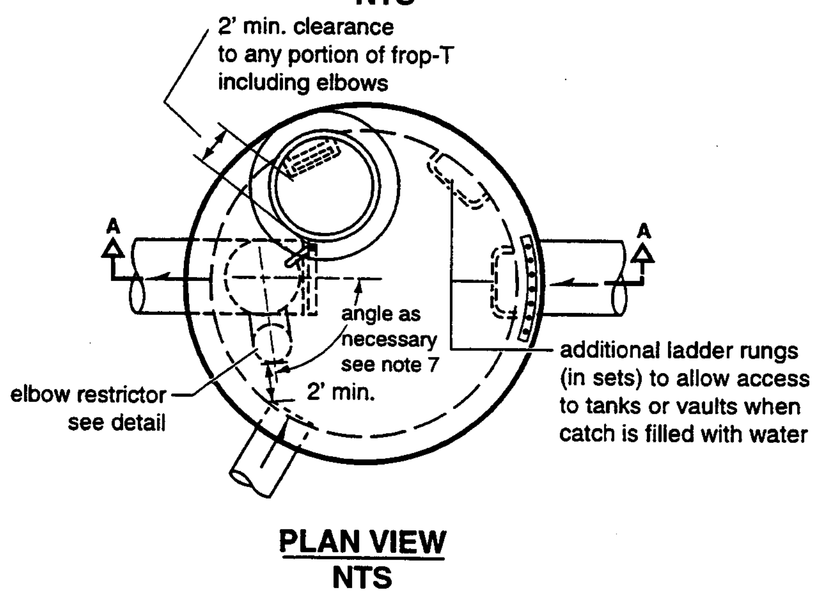
A brass or stainless steel plate shall be permanently attached inside each control structure. Engraved information on the plate shall include the following:

- Name and file number of project
- Name and company of (1) developer, (2) engineer, and (3) contractor
- Date constructed
- Date of manual used for design
- Outflow performance criteria
- Release mechanism size, type, and invert elevation
- List of stage, discharge, and volume at one-foot increments
- Elevation of overflow
- Recommended frequency of maintenance.

FIGURE 5.3.4.A FLOW RESTRICTOR (TEE)







NOTES:

1. Use a minimum of a 54" diameter type 2 catch basin.
2. Outlet Capacity: 100-Year developed peak flow.
3. Metal Parts: Corrosion resistant. Non-Galvanized parts perferred. Galvanized pipe parts to have asphalt treatment 1.
4. Frame and ladder or steps offset so:
   A. Cleanout gate is visible from top.
   B. Climb-down space is clear of riser and cleanout gate.
   C. Frame is clear of curb.
5. If metal outlet pipe connects to cement concrete pipe: outlet pipe to have smooth O.D. equal to concrete pipe I.D. less 1/4".
6. Provide at least one 3" X .090 gage support bracket anchored to concrete wall. (maximum 3'-0" vertical spacing)
7. Locate elbow restrictor(s) as necessary to provide minimum clearance as shown.
8. Locate additional ladder rungs in structures used as access to tanks or vaults to allow access when catch basin is filled with water.

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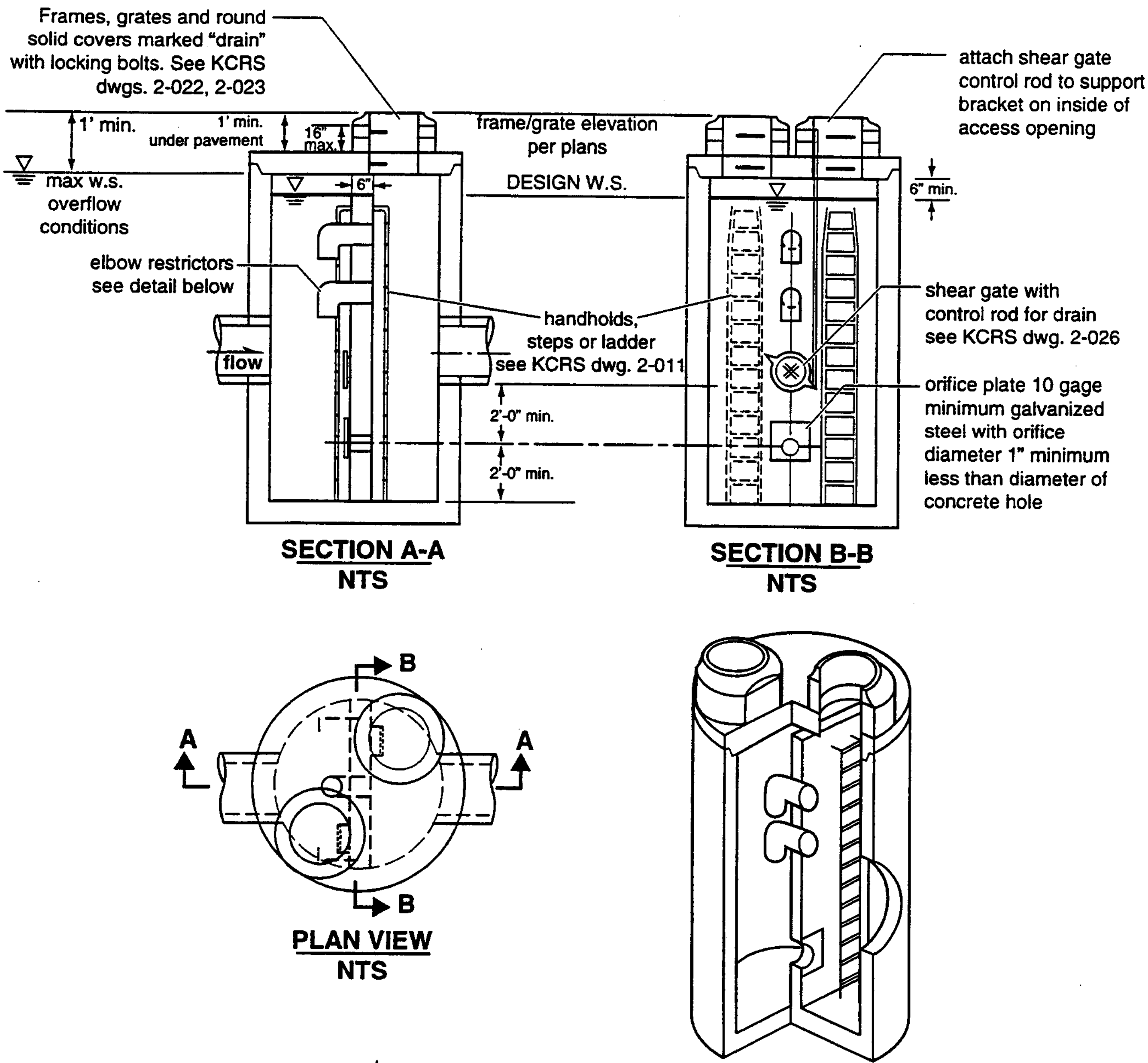
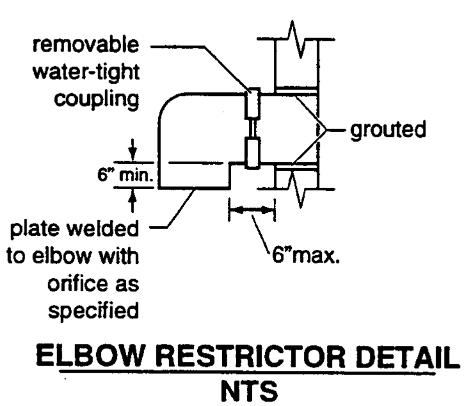
FIGURE 5.3.4.B FLOW RESTRICTOR (BAFFLE)





NOTES:

outlet capacity: 100 year developed peak flow

metal parts: corrosion resistant steel parts galvanized and asphalt coated

catch basin: type 2 minimum 72" diameter to be constructed in accordance with KCRS dwg. 2-005 and AASHTO M-199 unless otherwise specified

orifices: sized and located as required with lowest orifice a minimum of 2' from base

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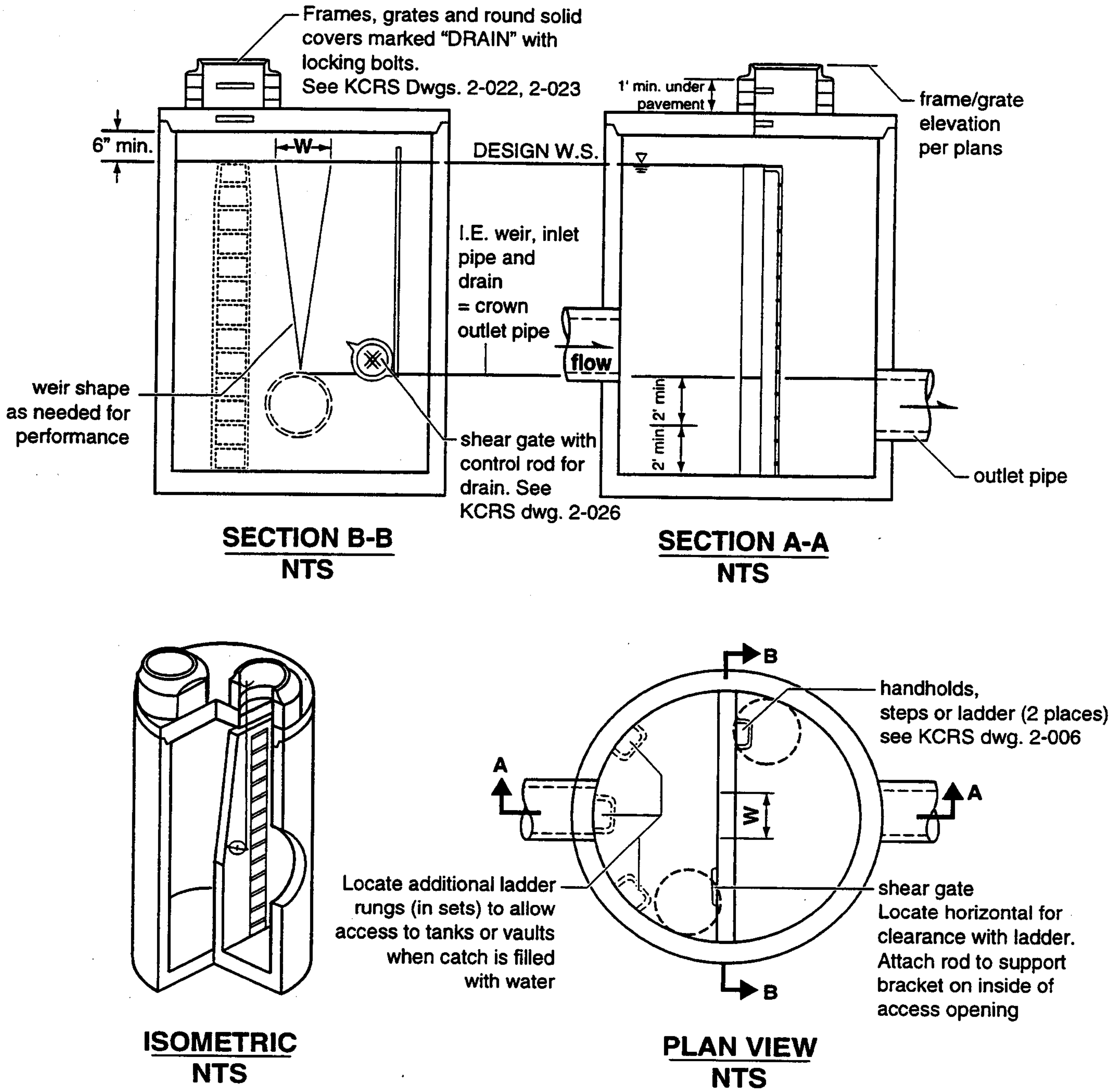
FIGURE 5.3.4.C FLOW RESTRICTOR (WEIR)



NOTES:

Outlet Capacity: 100-year developed peak flow.
Metal Parts: corrosion resistant steel parts galvanized and asphalt coated.
Catch Basin: type 2 Min. 72" diameter to be constructed in accordance with KCRS dwg 2-005 and AASHTO M-199 unless otherwise specified.
Baffle Wall: to be designed with concrete reinforcing as required.
Spill Control Requirements: see Section 4.2.

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5.3.4.2 METHODS OF ANALYSIS

This section presents the methods and equations for design of **control structure restrictor devices**. Included are details for the design of orifices, rectangular sharp-crested weirs, v-notch weirs, sutro weirs, and overflow risers.

Orifices

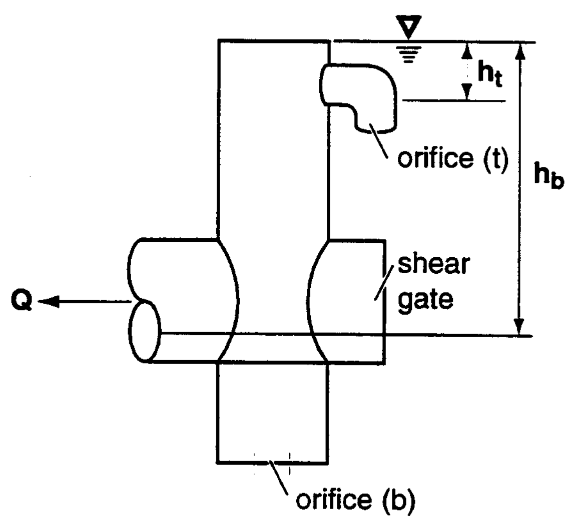
Flow-through orifice plates in the standard tee section or turn-down elbow may be approximated by the general equation:

$$Q = CA\sqrt{2gh} \quad (5\text{-}4)$$

where Q = flow (cfs)
C = coefficient of discharge (0.62 for plate orifice)
A = area of orifice (sf)
h = hydraulic head (ft)
g = gravity (32.2 ft/sec^2)

Figure 5.3.4.D illustrates this simplified application of the orifice equation.

FIGURE 5.3.4.D SIMPLE ORIFICE



$$Q = CA_b\sqrt{2gh_b} + CA_t\sqrt{2gh_t}$$
$$= C\sqrt{2g}\left(A_b\sqrt{h_b} + A_t\sqrt{h_t}\right)$$

hb = distance from hydraulic grade line at the 2-year flow of the outflow pipe to the overflow elevation

The diameter of the orifice is calculated from the flow. The orifice equation is often useful when expressed as the orifice diameter in inches:

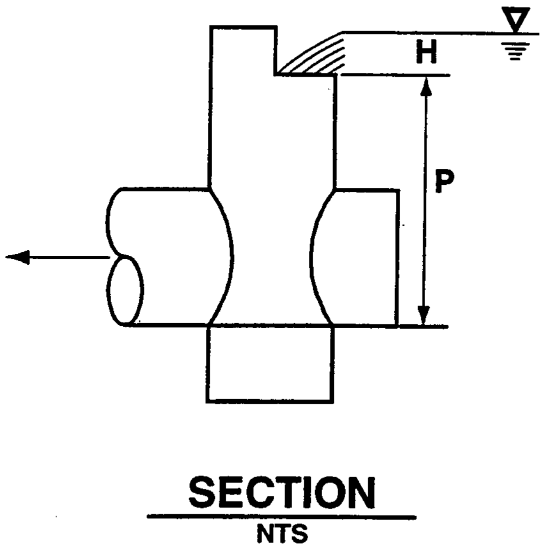
$$d = \sqrt{\frac{36.88Q}{\sqrt{h}}} \quad (5\text{-}5)$$

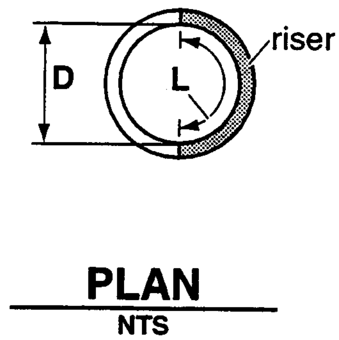
where d = orifice diameter (inches)
Q = flow (cfs)
h = hydraulic head (ft)

Rectangular, Sharp-Crested Weir

The rectangular, sharp-crested weir design shown in Figure 5.3.4.E may be analyzed using standard weir equations for the fully contracted condition.

FIGURE 5.3.4.E RECTANGULAR, SHARP-CRESTED WEIR





$$Q = C(L - 0.2H)H^{3/2} \qquad (5\text{-}6)$$

where Q = flow (cfs)
C = $3.27 + 0.40\ H/P$ (ft)
H,P are as shown above
L = length (ft) of the portion of the riser circumference as necessary not to exceed 50% of the circumference
D = inside riser diameter (ft)

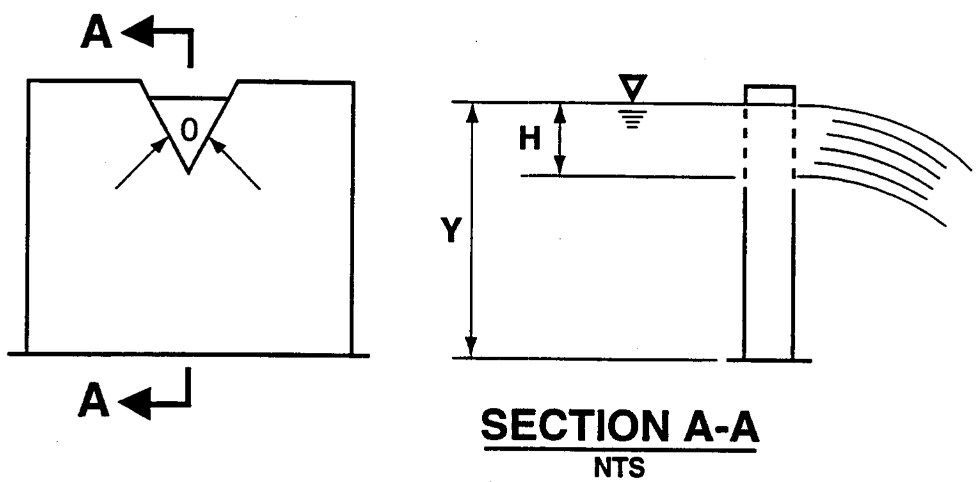
Note that this equation accounts for side contractions by subtracting 0.1H from L for each side of the notch weir.

AR 032025

V-Notch, Sharp-Crested Weir

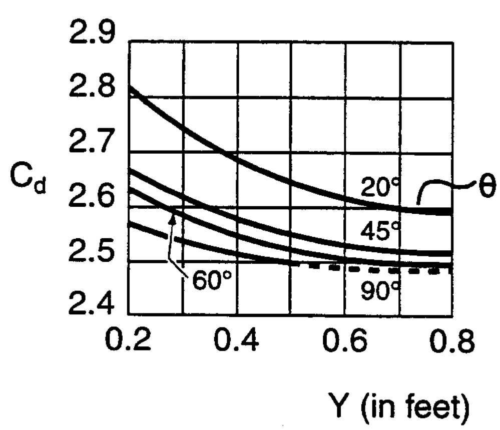
V-notch weirs, as shown in Figure 5.3.4.F, may be analyzed using standard equations for the fully contracted condition.

FIGURE 5.3.4.F V-NOTCH, SHARP-CRESTED WEIR



$$Q = C_d (\text{Tan } \theta/2) Y^{5/2}, \text{ in cfs}$$

Where values of C_d may be taken from the following chart:



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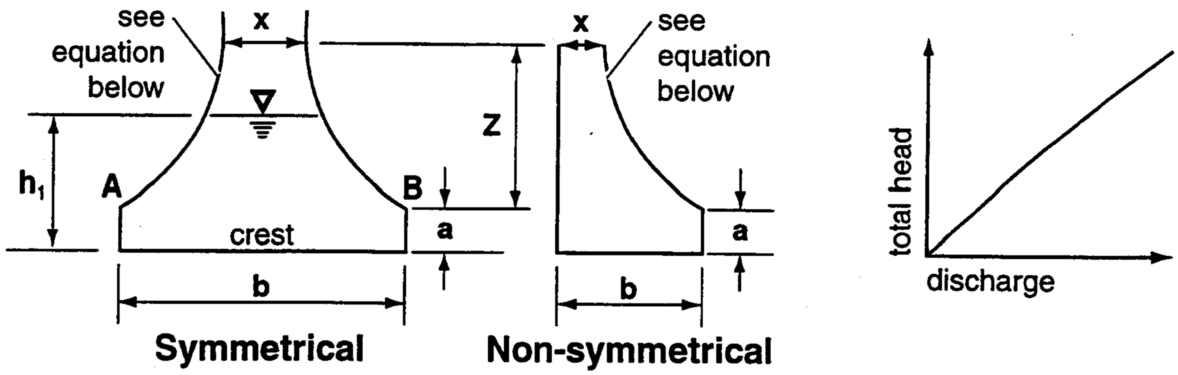
Proportional or Sutro Weir

Sutro weirs are designed so that the discharge is proportional to the total head. This design may be useful in some cases to meet performance requirements.

The sutro weir consists of a rectangular section joined to a curved portion which provides proportionality for all heads above the line A-B (see Figure 5.3.4.G). The weir may be symmetrical or non-symmetrical.

FIGURE 5.3.4.G SUTRO WEIR



For this type of weir, the curved portion is defined by the following equation (calculated in radians):

$$\frac{x}{b} = 1 - \frac{2}{\pi}\,\mathrm{Tan}^{-1}\sqrt{\frac{Z}{a}} \qquad (5\text{-}7)$$

where a, b, x and Z are as shown in Figure 5.3.4.F. The head-discharge relationship is:

$$Q = C_d\, b\,\sqrt{2g\, a(h_1 - \frac{a}{3})} \qquad (5\text{-}8)$$

Values of C_d for both symmetrical and non-symmetrical sutro weirs are summarized in Table 5.3.4.A (p. 5-49).

Note: When b > 1.50 or a > 0.30, use $C_d = 0.6$.

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TABLE 5.3.4.A VALUES OF C_d FOR SUTRO WEIRS

C_d Values, Symmetrical

a (ft)	*b* (ft) 0.50	0.75	1.0	1.25	1.50
0.02	0.608	0.613	0.617	0.6185	0.619
0.05	0.606	0.611	0.615	0.617	0.6175
0.10	0.603	0.608	0.612	0.6135	0.614
0.15	0.601	0.6055	0.610	0.6115	0.612
0.20	0.599	0.604	0.608	0.6095	0.610
0.25	0.598	0.6025	0.6065	0.608	0.6085
0.30	0.597	0.602	0.606	0.6075	0.608

C_d Values, Non-Symmetrical

a (ft)	*b* (ft) 0.50	0.75	1.0	1.25	1.50
0.02	0.614	0.619	0.623	0.6245	0.625
0.05	0.612	0.617	0.621	0.623	0.6235
0.10	0.609	0.614	0.618	0.6195	0.620
0.15	0.607	0.6115	0.616	0.6175	0.618
0.20	0.605	0.610	0.614	0.6155	0.616
0.25	0.604	0.6085	0.6125	0.614	0.6145
0.30	0.603	0.608	0.612	0.6135	0.614

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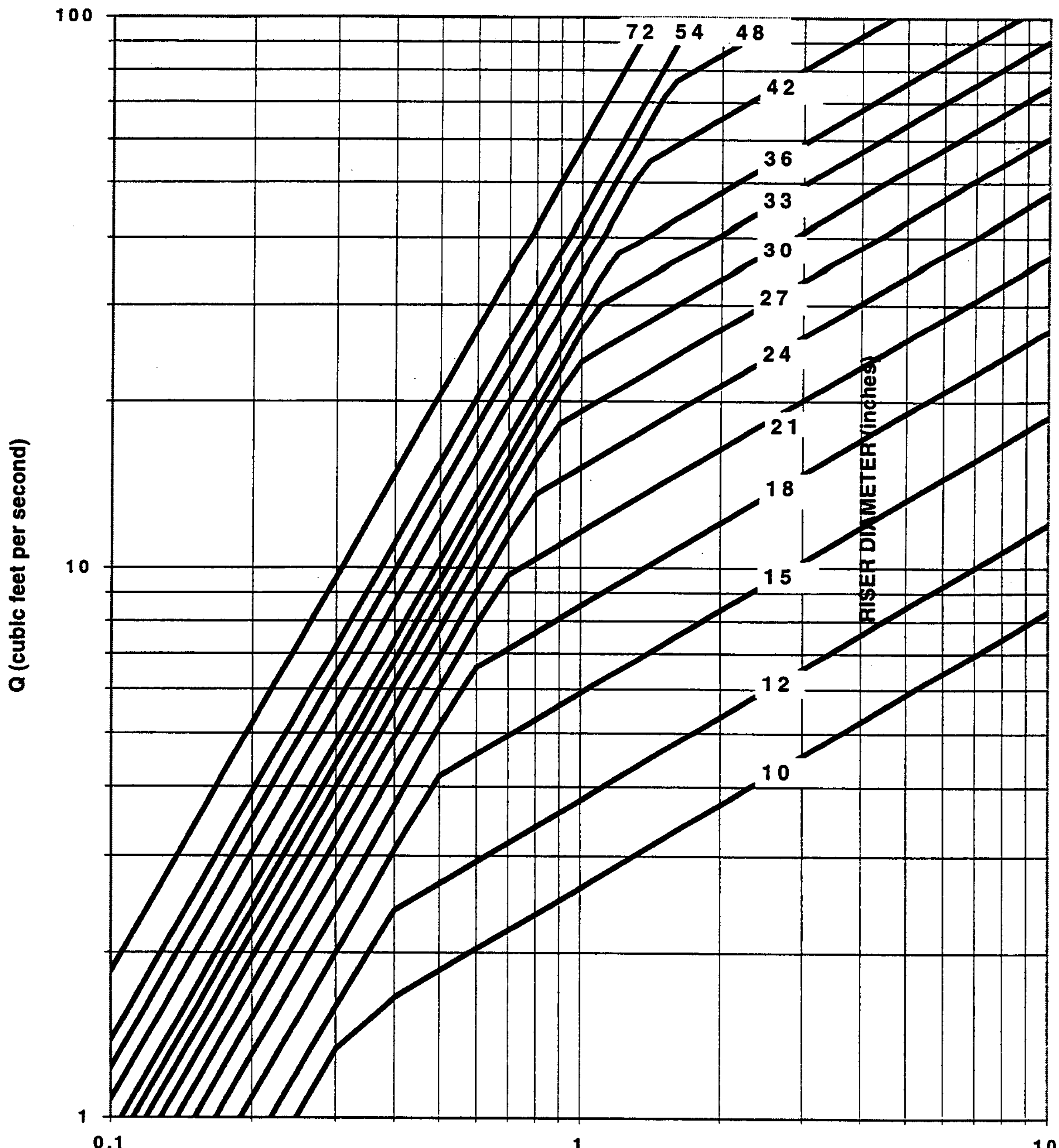
Riser Overflow

The nomograph in Figure 5.3.4.H can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year peak flow for developed conditions).

FIGURE 5.3.4.H RISER INFLOW CURVES



$Q_{weir} = 9.739\ DH^{3/2}$

$Q_{orifice} = 3.782\ D^2H^{1/2}$

Q in cfs, D and H in feet

Slope change occurs at weir-orifice transition

5.3.5 OTHER DETENTION OPTIONS

This section presents other design options for detaining flows to meet flow control facility requirements.

Use of Parking Lots for Additional Detention

Private parking lots may be used to provide additional detention volume for runoff events greater than the 2-year runoff event provided all of the following conditions are met:

1. The depth of water detained does not exceed 1 foot at any location in the parking lot for runoff events up to and including the 100-year event.
2. The gradient of the parking lot area subject to ponding is 1 percent or greater.
3. The emergency overflow path is identified and noted on the engineering plan, and the path complies with Core Requirements #1 and #2 (see Sections 1.2.1 and 1.2.2).
4. Fire lanes used for emergency equipment are free of ponding water for all runoff events up to and including the 100-year event.

Note: Flows may be backed up into parking lots by the control structure (i.e., the parking lot need not function as a flow-through detention pond).

Use of Roofs for Detention

Detention ponding on roofs of structures may be used to meet flow control requirements provided all of the following conditions are met:

1. The roof support structure is analyzed by a structural engineer to address the weight of ponded water.
2. The roof area subject to ponding is sufficiently waterproofed to achieve a minimum service life of 30 years.
3. The minimum pitch of the roof area subject to ponding is $^1/_4$-inch per foot.
4. An overflow system is included in the design to safely convey the 100-year peak flow from the roof.
5. A mechanism is included in the design to allow the ponding area to be drained for maintenance purposes or in the event the restrictor device is plugged.

Use of Wetlands for Detention

1. A Class 1, 2, or 3 wetland or buffer may be used by a public agency or utility for regional detention only under certain conditions as specified in the Sensitive Areas Ordinance (codified in KCC 21A.24).
2. Isolated Class 3 wetlands and buffers which are grazed wet meadows may be used for any proposed detention provided the conditions for such use are met as specified in KCC 21A.24.

5.4 INFILTRATION FACILITIES

This section presents the methods, criteria, and details for design and analysis of infiltration facilities. These facilities are used where soils are suitable for soaking the increased runoff from development into the ground. Such facilities usually have a detention volume component to allow for temporary storage of runoff while it is being infiltrated. This detention volume is typically dependent on the infiltration capacity of the soils and the required facility performance.

There are five types of infiltration facilities allowed for use in complying with Core Requirement #3, "Flow Control": infiltration ponds, infiltration tanks, infiltration vaults, infiltration trenches, and small infiltration basins. In general, ponds are preferred because of the ease of maintenance and the water quality treatment that surface soil and vegetation provide. Tanks and trenches are useful where site constraints prevent use of a pond, and small infiltration basins are simple to design but have limited uses.

The information presented in this section is organized as follows:

5.4.1 GENERAL REQUIREMENTS FOR INFILTRATION FACILITIES

This section presents the design requirements generally applicable to all infiltration facilities. Included are the general requirements for determining acceptable soil conditions, determining infiltration rates, and providing overflow protection, spill control, presettling, groundwater protection, protection from upstream erosion, and construction.

☐ SOILS

The applicant must demonstrate through infiltration testing, soil logs, and the written opinion of a geotechnical engineer that sufficient permeable soil exists on the site to allow construction of a properly functioning infiltration facility.

The basic requirement is a minimum of 3 feet of permeable soil below the bottom of the facility (bottom of pond or excavation for tank) and at least 3 feet between the bottom of the facility and the maximum wet-season water table. Test pits or borings should extend at least 5 feet below the bottom of the infiltration facility, and at least one test hole should reach the water table. If the water table is very deep, the test hole need not extend more than one-fourth the maximum width of the pond below the bottom of a pond, or more than 5 feet below the bottom of a tank. If there is any question about the actual wet-season water table elevation, measurements shall be made during the period when the water level is expected to be at a maximum.

Any requirements related to steep slope, landslide hazard, or other sensitive area impacts should also be addressed in the soil study.

The geotechnical engineer shall provide a report stating whether the site is suitable for the proposed infiltration facility, and shall recommend a design infiltration rate (see "Design Infiltration Rate" below).

❑ MEASURED INFILTRATION RATES

Infiltration rate tests are used to help estimate the maximum sub-surface vertical infiltration rate of the soil below a proposed infiltration facility (e.g., pond or tank) or a closed depression. The tests are intended to simulate the physical process that will occur when the facility is in operation; therefore, a saturation period is required to approximate the soil moisture conditions that may exist prior to the onset of a major winter runoff event.

Testing Procedure

1. Excavations shall be made to the bottom elevation of the proposed infiltration facility. The measured infiltration rate of the underlying soil shall be determined using either the **EPA falling head percolation test procedure** (*Design Manual - Onsite Wastewater Treatment and Disposal Systems*, EPA, 1980) or the **double ring infiltrometer test** (ASTM D3385).
2. The test hole or apparatus shall be filled with water and maintained at depths above the test elevation for the saturation periods specified for the appropriate test.
3. Following the saturation period, the rate shall be determined in accordance with the specified test procedures, with a head of 6 inches of water.
4. The engineer shall perform sufficient tests to determine a representative infiltration rate for the site, but at least **three tests shall be performed for each proposed infiltration facility site**, and at least 2 tests per acre (minimum of 4 tests) shall be performed for a closed depression.
5. A minimum of two **soils logs** shall be obtained for each tank and for each 10,000 square feet (plan view area) of proposed pond infiltration surface area. Soils shall be logged for a minimum of 5 feet below the bottom of each proposed infiltration facility. The logs shall describe the SCS series of the soil, indicate the textural class of the soil horizons throughout the depth of the log, note any evidence of high groundwater level (such as mottling), and estimate the maximum groundwater elevation, if within the limits of the log.

❑ DESIGN INFILTRATION RATE

In the past, many infiltration facilities have been built which have not performed as the designer intended. This has resulted in flooding and substantial public expenditures to correct problems. Monitoring of actual facility performance has shown that the full-scale infiltration rate is far lower than the rate determined by small-scale testing. Actual measured facility rates of 10% of the small-scale test rate have been seen. It is clear that great conservatism in the selection of design rates is needed, particularly where conditions are less than ideal. Ideally, the design infiltration rate will be determined using an analytical groundwater model to investigate the effects of the local hydrologic conditions on facility performance, but this may be excessively costly for small projects.

A simplified method may be used for determining the design infiltration rate by applying correction factors to the measured infiltration rate. The correction factors account for uncertainties in testing, depth to the water table or impervious strata, infiltration receptor geometry, and long-term reductions in permeability due to biological activity and accumulation of fines. Equation 5-9 has been developed to account for these factors. This equation estimates the **maximum** design infiltration rate (I_{design}); additional reduction in rate beyond that produced by the equation may be appropriate. Note that the design infiltration rate I_{design} **must not exceed 20 inches/hour.**

$$I_{design} = I_{measured} \times F_{testing} \times F_{geometry} \times F_{plugging} \qquad (5\text{-}9)$$

Correction factor $F_{testing}$ accounts for uncertainties in the testing methods. For the EPA method, $F_{testing}$ = 0.30; for the ASTM D3385 method, $F_{testing}$ = 0.50

$F_{geometry}$ accounts for the influence of facility geometry and depth to the water table or impervious strata on the actual infiltration rate. A shallow water table or impervious layer will reduce the effective infiltration rate of a large pond, but this will not be reflected in a small scale test. Clearly, a large pond built over a thin pervious stratum with a shallow water table will not function as well as the same pond built over a thick pervious stratum with a deep water table. $F_{geometry}$ must be between 0.25 and 1.0 as determined by the following equation:

$$F_{geometry} = 4\ D/W + 0.05 \qquad (5\text{-}10)$$

where D = depth from the bottom of the proposed facility to the maximum wet-season water table or nearest impervious layer, whichever is less

W = width of the facility

$F_{plugging}$ accounts for reductions in infiltration rates over the long term due to plugging of soils. This factor is:

- 0.7 for loams and sandy loams
- 0.8 for fine sands and loamy sands
- 0.9 for medium sands
- 1.0 for coarse sands or cobbles, or any soil type in an infiltration facility preceded by a water quality facility.

❑ 100-YEAR OVERFLOW CONVEYANCE

An overflow route shall be identified for stormwater flows that overtop the facility when infiltration capacity is exceeded or the facility becomes plugged and fails. The overflow route must be able to safely convey the 100-year developed peak flow to the downstream conveyance system or other acceptable discharge point in accordance with conveyance requirements in Section 1.2.4.

The requirement to identify and analyze a 100-year overflow pathway may be waived if (1) an additional correction factor of 0.5 is used in calculating the **design infiltration rate**, (2) the facility is sized to fully infiltrate the 100-year runoff event, and (3) the facility is not bermed on any side. **Intent:** to address situations where the infiltration facility may be a highly permeable closed depression, such as a gravel pit, where all stormwater is infiltrated.

❑ SPILL CONTROL DEVICE

All infiltration facilities must have a spill control device upstream of the facility to capture oil or other floatable contaminants before they enter the infiltration facility (see Section 4.2.1.1). If a tee section is used, the top of the riser should be set above the 100-year overflow elevation to prevent oils from entering the infiltration facility.

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☐ PRESETTLING

Presettling must be provided before stormwater enters the infiltration facility. This requirement may be met by either of the following:

- A water quality facility from the Basic WQ menu (this alternative is recommended; see Section 6.1.1 for facility options).
- A presettling pond or vault with a treatment volume equal to 0.75 times the runoff from the mean annual storm V_r (see Section 6.4.1.1 for information on computing V_r.).

If water in the WQ facility or presettling facility will be in direct contact with the soil, the facility must be lined according to the liner requirements in Section 6.2.4. If the presettling facility is a vault, design of the vault shall be the same as required for presettling cells in sand filter vaults (see Section 6.5.3.2).

The settling pond or vault shall be designed to pool water 4 to 6 feet deep with an overflow capacity sufficient to pass the developed 100-year peak flow. Settling facilities must have a length-to-width ratio of at least 3:1. The inlet(s) and outlet should be situated to maximize the length of travel through the settling pond or vault. Berms or baffles may be used to lengthen the travel distance if site constraints limit the inlet/outlet placement. Inlets should be designed to minimize velocity and turbulence. Roof runoff need not be treated before entering an infiltration facility.

☐ PROTECTION FROM UPSTREAM EROSION

Infiltration facilities must not be put into service before the upstream areas are properly stabilized since untreated runoff can permanently impair the functioning of the system. **Infiltration facilities may not be operated until all proposed project improvements which produce surface runoff are complete, especially revegetation and landscaping,** except as allowed by DDES. In the case of projects with individual lots remaining undeveloped, these lots must contain and infiltrate their runoff through individual sediment traps acting as infiltration ponds until permanent improvements and landscaping are established.

An **alternative** to this approach is to serve the undeveloped lots with a large sediment trap on an undeveloped tract; the trap is to be left in place until all clearing and construction is complete and all permanent landscaping is in place. See *Erosion and Sediment Control Standards* (detached Appendix D) for design details. At the completion of all construction, the sediment trap must be cleaned out (taking care that no sediment enters the drainage system) and filled in, and the flow routed to the permanent drainage system.

Another alternative for subdivisions is to stage excavation of the pond as follows:

1. Bottom elevation of the pond prior to paving of plat roadways: 3 feet above the final pond bottom elevation. At this stage of rough grading, the facility may be used to meet sediment retention requirements.
2. Bottom elevation of the pond during and after paving and prior to construction of 80% of the houses: 18 inches above the final pond bottom elevation with upstream sediment retention, as needed. At this stage, the pond will serve as an interim flow control facility pending final stabilization of the site. KCC 9.04.090 requires that flow control facilities be operational prior to the construction of any improvements.
3. Bottom elevation of the pond during construction of the remaining 20% of the houses: final pond bottom elevation. *Note: The remaining 20% of lots must contain and infiltrate their runoff through individual sediment traps until permanent improvements and landscaping are established.*

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❑ CONSTRUCTION GUIDELINES

Excavation of infiltration facilities should be done with a backhoe working at "arms length" to **minimize disturbance and compaction of the completed infiltration surface**. If the bottom of the facility will be less than three feet below final grade, the facility area should be cordoned off so that construction traffic does not traverse the area. The exposed soil should be inspected by a soils engineer after excavation to confirm that soil conditions are suitable.

Two simple **staff gages for measuring sediment depth** should be installed at opposite ends of the bottom of ponds. The gages can consist of 1-inch pipe driven at least one foot into the soil in the bottom of the pond, with 12 inches of the pipe protruding above grade.

❑ OFFSITE GROUNDWATER LEVEL IMPACTS

Potential impacts to groundwater levels off the project site should be considered. In general, replacing vegetation with impervious cover will increase the total annual volume of runoff generated on a site. Infiltrating this runoff will tend to increase ground water recharge, which may affect groundwater levels offsite. The impacts of infiltration could include increased water to landslide hazard areas, increased groundwater resources available, increased water levels in closed depressions, and higher groundwater levels. Higher groundwater levels offsite could result in increased flooding of basements, or impaired functioning of infiltration systems resulting in surface water flooding. Evidence of offsite groundwater flooding problems should be examined during the offsite analysis required under Core Requirement #2 (see Section 1.2.2).

In general, groundwater level impacts will be very difficult to reduce, and there are no specific requirements which apply in many cases. The design engineer is encouraged to consider whether there are any feasible approaches to reduce groundwater flooding impacts, such as moving facilities or changing facility geometry, retaining forest cover, minimizing impervious coverage, or fixing downstream problems.

❑ GROUNDWATER PROTECTION

The protection of groundwater quality is recognized as an issue of greater concern than in the past, and groundwater protection standards are changing rapidly. Increased safeguards are often required. The applicant should check groundwater management plans for the area, as well as with **local water purveyors** to determine if the project lies within a **wellhead or groundwater protection zone, or aquifer recharge area.**

The **groundwater protection requirements** of this manual set forth in Chapter 1 call for implementing one of the following actions when infiltrating runoff from pollution-generating surfaces:

1. Provide water quality treatment prior to infiltration as specified in Core Requirement #8and Special Requirement #5or
2. Demonstrate that the soil beneath the infiltration facility has properties which reduce the risk of groundwater contamination from typical stormwater runoff. Such properties are defined below depending on whether the project is located outside of or within a **sole-source aquifer area**. Sole-source aquifers are shown in the King County Comprehensive Plan (1994).

Note: The soil properties given below are primarily for groundwater protection and do not necessarily satisfy other protection needs. For example, projects infiltrating runoff within a quarter-mile of a sensitive lake may still be required to provide water quality treatment to meet the resource protection needs of the sensitive lake. See Core Requirement #8 (Section 1.2.8) for additional WQ requirements.

Soil Properties Required for Groundwater Protection Outside Sole-Source Aquifers

For infiltration facilities located outside of a sole-source aquifer area, acceptable groundwater protection is provided by the soil if the first two feet or more of the soil beneath the infiltration facility meets **one of the following** criteria:

a) The soil has a measured infiltration rate less than or equal to 9 inches per hour[7] or is logged as one of the classes from the **USDA Textural Triangle** (Figure 5.4.1.A, p. 5-59), excluding sand and loamy sand. Soil texture classes other than sand and loamy sand may be assumed to have an infiltration rate of less than or equal to 9 inches per hour without doing field testing to measure rates.[8]

b) The soil has a *cation exchange capacity*[9] greater than 5 and an *organic content*[10] greater than 0.5%.

c) The soil is composed of less than 25% gravel by weight with at least 75% of the soil passing the #4 sieve. The portion passing the #4 sieve must meet one of the following gradations:

- At least 50% must pass the #40 sieve and at least 2% must pass the #100 sieve, or
- At least 25% must pass the #40 sieve and at least 5% must pass the #200 sieve.

Note: These soil properties must be met by the native soils onsite. Soil may not be imported in order to meet groundwater protection criteria without an approved adjustment.

Soil Properties Required for Groundwater Protection Within Sole-Source Aquifers

For projects located within a sole-source aquifer area, acceptable groundwater protection is provided by the soil if the first two feet or more of the soil beneath the infiltration facility meets **one of the following** criteria:

a) The soil has a **measured infiltration rate** less than or equal to **2.4 inches per hour** or is logged as one of the classes from the **USDA Textural Triangle** (Figure 5.4.1.A, p. 5-59), excluding sand, loamy sand, and sandy loam. Soil triangle texture classes other than sand, loamy sand, and sandy loam may be assumed to have an infiltration rate of less than or equal to 2.4 inches per hour without doing field testing to measure rates.[11]

b) The soil has a **cation exchange capacity** greater than 5 and an **organic content** greater than 0.5%, and the infiltration rate must be less than or equal to 9 inches per hour.

c) The soil has a measured infiltration rate less than or equal to 9 inches per hour, and it must be composed of less than 25% gravel by weight with at least 75% of the soil passing the #4 sieve. The portion passing the #4 sieve must meet one of the following gradations:

- At least 50% must pass the #40 sieve and at least 2% must pass the #100 sieve, or
- At least 25% must pass the #40 sieve and at least 5% must pass the #200 sieve.

Note: The above soil properties must be met by the native soils on site. Soil may not be imported in order to meet groundwater protection criteria without an approved adjustment.

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[7] See discussion of the measured infiltration rate on page 5-54.

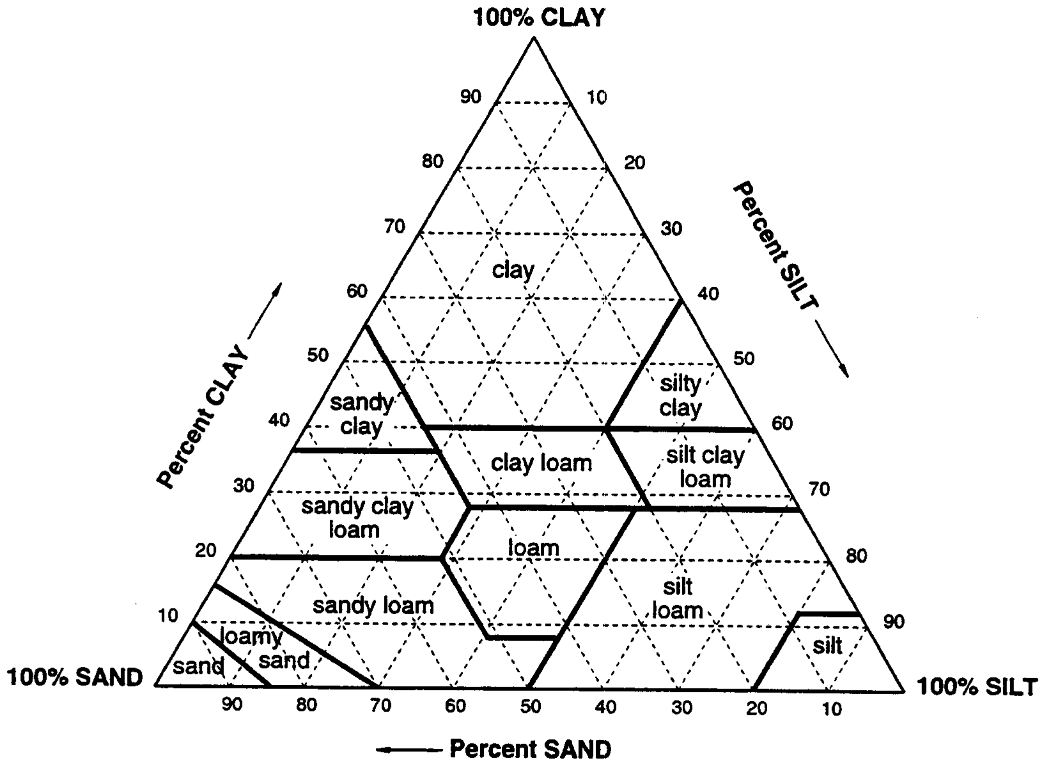
[8] Criteria (a) is based on the relationship between infiltration rates and soil texture. However, there are many other factors, such as high water table, presence of impervious strata or boulders close to the surface, etc., which also affect infiltration rate. When any such condition is suspected because soils are coarser than expected from the measured infiltration rate, a sieve analysis should be done to establish soil characteristics. The judgment of a geotechnical engineer, geologist or soil scientist shall determine whether a sieve analysis is warranted. The sieve analysis must meet Criteria (c) above to be considered protective.

[9] *Cation exchange capacity* shall be tested using EPA Laboratory Method 9081.

[10] *Organic content* shall be measured on a dry weight basis using method ASTM D2974 for the fraction passing the #40 sieve.

[11] Concerns regarding Criteria (a) and the correspondence between the measured infiltration rate and soil textures are the same as discussed for projects outside sole-source aquifer areas.

FIGURE 5.4.1.A USDA TEXTURAL TRIANGLE



Infiltration Near Water Supply Wells

The design engineer should consider the following when designing infiltration facilities near water supply wells:

1. In no case should infiltration facilities be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies. Where water supply wells exist nearby, it is the responsibility of the applicant's engineer to locate such wells, meet any applicable protection standards, and assess possible impacts of the proposed infiltration facility on groundwater quality. If negative impacts on an individual or community water supply are possible, additional runoff treatment must be included in the facility design, or relocation of the facility should be considered.

2. All infiltration facilities located within the one-year capture zone of any well should be preceded by a water quality treatment facility.

Infiltration Near Steep Slopes and Landslide Hazard Areas

The following restrictions apply to the design of infiltration systems located upslope of landslide hazard areas.

1. Infiltration facilities (excluding individual lot systems) may be placed no closer to the top of slope than the distance equal to the total vertical height of the slope area that is steeper than 15%. Where infiltration facilities are proposed within 200 feet of steep slopes or a landslide hazard area, a detailed geotechnical evaluation may be required.

2. Individual lot infiltration and dispersion systems should be used to the extent feasible. The exception is for lots immediately adjacent to the potential hazard area that should be collected into the tightline system, if available.

5.4.2 INFILTRATION PONDS

Infiltration ponds may be constructed by excavating or constructing berms. See Figure 5.4.2.A (p. 5-62) for a typical detail.

5.4.2.1 DESIGN CRITERIA

General

The following criteria for ponds are in addition to the general requirements for infiltration facilities specified in Section 5.4.1:

1. The proposed **pond bottom** must be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of **permeable soil** beneath the bottom.
2. Infiltration ponds are **not allowed on slopes greater than 25%** (4:1). A geotechnical analysis and report may be required on slopes over 15% or if located within 200 feet of the top of a steep slope or landslide hazard area.
3. The infiltration surface **must be in native soil** (excavated at least one foot in depth).
4. **Maintenance access** shall be provided to both the presettling pond or vault (if provided) and the infiltration pond.
5. An **overflow structure** such as that shown in Figure 5.3.1.C (p. 5-30) shall be provided. In addition, infiltration ponds shall have an emergency spillway as required for detention ponds in Section 5.3.1.1 (p. 5-19).
6. The criteria for **general design**, side slopes, embankments, planting, maintenance access, access roads, fencing, signage, and right-of-way shall be the **same as for detention ponds** (see Section 5.3.1, p. 5-19), except as required for the infiltration design.

Setbacks

1. The **toe of the exterior slope** of an infiltration pond berm embankment shall be set back 5 feet from the tract, easement, or property line.
2. The tract, easement, or property line on an **infiltration pond cut slope** shall be set back 5 feet from the emergency overflow water surface.
3. The infiltration pond design water surface shall be set back 100 feet from proposed or existing **septic system drainfields**. This setback can be reduced to 30 feet with approval from the Seattle - King County Department of Public Health.
4. The infiltration pond design water surface shall be a minimum of 50 feet from any **sensitive area steep slope,** unless an approved geotechnical report recommends closer placement. The facility soils report must address the potential impact of infiltration on the steep slope.
5. **Building setback lines for adjacent internal lots** shall be 20 feet. These may be reduced to the minimum allowed by zoning if the facility soils report addresses the potential impacts of the facility phreatic surface on structures so located.
6. The infiltration pond design water surface shall be set back 20 feet from **external tract, easement or property lines**. This may be reduced to 5 feet if the facility soils report addresses the potential impacts of the facility phreatic surface on existing or future structures located on adjacent external lots.

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5.4.2.2 METHODS OF ANALYSIS

The size of the pond shall be determined using the hydrologic analysis and routing methods described for detention ponds in Chapter 3. The **storage volume** in the pond is used to detain runoff prior to infiltration. The **stage/discharge curve** shall be developed from the design infiltration rate determined according to Section 5.4.1 (p. 5-53). At a given stage the discharge can be computed using the **area of pervious surface** through which infiltration will occur (which will vary with stage) multiplied by the recommended design infiltration rate (in appropriate units). Berms (which should be constructed of impervious soil such as till), maintenance access roads, and lined swales should not be included in the design pervious surface area.

Note: The KCRTS program "Size a Facility" module can provide a preliminary pond volume given side slopes, storage depth, design infiltration rate, and allowable release rates through a control structure (if applicable).

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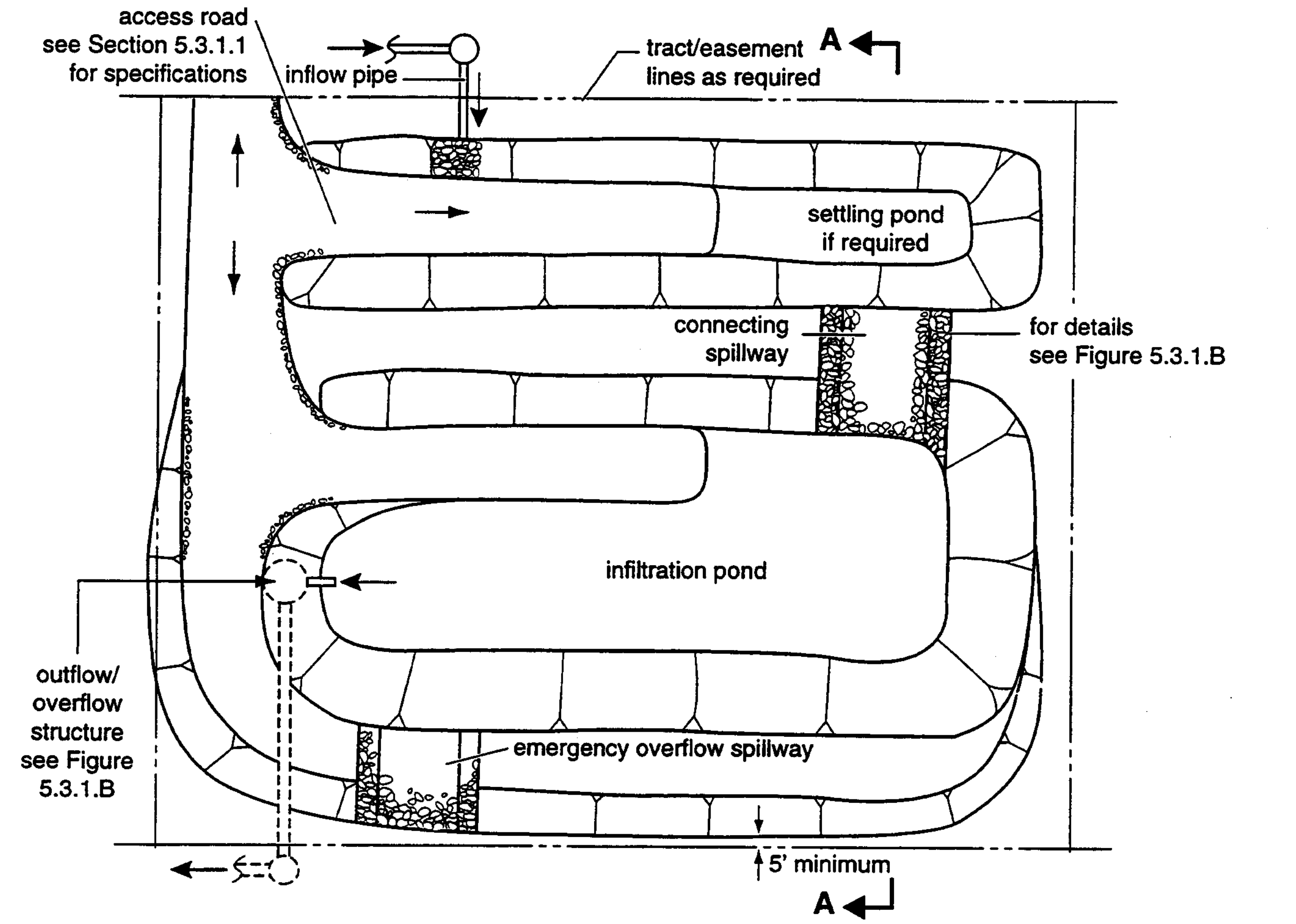
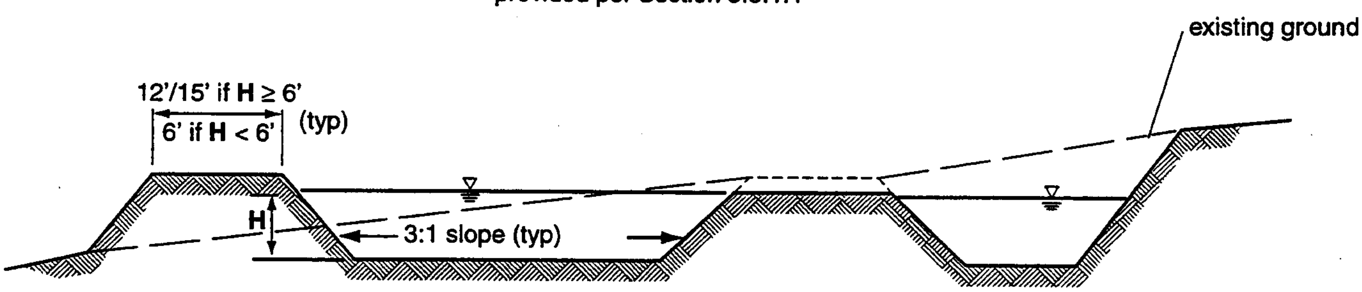
FIGURE 5.4.2.A TYPICAL INFILTRATION POND



PLAN VIEW

overflow/emergency overflow
provided per Section 5.3.1.1



SECTION A-A

NTS

NOTE:
Detail is a schematic representation only. Actual configuration will vary depending on specific site constraints and applicable design criteria.

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5.4.3 INFILTRATION TANKS

Infiltration tanks consist of underground pipe that has been perforated to allow detained stormwater to be infiltrated. Figure 5.4.3.A (p. 5-65) shows a typical infiltration tank.

5.4.3.1 DESIGN CRITERIA

General

The following criteria for tanks are in addition to the general requirements for infiltration facilities specified in Section 5.4.1:

1. The proposed **tank trench bottom** shall be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of **permeable soil** beneath the trench bottom.
2. Infiltration tanks are **not allowed on slopes greater than 25%** (4:1). A geotechnical analysis and report may be required on slopes over 15%, or if located within 200 feet of the top of a steep slope or landslide hazard area.
3. The infiltration surface elevation (bottom of trench) **must be in native soil** (excavated at least one foot in depth).
4. **Minimum spacing between parallel tanks** shall be equal to 2 times the distance from the bottom of the lowest tank to the ground surface.
5. Tanks shall be **bedded and backfilled with washed drain rock** that extends at least 1 foot below the bottom of the tank, at least 2 feet beyond the sides, and up to the top of the tank.
6. Drain rock (3 to $1^1/_2$ inches) shall be completely covered with **filter fabric** prior to backfilling.
7. The **perforations** (holes) in the tank must be one inch in diameter and located in the bottom half of the tank starting at an elevation of 6 inches above the invert of the tank. The number and spacing of the perforations should be sufficient to allow complete utilization of the available infiltration capacity of the soils with a safety factor of 2.0 without jeopardizing the structural integrity of the tank.
8. Infiltration tanks shall have an overflow structure equipped with a **solid bottom riser** (with clean-out gate) and outflow system for safely discharging overflows to the downstream conveyance system or another acceptable discharge point.
9. The criteria for **general design,** materials, structural stability, buoyancy, maintenance access, access roads, and right-of-way shall be the **same as for detention tanks** (see Section 5.3.2, p. 5-33), except for features needed to facilitate infiltration.

Setbacks

1. Tanks shall be set back 100 feet from proposed or existing **septic system drainfields**. This setback can be reduced to 30 feet with approval from the Seattle - King County Department of Public Health.
2. All tanks shall be a minimum of 50 feet from any **sensitive area steep slope**. The facility soils report must address the potential impact of infiltration on the steep slope.
3. **Building setback lines for adjacent internal lots** shall be 20 feet. These may be reduced to the minimum allowed by zoning if the facility soils report addresses the potential impacts of the facility phreatic surface on structures so located.
4. Infiltration tanks shall be set back 20 feet from **external tract, easement, or property lines**. This may be reduced to 5 feet if the facility soils report addresses the potential impacts of the facility phreatic surface on existing or future structures located on adjacent external lots.

5.4.3.2 METHODS OF ANALYSIS

The **size of the tank** shall be determined using the hydrologic analysis and routing methods described in Chapter 3, and the **stage/discharge curve** developed from the recommended design infiltration rate as described in Section 5.4.1 (p. 5-53). The **storage volume** in the tank is used to detain runoff prior to infiltration with the perforations providing the outflow mechanism. At any given stage, the discharge can be computed using the **area of pervious surface** through which infiltration will occur multiplied by the recommended design infiltration rate (in appropriate units). The area of pervious surface used for determining the potential infiltration from the tank shall be computed by taking the lesser of the trench width, or two times the width of the tank, and then multiplying by the length of the tank (assuming infiltration through the bottom of the trench only).

Note: The KCRTS program "Size a Facility" module can provide a preliminary tank length given tank diameter, storage depth, design infiltration rates, and allowable release rates through a control structure (if applicable).

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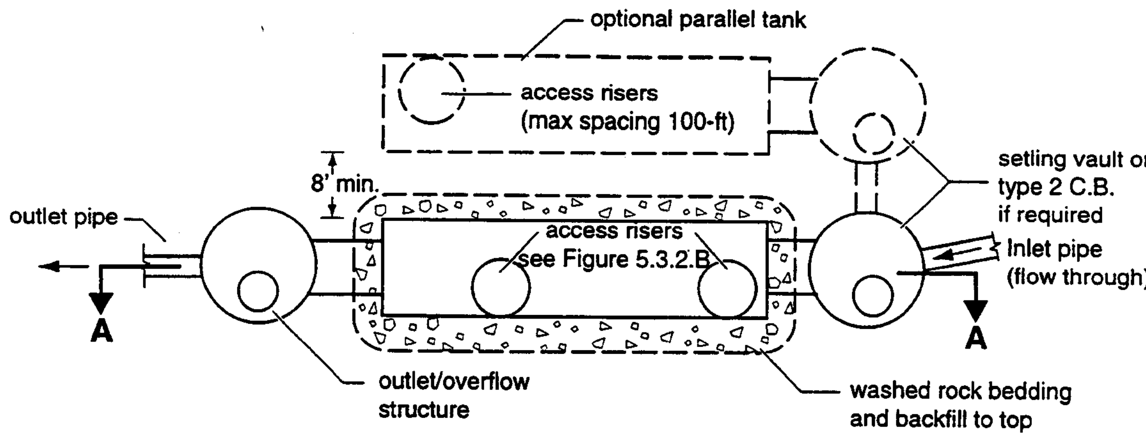
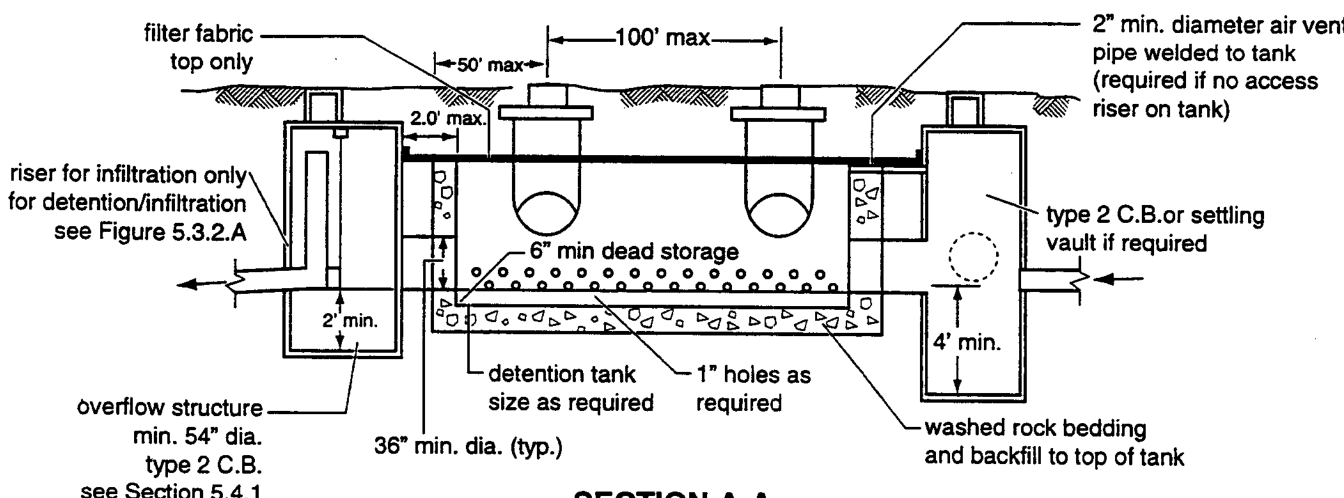
FIGURE 5.4.3.A TYPICAL INFILTRATION TANK



PLAN VIEW
NTS
optional design for parallel tank shown dashed



SECTION A-A
NTS

NOTES:

- All metal parts corrosion resistant. Steel parts galvanized and asphalt coated (treatment 1 or better).
- Filter fabric to be placed over washed rock backfill.

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5.4.4 INFILTRATION VAULTS

Infiltration vaults consist of a bottomless concrete vault structure placed underground in native infiltrative soils. Infiltration is achieved through the native soils at the bottom of the structure.

Infiltration vaults are similar to detention vaults. A standard detention vault detail is shown in Figure 5.3.3.A (p. 5-39). Overflow riser details are shown in Section 5.3.4 beginning on page 5-40.

5.4.4.1 DESIGN CRITERIA

General

The following criteria for vaults are in addition to the general requirements for infiltration facilities specified in Section 5.4.1:

1. The proposed **vault bottom** shall be at least 3 feet above the seasonal high groundwater level and have at least 3 feet of permeable soil beneath the bottom.
2. Infiltration vaults are **not allowed on slopes greater than 25%** (4:1). A geotechnical analysis and report may be required on slopes over 15%, or if located within 200 feet of the top of a steep slope or landslide hazard area.
3. The vault bottom **must be in native soil** (excavated at least one foot in depth).
4. Infiltration vaults shall have a **solid bottom riser** (with clean-out gate) and outflow system for safely discharging overflows to the downstream conveyance system or another acceptable discharge point.

Structural Stability

All vaults shall meet structural requirements for overburden support and H-20 vehicle loading. Vaults located under roadways must meet the live load requirements of the *King County Road Standards*. Cast-in-place wall sections shall be designed as retaining walls. Structural designs for cast-in-place vaults require a separate commercial building permit issued by DDES, and must be stamped by a licensed structural civil engineer. Bottomless vaults shall be provided with footings placed on stable, well-consolidated native material and sized considering overburden support, traffic loading (assume maintenance traffic, if placed outside ROW), and lateral soil pressures when the vault is dry. Infiltration vaults shall not be allowed in fill slopes unless analyzed in a geotechnical report for stability. The infiltration surface at the bottom of the vault must be in native soil.

Access Requirements

Same as specified for detention vaults in Section 5.3.3.1 (p. 5-37).

Access Roads

Same as specified for detention vaults in Section 5.3.3.1 (p. 5-37).

Right-of-Way

Infiltration vaults to be maintained by King County but not located in King County right-of-way shall be in a tract dedicated to King County. Any tract not abutting public right-of-way will require a 15-foot wide extension of the tract to accommodate an access road to the vault.

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Setbacks

1. Infiltration vaults shall be set back 100 feet from proposed or existing **septic system drainfields.** This setback can be reduced to 30 feet with approval from the Seattle - King County Department of Public Health.

2. Infiltration vaults shall be a minimum of 50 feet from any **sensitive area steep slope**. The facility soils report must address the potential impact of infiltration on the steep slope.
3. **Building setback lines for adjacent internal lots** shall be 20 feet. These may be reduced to the minimum allowed by zoning if the facility soils report addresses the potential impacts of the facility phreatic surface on structures so located.
4. Infiltration vaults shall be set back 20 feet from **external tract, easement, or property lines**. This may be reduced to 5 feet if the facility soils report addresses the potential impacts of the facility phreatic surface on existing or future structures located on adjacent external lots.

5.4.4.2 METHODS OF ANALYSIS

The **size of the vault** shall be determined using the hydrologic analysis and routing methods described in Chapter 3 and the **stage/discharge curve** developed from the recommended design infiltration rate as described in Section 5.4.1 (p. 5-53). The **storage volume** in the vault is used to detain runoff prior to infiltration. At any given stage, the discharge can be computed using the **area of pervious surface** through which infiltration will occur (the exposed soil comprising the vault bottom) multiplied by the recommended design infiltration rate (in appropriate units).

Note: The KCRTS program "Size a Facility" module can provide preliminary vault volume (modeled as an infiltration pond with vertical side slopes) given storage depth, design infiltration rate, and allowable release rate through a control structure (if applicable).

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5.4.5 INFILTRATION TRENCHES

Infiltration trenches can be a useful alternative for developments with constraints that make siting a pond difficult. Infiltration trenches may be placed beneath parking areas, along the site periphery, or in other suitable linear areas.

5.4.5.1 DESIGN CRITERIA

General

The following criteria for trenches are in addition to the general requirements for infiltration facilities specified in Section 5.4.1:

1. The proposed **trench bottom** must be at least 3 feet above the seasonal high groundwater level and 3 feet below finished grade.
2. There must be at least 3 feet of **permeable soil** beneath the trench bottom.
3. The infiltration surface elevation (bottom of trench) must be in **native soil** (excavated at least one foot in depth).
4. Infiltration trenches are **not allowed on slopes greater than 25%** (4:1). A geotechnical analysis and report may be required on slopes over 15% or if located within 200 feet of the top of a steep slope or landslide hazard area.
5. Trenches shall be a minimum of **24 inches wide.**
6. Trenches shall be **backfilled with $1^1/_2$ - $^3/_4$-inch washed rock**, completely surrounded by filter fabric and overlain by a minimum 1 foot of compact backfill.
7. Level 6-inch minimum diameter rigid **perforated distribution pipes** shall extend the length of the trench. Distribution pipe inverts shall be a minimum of 2 feet below finished grade. Provisions (such as clean-out wyes) shall be made for cleaning the distribution pipe.
8. Two feet minimum cover shall be provided in areas subject to vehicle loads.
9. Trenches shall be spaced no closer than 10 feet, measured on center.

Setbacks

1. Trench systems shall be set back **100 feet from proposed or existing septic system drainfields.** This setback can be reduced to 30 feet with approval from the Seattle - King County Department of Public Health.
2. Trench systems shall be a minimum of **50 feet from any sensitive area steep slope.** The facility soils report must address the potential impact of infiltration on the steep slope.
3. **Structures shall be set back 20 feet from individual trenches.** This may be reduced if the facility soils report addresses potential impacts of trench phreatic surface on structures so located.

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5.4.5.2 METHODS OF ANALYSIS

The sections and lengths of trenches shall be determined using the hydrologic analysis and routing methods for flow control design described in Chapter 3. The **stage/discharge curve** shall be developed from the design infiltration rate recommended by the soils engineer, as described in Section 5.4.1 (p. 5-53). **Storage volume** of the trench system shall be determined considering void space of the washed rock backfill and maximum design water surface level at the crown of the distribution pipe. At any given stage, the discharge can be computed using the **area of pervious surface** through which infiltration will occur (trench bottom area only) multiplied by the recommended design infiltration rate (in appropriate units).

Note: The KCRTS program "Size a Facility" module can provide preliminary total trench bottom areas given trench depth (from spring line), design infiltration rates, and allowable release rates through a control structure (if applicable). The program assumes 30% void space in the trench backfill.

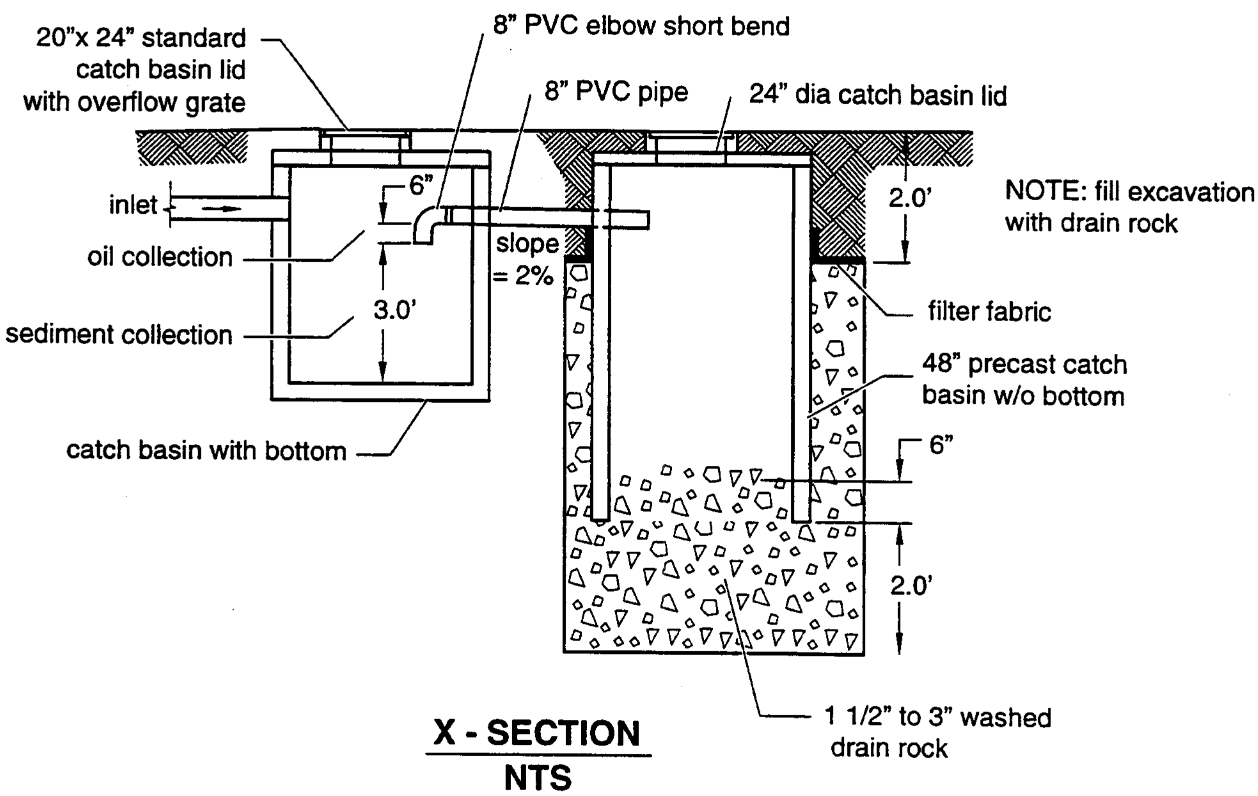
5.4.6 SMALL INFILTRATION BASINS

Small infiltration basins consist of a bottomless, precast concrete catch basin or equivalent structure placed in an excavation filled with washed drain rock. Stormwater infiltrates through the drain rock into the surrounding soil. This facility is intended for use with contributing surface areas of less than 5,000 square feet. Presettlement is most easily provided by a catch basin or manhole with a turned-down elbow; see Figure 5.4.6.A (below) for a generic design sketch. If water quality treatment is required by Core Requirement #8 or Special Requirement #5, runoff from pollution-generating impervious surfaces must be treated before it enters the infiltration portion of the system.

5.4.6.1 DESIGN CRITERIA

The design criteria for small infiltration basins are essentially the same as for infiltration tanks (see Sections 5.4.1 and 5.4.3), except that only one infiltration rate test and soil log is required for each small infiltration basin. Access into the basins shall be provided for inspection and maintenance. Designs may incorporate Type II catch basins, but equivalent designs using other materials may be accepted.

FIGURE 5.4.6.A CONCEPTUAL SMALL INFILTRATION BASIN



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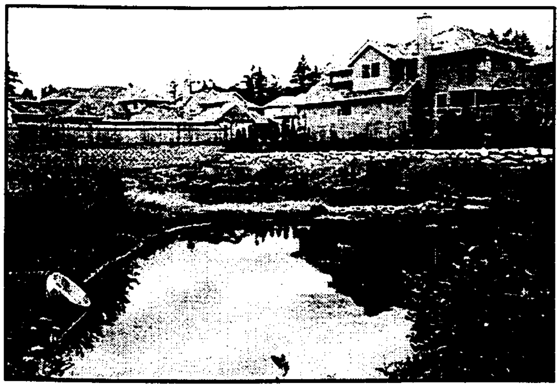
Chapter 6

CHAPTER 6

WATER QUALITY DESIGN



KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

CHAPTER 6
WATER QUALITY DESIGN

This chapter presents the King County approved methods, criteria, and details for analysis and design of water quality facilities pursuant to Core Requirement #8, discussed in Section 1.2.8, and Special Requirement #5, discussed in Section 1.3.5.

Chapter Organization

The information in this chapter is organized into the following six main sections:

- Section 6.1, "Water Quality Menus" (p. 6-3), details the **area-specific water quality menus** referred to in Core Requirement #8 of Chapter 1, and the **High-Use Menu** referred to in Special Requirement #5, also in Chapter 1.
- Section 6.2, "General Requirements for WQ Facilities" (p. 6-17), presents general design requirements and details pertinent to all water quality facilities.
- Section 6.3, "Biofiltration Facility Designs" (p. 6-37), presents the details for analysis and design of biofiltration facilities such as **biofiltration swales** and **filter strips**.
- Section 6.4, "Wetpool Facility Designs" (p. 6-67), presents the details for analysis and design of wetpool water quality facilities such as **wetponds, wetvaults, stormwater wetlands**, and combinations of these facilities with detention ponds.
- Section 6.5, "Media Filtration Facility Designs" (p. 6-99), presents the details for analysis and design of filtration facilities such as **sand filters** and **leaf compost filters**.
- Section 6.6, "Oil Control Facility Designs" (p. 6-135), presents the details for analysis and design of oil control facilities such as **catch basin inserts** and **oil/water separators**.

Required vs. Recommended Design Criteria

Both required and recommended design criteria are presented in this chapter. Criteria stated using **"shall"** or **"must"** are mandatory, to be followed unless there is a good reason to deviate as allowed per the adjustment process in Section 1.4. These criteria are **required design criteria** and generally affect facility performance or critical maintenance factors.

Sometimes options are stated as part of the required design criteria using the language **"should"** or **"may."** These latter criteria are really **recommended design criteria**, but are so closely related to the required criteria that they are placed with it. In some cases **recommended design features** are presented under a separate heading in the "Design Criteria" sections.

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Use of Chapter 6 Figures: The figures provided in Chapter 6 illustrate **one example** of how the WQ facility design criteria may be applied. There may be other engineering solutions that also meet the design criteria. Those options are also allowed unless it is the judgment of DDES that the option has other problems that render it a poor engineering choice. Although the figures are meant to illustrate many of the most important design criteria, they may not show **all** criteria which apply. In general, the figures in Chapter 6 are not used to specify requirements unless they are indicated elsewhere in the Manual.

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6.1 WATER QUALITY MENUS

This section identifies facility choices and, in some cases, non-structural options that comprise the water quality (WQ) menus referred to in Chapter 1. The menus covered in this section are as follows:

- Basic Water Quality Menu, Section 6.1.1 (p. 6-4)
- Sensitive Lake Protection Menu, Section 6.1.2 (p. 6-6)
- Resource Stream Protection Menu, Section 6.1.3 (p. 6-10)
- Sphagnum Bog Protection Menu, Section 6.1.4 (p. 6-12)
- High-Use Menu, Section 6.1.5 (p. 6-14).

Guide to Applying Water Quality Menus

1. Determine which area-specific menu applies to your project by consulting the Water Quality (WQ) Applications map (back pocket). The map will indicate if your project is covered by a special WQ menu or if the Basic WQ menu applies. If this determination cannot be made from the map, a more detailed delineation of WQ treatment areas is available on King County's Geographic Information System. The map also lists some of the inventoried sphagnum bog wetlands using the numbering convention of the King County wetlands inventory. If your project drains to one of these bogs, or an uninventoried sphagnum bog, it is also covered by a special WQ menu.
2. Read Core Requirement #8 to determine if any exemptions apply to your project.
3. If the map indicates your project is covered by a special WQ menu and no exemptions apply, determine if the site will actually drain to the sensitive resource (lake, stream reach, or bog). For instance, projects near drainage boundaries, especially in areas with underground storm drains, may drain in a direction different from the surface topography. Check the detailed threshold information in Section 1.2.8 to determine whether Core Requirement #8 applies to all or part of your project. If the project site does not drain to the sensitive resource, the Basic Water Quality menu applies.
4. Find the WQ menu in this section that applies to your project. Each menu presents two or more water quality treatment options; **select one**. Since all options are sized to provide equivalent removal of the target pollutant, the choice will depend only on the constraints and opportunities of your site. (If detention requirements apply, it will usually be most economical to use the combined WQ/detention pond option). Detailed facility designs for the option selected are given in Sections 6.3 (p. 6-37), 6.4 (p. 6-67), and 6.5 (p. 6-99). Information about non-structural options is included in the menu itself.
5. Read the implementation requirements in Chapter 1 (Section 1.2.8.2) that address pollution-generating pervious surfaces. For some WQ menus, and in some situations, the facility requirements for these surfaces are eased.
6. Determine if your project fits the definition of a high-use site (see Special Requirement #5 in Chapter 1). If it does, or if you elect to provide enhanced oil pollution control, choose one of the options presented in the High-Use menu, Section 6.1.5. Detailed designs for oil control facilities are given in Section 6.6 (p. 6-135).
7. General water quality facility requirements (see Section 6.2, p. 6-17) apply to all menus and may affect the placement of facilities on your site.

6.1.1 BASIC WATER QUALITY MENU

Where applied: The Basic Water Quality menu is generally applied to areas outside the drainage basin of sensitive lakes, regionally significant stream reaches, or sphagnum bog wetlands. Redevelopment projects, irrespective of location, also apply the basic WQ menu. The Basic WQ menu applies to stormwater conveyed to surface waters as well as to groundwater unless the project is exempt from treatment per Section 1.2.8. For precise details on the application of this and other area-specific water quality menus, refer to Section 1.2.8, "Core Requirement #8: Water Quality."

Treatment goal: The Basic Water Quality menu facility choices are designed to remove 80 percent of total suspended solids[1] (TSS) for flows or volumes up to and including the WQ design flow or volume (defined in Section 6.2.1, p. 6-17). Flows and volumes in excess of the WQ design flow or volume can be routed around the WQ facility or can be passed through untreated.

Basis: The goal of 80 percent TSS removal was chosen since it provides good pollutant removal. For higher removals, there are diminishing returns, and relatively less treatment is gained for incremental increases in facility size.

There are **seven facility options** that comprise the Basic WQ menu; **any one option** may be chosen to satisfy the basic WQ protection requirement.

❑ BASIC WQ OPTION 1—BIOFILTRATION SWALE

A *biofiltration swale* is a long, gently sloped, vegetated ditch designed to filter pollutants from stormwater. Grass is the most common vegetation used. Design details are given in Section 6.3.1 (p. 6-37). The wet biofiltration swale (see Section 6.3.2, p. 6-52) is a variation of the basic biofiltration swale for use where the longitudinal slope is slight (1 to 2 percent or less), water tables are high, or continuous low base flow is likely to result in saturated soil conditions. Under such conditions, healthy grass growth is not possible; wetland plants are used to provide the biofiltration mechanism in saturated soil conditions. The continuous inflow biofiltration swale (see Section 6.3.3, p. 6-55) may be used in situations such as roadways where water enters the swale continuously rather than at one discrete inflow point. Table 6.1.1.A (below) summarizes when the biofiltration swale and its variations are to be applied.

❑ BASIC WQ OPTION 2—FILTER STRIP

A *filter strip* is a grassy area with gentle slopes which treats stormwater runoff from adjacent paved areas before it concentrates into discrete channels; see Section 6.3.4 (p. 6-56) for design details. The narrow area filter strip may be used along a roadway or parking lot in limited space situations as specified in Section 6.3.5 (p. 6-64).

❑ BASIC WQ OPTION 3—WETPOND

Wetponds are stormwater ponds that maintain a pool of water for most of the year. Stormwater entering the pond is treated during the relatively long residence time within the pond. The sizing method used in this manual is based on a method developed by the Nationwide Urban Runoff Program (NURP). The basic wetpond has a volume three times larger than the volume of runoff from NURP's mean annual storm.[2] See Section 6.4.1 (p. 6-67) for design details.

❑ BASIC WQ OPTION 4—WETVAULT

An underground vault may be used to comply with the Basic Water Quality menu. The treatment volume is the same as for the basic wetpond; see Section 6.4.2 (p. 6-80) for design details.

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1 This goal assumes the project generates a typical level of TSS (between 30 and 100 milligrams per liter (mg/L). For projects expected to generate a higher level of TSS, such as a sand and gravel operation, a higher treatment goal may be appropriate.

2 The mean annual storm is derived from dividing the annual rainfall (in inches) by the number of storms per year.

❑ BASIC WQ OPTION 5—STORMWATER WETLAND

A *stormwater wetland* uses biological processes of plant uptake and bacterial degradation as well as physical and chemical processes and gravity settling to remove pollutants. The footprint of the stormwater wetland is sized based on the wetpond sizing, but the depth of water in the second cell is reduced to encourage plant growth; see Section 6.4.3 (p. 6-86) for design details.

❑ BASIC WQ OPTION 6—COMBINED DETENTION AND WETPOOL FACILITIES

This option allows the wetpond, wetvault, or stormwater wetland to be placed under the detention pond live storage. Where site conditions permit its use, this option occupies less space than separate siting of detention and water quality facilities. The basic wetpond portion of the combined facility is sized using the same method as the wetpond in Option 3; see Section 6.4.4 (p. 6-92) for design details.

❑ BASIC WQ OPTION 7—SAND FILTER

A *sand filter* is a depression or pond with the bottom made of a layer of sand. Stormwater is treated as it percolates downward through the sand layer. Sand filters treat to a higher level of TSS removal than do the other water quality facilities. Therefore, slightly less of the annual runoff volume can be treated through the sand filter and still meet the Basic WQ menu goal for TSS removal.

Sand filters can be built as open ponds, underground vaults or linear perimeter trenches; see Section 6.5.2 (p. 6-100) for basic and large sand filters, Section 6.5.3 (p. 6-120) for sand filter vaults, and Section 6.5.4 (p. 6-126) for linear sand filters. A sand layer can also be installed above an infiltration pond or vault to treat stormwater before it infiltrates. Presettling is required prior to sand filtration if no other WQ or detention facility precedes the sand filter.

TABLE 6.1.1.A SELECTION OF BIOFILTRATION SWALE TYPE APPROPRIATE FOR SITE

Site Circumstances	Biofiltration Swale Type
Flow enters at head of swale • Longitudinal slope 1% or less OR • Located downstream of a Level 2 or 3 detention facility	Wet biofiltration swale (Section 6.3.2, p. 6-52)
Flow enters at head of swale • Longitudinal slope between 1 and 2% • Soil saturation or base flows likely in wet season	EITHER wet biofiltration swale (Section 6.3.2), OR basic biofiltration swale (Section 6.3.1, p. 6-37), depending on site; may require underdrain or low-flow drain.
Flow enters at head of swale • Longitudinal slope ≥ 2% • Base flows may or may not be likely in wet season • Not downstream of Level 2 or 3 detention.	Basic biofiltration swale (Section 6.3.1, p. 6-37); may require low-flow drain, depending on site
Along a roadway or parking lot with: • Continuous inflow into the biofilter, OR • Numerous discrete inflows with no single inflow contributing more than about 10% of total swale flow.	Continuous inflow biofiltration swale (Section 6.3.3, p. 6-55)

6.1.2 SENSITIVE LAKE PROTECTION MENU

Where applied: The Sensitive Lake Protection menu is applied to the watersheds of lakes that have been determined to be particularly sensitive to phosphorus and that are being managed to reduce water quality impacts. This menu applies to stormwater conveyed to the lake by surface flow as well as to stormwater infiltrated within one-quarter mile of the lake in soils with high infiltration rates (i.e., measured rate exceeding 9 inches per hour). If stormwater is infiltrated further than one-quarter mile from the lake, or if the project is a redevelopment project, then the Basic WQ menu is applied unless the project is exempt from Core Requirement #8 per Section 1.2.8. For precise details on the application of this and other area-specific water quality menus, refer to Section 1.2.8, "Core Requirement #8: Water Quality."

*Note: The Sensitive Lake Protection menu is a **stand-alone menu**. It integrates the Basic WQ menu level of protection and the additional protection needed to achieve lake protection goals in the options described below. When this menu is required as specified in Core Requirement #8 (see Section 1.2.8), it is intended to replace the Basic WQ menu in the watersheds of sensitive lakes.*

Treatment goal: The Lake Protection menu is designed to achieve a goal of 50 percent total phosphorus (TP) removal for the WQ design flow or volume (defined in Section 6.2.1, p. 6-17), assuming typical forms and concentrations of phosphorus in untreated stormwater runoff.[3]

Basis: The Lake Protection menu will result in removal of more of the TSS load, including more of the finer fraction of TSS, than the Basic menu. The additional increment of solids removal will also provide enough phosphorus removal to meet the TP goal stated above.

❑ LAKE PROTECTION OPTION 1 — LARGE WETPOND

The 50 percent TP removal goal can be satisfied by use of a **large wetpond** or **large combined detention and wetpond** sized so that the wetpond volume is 4.5 times the volume of runoff from the mean annual storm, rather than 3 times the volume as in the basic pond. See Section 6.4.1.1 (p. 6-68) for the large wetpond design, and Section 6.4.4.1 (p. 6-92) for the large combined pond design. *Note: A large wetvault option is not included in this menu since the biological processes thought to remove phosphorus do not take place in underground vaults.*

❑ LAKE PROTECTION OPTION 2 — LARGE SAND FILTER

This option includes use of a **large sand filter, large sand filter vault**, or **large linear sand filter**. Sizing specifications for these facilities can be found in Sections 6.5.2 (p. 6-100), 6.5.3 (p. 6-120), and 6.5.4 (p. 6-126), respectively. *Note: A presettling cell is required if the sand filter is not preceded by a Level 2 or 3 detention facility.*

❑ LAKE PROTECTION OPTION 3 — TWO-FACILITY TREATMENT TRAIN

This option involves use of one of the basic water quality treatment options, listed in Table 6.1.2.A, followed by either a basic sand filter (Section 6.5.2, p. 6-100) or basic sand filter vault (Section 6.5.3, p. 6-120). For dispersed flows, a linear sand filter can be used as the second facility.

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[3] Typical TP concentrations in untreated Seattle-area runoff are considered to be between 0.10 and 0.50 mg/L. For projects that are expected to generate higher levels of TP, such as animal husbandry operations, a higher treatment goal may be appropriate.

TABLE 6.1.2.A PAIRED FACILITIES FOR LAKE PROTECTION TREATMENT TRAIN, OPTION 3	
First Basic WQ Facility	**Second WQ Facility**
Biofiltration swale (Sections 6.3.1, 6.3.2, and 6.3.3)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3)
Filter strip (Sections 6.3.4 and 6.3.5)	Linear sand filter (no presettling cell needed) (Section 6.5.4)
Linear sand filter (Section 6.5.4)	Filter strip (Sections 6.3.4 and 6.3.5)
Basic wetpond (Section 6.4.1)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3)
Wetvault (Section 6.4.2)	Basic sand filter or sand filter vault (Section 6.5.1 or 6.5.3)
Stormwater wetland (Section 6.4.3)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3)
Basic combined detention and wetpool facility (Section 6.4.4)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3)

❑ LAKE PROTECTION OPTION 4—BASIC MENU PLUS PHOSPHORUS CREDIT

This option provides credit to developments that integrate land use and site design measures to prevent or reduce the levels of phosphorus leaving the site. Credit is also given for the voluntary use of extra levels of onsite detention, since less in-stream erosion is likely to take place with more highly controlled stormwater releases. This reduction in in-stream erosion and bank failure translates directly into control of the phosphorus load delivered to downstream lakes.

The measures for which credit is given are detailed below, along with the point values assigned to each of the actions. Providing any combination of these measures equaling 10 points or more earns this credit. The credit excuses the applicant from the requirement to provide a second water quality facility. Thus, even though the development is located in the watershed of a sensitive lake, **the water quality requirements can be fully met with the provision of a single water quality facility from the Basic Water Quality menu.**

Credit-Earning Actions

Several land use actions and source controls are particularly effective in reducing phosphorus. These actions are not required by this manual or other regulations; they are an alternative to end-of-the-pipe treatment of stormwater. Credit options for phosphorus-reducing actions are described below.

1. **Leaving at least 65 percent of the site undisturbed, including undevelopable land.** Full credit, or 10 points, is awarded for leaving 65 percent of a site in undisturbed native vegetation or allowing native vegetation to re-establish. Sensitive areas and their buffers may be counted. All areas for phosphorus credit must be in tracts dedicated to the County or protected by covenant (one example of covenant language to protect vegetated tracts from disturbance is shown in Reference section 8-I). A descending scale of points applies where lower percentages of the site are left undisturbed. **Possible credit = 1 to 10 points.** *Note: In rural residential projects, an exemption from all WQ requirements is possible in certain situations if 65% of the area is set aside in open space. See Core Requirement #8 exemptions in Section 1.2.8.*
2. **Providing extra flow control.** Credit for providing extra flow control applies only in cases where site runoff travels via stream or open drainage system to the sensitive lake. Voluntary use of the Level 2 flow control standard when the Level 1 standard would be required = 5 points. Voluntary use of the

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Level 3 flow control standard when the Level 1 standard would be required = 8 points. Voluntary use of the Level 3 flow control standard when the Level 2 standard would be required = 3 points. **Possible credit = 3 to 8 points.**

3. **Directing runoff from pollution-generating surfaces to grassy areas with level spreading.** Directing runoff from pollution-generating areas to grassy areas that are not routinely fertilized or to areas of native vegetation results in pollutant removals similar to those obtained in swales while also providing an increased opportunity for infiltration. To use this option, flows must remain unconcentrated and be spread uniformly over the intended area. (Flow spreader details are given in Section 6.2.6.)

   In general, the vegetated area receiving dispersed flows should be at least 25 percent as large as the area contributing flow. The receiving area should be increased by one percent for each percent increase in slope over four percent. The area should be configured so that the length of the flow path is no longer than the width over which flows are dispersed.

   Example:

   Assume a parking lot is 100' × 600', or 60,000 sf. Flows will be dispersed through an adjacent area of native vegetation with a slope of 8 percent.

   The area of vegetation must be at least 17,400 sf (25% + 4% (for steeper slope) × 60,000 sf). Assuming runoff is dispersed continuously along the wider edge of the parking lot, the flow path would need to be at least 29 feet (17,400' ÷ 600'). If the water were dispersed along the shorter edge, flow path would be 174 feet (17,400' ÷ 100'). However, this flow path would be longer than the width over which flows were dispersed (100'), and would not be a satisfactory option. The parking lot could be graded, however, so that flows would be dispersed at both of the 100 foot ends, making each flow path 87 feet, which would be acceptable.

   Credit is proportional to the total volume of runoff diverted; one point is earned for every 25 percent of total volume so directed. **Possible credit = 1 to 4 points.**

4. **Providing covered parking or covered waste disposal and recycling areas isolated from the stormwater conveyance system.** This item applies to all land uses for which covered parking for employees, residents, guests, and the general public is provided. This can be achieved for commercial land uses simply by covering the parking required by code. For other land uses, provision of additional covered parking for guests or the general public (total parking) in lieu of on-street parking can be used to provide this assurance. It is intended that covered parking would isolate the area from stormwater run-on as well as direct rainfall. A low curb, berm, or enclosing walls, in addition to a roof, would typically be needed.

   The water quality credit is proportional to the percentage of the total surface area that is effectively covered. One point is earned for every 25 percent of parking covered and protected from run-on. One additional point is earned if all solid waste management areas are covered and protected from stormwater run-on. **Possible credit = 1 to 5 points**

5. **Providing covered vehicle washing areas connected to the sanitary sewer system.** This item applies to commercial, industrial, and multifamily sites. Frequent car-washing can contribute significant amounts of phosphorus to stormwater. Note that sewer districts may have pretreatment requirements before allowing connection to the sanitary sewer. **Possible credit = 3 points.**

Table 6.1.2.B (p. 6-9) details the credit options and associated point totals.

Credit may be applied to the whole site or to a *natural discharge area*[4] within the site. It may be advantageous for a developer to concentrate only on a natural discharge area if the point total for that particular area could equal 10. For example, assume a particular natural discharge area is one half the total

[4] The *natural discharge area* is onsite area tributary to a single natural discharge location. Natural discharge location means the location where runoff leaves the project under existing conditions.

site area. If 65 percent of the land area in the natural discharge area will remain undisturbed, that natural discharge area is eligible for 10 points (see Table 6.1.2.B). The stormwater from that natural discharge area could be treated with a single water quality facility from the Basic WQ menu; the second facility could be waived. The rest of the site would still have the two-facility requirement.

Alternatively, if the entire site were considered, the undisturbed area decreases to 35 percent, eligible for only 3 points. In this case, the developer would need to implement other controls worth 7 points in order to waive the second water quality facility for the entire site.

If the credit option is used, it should be applied for during initial drainage review by the King County Department of Development and Environmental Services (DDES). The application should include a **written request for credit** based on either the site plan or the grading plan for the project, and the threshold discharge areas should be delineated on the plans. The request should outline where the credit would be applied and how the point totals are to be achieved. DDES staff would then evaluate the request and may waive the second water quality treatment requirement for the site or threshold discharge area based on point totals outlined in Table 6.1.2.B (below). **Credit is not given unless requested.**

TABLE 6.1.2.B WATER QUALITY CREDIT FOR PHOSPHORUS CONTROL

Credit Option	Points	Credit Option	Points
Leaving site undisturbed, in native vegetation. Buffers without trails may be counted.	At least 65 % = 10 60 % = 9 55 % = 8 50 % = 7 45 % = 6 40 % = 5	Covered parking protected from run-on	100 % parking = 4 75 % parking = 3 50 % parking = 2 25 % parking = 1
	35 % = 4 30 % = 3 25 % = 2 20 % = 1	Covered car wash area connected to sanitary sewer (multifamily)	3
Directing road runoff to pervious, non-pollution-generating vegetated area.	100 % of volume = 4 75 % of volume = 3 50 % of volume = 2 25 % of volume = 1	Covered solid waste storage area	1
		Extra detention with next most restrictive release rate (if discharge to stream)	Level 1→ Level 2 = 5 Level 1→ Level 3 = 8 Level 2→ Level 3 = 3

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6.1.3 RESOURCE STREAM PROTECTION MENU

Where applied: The Resource Stream Protection menu[5] is applied to stream reaches determined to be regionally significant because of salmon use. It applies to stormwater conveyed by surface flow to the designated stream reach. If stormwater is infiltrated by the project, or if the project is a redevelopment project, then the Basic WQ menu is applied unless the project is exempt from Core Requirement #8 per Section 1.2.8. For precise details on the application of this and other area-specific water quality menus, refer to Section 1.2.8, "Core Requirement #8: Water Quality."

*Note: The Resource Stream Protection menu is a **stand-alone menu**. It integrates the Basic menu level of protection and the additional measures needed to achieve stream protection goals in the options described below. When this menu is required as specified in Core Requirement #8 (see Section 1.2.8), it is intended to replace the Basic WQ menu in drainage areas of regionally significant stream reaches.*

Treatment goal: The Stream Protection menu is designed to achieve 50 percent total zinc removal for flows up to and including the WQ design flow or volume (defined in Section 6.2.1, p. 6-17).[6]

Basis: The treatment goal is expressed in terms of total zinc removal. Although zinc is not the most toxic metal in stormwater, it is usually present in significant amounts, making it a practical and reliable indicator of overall performance. Many metals are readily adsorbed onto particulates in the runoff, usually the finer fraction of the particulates. Facility combinations that remove more of the particulate load than the Basic menu, including the finer fraction, are specified by the menu. Facilities providing organic binding sites that enhance metal adsorption are also specified.

❑ STREAM PROTECTION OPTION 1 — LARGE SAND FILTER

This option includes use of a **large sand filter, large sand filter vault**, or **large linear sand filter**. Sizing specifications for these facilities can be found in Sections 6.5.2 (p. 6-100), 6.5.3 (p. 6-120), and 6.5.4 (p. 6-126), respectively. *Note: A presettling cell is required if the sand filter is not preceded by a detention facility.*

❑ STREAM PROTECTION OPTION 2 — STORMWATER WETLAND

Provision of a **stormwater wetland** (see Section 6.4.3, p. 6-86) or **combined detention and stormwater wetland** (see Section 6.4.4, p. 6-92) satisfies the 50 percent zinc removal goal without additional facilities. The large amount of organic material in the stormwater wetland provides organic binding sites and is considered very effective in removing metals.

❑ STREAM PROTECTION OPTION 3 — TWO-FACILITY TREATMENT TRAIN

This option involves use of one of the basic water quality treatment options listed in Table 6.1.3.A (p. 6-11) followed by a basic sand filter (see Section 6.5.2, p. 6-100), sand filter vault (see Section 6.5.3, p. 6-120), linear sand filter (see Section 6.5.4, p. 6-126), or leaf compost filter (see Section 6.5.5, p. 6-131). The *leaf compost filter* is a patented treatment device which uses a specially prepared and patented compost product to remove pollutants from stormwater.

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[5] The Resource Stream Protection menu targets different pollutants than the lake or bog protection menus. It does not necessarily provide a higher level of treatment except for the target pollutant, metal contaminants.

[6] This goal assumes total zinc concentrations for untreated runoff are between 0.10 and 0.25 micrograms per liter (μg/L). For projects that are expected to generate higher levels of metals, such as a mining operation, a higher treatment goal may be appropriate.

TABLE 6.1.3.A PAIRED FACILITIES FOR STREAM PROTECTION TREATMENT TRAIN, OPTION 3	
First Basic WQ Facility:	**Second WQ Facility:**
Biofiltration swale (Sections 6.3.1, 6.3.2, and 6.3.3)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3) or leaf compost filter (Section 6.5.5)
Filter strip (Sections 6.3.4 and 6.3.5)	Linear sand filter (Section 6.5.4) with no presettling cell needed
Linear sand filter (Section 6.5.4)	Filter strip (Sections 6.3.4 and 6.3.5)
Basic wetpond (Section 6.4.1)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3) or leaf compost filter (Section 6.5.5)
Wetvault (Section 6.4.2)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3) or leaf compost filter (Section 6.5.5)
Basic combined detention and wetpool facility (Section 6.4.4)	Basic sand filter or sand filter vault (Section 6.5.2 or 6.5.3) or leaf compost filter (Section 6.5.5)
Basic sand filter or sand filter vault (Sections 6.5.2 or 6.5.3). **A presettling cell is required if the sand filter is not preceded by a detention facility.**	Leaf compost filter (Section 6.5.5)

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6.1.4 SPHAGNUM BOG PROTECTION MENU

Where applied: The Sphagnum Bog Protection menu[7] covers sphagnum bog wetlands[8] greater than 0.25 acres in size.[9] It applies to stormwater conveyed by surface flow to the sphagnum bog vegetation community. If stormwater is infiltrated by the project, or if the project is a redevelopment project, then the Basic WQ menu is applied unless the project is exempt from Core Requirement #8, "Water Quality." For precise details on the application of this and other area-specific water quality menus, refer to Section 1.2.8.

*Note: The Sphagnum Bog Protection menu is a **stand-alone menu**. It integrates the Basic WQ menu level of protection and the additional measures needed to achieve bog protection goals in the options described below. When this menu is required as specified in Core Requirement #8 (see Section 1.2.8), it is intended to replace the Basic WQ menu in areas draining to sphagnum bogs.*

Treatment goal: If surface water must be discharged to a bog, the treatment goal is to reduce total phosphate by 50 percent, reduce nitrate + nitrite by 40 percent, maintain alkalinity below 10 mg/L, and maintain pH below 6.

Basis: In their undeveloped condition, bogs are isolated from surface water, being supplied almost solely by rainwater. The best strategy for protection of bog water quality is to infiltrate the water quality design volume while routing high flows around the bog. Although it is not known whether alkalinity or nitrogen can be reduced sufficiently by the options outlined below, there are no other technologically-feasible alternatives at this time. An experimental design adjustment (see Section 1.4) could be pursued as additional technology becomes available.

❑ SPHAGNUM BOG PROTECTION OPTION 1 — LARGE WETPOND FOLLOWED BY LARGE SAND FILTER

This option uses a **large wetpond** (see Section 6.4.1, p. 6-67) or a **large combined detention and wetpond** (see Section 6.4.2, p. 6-80), sized so that the wetpond volume is 4.5 times the volume of runoff from the mean annual storm, rather than 3 times the volume as in the Basic Water Quality menu. A large sand filtration facility (see Section 6.5.2, p. 6-100, or 6.5.3, p. 6-120) must follow the pond. In order to ensure that algae and sources of alkalinity from the pond are not washed from the pond into the bog, the **sand filter must be the last facility.**

❑ SPHAGNUM BOG PROTECTION OPTION 2 — STORMWATER WETLAND IN SERIES WITH A LARGE SAND FILTER

This option uses a **stormwater wetland** (see Section 6.4.3, p. 6-86) or **combined detention and stormwater wetland** (see Section 6.4.4, p. 6-92) to remove solids and enhance the concentration of organic acids, and a **large sand filter** (see Section 6.5.2, p. 6-100) to remove the finer sediment for alkalinity and nutrient reduction. **The order of facilities is interchangeable** since there are both advantages and disadvantages to having the sand filter last in the train. *Note: A presettling cell is required if the first treatment facility is not preceded by a detention facility.*

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7 The Bog Protection menu targets a different set of pollutants than the Lake or Stream Protection menus. Since the targeted pollutants are more difficult to remove, use of larger and/or additional treatment facilities is required.

8 A *sphagnum bog wetland* is defined as a wetland having a predominance of sphagnum moss creating a substrate upon which a distinctive community of acid-loving plants is established (see "Definitions" for more detail). There are several classification schemes for wetlands dominated by sphagnum moss, and a successional series from conventional wetlands to fens to sphagnum bog is recognized by most ecologists. Some biologists use water chemistry and plant community composition to determine where in this successional series a wetland should be placed. In these classification schemes, the sphagnum wetlands defined in this manual would be bogs. Others base the wetland type on the source of water, in which case most King County sphagnum wetlands would be fens. This manual has adopted the classification scheme based on water chemistry and plant communities and hence refers to these wetlands as bogs rather than fens.

9 The *size* of a sphagnum bog wetland is defined by the boundaries of the sphagnum bog plant community.

❑ SPHAGNUM BOG PROTECTION OPTION 3— LARGE SAND FILTER IN SERIES WITH A LEAF COMPOST FILTER

This option uses a **large sand filter** or **large sand filter vault** followed by a **leaf compost filter**. Sizing specifications for the large sand filters can be found in Sections 6.5.2 (p. 6-100) and 6.5.3 (p. 6-120). Leaf compost filters are detailed in Section 6.5.5 (p. 6-131). **The order of facilities is interchangeable** since there are both advantages and disadvantages to having the leaf compost filter last in the train. *Note: A presettling cell is required if the first treatment facility is not preceded by a detention facility.*

❑ SPHAGNUM BOG PROTECTION OPTION 4—THREE-FACILITY TREATMENT TRAIN

This option uses one of the basic water quality treatment options followed by two other facilities. Table 6.1.4.A lists the possible choices of facilities for this option.

TABLE 6.1.4.A
FACILITY COMBINATIONS FOR BOG PROTECTION TREATMENT TRAIN, OPTION 4

First Facility	Second Facility	Third Facility
Biofiltration swale (Sections 6.3.1, 6.3.2 and 6.3.3	Leaf compost filter* (Section 6.5.5)	Basic sand filter (Sections 6.5.2, 6.5.3 or 6.5.4)
Filter strip (Sections 6.3.4 and 6.3.5)	Leaf compost filter* (Section 6.5.5)	Basic sand filter (Sections 6.5.2, 6.5.3 or 6.5.4)
Basic wetpond (Section 6.4.1)	Basic sand filter (Sections 6.5.2, 6.5.3 or 6.5.4)	Leaf compost filter* (Section 6.5.5)
Basic combined detention and wetpool facility (Section 6.4.4)	Basic sand filter (Sections 6.5.2, 6.5.3 or 6.5.4)	Leaf compost filter* (Section 6.5.5)
Wetvault (Section 6.4.2)	Basic sand filter (Sections 6.5.2, 6.5.3 or 6.5.4)	Leaf compost filter* (Section 6.5.5)
Stormwater wetland (Section 6.4.3	Basic sand filter (Sections 6.5.2, 6.5.3 or 6.5.4)	Leaf compost filter* (Section 6.5.5)

* *Note that the order of the second and third facilities may be interchanged. Other treatment options may be pursued through an experimental design adjustment per Section 1.4.*

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6.1.5 HIGH-USE MENU

Where applied: The High-Use menu is applied to all new and redevelopment projects that have high-use site characteristics, as defined in Chapter 1 (see "Special Requirement # 5, Oil Control"). Oil control devices are to be placed upstream of other facilities, as close to the source of oil generation as practical.

Note: Where this menu is applicable, it is ***in addition to*** *the area-specific WQ menus.*

Treatment goal: Oil control options given in the High-Use menu are designed to meet the goals of no visible sheen or less than 10 mg/L total petroleum hydrocarbons (TPH) leaving the site.

❑ OIL CONTROL OPTION 1 — CATCH BASIN INSERT

Catch basin inserts (see Section 6.6.1, p. 6-135) may be used to meet the oil control requirements for new or redeveloped high-use sites. For new development, the criteria for flow capture given in "Design Criteria" (p. 6-137) must be met. The flow capture criteria apply to the high-use area only, provided that flows not subject to high use are shunted around the insert. For redevelopment sites, additional flow may be routed through the insert if it is not possible for the site to meet the flow capture criteria without installing new catch basins. Up to 40 percent additional flow can be directed to the insert in these cases.

All catch basin inserts must be fitted with oil sorbent media, to be changed at least monthly in wet weather (generally October through May) and whenever the surface of the media is covered with sediment. Acceptable sorbent media include wood fiber products, such as *Absorbent W* or *SuperSorb*; whole, green fibrous moss such as that supplied by floral shops (must not be ground peat moss); or polymers such as *Petrolok* and *Streamguard*™. These media have been investigated and found to retain captured oil fairly effectively. Cedar Grove compost was tested and found unacceptable for oil retention. Stormwater Management's patented leaf compost mix was also tested, and although it performed fairly well. it did not retain oil as well as the other products tested. Therefore, the leaf compost should not be used in catch basin inserts for oil control.

Alternative media may be used if it can be shown they are substantially equivalent to the media listed above. The method that should be used to demonstrate oil retention is given in the decision paper entitled "Oil leachate tests for various adsorbent filter media," May 1994, King County Surface Water Management Division (now Water and Land Resources Division).

❑ OIL CONTROL OPTION 2 — BAFFLE OIL/WATER SEPARATOR

Baffle oil/water separators (see Section 6.6.2, p. 6-141) may be used to treat stormwater runoff from high-use developments and facilities that produce relatively high concentrations of oil and grease. Baffle separators historically have been effective in removing oil having droplet sizes of 150 microns or larger. If sized properly, they can achieve effluent concentrations as low as 10 to 15 mg/L.

❑ OIL CONTROL OPTION 3 — COALESCING PLATE OIL/WATER SEPARATOR

Coalescing plate separators (see Section 6.6.2, p. 6-141) may be used to treat stormwater runoff from high-use developments and facilities that can produce relatively high concentrations of oil and grease. Current technology and design of coalescing plate separators achieve effluent concentrations as low as 10 mg/L with removal of oil droplet sizes as small as 20 to 60 microns.

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❑ OIL CONTROL OPTION 4 — LINEAR SAND FILTER

The linear sand filter (see Section 6.5.4, p. 6-126) is used in the Basic and Special Resource Protection water quality menus, as well as for oil control in the High-Use menu. However, if used to satisfy a basic or special WQ menu, the same facility shall not also be used to satisfy the oil control requirement unless enhanced maintenance is assured. This is to prevent clogging of the filter by oil so that it will function for TSS or TP removal as well. Quarterly cleaning is required unless specified otherwise by the designer.

❑ OIL CONTROL OPTION 5—WETVAULT WITH BAFFLE

A wetvault may be modified to fulfill requirements for oil control provided the following are true:

1. The criteria given at the end of Section 6.4.2.2 for modification of wetvaults for use as a baffle oil/water separators shall be met, and
2. Assurance is provided that the maintenance frequency and oil removal frequency for baffle oil/water separators will be followed (see Section 6.6.2, p. 6-141).

❑ OIL CONTROL OPTION 6— PARKING LOT WASHING WITH PROPER WASH WATER DISPOSAL

Quarterly washing of a parking lot may be used instead of a structural oil control measure if proper disposal of the wash water is arranged. Proper disposal may include holding the water in a blind sump with subsequent hauling off site, or discharge to the sanitary sewer or septic system after holding the water for 24 hours and skimming off the oil for recycling. If wash water is discharged to a sanitary sewer or septic tank, detergents or emulsifiers should be avoided so that subsequent separation and removal of the oil can take place in a reasonable time frame. A waste discharge permit, issued by the King County Department of Natural Resources, may be needed to discharge wash water to the sanitary sewer.

❑ OIL CONTROL OPTION 7—COMPLIANCE WITH OTHER AGENCY REQUIREMENTS

If the site has a National Pollutant Discharge Elimination System (NPDES) permit that specifically addresses oil control for the pollution-generating impervious surface of the site, compliance with NPDES permit conditions is adequate to comply with the oil control requirements of Special Requirement #5.

If the area under the covered fueling island drains to the sanitary sewer, then only the remaining high-use area actually draining to the storm drainage system (normally ingress and egress routes) need comply with the High-Use menu.

Note: Covered fueling islands draining to the sanitary sewer or a dead-end sump are recommended in the Department of Ecology's Stormwater Management Manual for the Puget Sound Basin, Section IV 4.1 and required by the King County Industrial Waste Section for new construction.

6.2 GENERAL REQUIREMENTS FOR WQ FACILITIES

This section presents the general requirements for water quality (WQ) facilities. When detail in the WQ designs is lacking, refer to Chapter 5 for guidance. In cases where requirements are extremely costly, a less expensive alternative that is functionally equivalent in terms of performance, environmental effects, health and safety, and maintenance can be sought through the adjustment process (see Section 1.4).

Use of Metal Materials

Galvanized metals leach zinc into the environment, especially in standing water situations. High zinc concentrations, sometimes in the range that can be toxic to aquatic life, have been observed in the region.[10] Therefore, use of galvanized materials in stormwater facilities and conveyance systems is discouraged. Where other metals, such as aluminum or stainless steel, or plastics are available, they should be used.

6.2.1 WATER QUALITY DESIGN FLOWS

Water Quality Design Flow

The water quality design flow is defined as follows:

- *Preceding detention*: **60% of the developed two-year peak flow rate, as determined using the KCRTS model** with 15-minute time steps calibrated to site conditions (see Chapter 3). *Note: If KCRTS is not being used on a project, the WQ design flow may also be estimated using 64% of the 2-year 24-hour precipitation in the SBUH model.*[11]
- *Downstream of detention*: The full **2-year release rate from the detention facility**.

The KCRTS model will typically be used to compute the WQ design flow. When examining the peak flow rates associated with various runoff volumes, it was found that detained flows and undetained flows must be described differently. However, unlike peak flows, the KCRTS model computation of volume of runoff is unaffected by whether or not the runoff is detained. Therefore, facilities such as wetponds, which are sized by a simple volume-based approach that does not route flows through a detention pond, are the same size whether they precede or follow detention.

Note that facilities which are sized based on volume and which include routing of flows through a detention pond, such as the detailed sand filter method, are significantly smaller when located downstream of detention, even though the same volume of water is treated in either situation. This is because the detention pond routing sequence stores peaks within the pond and releases them at a slow rate, reducing the size of the sand filter pond subsequently needed (the volume needed to store the peaks need not be provided again in the sand filter pond).

Flow Volume to be Treated

When water quality treatment is required pursuant to the core and special requirements of this manual, it is intended that a minimum of **95% of the annual average runoff volume** in the time series, as determined with the KCRTS model, be treated. Designs using the WQ design flow (as discussed above) will treat this minimum volume.

Treatable Flows

As stated in Chapter 1, only runoff from pollution-generating surfaces must be treated using the water quality facility options indicated in the applicable water quality menu. Pollution-generating impervious

[10] Finlayson, 1990. Unpublished data from reconnaissance of Metro Park and Ride lot stormwater characteristics.

[11] The Department of Ecology WQ design flow is based on the flow predicted by the SBUH model for 64% of the 2-year 24-hour precipitation. This is roughly equivalent to the WQ design flows given here for the KCRTS model.

surfaces(PGIS) are those impervious surfaces which are subject to vehicular use or storage of erodable or leachable materials, wastes, or chemicals; and which receive direct rainfall or the run-on or blow-in of rainfall. For subdivisions, pollution-generating impervious areas typically include right-of-way improvements (roads), parking areas and driveways. Metal roofs are also considered to be PGIS unless they are treated to prevent leaching. Pollution-generating pervious surfaces(PGPS) are those non-impervious surfaces with vegetated ground cover subject to use of pesticides and fertilizers. For subdivisions, pollution-generating pervious areas typically include lawns and landscaped areas. Gold courses, parks and sports fields are also typically PGPS.

The following points summarize which site flows must be treated and under what circumstances:

- All runoff from **pollution-generating impervious surfaces** is to be treated through the water quality facility(ies) required in Chapter 1 and specified in the Chapter 6 menus.
- Runoff from lawns and landscaped areas generally overflows toward street drainage systems where it is conveyed to treatment facilities along with the road runoff. However, sometimes runoff from backyards drains into open space or buffer areas. In these cases, buffers may be used to provide the requisite water quality treatment provided (1) runoff sheetflows into the buffer or a dispersal trench is provided to disperse flows broadly into the buffer, and (2) the flow path through the pollution-generating area is limited to about 200 feet.
- Drainage from impervious surfaces that are **not pollution-generating** (such as most roofs) need not be treated and may bypass the treatment facility.[12] Roof runoff is, however, still subject to flow control per Core Requirement #3. Note that **metal roofs** are considered pollution-generating unless they are treated to prevent leaching.
- Drainage from areas in native vegetation should not be mixed with untreated runoff from streets and driveways, if possible. It is best to infiltrate or disperse this relatively clean runoff to maximize recharge to shallow groundwater, wetlands, and streams.
- If runoff from roofs or areas in native vegetation reaches a water quality facility, flows from those areas must be included in the sizing calculations for the facility. Once runoff from non-pollution-generating areas is combined with runoff from pollution-generating areas, it cannot be separated before treatment.

6.2.2 SEQUENCE OF FACILITIES

As specified in the water quality menus, where more than one water quality facility is used, the order is often prescribed. This is because the specific pollutant removal role of the second or third facility in a treatment train often assumes that significant solids settling has already occurred. For example, phosphorus removal using a two-facility treatment train relies on the second facility (sand filter) to remove a finer fraction of solids than those removed by the first facility.

There is a larger question, however, of whether water quality facilities should be placed upstream or downstream of detention facilities. In general, all water quality facilities may be installed upstream of detention facilities, although presettling basins are needed for sand filters and infiltration basins. Not all water quality facilities, however, can be located downstream of detention facilities. Those facilities that treat unconcentrated flows, such as filter strips and narrow-area biofilters, will seldom be practical downstream of detention facilities. Other facilities present special problems that must be considered before placement downstream is advisable.

Two facilities that fall into this latter category are the basic biofiltration swale (see Section 6.3.1, p. 6-37) and the sand filter or sand filter vault (see Sections 6.5.2 or 6.5.3). For both of these facilities, the

[12] Available data on the quality of roof runoff was examined. Although there are instances of polluted roof runoff, they tend to be related to galvanized roofing materials or industrial processes. There is also data that suggests the pollutant concentration of atmospheric fallout decreases with vertical elevation. See "Water Quality Thresholds Decision Paper," April 1994, King County Surface Water Management Division (now Water and Land Resources Division).

prolonged low flows resulting from Level 2 or 3 flow control may interfere with facility operation. In the case of basic biofilters, prolonged flows, generally in excess of about two weeks, will cause the grass to die. This can be dealt with by using the wet biofilter design.

In the case of sand filters, prolonged flows may result in the sand being saturated for long periods. Saturated sand can become anoxic (lose all oxygen) when dissolved oxygen in the pore water becomes depleted. If the sand layer becomes anoxic, some forms of phosphorus can become soluble and be released, negating the positive P removals achieved earlier. To prevent long periods of sand saturation, adjustments may be necessary after the sand filter is in operation to bypass some areas of the filter, allowing them to drain completely. It may also be possible to employ a different alternative that uses facilities less sensitive to prolonged flows. Table 6.2.2.A summarizes placement considerations of water quality facilities in relation to detention.

Oil control facilities must be located upstream of water quality facilities and as close to the source of oil-generating activity as possible. They should also be located upstream of detention facilities, if possible.

TABLE 6.2.2.A WATER QUALITY FACILITY PLACEMENT IN RELATION TO DETENTION

Water Quality Facility	Preceding Detention	Following Detention
Basic biofiltration swale (Section 6.3.1)	OK	OK if downstream of Level 1 detention. However, prolonged flows may cause soil saturation and injure grass. If downstream of a Level 2 or 3 flow control pond, the wet biofiltration swale may be needed. (See Section 6.3.2.)
Wet biofiltration swale (Section 6.3.2)	OK	OK
Continuous inflow biofiltration swale (Section 6.3.3)	OK	No—must be installed before flows concentrate.
Filter strip or roadway filter strip (Sections 6.3.4 and 6.3.5)	OK	No—must be installed before flows concentrate.
Basic or large wetpond (Section 6.4.1)	OK	OK—less water level fluctuation in ponds downstream of detention may improve aesthetic qualities.
Basic or large combined detention and wetpond (Section 6.4.4)	Not applicable	Not applicable
Wetvault (Section 6.4.2)	OK	OK
Basic or large sand filter or sand filter vault (Section 6.5.2 or 6.5.3)	OK, but presettling and control of floatables needed	OK—sand filters downstream of a Level 2 or 3 flow control pond may require field adjustments if prolonged flows cause sand saturation and interfere with the phosphorus removal mechanism.
Stormwater wetland/pond (Section 6.4.3)	OK	OK—less water level fluctuation and better plant diversity are possible if the stormwater wetland is located downstream of the detention facility.

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6.2.3 SETBACKS, SLOPES, AND EMBANKMENTS

This section presents the general requirements for water quality facility setbacks, side slopes, fencing, and embankments.

When locating water quality facilities near wetlands and streams, there is a potential that the water level may be lowered. Care in the design and siting of the facility or conveyance elements associated with the facility is needed to assure this impact is avoided. Sufficient setback of the facility from the water body is one method to prevent impact.

❑ SETBACKS FROM TRACT LINE

Water quality facilities that are maintained by the County must be in tracts dedicated to the County. Different water quality facilities and different types of side slopes (bermed vs. cut) have somewhat different requirements for setback from the tract line or setbacks for structures on adjacent tracts; these various requirements are given in Table 6.2.3.A (p. 6-21).

Most setbacks from tract lines are for maintenance equipment maneuverability. Setback requirements do not apply to water quality facilities that are privately maintained, but adequate room for maintenance equipment should be considered during site design. Restrictions on the placement of structures on adjacent internal lots, as specified for infiltration facilities in Sections 5.4.2, 5.4.3 and 5.4.4 do however, apply to privately maintained facilities.

❑ SIDE SLOPES, FENCING, AND EMBANKMENTS

Side slopes for water quality facilities should not exceed a slope of 3H:1V. Moderately undulating slopes are acceptable and can provide a more natural setting for the facility. In general, gentle side slopes improve the aesthetic attributes of the facility and enhance safety.

Water quality facilities must meet the following requirements for side slopes, fencing, and embankments:

1. If the water quality facility (wetpond, sand filter, or stormwater wetland) will hold standing water deeper than 2 feet, **fencing is required** for interior slopes steeper than 3H:1V. If only sections of the slope are steeper than 3:1, barrier shrubs, such as barberry, may be used rather than fencing for sections shorter than 20 feet. Planting climbing vines at the base of a fence can enhance its aesthetic qualities.
2. If required, fencing shall be placed **at or above the overflow water surface**. Side slope and attendant fencing requirements are not applicable to slopes **above** the overflow water surface. The specific fencing requirements given in Chapter 5 (see Section 5.3) also apply to WQ facilities.
3. If facilities are **privately owned and maintained**, the fencing requirements of this manual are recommended rather than required. However, the site must still comply with any fencing requirements in other codes or regulations.
4. For facilities owned and maintained by the County, at least **25 percent of the facility perimeter** shall have interior sides no steeper than 3H:1V, even if fenced, to minimize safety risks. For private facilities, the same is recommended rather than required.
5. Interior side slopes may be **retaining walls**, provided that the design is prepared and stamped by a licensed civil engineer. A fence shall be provided along the top of the wall.
6. Exterior side slopes shall not be **steeper than 2H:1V** unless confirmed stable by a geotechnical engineer.
7. Water quality facilities with embankments that impound water must comply with Washington State **dam safety regulations** (WAC 173-175). Under current regulations (as of January 1996), if the impoundment has a storage capacity (including both water and sediment storage volumes) greater than

10 acre-feet above natural ground level and a dam height of more than 6 feet, then dam safety design and review are required by the Washington Department of Ecology (Ecology). If the storage capacity is less than 10 acre-feet above natural ground level, then the facility is exempt from Ecology review. If the dam height is less than 6 feet but capacity is greater than 10 acre-feet, then Ecology reviews on a case-by-case-basis to determine the hazard potential downstream in the event of a failure.

Intent: The requirements for slopes and fencing are intended to accomplish the following objectives:

- To prevent persons from inadvertently slipping into the pond, either by providing gentle interior side slopes (3H:1V or gentler) or by fencing or other barrier
- To allow easy egress from the pond (gentle side slopes, safety benches, etc.) when access is not restricted by a fence or other barrier
- To ensure interior and exterior slopes or embankments are stable and will not create a hazardous or damaging situation.

TABLE 6.2.3.A SETBACK REQUIREMENTS *

WQ FACILITY	SETBACK FROM TRACT LINE		
	At Grade or Underground	If Facility Slope is Cut into Grade	If Slope is an Embankment
Biofiltration swale	N/A	See conveyance system requirements (Section 4.1)	5 feet from toe of exterior slope
Filter strip	5 feet from toe	5 feet from toe	N/A
Wetpond	N/A	5 feet from emergency overflow water surface (WS)	5 feet from toe of exterior slope
Combined detention and wetpond	N/A	5 feet from emergency overflow WS	5 feet from toe of exterior slope
Wetvault or sand filter vault	5 feet from property line	N/A	N/A
Sand filter ponding area	N/A	5 feet from emergency overflow WS	5 feet from toe of exterior slope
Linear sand filter	5 feet from property line	N/A	N/A
Leaf compost filter ponding area	5 feet from property line	5 feet from emergency overflow WS	5 feet from toe of exterior slope

* Greater setback distances are required whenever expressly stated or referenced in this manual or when required by other County codes or other agencies. Steep slopes, land slide areas, open water features, springs, wells, and septic tank drainfields are features that often have additional setback requirements. Some typical setback distances imposed by the Seattle-King County Department of Public Health include the following:

- Open water features: 100 feet
- Wells: 100 feet
- Springs used for potable water: 200 feet
- Septic tank drainfields: 100 feet for open ponds. Wetvaults or tanks are usually considered watertight and often have no specific setback requirements. However, tanks or vaults must not be located so that they could impede downgradient subsurface effluent flows.

6.2.4 FACILITY LINERS

Water quality facilities in which water is in direct contact with the soil must be lined with either a **low permeability liner** or a **treatment liner** when the soil does not have properties which reduce the risk of groundwater contamination from stormwater runoff that may infiltrate in the facility. Such properties are defined and determined as specified in the "Groundwater Protection" requirements for infiltration facilities in Section 5.4.1. In short, a liner is required if the soil has an *infiltration rate*[13] greater than 9 inches per hour (0.15 inches per minute) and does not meet any of the other soil property criteria required for groundwater protection in Section 5.4.1. In areas designated as **sole-source aquifers**, this liner requirement applies when the soil infiltration rate exceeds 2.4 inches per hour (0.04 inches per minute) and the other soil property criteria for sole-source aquifers are not met. If detention ponds are used in soils with infiltration rates above the specified rates, either water quality treatment facilities must precede the detention pond, or the detention pond must also be lined.

In addition to groundwater protection considerations, some facility types require permanent water for proper functioning. An example is the first cell of a wetpond.

Low permeability liners reduce infiltration to a very slow rate, generally less than 0.02 inches per hour (1.4×10^{-5} cm/s). Low permeability liners may be fashioned from compacted till, clay, geomembrane, or concrete as detailed in Section 6.2.4.1 (p. 6-24). Till liners are preferred because of their general resilience and ease of maintenance.

Treatment liners amend the soil with materials that treat stormwater before it reaches more freely draining soils. They have slow rates of infiltration, generally less than 2.4 inches per hour (1.7×10^{3} cm/s), but not as slow as low permeability liners. Treatment liners may use in-place native soils or imported soils. Options for this type of liner include a fine sand layer or a soil layer which has high organic content; see Section 6.2.4.2 (p. 6-25) for more option details.

Intent: In soils with high rates of infiltration, the potential exists for the transfer of pollutants from stormwater to groundwater before treatment in water quality facilities occurs. Liners are intended to reduce the likelihood that pollutants in stormwater will reach the groundwater when WQ treatment facilities are constructed in soils with high infiltration rates. A more conservative infiltration rate is used as the lining threshold for WQ facilities in sole-source aquifer areas. This is because the potential consequences of pollutant transfer are more serious in these areas.

General Design Criteria

1. Table 6.2.4.A (p. 6-23) recommends the type of liner generally best suited for use with various water quality treatment facilities.
2. Liners shall be evenly placed over the bottom and/or sides of the treatment area of the facility as indicated in Table 6.2.4.A. Areas above the treatment volume that are required to pass flows greater than the water quality treatment flow (or volume) need not be lined. However, the lining must be extended to the top of the interior side slope and anchored if it cannot be permanently secured by other means.
3. For **low permeability liners**, the following criteria apply:
   a) Where the seasonal high groundwater elevation is likely to contact a low permeability liner, liner buoyancy may be a concern. A low permeability liner shall not be used in this situation unless evaluated and recommended by a geotechnical engineer.
   b) Where grass must be planted over a low permeability liner per the facility design, a minimum of 6 inches of good topsoil or compost-amended native soil (2 inches compost tilled into 6 inches of native soil) must be placed over the liner in the area to be planted. Twelve inches is preferred.

[13] Infiltration rates can either be measured in the field using methods given in Chapter 5 or inferred from the USDA soil textural triangle (shown in Section 5.4.1). If inferred, the measured infiltration rate is assumed less than 9 inches per hour for all soil texture classes except sand and loamy sand.

c) If an **identification sign** is required for the facility (see detention pond requirements in Section 5.3.1), the face of the sign shall bear a note indicating the facility is lined to protect water quality. In addition, the back of the sign shall include information indicating which facilities are lined, the extent of lining, the liner material used, the liner thickness (if clay or till), and the type and distance of the marker above the liner (if a geomembrane). This information need only be readable by someone standing at arms-length from the sign.

4. If a **treatment liner** will be below the seasonal high water level, the pollutant removal performance of the liner must be evaluated by a geotechnical or groundwater specialist and found to be as protective as if the liner were above the level of the groundwater.

See Sections 6.2.4.1 and 6.2.4.2 for more specific design criteria on the various options for low permeability liners and treatment liners.

TABLE 6.2.4.A LINING TYPES RECOMMENDED FOR WQ FACILITIES

WQ Facility	Area to be Lined	Type of Liner Recommended
Basic biofiltration swale	Bottom and sides	Treatment liner
Wet biofiltration swale	Bottom and sides	Low permeability liner (If the swale will intercept the seasonal high groundwater table, a treatment liner is recommended.)
Continuous inflow biofiltration swale	Bottom and sides	Treatment liner
Filter strip, narrow-area filter strip	Bottom	Treatment liner
Wetpond	**First cell**: bottom and sides to WQ design water surface	Low permeability liner (If the cell will intercept the seasonal high groundwater table, a treatment liner is recommended.)
	Second cell: bottom and sides to WQ design water surface	Treatment liner
Combined detention/WQ facility	**First cell**: bottom and sides to WQ design water surface	Low permeability liner (If the cell will intercept the seasonal high groundwater table, a treatment liner is recommended.)
	Second cell: bottom and sides to WQ design water surface	Treatment liner
Wet vault	Not applicable	No liner needed
Stormwater wetland	Bottom and sides, both cells	Low permeability liner (If the facility will intercept the seasonal high groundwater table, a treatment liner is recommended.)
Sand filter	Pond sides only	Treatment liner
Sand filter vault	Not applicable	No liner needed
Linear sand filter	Not applicable if in vault	No liner needed
	Bottom and sides of presettling cell if not in vault	Low permeability or treatment liner
Leaf compost filter (in vault)	Not applicable	No liner needed

6.2.4.1 DESIGN CRITERIA FOR LOW PERMEABILITY LINER OPTIONS

This section presents the design criteria for each of the following four low permeability liner options:

- Compacted till liners
- Clay liners
- Geomembrane liners
- Concrete liners.

❑ COMPACTED TILL LINERS

1. Liner thickness shall be 18 inches after compaction.
2. Soil shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
3. A different depth and density sufficient to retard the infiltration rate to 2.4 x 10^{-5} inches per minute (1 x 10^{-6} cm/s) may also be used in lieu of Criteria 1 and 2.
4. Soil should be placed in 6 inch lifts.
5. Soils may be used that meet the following gradation:

Sieve Size	Percent Passing
6 inch	100
4 inch	90
#4	70 - 100
#200	20 - 100

❑ CLAY LINERS

1. Liner thickness shall be 12 inches.
2. Clay shall be compacted to 95% minimum dry density, modified proctor method (ASTM D-1557).
3. A different depth and density sufficient to retard the infiltration rate to 2.4 x 10^{-5} inches per minute (1 x 10^{-6} cm/s) may also be used in lieu of Criteria 1 and 2.
4. The slope of clay liners must be restricted to 3H:1V for all areas requiring soil cover; otherwise, the soil layer must be stabilized by another method so that soil slippage into the facility does not occur. Any alternative soil stabilization method must take maintenance access into consideration.
5. Where clay liners form the sides of ponds maintained by the County, the interior side slope must not be steeper than 3:1, irrespective of fencing. This restriction is to ensure that anyone falling into the pond may safely climb out. The same criterion is recommended for privately owned and maintained ponds.

❑ GEOMEMBRANE LINERS

1. Geomembrane liners shall be UV resistant and have a minimum thickness of 30 millimeters. A thickness of 40 millimeters shall be used in areas of maintenance access or where heavy machinery must be operated over the membrane.
2. Geomembranes shall be bedded according to the manufacturer's recommendations.

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3. Liners shall be installed so that they can be covered with 12 inches of top dressing forming the bottom and sides of the water quality facility.[14] Top dressing shall consist of 6 inches of crushed rock covered with 6 inches of native soil. The rock layer is to mark the location of the liner for future maintenance operations. As an alternative to crushed rock, 12 inches of native soil may be used if orange plastic "safety fencing" or another highly-visible, continuous marker is embedded 6 inches above the membrane.
4. If possible, liners should be of a contrasting color so that maintenance workers are aware of any areas where a liner may have become exposed when maintaining the facility.
5. Geomembrane liners shall not be used on slopes steeper than 5H:1V to prevent the top dressing material from slipping. Textured liners may be used on slopes up to 3H:1V upon recommendation by a geotechnical engineer that the top dressing will be stable for all site conditions, including maintenance.

❑ CONCRETE LINERS

1. Portland cement liners are allowed irrespective of facility size, and shotcrete may be used on slopes. However, specifications must be developed by an engineer who certifies the liner against cracking or losing water retention ability under expected conditions of operation, including facility maintenance operations. Weight of maintenance equipment can be up to 80,000 pounds when fully loaded.
2. Asphalt concrete may not be used for liners due to its permeability to many organic pollutants.
3. If grass is to grown over a concrete liner, slopes must be no steeper than 5H:1V to prevent the top dressing material from slipping.

6.2.4.2 DESIGN CRITERIA FOR TREATMENT LINER OPTIONS

This section presents the design criteria for each of the following two treatment liner options:

- Sand layer
- Organic layer.

❑ SAND LAYER

1. A two-foot thick layer of sand can be used as a treatment layer beneath a water quality or detention facility if it is equivalent or finer than one of the following:
   a) The sand filter specification given in Table 6.5.2.C (p. 6-109)
   b) One of the following specifications:

Sieve Size	**Option 1** Minimum Percent Passing	**Option 2** Minimum Percent Passing
#4	75	75
#40	25	50
#200	5	2

2. Certification shall be provided to the DDES inspector that the sand meets one of the above criteria. Such certification can be provided by the sand supplier or by a soils testing laboratory.

[14] An exception is the linear sand filter which does not require a soil top dressing to the liner.

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3. In-place soils may be substituted for sand if they meet one of the above criteria as demonstrated by testing one soil sample per 1,000 square feet of facility area. Each sample shall be a composite of subsamples taken throughout the depth of the treatment layer.

❑ ORGANIC SOIL LAYER

1. A two-foot thick layer of soil with a minimum organic content of 5% AND a minimum cation exchange capacity (CEC) of 5 milliequivalents/100 grams can be used as a treatment layer beneath a water quality or detention facility.

   If a thicker layer of treatment soil is available, the organic content and CEC requirements can be reduced by 1/2 unit for each additional foot of soil thickness provided.

   Example

   If the treatment liner will be 4 feet thick, 2 feet more than the required 2 feet, the organic content may be reduced by 1/2 x 2 = 1 unit. The organic content could then be 4%, and the CEC requirement could be 4 milliequivalents/100 grams and still meet the groundwater protection criteria.

2. **Organic content** shall be measured on a dry weight basis using ASTM D2974.
3. **Cation exchange capacity** (CEC) shall be tested using EPA laboratory method 9081.
4. **Certification** by a soils testing laboratory that imported soil meets the organic content and CEC criteria above shall be provided to the DDES inspector.
5. **Animal manures** used in treatment soil layers must be sterilized because of potential for bacterial contamination of the groundwater.
6. To demonstrate that in-place soils meet Requirement 1 above, one **sample** per 1,000 square feet of facility area shall be tested. Each sample shall be a composite of subsamples taken throughout the depth of the treatment layer (usually two to six feet below the expected facility invert).
7. If a reduction in the organic content and CEC criteria is sought because the treatment layer is thicker than 2 feet, soil tests must represent the entire treatment layer.

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6.2.5 FLOW SPLITTER DESIGNS

Most water quality facilities can be designed as **flow-through, or on-line, systems** with flows above the water quality design flow or volume simply passing through the facility untreated. However, it is sometimes desirable to restrict flows to water quality treatment facilities and bypass the remaining higher flows around them (**off-line facilities**). This can be accomplished by **splitting flows** in excess of the water quality design flow upstream of the facility and diverting higher flows to a bypass pipe or channel. The bypass typically enters a detention pond or the downstream receiving drainage system, depending on flow control requirements. In most cases, it is a designer's choice whether WQ facilities are designed as on-line or off-line; an exception is oil/water separators, which must be designed off-line.

A crucial factor in designing flow splitters is to ensure that low flows are delivered to the treatment facility up to the **WQ design flow rate**. Above this rate, additional flows are diverted to the bypass system with minimal increase in head at the flow splitter structure to avoid surcharging the water quality facility under high flow conditions.

Flow splitters are typically catch basins or vaults with concrete baffles. In place of baffles, the splitter mechanism may be a half tee section with a solid top and an orifice in the bottom of the tee section. A full tee option may also be used (see "Design Criteria" below). Two possible design options for flow splitters are shown in Figure 6.2.5.A and Figure 6.2.5.B. Other equivalent designs that achieve the result of splitting low flows, up to the WQ design flow, into the WQ treatment facility and divert higher flows around the facility are also acceptable.

6.2.5.1 METHODS OF ANALYSIS

Flow splitters may be modeled using the two outlet reservoir routine as described in Section 3.2.4, Storage Routing. The stage/discharge relationship of the outflow pipes should be determined using the backwater analysis techniques in Chapter 5. The orifice shall be sized per Section 5.3.4.2. Weirs should be analyzed as sharp-crested weirs.

6.2.5.2 DESIGN CRITERIA

General

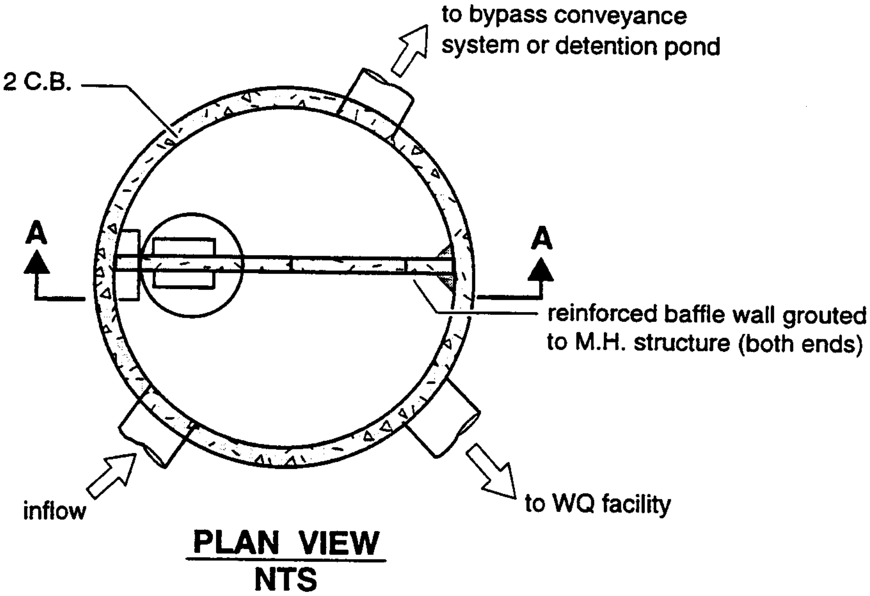
1. A flow splitter shall be designed to deliver the required **water quality design flow rate** specified in Section 6.2.1 (p. 6-17) to the WQ treatment facility. For the basic size sand filter, which is sized based on volume, use the WQ design flow rate to design the splitter. For the large sand filter, use the 2-year flow rate.
2. The **top of the weir** shall be located at the water surface for the design flow. Remaining flows enter the bypass line. Flows modeled using the KCRTS program should use 15-minute time steps.
3. The **maximum head** shall be minimized for flow in excess of the water quality design flow. Specifically, flow to the WQ facility at the 100-year water surface shall not increase the design WQ flow by more than 10%.
4. Either design shown in Figure 6.2.5.A (p. 6-29) or Figure 6.2.5.B (p. 6-30) may be used. Equivalent designs are also acceptable.
5. Special applications, such as roads, may require the use of a **modified flow splitter**. The baffle wall may be fitted with a notch and adjustable weir plate to proportion runoff volumes other than high flows.
6. For ponding facilities, backwater effects must be included in designing the height of the standpipe in the catch basin.

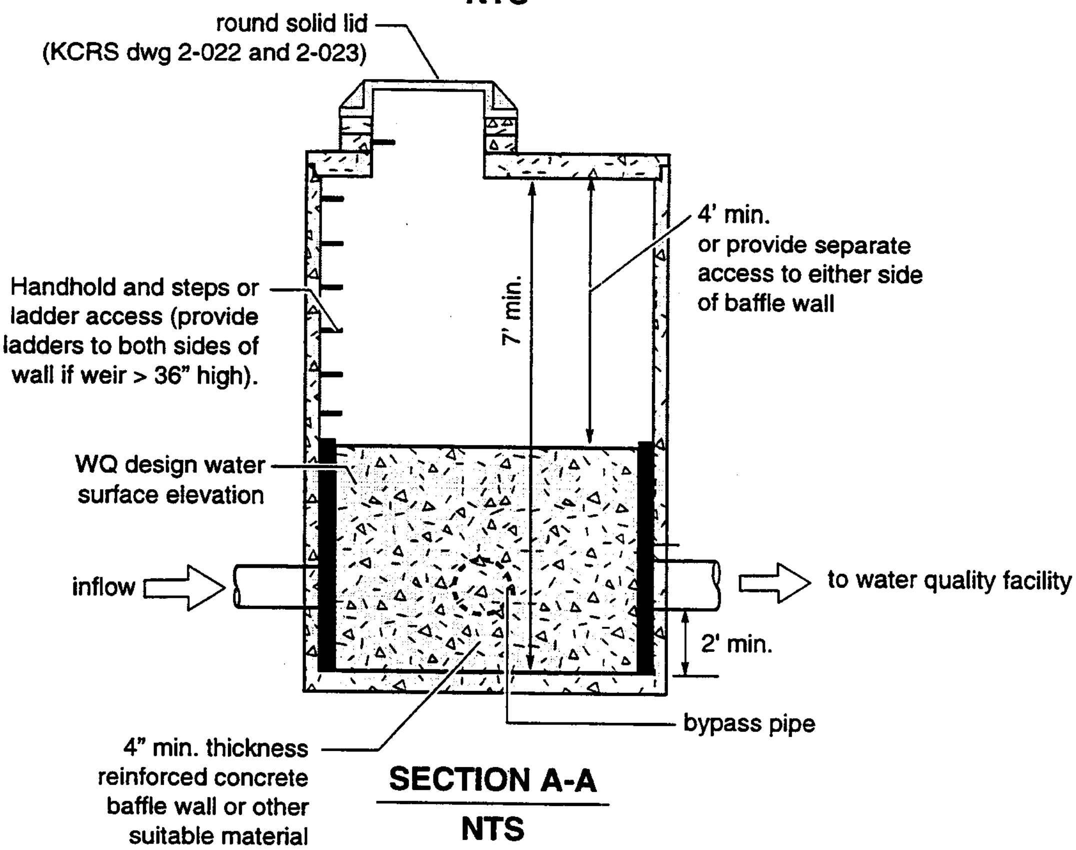
7. Ladder or step and handhold access (per King County Road standards) shall be provided. If the weir wall is higher than 36 inches, two ladders, one to either side of the wall, are required.

Material Requirements

1. The **splitter baffle** shall be installed in a Type 2 catch basin or vault.
2. The **baffle wall** shall be made of reinforced concrete or another suitable material resistant to corrosion, and have a minimum 4-inch thickness. The minimum clearance between the top of the baffle wall and the bottom of the catch basin cover shall be 4 feet; otherwise, dual access points shall be provided.
3. All **metal parts** shall be corrosion resistant. Examples of preferred materials include aluminum, stainless steel, and plastic. Zinc and galvanized materials are discouraged because of aquatic toxicity. Painting metal parts shall not be allowed because of poor longevity.

FIGURE 6.2.5.A FLOW SPLITTER, OPTION A





Note: The water quality discharge pipe may require an orifice plate be installed on the outlet to control the height of the design water surface (weir height). The design water surface should be set to provide a minimun headwater/diameter ratio of 2.0 on the outlet pipe.

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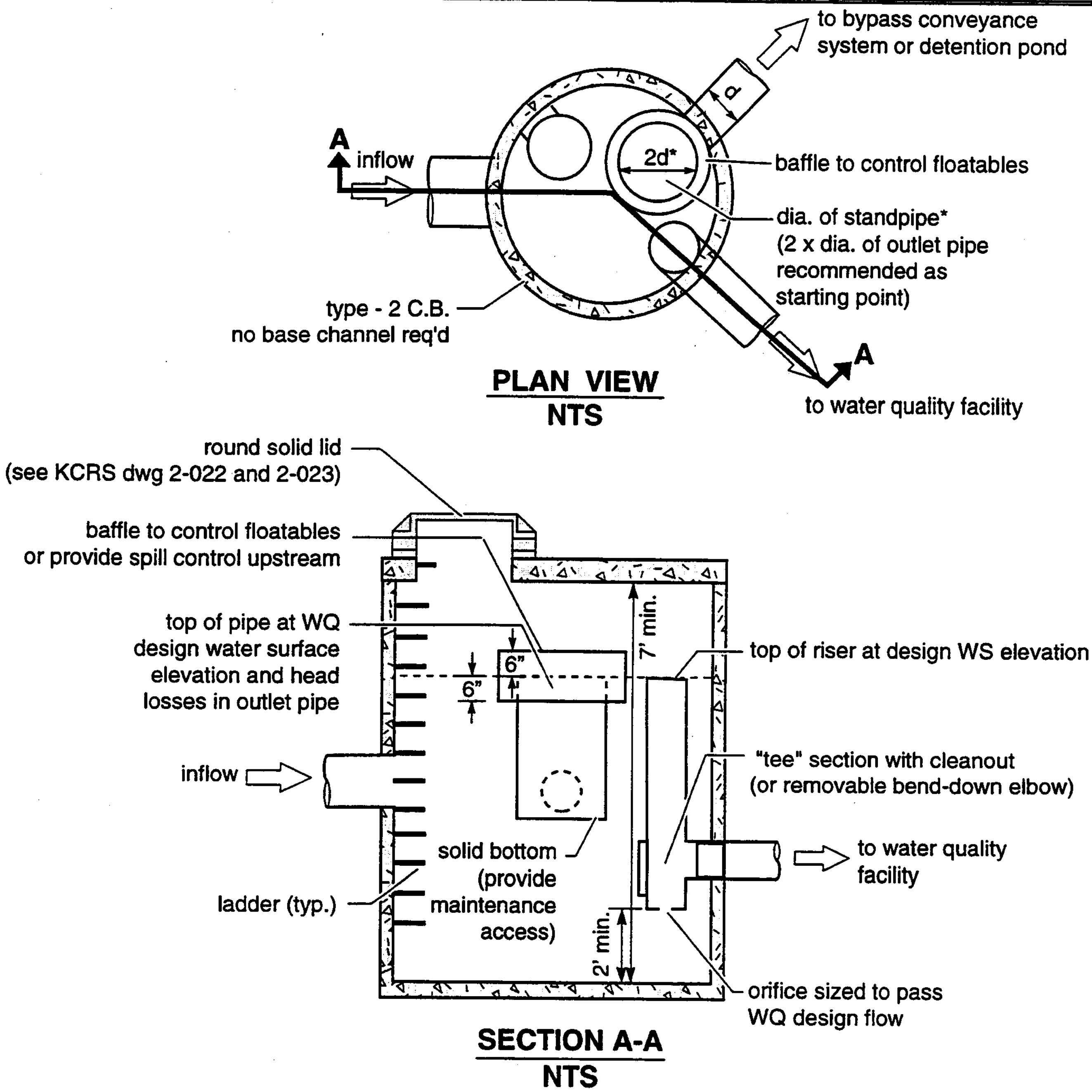
FIGURE 6.2.5.B FLOW SPLITTER, OPTION B



* **NOTE:** Diameter (d) of standpipe should be large enough to minimize head above WQ design WS and to keep WQ design flows from increasing more than 10% during 100-year flows.

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6.2.6 FLOW SPREADING OPTIONS

Flow spreaders function to uniformly spread flows across the inflow portion of water quality facilities (e.g., sand filter, biofiltration swale, or filter strip). There are five flow spreader options presented in this section:

- Anchored plate (Option A)
- Concrete sump box (Option B)
- Notched curb spreader (Option C)
- Through-curb ports (Option D)
- Interrupted curbing (Option E).

Options A through C can be used for spreading flows that are concentrated. Any one of these options can be used when spreading is required by the facility design criteria. Options A through C can also be used for unconcentrated flows, and in some cases must be used, such as to correct for moderate grade changes along a filter strip.

Options D and E are only for flows that are already unconcentrated and enter a filter strip or continuous inflow biofiltration swale. Other flow spreader options are possible with approval from DDES.

6.2.6.1 DESIGN CRITERIA FOR FLOW SPREADER OPTIONS

General Design Criteria

1. Where flow enters the flow spreader through a pipe, it is recommended that the **pipe be submerged** to the extent practical to dissipate energy as much as possible.
2. For **higher velocity inflows** (greater than 5 cfs for the 100-yr storm), a Type 1 catch basin should be positioned in the spreader, and the inflow pipe should enter the catch basin with flows exiting through the top grate. The top of the grate should be lower than the level spreader plate, or if a notched spreader is used, lower than the bottom of the v-notches.
3. Table 4.2.2.F in Chapter 4 provides general guidance for rock protection at outfalls.

☐ OPTION A — ANCHORED PLATE (FIGURE 6.2.6.A)

1. An anchored plate flow spreader shall be **preceded by a sump** having a minimum depth of 8 inches and minimum width of 24 inches. If not otherwise stabilized, the sump area shall be lined to reduce erosion and to provide energy dissipation.
2. The top surface of the flow spreader plate **shall be level**, projecting a minimum of 2 inches above the ground surface of the water quality facility, or **v-notched** with notches 6 to 10 inches on center and 1 to 6 inches deep (use shallower notches with closer spacing). Alternative designs are allowed.
3. A flow spreader plate shall extend horizontally beyond the bottom width of the facility to prevent water from eroding the side slope. The **horizontal extent** should be such that the bank is protected for all flows up to the 100-year flow or the maximum flow that will enter the WQ facility.
4. Flow spreader plates shall be **securely fixed in place**.
5. Flow spreader plates may be made of either **wood, metal, fiberglass reinforced plastic, or other durable material**. If wood, pressure treated 4 by 10-inch lumber or landscape timbers are acceptable.
6. **Anchor posts** shall be 4-inch square concrete, tubular stainless steel, or other material resistant to decay.

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❑ OPTION B—CONCRETE SUMP BOX (FIGURE 6.2.6.B)

1. The **wall of the downstream side** of a rectangular concrete sump box shall extend a minimum of 2 inches above the treatment bed. This serves as a weir to spread the flows uniformly across the bed.
2. The **downstream wall** of a sump box shall have "wing walls" at both ends. **Side walls and returns** shall be slightly higher than the weir so that erosion of the side slope is minimized.
3. **Concrete** for a sump box can be either cast-in-place or precast, but the bottom of the sump shall be reinforced with wire mesh for cast-in-place sumps.
4. Sump boxes shall be placed over bases that consists of 4 inches of crushed rock, 5/8-inch minus to help assure the sump remains level.

❑ OPTION C—NOTCHED CURB SPREADER (FIGURE 6.2.6.C)

Notched curb spreader sections shall be made of extruded concrete laid side by side and level. Typically five "teeth" per four-foot section provide good spacing. The space between adjacent "teeth" forms a v-notch.

❑ OPTION D—THROUGH-CURB PORTS (FIGURE 6.2.6.D)

Unconcentrated flows from paved areas entering filter strips or continuous inflow biofiltration swales can use curb ports or interrupted curbs (Option E) to allow flows to enter the strip or swale. Curb ports use fabricated openings that allow concrete curbing to be poured or extruded while still providing an opening through the curb to admit water to the WQ facility.

Openings in the curb shall be at regular intervals but at least every 6 feet (minimum). The width of each curb port opening shall be a minimum of 11 inches. Approximately 15 percent or more of the curb section length should be in open ports, and no port should discharge more than about 10 percent of the flow.

❑ OPTION E—INTERRUPTED CURB (NO FIGURE)

Interrupted curbs are sections of curb placed to have gaps spaced at regular intervals along the total width (or length, depending on facility) of the treatment area. At a minimum, **gaps** shall be every 6 feet to allow distribution of flows into the treatment facility before they become too concentrated. The opening shall be a minimum of 11 inches. As a general rule, no opening should discharge more than 10 percent of the overall flow entering the facility.

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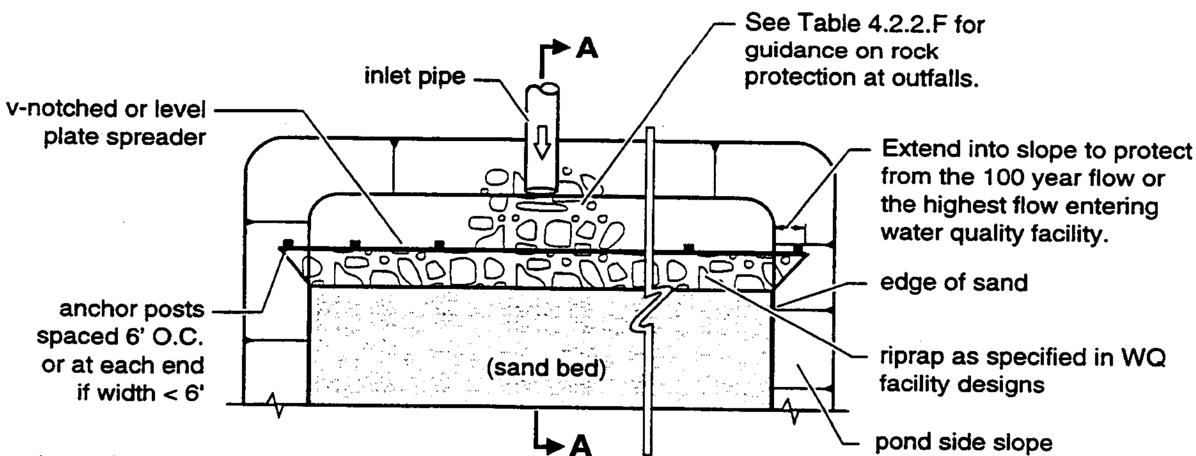
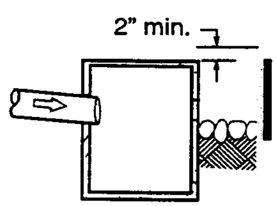
FIGURE 6.2.6.A FLOW SPREADER OPTION A: ANCHORED PLATE

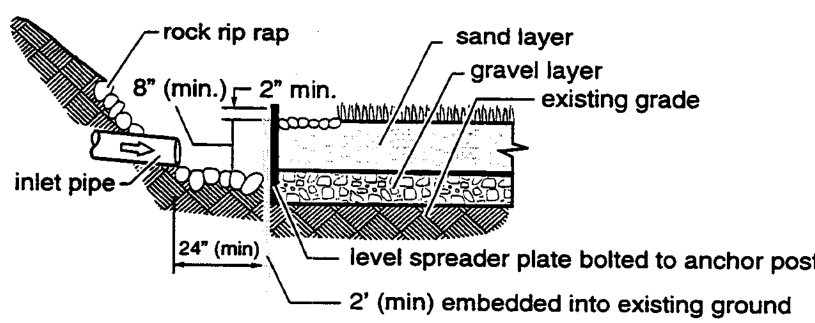
Example of anchored plate used with a sand filter* (may also be used with other water quality facilities).



*sand filter may use other spreading options

PLAN VIEW
NTS





Alternative Design
Catch basin recommended for higher flow situations (generally for inflow velocities of 5 fps or greater for 100 year storm).

SECTION A-A
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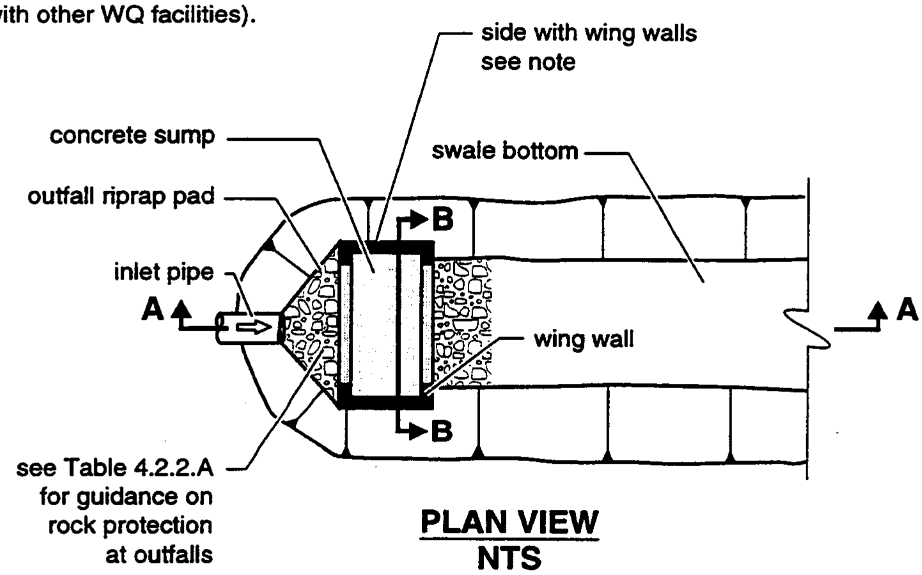
FIGURE 6.2.6.B FLOW SPREADER OPTION B: CONCRETE SUMP BOX

Example of a concrete sump flow spreader used with a biofiltration swale (may be used with other WQ facilities).



PLAN VIEW
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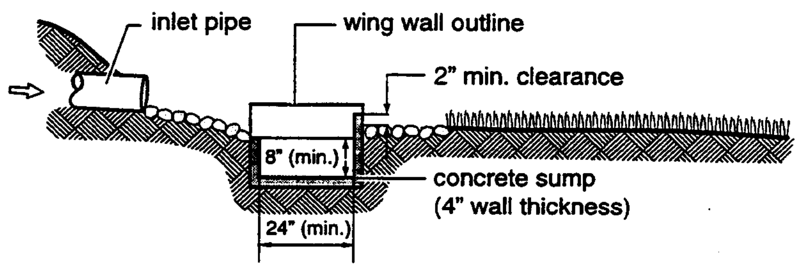

Note: Extend sides into slope. Height of side wall and wing walls must be sufficient to handle the 100-year flow or the highest flow entering the facility.

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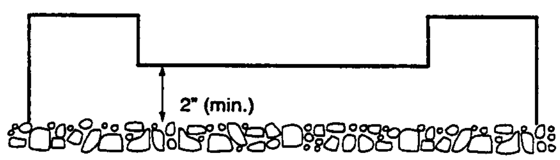

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FIGURE 6.2.6.C FLOW SPREADER OPTION C: NOTCHED CURB SPREADER

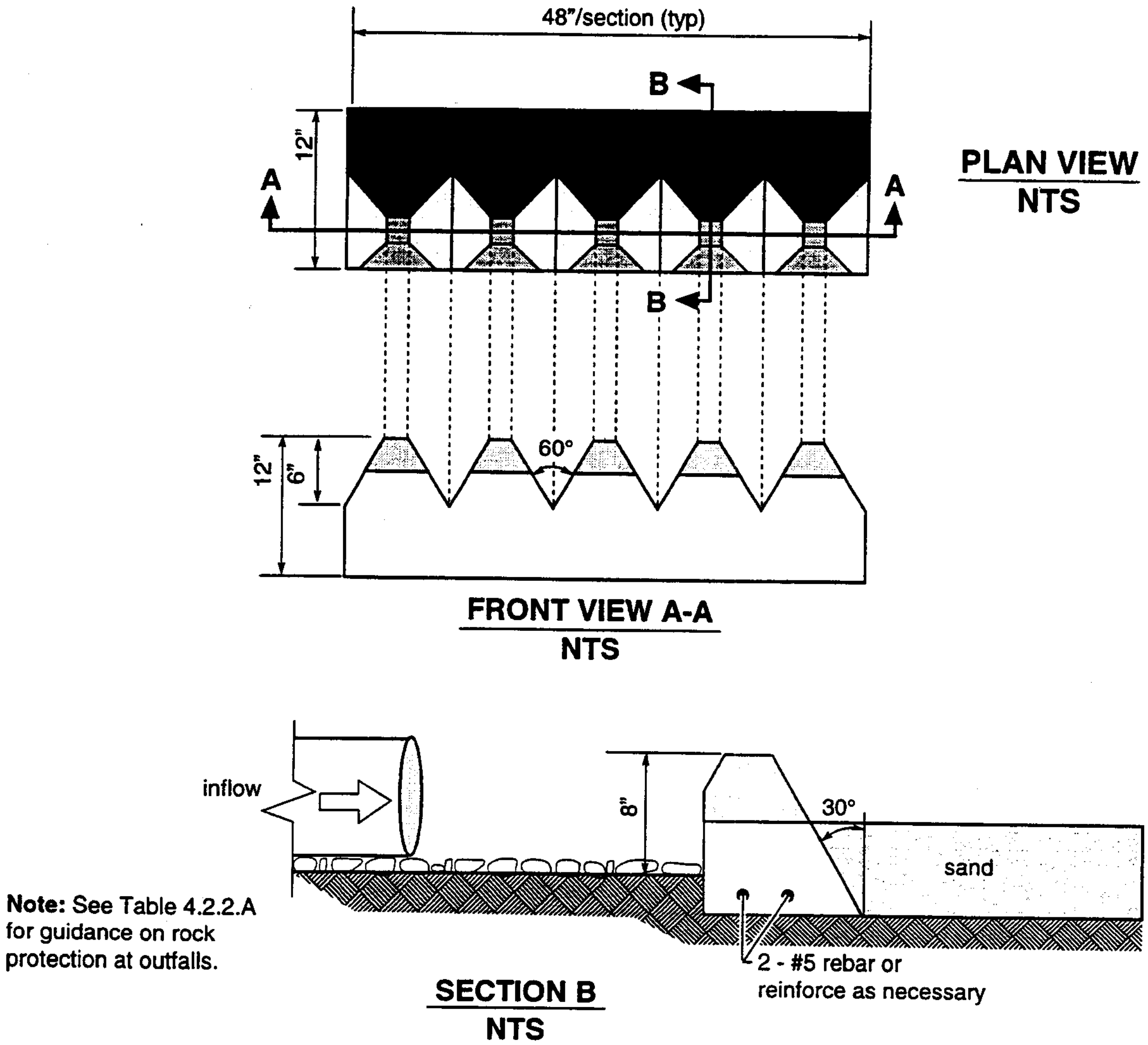
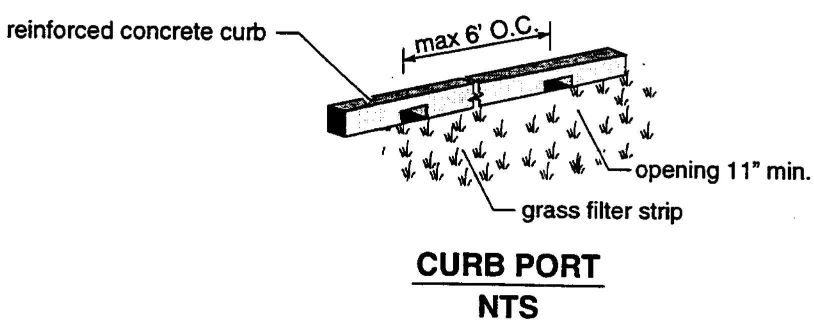


FIGURE 6.2.6.D FLOW SPREADER OPTION D: THROUGH-CURB PORT



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6.3 BIOFILTRATION FACILITY DESIGNS

This section presents the methods, details of analysis, and design criteria for biofiltration swales and filter strips. Included in this section are the following specific facility designs:

- Basic Biofiltration Swales, Section 6.3.1
- Wet Biofiltration Swales, Section 6.3.2
- Continuous Inflow Biofiltration Swales, Section 6.3.3
- Basic Filter Strips, Section 6.3.4
- Narrow Area Filter Strips, Section 6.3.5.

The information presented for each facility is organized into the following two categories:

1. **Methods of Analysis:** Contains a step-by-step procedure for designing and sizing each facility. Information presented in the procedure is based on available literature, but clarified or modified where deficiencies were identified.[15]
2. **Design Criteria:** Contains the details, specifications, and material requirements for each facility.

6.3.1 BASIC BIOFILTRATION SWALES

A *biofiltration swale* is an open, gently sloped, vegetated channel designed for treatment of stormwater (see the details in Figure 6.3.1.A through Figure 6.3.1.E beginning on page 6-49). The primary pollutant removal mechanisms are filtration by grass blades which enhance sedimentation, and trapping and adhesion of pollutants to the grass and thatch. Biofiltration swales generally do not remove dissolved pollutants effectively.

Applications and Limitations

A biofiltration swale is designed so that water will flow evenly across the entire width of a densely-vegetated area. A swale can be designed for both treatment and conveyance of onsite stormwater flow. This combined use can reduce development costs by eliminating the need for separate conveyance systems.

Biofiltration swales are best applied on a relatively small scale (generally less than 5 acres of impervious surface). They work well along roadways, driveways, and parking lots. Swales are more costly to apply in situations where the swale channel would be deep; in deep swales, self-shading can inhibit the necessary grass growth, resulting in poor pollutant removal performance. Some specific considerations for biofiltration swale applications are as follows:

- A biofiltration swale **should not be located in a shaded area**. For healthy grass growth, a swale should receive a minimum of 6 hours of sunlight daily during the summer months throughout the length of the swale.
- To maintain healthy grass growth, a **swale must dry between storms**. It should not receive continuous base flows (such as seepage from a hill slope throughout the winter) or be located in a high groundwater area, because saturated soil conditions will kill grass. If these conditions are likely to occur, design options are given under "Design Criteria" (p. 6-41), or the wet biofiltration swale design can be used (see Section 6.3.2, p. 6-52, for details).
- Stormwater runoff carrying **high concentrations of oil and grease impairs the treatment capability** of a swale. Oil control options given in Section 6.6 (p. 6-135) should be applied in these situations.

[15] Such modifications are often based on computer modeling using the King County Runoff Time Series (KCRTS) model. Occasionally they were based on bench-scale studies. Back-up studies are listed in Reference Section 5.

- **Modifying an existing drainage ditch** to create an engineered biofiltration swale may be difficult due to physical constraints and because ditches often serve as conveyance for flows from larger offsite areas.
- **Utilities** may be located in swale side slopes above the WQ design depth. However, the repair or placement of utilities in swale side slopes requires aggressive implementation of erosion control practices to prevent soil and sediment from reaching the treatment area of the swale.

Note: Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement # 8. Also see Table 6.1.1.A on page 6-5 for guidance on which type of biofiltration swale(basic, wet or continuous inflow)to use for a given set of site characteristics.

6.3.1.1 METHODS OF ANALYSIS

Biofiltration swale sizing is based on several variables, including the peak water quality design flow, longitudinal slope, vegetation height, bottom width, side slope, required hydraulic residence time (i.e., the time required for flow to travel the full length of the swale), and design flow depth. Swales sized and built using the method of analysis outlined in this section and the required design criteria presented in Section 6.3.1.2 are expected to meet the Basic Water Quality menu goal of 80% TSS removal. Procedures for sizing swales are summarized below.

Step 1: Calculate design flows. The swale design is based on the water quality design flow Q_{wq} (see Section 6.2.1, p. 6-17, for a definition of water quality design flow). If a biofilter is used for conveyance, the capacity requirements of Core Requirement #4 must be met. These flows must be estimated using the hydrologic analysis procedures described in detail in Chapter 3. If the swale is located downstream of an onsite detention facility, the swale design flow should correspond to the 2-year release rate from the detention facility.

Step 2: Calculate swale bottom width. The swale bottom width is calculated based on Manning's equation for open-channel flow. This equation can be used to calculate discharges as follows:

$$Q = \frac{1.49}{n} A R^{0.67} s^{0.5} \qquad (6\text{-}1)$$

where
Q = flow rate (cfs)
n = Manning's roughness coefficient (unitless)
A = cross-sectional area of flow (sf)
R = hydraulic radius (ft) = area divided by wetted perimeter
s = longitudinal slope (ft/ft)

For shallow flow depths in swales, channel side slopes are ignored in the calculation of bottom width. Use the following equation (a simplified form of Manning's formula) to estimate the swale bottom width:

$$b = \frac{Q_{wq} n_{wq}}{1.49 y^{1.67} s^{0.5}} \qquad (6\text{-}2)$$

where
b = bottom width of swale (ft)
Q_{wq} = water quality design flow (cfs)
n_{wq} = Manning's roughness coefficient for shallow flow conditions = 0.20 (unitless)
y = design flow depth (ft)
s = longitudinal slope (along direction of flow) (ft/ft)

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See "Water Depth and Base Flow" (p. 6-42) to determine the allowable design water depth. Proceed to Step 3 if the bottom width is calculated to be between 2 and 10 feet.

A minimum 2-foot bottom width is required. Therefore, if the calculated bottom width is less than 2 feet, increase the width to 2 feet and recalculate the design flow depth y using Equation (6-3) as follows:

$$y = \left(\frac{Q_{wq}n_{wq}}{1.49s^{0.5}b}\right)^{3/5} \tag{6-3}$$

where Q_{wq}, n_{wq}, and s are the same values as used in Equation (6-2), but b = 2 feet.

The maximum bottom width is 10 feet; therefore if the calculated bottom width exceeds 10 feet, then one of the following steps is necessary to reduce the design bottom width:

- Increase the longitudinal slope s to a maximum of 6 feet in 100 feet (0.06 feet per foot).
- Increase the design flow depth y to a maximum of 4 inches (0.333 feet).
- Reduce the design flow rate by rearranging the swale location with respect to detention facilities; a swale located downstream of a detention facility may have a lower flow rate due to flow attenuation in the detention facility. However, if a swale is located downstream of a detention pond providing Level 2 or Level 3 flow control, and it is located in till soils (according to the KCRTS soil group in Chapter 3), then the swale must be designed as a wet biofiltration swale (see Section 6.3.2, p. 6-52).
- Place a divider lengthwise along the swale bottom (cross section) at least three-quarters of the swale length (beginning at the inlet), without compromising the design flow depth and swale lateral slope requirements. See "Design Criteria" (p. 6-41) for swale divider requirements. A flow spreader must be provided at the inlet to evenly divide flows into each half of the swale cross section. See Section 6.2.6 (p. 6-31) for details on flow spreaders.

Step 3: Determine design flow velocity. To calculate the design flow velocity through the swale, use the flow continuity equation:

$$V_{wq} = \frac{Q_{wq}}{A_{wq}} \tag{6-4}$$

where V_{wq} = design flow velocity (fps)
A_{wq} = $by + Zy^2$ = cross-sectional area (sf) of flow at design depth
Z = side slope length per unit height (e.g., Z = 3 if side slopes are 3H:1V)

If the design flow velocity exceeds 1 foot per second, go back to Step 2 and modify one or more of the design parameters (longitudinal slope, bottom width, or flow depth) to reduce the design flow velocity to 1 foot per second or less. If the design flow velocity is calculated to be less than 1 foot per second, proceed to Step 4. *Note: It is desirable to have the design velocity as low as possible, both to improve treatment effectiveness and to reduce swale length requirements.*

Step 4: Calculate swale length. Use the following equation to determine the necessary swale length to achieve a hydraulic residence time of at least 9 minutes (540 seconds):

$$L = 540V_{wq} \tag{6-5}$$

where L = minimum allowable swale length (ft)
V_{wq} = design flow velocity (fps)

The minimum swale length is 100 feet; therefore, if the swale length is calculated to be less than 100 feet, increase the length to a minimum of 100 feet, leaving the bottom width unchanged. If a larger swale could be fitted on the site, consider using a greater length to increase the hydraulic residence time and improve the swale's pollutant removal capability. If the calculated length is too long for the site, or if it would cause layout problems, such as encroachment into shaded areas, proceed to Step 5 to further modify the layout. If the swale length can be accommodated on the site, proceed to Step 6.

Step 5: Adjust swale layout to fit on site. If the swale length calculated in Step 4 is too long for the site, the length can be reduced (to a minimum of 100 feet) by increasing the bottom width up to a maximum of 16 feet. However, the length cannot be increased in order to reduce the bottom width because Manning's depth-velocity-flow rate relationships would not be preserved. If the bottom width is increased to greater than 10 feet, a low dividing berm is needed to split the swale cross section in half.

Length can be adjusted by finding the top area of the swale and providing an equivalent top area with the adjusted dimensions.

a) Calculate the swale treatment top area based on the swale length calculated in Step 4:

$$A_{top} = (b_i + b_{slope})\, L_i \qquad (6\text{-}6)$$

where
A_{top} = top area (sf) at the design treatment depth
b_i = bottom width (ft) calculated in Step 2
b_{slope} = the additional top width (ft) above the side slope for the design water depth (for 3:1 side slopes and a 4-inch water depth, b_{slope} = 2 feet)
L_i = initial length (ft) calculated in Step 4.

b) Use the swale top area and a reduced swale length L_f to increase the bottom width, using the following equation:

$$L_f = \frac{A_{top}}{(b_f + b_{slope})} \qquad (6\text{-}7)$$

where
L_f = reduced swale length (ft)
b_f = increased bottom width (ft).

c) Recalculate V_{wq} according to Step 3 using the revised cross-sectional area A_{wq} based on the increased bottom width b_f. Revise the design as necessary if the design flow velocity exceeds 1 foot per second.

Step 6: Provide conveyance capacity for flows higher than Q_{wq}. Biofiltration swales may be designed as flow-through channels that convey flows higher than the water quality design flow rate, or they may be designed to incorporate a high-flow bypass upstream of the swale inlet. A high-flow bypass usually results in a smaller swale size (see flow splitter options, page 6-27, for more information on designing bypasses). If a high-flow bypass is provided, this step is not needed. If no high-flow bypass is provided, proceed with the procedure below.

a) Check the swale sized using Steps 2 through 5 above to determine whether the swale can convey the 25-year and 100-year peak flows consistent with the conveyance requirements of Core Requirement #4 in Chapter 1. The roughness coefficient n in Manning's equation should be selected to reflect the deeper flow conditions with less resistance provided by grass during these high-flow events. The bottom width (Step 2) should be calculated as per Section 4.4.1.2, "Methods of Analysis" for open channels.

b) The 100-year peak flow velocity ($V_{100} = Q_{100}/A_{100}$) based on the 100-year flow depth must be less than 5.0 feet per second. If V_{100} exceeds 5.0 feet per second, return to Step 2 and increase the bottom width or flatten the longitudinal slope as necessary to reduce the 100-year peak flow velocity to 5.0 feet per second or less. If the longitudinal slope is flattened, the swale bottom width must be recalculated (Step 2) and meet all design criteria.

c) The conveyance requirements in Core Requirement #4 (see Section 1.2.4) must be met.

6.3.1.2 DESIGN CRITERIA

An effective biofiltration swale achieves uniform sheet flow over and through a densely vegetated area for a period of several minutes. Figure 6.3.1.A (p. 6-49) shows a typical biofiltration swale schematic. Basic design requirements for achieving proper flow conditions through a biofiltration swale are described below.

Swale Geometry

1. Swale **bottom width** shall be between 2 and 16 feet.[16]
   a) **Minimum bottom width** is 2 feet to allow for ease of mowing.
   b) If the bottom width exceeds 10 feet, a length-wise divider shall be provided. The divider shall extend from the flow spreader at the inlet for at least three-quarters of the swale length.
   c) **Maximum bottom width** is 16 feet, excluding the width of the divider.

   Note: Multiple swales may be placed side by side provided the flow to each swale is split at the inlet and spread separately for each swale. Adjacent swales may be separated with a vertical wall, but a low berm is preferred for easier maintenance and better landscape integration.
2. The **longitudinal slope** (along the direction of flow) shall be between 1 percent and 6 percent.
   a) If the longitudinal slope is less than 1.5 percent, **underdrains** must be provided (see next page and Figure 6.3.1.C, p. 6-50, for underdrain specifications).
   b) If the longitudinal slope is less than 1 percent, the swale must be designed according to the criteria presented in Section 6.3.2 (p. 6-52) for **wet biofiltration swales.**
   c) If the longitudinal slope exceeds 6 percent, **check dams** with vertical drops of 12 inches or less shall be provided to achieve a bottom slope of 6 percent or less between the drop sections.
3. The swale shall be **flat** in cross section (perpendicular to the flow direction) to promote even flow across the whole width of the swale.
4. The **minimum swale length** shall be 100 feet; no maximum length is set.
5. The **swale treatment area** (below the WQ design water depth) shall be trapezoidal in cross-section. If trapezoidal, **side slopes within the treatment area** should be 3H:1V or flatter whenever possible, but not steeper than 2H:1V.
6. **Side slope sections above the treatment area** may be steeper than 3H:1V, subject to the following provisions:
   a) If there is an interior side slope between 1H:1V and 2H:1V outside the treatment area, the slope shall be reinforced with **erosion control netting or matting** during construction.
   b) Any interior slope steeper than 1H:1V shall be constructed as a **rockery or structural retaining wall**[17] to prevent the swale slope from sloughing. To ensure that adequate sunlight reaches the swale bottom, **only one wall can be taller than 2 feet.** If possible, the higher wall should be on the northern or eastern side of the swale to maximize the amount of light reaching the swale bottom.

[16] Experience with biofiltration swales shows that when the width exceeds about 10 feet it is difficult to keep the water from forming low-flow channels. It is also difficult to construct the bottom level and without sloping to one side. Biofilters are best constructed by leveling the bottom after excavating, and after the soil is amended. A single-width pass with a front-end loader produces a better result than a multiple-width pass.

[17] Soil bioengineering techniques may be used as an alternative to a rockery or structural retaining wall.

7. **Curved swales** are encouraged for aesthetic reasons, but curves must be gentle to prevent erosion and allow for vehicle access to remove sediment. Criteria for maintenance access road curves should also be applied for swale curves (see Section 5.3.1.1 for design of access roads).

Water Depth and Base Flow

1. A swale that will be **frequently mowed**, as in commercial or landscaped areas, shall have a **design water depth** of no more than 2 inches (0.17 feet) under the water quality design flow conditions.
2. A swale that will **not be frequently mowed**, such as along roadsides or in rural areas, shall have a **design water depth** of no more than 4 inches (0.33 feet) under the water quality design flow conditions.
3. If a swale is located **downstream of a detention pond providing Level 2 or Level 3 flow control**, and it is located in till soils (according to the KCRTS soil group in Chapter 3), then the swale must be designed as a **wet biofiltration swale** (see Section 6.3.2, p. 6-52).
4. If a swale will receive **base flows** because of seeps and springs on site, then either a low-flow drain shall be provided or a wet biofiltration swale shall be used. *Low-flow drains* are narrow surface drains filled with pea gravel that run lengthwise through the swale to bleed off base flows; they should not be confused with underdrains. In general, base flows less than 0.01 cfs per acre can be handled with a low-flow drain. If flows are likely to be in excess of this level, a wet biofiltration swale should be used.
5. If a **low-flow drain** is used, it shall extend the entire length of the swale. The drain shall be a minimum of 6 inches deep, and its width shall be no greater than 5 percent of the calculated swale bottom width; the width of the drain shall be in addition to the required bottom width. If an anchored plate or concrete sump is used for flow spreading at the swale inlet, the plate or sump wall shall have a v-notch (maximum top width = 5% of swale width) or holes to allow preferential exit of low flows into the drain. See Figure 6.3.1.D (p. 6-51) for low-flow drain specifications and details.

Flow Velocity, Energy Dissipation, and Flow Spreading

1. The **maximum flow velocity** through the swale under the water quality design flow conditions shall not exceed 1.0 foot per second.
2. The **maximum flow velocity** through the swale under the peak 100-year flow conditions shall not exceed 5.0 feet per second.
3. A **flow spreader** shall be used at the inlet of a swale to dissipate energy and evenly spread runoff as sheet flow over the swale bottom. Flow spreaders are recommended but not required at mid-length. For details on various types of flow spreaders, see Section 6.2.6 (p. 6-31).
4. If **check dams** are used to reduce the longitudinal slope of the swale, a **flow spreader** shall be provided at the toe of each vertical drop. The spreader must span the width of the swale. An **energy dissipater** should also be provided if flows leaving the spreader could be erosive.
5. If a swale **discharges flows to a slope** rather than to a piped system or confined channel, an **energy dissipater** shall be provided at the swale outlet. This requirement also applies to discharges from swale underdrains. The outlet energy dissipater can be a riprap pad sized according to the specifications described in Table 4.2.2.A for conveyance system outfalls.

Underdrains

If underdrains are required by Criterion 2 under "Swale Geometry" (p.6-41), they must meet the following criteria:

1. Underdrains must be made of **PVC perforated pipe** (SDR 35), laid parallel to the swale bottom and backfilled and bedded as shown in Figure 6.3.1.C (p. 6-50).

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2. For facilities to be maintained by the County, the underdrain pipe must be 6 inches or greater in **diameter**. (Six inches is the smallest diameter pipe that can be cleaned without damage to the pipe.)
3. Six inches of clean **drain rock** ($^5/_8$-inch minus) must be above the top of the pipe.
4. The drain rock must be wrapped in **geotextile**. Geotextile requirements are summarized in Table 6.3.1.A below.
5. The underdrain **must infiltrate** into the subsurface **or drain freely** to an acceptable discharge point.

TABLE 6.3.1.A GEOTEXTILE MATERIAL MINIMUM REQUIREMENTS

Geotextile Property	Value	Test Method
Trapezoid tear (lbs)	40 (min)	ASTM D4533
Permeability (cm/sec)	0.2 (min)	ASTM D4491
AOS (sieve size)	#60 - 70 (min)	ASTM D4751
Ultraviolet resistance	70 percent or greater	ASTM D4355

Note: If construction conditions dictate use of a more durable geotextile material to prevent punctures or tearing during installation, a heavier fabric should be used.

Swale Divider

1. If a swale divider is used (such as when swale bottom widths are greater than 10 feet), the divider should be constructed of a **firm material** that will resist weathering and not erode, such as treated lumber, concrete, plastic, or compacted soil seeded with grass. Selection of divider material should take into consideration swale maintenance, especially mowing.
2. The divider shall have a **minimum height** of one inch higher than the water quality design water depth.
3. **Earthen berms** should be no steeper than 2H:1V.
4. Materials other than earth (e.g. treated lumber, recycled plastic lumber, concrete, etc.) shall be embedded to a depth sufficient to be stable.

Access

1. For swales to be maintained by King County, an **access road** shall be provided to the swale inlet and along one side of the swale according to the schedule shown in Table 6.3.1.B below. *Note: County streets and paved parking areas adjacent to the top of slope may be counted as access.*

TABLE 6.3.1.B REQUIREMENTS FOR BIOFILTRATION SWALE ACCESS ROAD

Swale Area: L x w (sf)	Access Road Length
200 - 1000	1/2 swale length L
1000 - 1600	2/3 swale length L
Over 1600	entire swale length L

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2. In areas outside sensitive area buffers, **wheel strips** made of modular grid pavement may be built into the swale bottom for maintenance vehicle access instead of an access road. The subgrade for the strips must be engineered to support a vehicle weight of 16,000 pounds and installed according to the manufacturer's recommendations on firm native soil or structural fill, not on the amended topsoils. Each strip shall be 18 inches wide and spaced as shown in Figure 6.3.1.E (p. 6-51). The strip lattice should be filled or covered with native soil (no amendments required) and overseeded with grass. If a low-flow drain is also needed (see "Water Depth and Base Flow" on page 6-42), a portion of the wheel strip may be filled with pea gravel as appropriate to form the drain. Wheel strips shall not be counted as treatment area; therefore, the swale bottom width must be increased accordingly.

Soil Amendment

1. Two inches (minimum) of **well-rotted compost** shall be tilled into the entire swale treatment area to amend the topsoil unless the soil already has an organic content of 10 percent or greater. This applies to both till soils as well as sandy soils. In very coarse soils (gravels or courser), **top soil** must be imported and amended to the required organic content.
   a) Compost must be tilled into the underlying native soil to a depth of 6 inches to prevent the compost from being washed out and to avoid creating a defined layer of different soil types that can prevent downward percolation of water.
   b) Compost shall not contain any sawdust, straw, green or under-composted organic matter, or toxic or otherwise harmful materials.
   c) Compost should not contain unsterilized manure because it can leach fecal coliform bacteria into receiving waters.
2. **Soil or sod** with a clay content of greater than 10 percent should be avoided. If there is concern for contamination of the underlying groundwater, the swale bottom should be lined with a treatment liner to prevent groundwater contamination. See Section 6.2.4 (p. 6-22) for details on treatment liner options.

Planting Requirements

1. Grass shall be established throughout the entire treatment area of the swale subject to the following provisions:
   a) **Seeding** is best performed in spring (mid-March to June) or fall (late September to October). For summer seeding, sprinkler systems or other measures for watering the grass seed must be provided.
   b) Seed may be applied via **hydroseeding** or broadcast application.
   c) **Irrigation** is required during the first summer following installation if seeding occurs in spring or summer. Swales seeded in the fall may not need irrigation. However, the maintenance and defect financial guarantee will not be released unless a healthy grass cover is established. Therefore, site planning should address the need for sprinklers or other means of irrigation.
2. Swale treatment areas are subject to both dry and wet conditions, as well as accumulation of sediment and debris. A mixture of dry-area and wet-area grass species that can continue to grow through silt deposits is most effective. Two acceptable **grass seed mixes** for the King County area are listed in Table 6.3.1.C (p. 6-45). The mixes should be applied throughout the swale in the treatment area at a rate of 80 pounds per acre. As an alternative to these mixes, a horticultural or erosion control specialist may develop a seed specification tailored to the site. Table 6.3.1.D (p. 6-45) lists grasses or other plants particularly tolerant of wet conditions. Some of these seed types, however, may not be commercially available.

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TABLE 6.3.1.C
GRASS SEED MIXES SUITABLE FOR BIOFILTRATION SWALE TREATMENT AREAS

Mix 1		Mix 2	
75-80 percent	Tall or Meadow Fescue	60-70 percent	Tall Fescue
10-15 percent	Seaside Creeping Bentgrass or Colonial Bentgrass	10-15 percent	Seaside Creeping Bentgrass or Colonial Bentgrass
5-10 percent	Redtop	10-15 percent	Meadow Foxtail
		6-10 percent	Alsike Clover
		1-5 percent	Marshfield Big Trefoil
		1-6 percent	Redtop

Note: All percentages are by weight.

TABLE 6.3.1.D FINELY-TEXTURED PLANTS TOLERANT OF FREQUENT SATURATED SOIL CONDITIONS OR STANDING WATER

Grasses		Wetland Plants	
Water Foxtail	*Alopecurus geniculatus*	Sawbeak Sedge	*Carex stipata*
Shortawn Foxtail	*Alopecurus aequalis*	Spike Rush	*Eleocharis palustris*
Bentgrass	*Agrosits* spp.	Slender Rush	*Juncus tenuis*
Spike Bentgrass	*A. exarata*		
Redtop	*A. alba* or *gigantea*		
Colonial Bentgrass	*A. tenuis* or *capillaris*		
Mannagrass	*Glyceria* spp.		
Western	*G. occidentalis*		
Northern	*G. borealis*		
Slender-Spiked	*G. leptostachya*		
Rough-Stalked Bluegrass	*Poa trivialis*		
Velvet Grass	*Holcus mollis*		

3. A newly constructed swale shall be **protected from stormwater flows until grass has been established**. This may be done by diverting flows or by covering the swale bottom with clear plastic until the grass is well rooted. If these actions are not feasible, an erosion control blanket shall be placed over the freshly applied seed mix. See detached Appendix D, *ESC Standards*, for details on erosion control blankets.

4. **Above the design treatment elevation**, either a typical lawn seed mix or landscape plants may be used. However, for swales also used to convey high flows, consideration should be given to the soil binding capacity of the vegetation. Acceptable grasses and groundcovers are presented in Table 6.3.1.E (p. 6-46). Plant material other than that given in the table may be used if the swale is

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privately maintained and the plants selected will not spread into the swale treatment area. Ivy may not be used because of its tendency to spread. Native plant species (e.g., kinnikinnick) are preferred.

Note: These recommendations are for the King County area. If these designs are used in other areas, local knowledge should be used to tailor these recommendations to local conditions.

TABLE 6.3.1.E GROUNDCOVERS AND GRASSES SUITABLE FOR THE UPPER SIDE SLOPES OF A BIOFILTRATION SWALE

Groundcovers	
Kinnikinnick*	*Arctostaphylos uva-ursi*
Epimedium	*Epimedium grandiflorum*
—	*Euonymus lanceolata*
Strawberry*	*Fragaria chiloensis*
—	*Genista*
St. John's-Wort	*Hypericum sempervirens*
Broadleaf Lupine*	*Lupinus latifolius*
White Sweet Clover*	*Melilotus alba*
Creeping Forget-Me-Not	*Omphalodes verna*
—	*Rubus calycinoides*
White Lawn Clover	*Trifolium repens*
Yellow-Root	*Xanthorhiza simplissima*
Grasses (drought-tolerant, minimum mowing)	
Buffalo Grass	*Buchloe dactyloides*
Tufted Fescue	*Festuca amethystina*
Tall Fescue *	*Festuca arundinacea*
Hard Fescue	*Festuca ovina duriuscula* (e.g., Reliant, Aurora)
Red Fescue*	*Festuca rubra*
Dwarf Tall Fescues	*Festuca* spp. (e.g., Many Mustang, Silverado)
Blue Oatgrass	*Helictotrichon sempervirens*
Low-growing turf mix: 40% dwarf tall fescue 30% dwarf perenial rye "Barclay" 25% red fescue 5% colonial bentgrass	

* *Native species.*

Notes:

- *Many other ornamental grasses which require only annual mowing are suitable.*
- *Ivy is not permitted because of its tendency to spread.*

5. **Sod** may be used as a temporary cover during the wet season, but sodded areas must be reseeded with a suitable grass seed mix as soon as the weather is conducive to seed germination, unless the sod is grown from a seed mix suitable for the wetter conditions of a biofiltration swale. Sod must be removed or rototilled into the underlying soil before reseeding. Criteria #1 and 2 above for seeding should then be followed.

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Recommended Design Features

The following features should be incorporated into biofiltration swale designs where site conditions allow.

Swale Layout and Grading

1. If the longitudinal slope is less than 1.5 percent (requiring the use of underdrains along the swale length), the **subgrade** should contain 10 percent or more of sand to promote infiltration of standing water. If sand is added to promote drainage, the soil or sand substrate must still be amended with compost.
2. **Underdrains** are also recommended for swales greater than 1.5 percent longitudinal slope on till soils, especially if it is likely that the swale will intercept groundwater.
3. Biofiltration swales should be aligned to avoid sharp bends where erosion of the swale side slope can occur. However, gradual meandering bends in the swale are desirable for aesthetic purposes and to promote slower flow.

Location and Landscaping

1. During seeding, slow-release **fertilizers** may be applied to speed the growth of grass. If the swale is located in a sensitive lake watershed, low phosphorus fertilizers (such as formulations in the proportion 3:1:3 N-P-K or less) or a slow-release phosphorus formulation such as rock phosphate or bone meal should be used. A typical fertilizer application rate should be 2 pounds per 1,000 square feet. If animal manures are used in the fertilizer, they must be sterilized to avoid leaching fecal coliform bacteria into receiving waters.
2. Consultation with a **landscape or erosion control specialist** is recommended for project-specific recommendations on grass seed, fertilizer, and mulching applications to ensure healthy grass growth. The **grass mix** should be capable of surviving and remaining healthy under both dry and wet conditions with limited maintenance.
3. A grassy swale should be incorporated into the site landscape design. **Shrubs** may be planted along the edges of a swale (above the WQ treatment level) provided that exposure of the swale bottom to sunlight and maintenance accessibility are not compromised. *Note: For swales used to convey high flows, the plant material selected must bind the soil adequately to prevent erosion.*
4. Swales should not be located in areas where **trees** will drop leaves or needles that can smother the grass or clog part of the swale flowpath. Likewise, landscaping plans should take into consideration the problems that **falling leaves and needles** can cause for swale performance and maintenance. Landscape **planter beds** should be designed and located so that soil does not erode from the beds and enter a nearby biofiltration swale.

Construction Considerations

1. If a biofiltration swale is put into operation before all construction in the drainage area of the swale is complete, the swale must be cleaned of sediment and reseeded prior to acceptance by the County. The County will not release financial guarantees if swales are not restored and vigorous grass growth established.
2. It is preferable to provide good erosion control before runoff enters a biofiltration swale. Swales are designed to handle only modest sediment loads from stabilized sites.

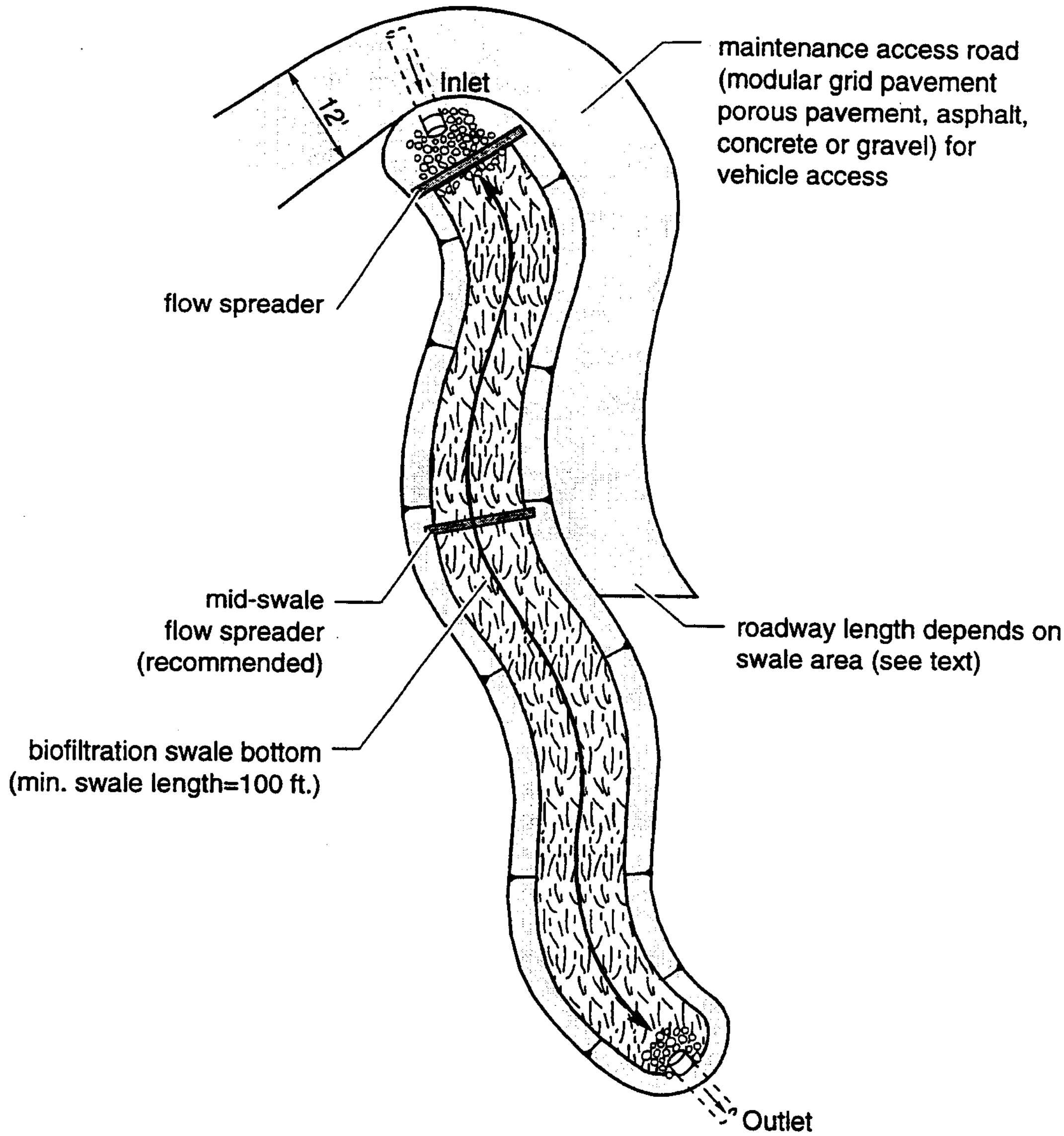
Maintenance Considerations

The design criteria given previously have incorporated maintenance concerns into swale design. However, the designer should know the type and frequency of maintenance anticipated so that alternative proposals can incorporate maintenance activity.

Typical swale maintenance includes routine mowing, sediment and debris removal, and repair of eroded or scoured channel sections as described below.

1. Grass should be **mowed to maintain an average grass height** between 4 inches and 9 inches, depending on the site situation. Monthly mowing is needed from May through September to maintain grass vigor. If a swale is not mowed at least annually, trees and brush will invade the swale and inhibit grass growth, compromising the swale's performance for water quality treatment.
2. **Grass clippings** should be removed from the swale and composted on site or disposed of properly off site.
3. **Sediment** deposited at the head of the swale should be removed if grass growth is being inhibited for more than 10 percent of the swale length or if the sediment is blocking the even spreading or entry of water to the rest of the swale. Annual sediment removal and spot reseeding will probably be necessary.
4. If flow **channelization or erosion** has occurred, the swale should be regraded to produce a flat bottom width, then reseeded as necessary. If the channel results from constant base flow, it may be better to install a low-flow drain rather than to regrade. Regrading should not be required every year.
5. For swales with underdrains, **vehicular access to the swale bottom** (other than grass mowing equipment) should be avoided because the drainpipe cannot support vehicle weight. Consideration should be given to providing wheel strips in the swale bottom if access is needed.

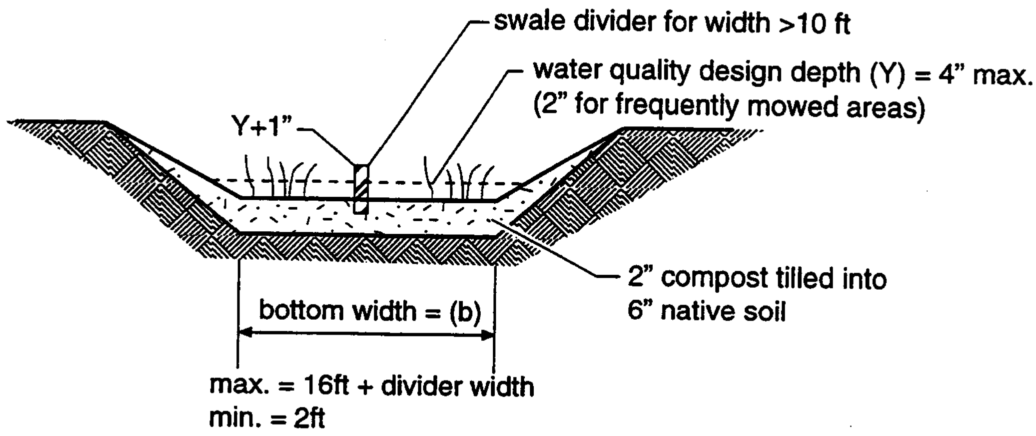
FIGURE 6.3.1.A BIOFILTRATION SWALE SCHEMATIC



NOTE: Longitudinal slope 1-6%.
Provide underdrain for slopes < 1.5%.

PLAN
NTS

FIGURE 6.3.1.B BIOFILTRATION SWALE CROSS-SECTIONS



TYPICAL SWALE SECTION
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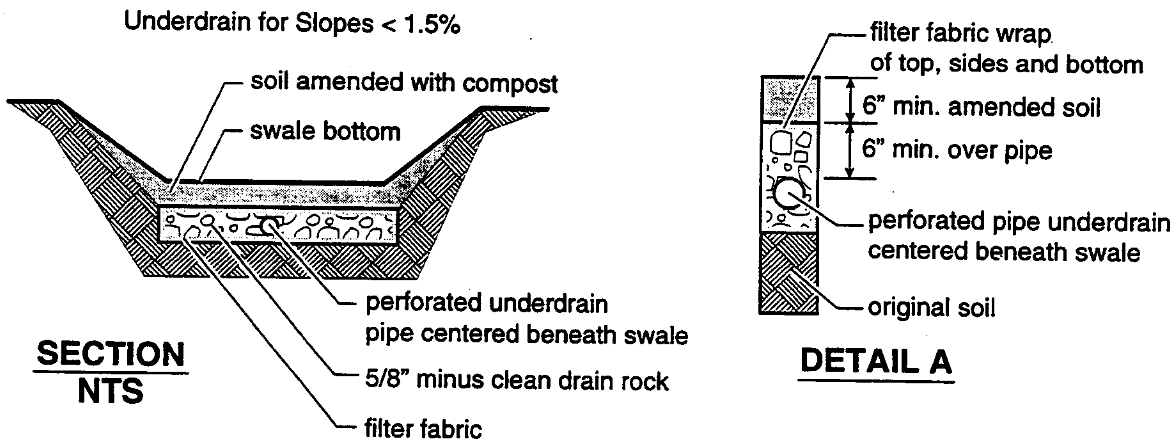
FIGURE 6.3.1.C BIOFILTRATION SWALE UNDERDRAIN DETAIL

Underdrain for Slopes < 1.5%



NOTE: Underdrain must infiltrate or drain freely to an acceptable discharge point.

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FIGURE 6.3.1.D BIOFILTRATION SWALE LOW-FLOW DRAIN

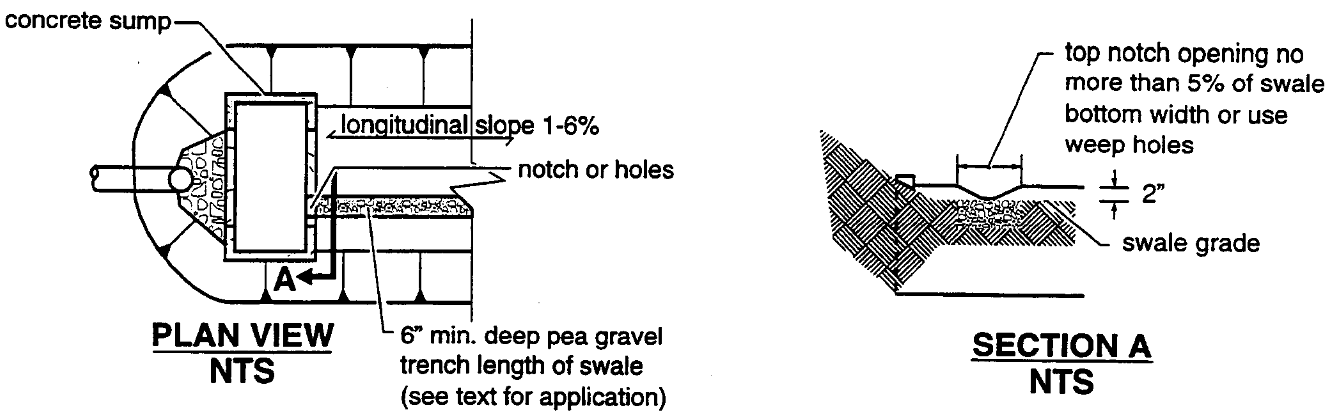
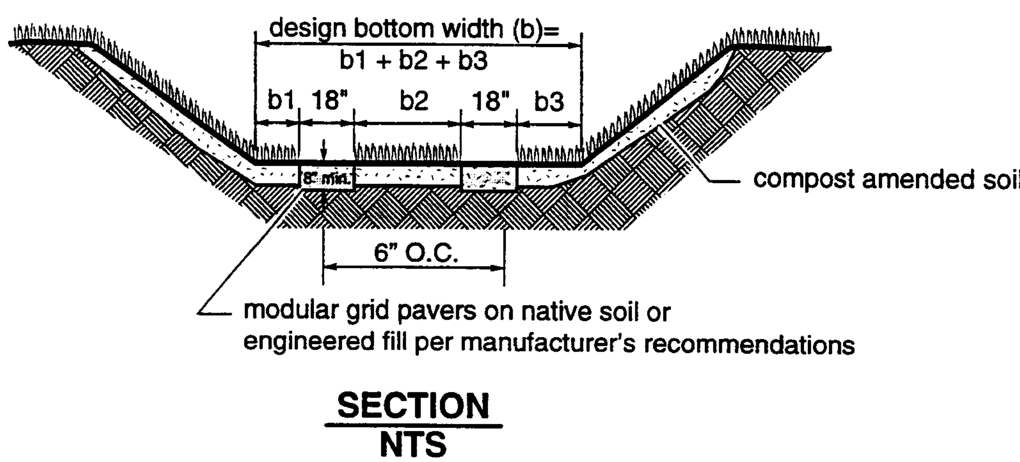


FIGURE 6.3.1.E BIOFILTRATION SWALE WHEEL STRIPS



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6.3.2 WET BIOFILTRATION SWALES

A *wet biofiltration swale* is a variation of a basic biofiltration swale for use where the longitudinal slope is slight, water tables are high, or continuous low base flow is likely to result in saturated soil conditions. Where saturation exceeds about 2 weeks, typical grasses will die. Thus, vegetation specifically adapted to saturated soil conditions is needed. Different vegetation in turn requires modification of several of the design parameters for the basic biofiltration swale detailed in Section 6.3.1 (p. 6-37).

Applications

Wet biofiltration swales are applied where a basic biofiltration swale is desired but not allowed or advisable because one or more of the following conditions exist:

- The swale is on till soils and is downstream of a detention pond providing Level 2 or 3 flow control.
- Saturated soil conditions are likely because of seeps or base flows on the site.
- Longitudinal slopes are slight (generally less than 2 percent).

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement #8.

6.3.2.1 METHODS OF ANALYSIS

Wet biofiltration swales use the **same methods of analysis as basic biofiltration swales** (see Section 6.3.1.1, p.6-38) except the following **step is added:**

Step 7: Adjust for extended wet season flow. If the swale will be downstream of a detention pond providing Level 2 or 3 flow control, multiply the treatment area (bottom width times length) of the swale by 2, and readjust the swale length, if desired. Maintain a 5:1 length to width ratio (see criteria under "Swale Geometry" below).

Intent: An increase in the treatment area of swales following Level 2 or 3 detention ponds is required because of the differences in vegetation established in a constant flow environment. Although flows following Level 2 or 3 detention are small, and swales are likewise much smaller than those sized for upstream flows, they are much more protracted. These protracted flows result in more stream-like conditions than are typical for other wet biofilter situations. Since vegetation growing in streams is often less dense, this increase in treatment area is needed to ensure that equivalent pollutant removal is achieved in extended flow situations.

6.3.2.2 DESIGN CRITERIA

Swale Geometry

Same as specified for **basic biofiltration swales** (see Section 6.3.1.2, p. 6-41) except for the following **modifications:**

1. **Criterion 1:** The **maximum bottom width** may be increased to 25 feet, but a length-to-width ratio of 5:1 must be provided. No longitudinal dividing berm is needed. *Note: The minimum swale length is still 100 feet.*
2. **Criterion 2:** If **longitudinal slopes** are greater than 2 percent, the wet swale must be stepped so that the slope within the stepped sections averages 2 percent. Steps may be made of retaining walls, log check dams, or short riprap sections. **No underdrain or low-flow drain is required.**

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High-Flow Bypass

A high-flow bypass is required for flows greater than the water quality design flow to protect wetland vegetation from damage.[18] The bypass may be an open channel parallel to the wet biofiltration swale.

Water Depth and Base Flow

Same as for basic biofiltration swales (see page 6-42) except the **design water depth** shall be 4 inches for all wetland vegetation selections, and **no underdrains or low-flow drains are required.**

Flow Velocity, Energy Dissipation, and Flow Spreading

Same as for basic biofiltration swales (see page 6-42) except **no flow spreader is needed.**

Access

Same as for basic biofiltration swales (see page 6-43) except access is only required to the inflow and the outflow of the swale; access along the length of the swale is not required. Also, wheel strips may not be used for access in the swale.

Intent: An access road is not required along the length of a wet swale because of infrequent access needs. Frequent mowing or harvesting is not desirable. In addition, wetland plants are fairly resilient to sediment-induced changes in water depth, so the need for access should be infrequent.

Soil Amendment

Same as for basic biofiltration swales (see page 6-44).

Planting Requirements

Same as for **basic biofiltration swales** (see page 6-44) except for the following **modifications:**

1. A list of acceptable plants with recommended spacing is given in Table 6.3.2.A (p. 6-54). In general, it is best to plant several species to increase the likelihood that at least some of the selected species will find growing conditions favorable.
2. A wetland seed mix may be applied by hydroseeding, but if coverage is poor, planting of rootstock or nursery stock is required. Poor coverage is considered to be more than 30 percent bare area through the upper 2/3 of the swale after four weeks.

Recommended Design Features

Same as for basic biofiltration swales (see page 6-47).

Construction Considerations

Same as for basic biofiltration swales (see page 6-47).

Maintenance Considerations

Same as for basic biofiltration swales (see page 6-47) except mowing of wetland vegetation is not required. However, harvesting of very dense vegetation may be desirable in the fall after plant die-back to prevent the sloughing of excess organic material into receiving waters. Many native *Juncus* species remain green throughout the winter; therefore, fall harvesting of *Juncus* species is not recommended.

[18] Unlike grass, wetland vegetation will not quickly regain an upright attitude after being laid down by high flows. New growth, usually from the base of the plant, often taking several weeks, is required to regain its upright form.

TABLE 6.3.2.A RECOMMENDED PLANTS FOR WET BIOFILTRATION SWALE		
Common Name	**Scientific Name**	**Spacing (on center)**
Shortawn foxtail	*Alopecurus aequalis*	seed
Water foxtail	*Alopecurus geniculatus*	seed
Spike rush	*Eleocharis spp.*	4 inches
Slough sedge*	*Carex obnupta*	6 inches or seed
Sawbeak sedge	*Carex stipata*	6 inches
Sedge	*Carex* spp.	6 inches
Western mannagrass	*Glyceria occidentalis*	seed
Velvetgrass	*Holcus mollis*	seed
Slender rush	*Juncus tenuis*	6 inches
Water parsley*	*Oenanthe sarmentosa*	6 inches
Hardstem bulrush	*Scirpus acutus*	6 inches
Small-fruited bulrush	*Scirpus microcarpus*	12 inches

** Good choices for swales with significant periods of flow, such as those downstream of a Level 2 or 3 detention facility.*

Note: Cattail (Typha latifolia) is not appropriate for most wet swales because of its very dense and clumping growth habit which prevents water from filtering through the clump.

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6.3.3 CONTINUOUS INFLOW BIOFILTRATION SWALES

In situations where water enters a biofiltration swale continuously along the side slope rather than discretely at the head, a different design approach–the continuous inflow biofiltration swale–is needed. The basic swale design (see Section 6.3.1, p. 6-37) is modified by increasing swale length to achieve an equivalent average residence time.

Applications

A continuous inflow biofiltration swale is to be **used when inflows are not concentrated**, such as locations along the shoulder of a road without curbs. This design may also be **used where frequent, small point flows enter a swale**, such as through curb inlet ports spaced at intervals along a road, or from a parking lot with frequent curb cuts. In general, no inlet port should carry more than about 10 percent of the flow.

A continuous inflow swale is not appropriate for a situation in which significant lateral flows enter a swale at some point downstream from the head of the swale. In this situation, the swale width and length must be recalculated from the point of confluence to the discharge point in order to provide adequate treatment for the increased flows.

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement #8.

6.3.3.1 METHODS OF ANALYSIS

The design flow for continuous inflow swales must include runoff from the pervious side slopes draining to the swale along the entire swale length.

The method of analysis for continuous inflow swales is the same as for basic biofiltration swales (see Section 6.3.1.1, p. 6-38) except for the following **clarification of Step 1** and **modification to Step 4**:

- **Step 1:** The WQ design flow can be variable to reflect the increase in flows along the swale length. If only a single design flow is used, the flow at the outlet should be used.
- **Step 4:** Double the hydraulic residence time so that it is a minimum of 18 minutes (1,080 seconds). Equation (6-5) becomes:

$$L = 1080V_{wq} \qquad (6\text{-}8)$$

where L = minimum allowable swale length (ft)
V_{wq} = design flow velocity calculated in Step 3 (fps).

Note: Although bottom widths can be increased to reduce length, bottom width cannot be reduced because Manning's depth-velocity-flow rate relationships would not be preserved.

6.3.3.2 DESIGN CRITERIA

Same as specified for **basic biofiltration swales** (in Section 6.3.1.2, p. 6-41) except for the following **modification:**

Planting Requirements, Criterion 4: For continuous inflow biofiltration swales, interior side slopes above the WQ design treatment elevation shall be planted in grass. A typical lawn seed mix or the biofiltration seed mixes are acceptable. Landscape plants or groundcovers other than grass may not be used anywhere between the runoff inflow elevation and the bottom of the swale.

Intent: The use of grass on interior side slopes reduces the chance of soil erosion and transfer of pollutants from landscape areas to the biofiltration treatment area.

6.3.4 BASIC FILTER STRIPS

A *filter strip* is a grassy slope located adjacent and parallel to a impervious area such as a parking lot, driveway, or roadway (see the filter strip detail in Figure 6.3.4.A on page 6-63). A filter strip is graded to maintain sheet flow of stormwater runoff over the entire width of the strip. A filter strip removes pollutants primarily by means of filtration by grass blades which enhance sedimentation, and the trapping and adhesion of pollutants to the grass and thatch. Pollutants can also be adsorbed by the underlying soil when infiltration occurs, but the extent of infiltration depends on the type of soil, the density of the grass, and the slope of the strip.

In this manual, design procedures are provided for two types of filter strip applications: (1) the basic filter strip that should typically apply to parking lots, driveways, and roads where sufficient space is available, and (2) a modified, narrow area filter strip for roadside applications with limited right-of-way space that constricts the filter strip sizing. The basic filter strip is covered in this section, and the narrow area filter strip is covered in Section 6.3.5.

Applications and Limitations

Filter strip design is based on the expectation that water will flow fairly evenly across the entire width and length of the strip area. Thus, paved sites without underground stormwater collection systems, gutters, or other runoff control features are good candidates for filter strips.

Filter strips are suitable for sites that meet the following conditions:

- Stormwater runoff from the area requiring treatment should be uniformly distributed along the top of the entire filter strip. If stormwater runoff from the entire site cannot be spread evenly along the top of the filter strip, the filter strip should be applied only to flows that can be uniformly distributed. A different stormwater treatment facility, such as a swale, should be used for areas of the site with concentrated flow (for instance, at road intersections).
- The flowpath draining to the filter strip should not exceed 150 feet. Runoff flows traveling greater distances tend to concentrate before entering the filter strip.
- The lateral slope of the drainage area contributing flows to the filter strip (parallel to the edge of pavement) should be less than 2 percent. A stepped series of flow spreaders installed at the head of the strip could compensate for slightly steeper slopes (see "Flow Spreading and Energy Dissipation," p. 6-59).
- The longitudinal slope of the contributing drainage area (parallel to the direction of flow entering the filter strip) should be less than 5 percent. Contributing drainage areas with slopes steeper than 5 percent should either use a different WQ facility or must provide energy dissipation and flow spreading mechanisms upslope of the upper edge of the filter strip.

A filter strip generally requires more land area than a biofiltration swale because the flow depth through the filter is shallower than through a swale. Although the space requirements may be greater, the filter strip is a viable water quality treatment option in locations where grassy slopes already exist, or where a slope can be incorporated easily into the landscape design for the site. Other limitations that should be considered are listed below:

1. Filter strips are susceptible to short-circuiting via flow channelization because they rely on a large smoothly graded area. If rills, gullies, or channels occur in the filter strip area, inflows will travel too quickly through the filter strip, reducing contact time and pollutant removal performance. A filter strip slope with uneven grading perpendicular to the sheet flow path will develop flow channels over time. These problems can be overcome with careful site planning, good soil compaction, skillful grading, and periodic maintenance.

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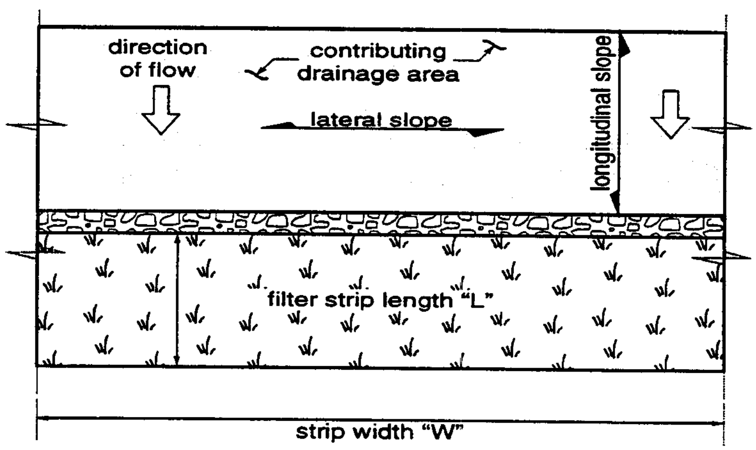
2. Filter strip areas cannot be used for material storage or any activities that could cause disturbance of the ground surface in a manner that could create or promote preferential flowpaths (rills or channels) in the filter strip.
3. Filter strips should not be located in shaded areas, for filter strips require exposure to sunlight to ensure healthy grass growth.

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement # 8.

6.3.4.1 METHODS OF ANALYSIS

In this manual, *filter strip length* is defined as the length of the flowpath through the strip. Strip width is typically the same as the extent of pavement along the upstream edge of the strip. Thus, in sizing filter strips, the length is normally the dimension to be sized (see Figure 6.3.4.A below for definitions of terms).

FIGURE 6.3.4.A FILTER STRIP TERMINOLOGY



The procedure for filter strip design (described below) relies on Manning's equation to calculate some design variables. It is recognized that there are problems in this application.[19] The filter strip sizing method will be modified as new research results become available.

Filter strips sized and built using the method of analysis outlined below and the required design criteria presented in Section 6.3.4.2 are expected to meet the Basic Water Quality menu goal of 80% TSS removal.

Step 1: Calculate design flow. Determine the water quality design flow Q_{wq} (see Section 6.2.1, p. 6-17) using the hydrologic analysis procedures described in Chapter 3.

Step 2: Calculate design flow depth. The design flow depth is calculated based on the width of the filter strip (typically equivalent to the length of the edge of impervious surface contributing flow to the filter strip) and the longitudinal slope of the filter strip (parallel to the direction of flow) using a form of Manning's equation as follows:

[19] Ree, W.O., F.L. Wimberley, and F.R. Crow. 1977. Manning *n* and the overland flow equation. Transactions of the American Society of Agricultural Engineers 20 (89).

$$Q_{wq} = \frac{1.49}{n_{wq}} W d_f^{1.67} s^{0.5} \qquad (6\text{-}9)$$

where Q_{wq} = water quality design flow (cfs)
n_{wq} = Manning's roughness coefficient (either 0.35 or 0.45; see the criteria under "Filter Strip Geometry and Flow Resistance," p. 6-59)
W = width of filter strip perpendicular to the direction of flow (ft) (≡ length of impervious surface contributing flow)
d_f = design depth of flow (ft), which is also assumed to be the hydraulic radius (maximum 1 inch, or 0.083 feet; see the criteria under "Water Depth and Velocity," p. 6-59)
s = longitudinal slope of filter strip parallel to the direction of flow (ft/ft) (averaged over the width of the filter strip; all portions averaged must also meet the slope design criteria).

Rearranging the above equation, the design depth of flow can be calculated using the following equation:

$$d_f = \left(\frac{Q_{wq} n_{wq}}{1.49 W s^{0.5}}\right)^{0.6} \qquad (6\text{-}10)$$

If the calculated flow depth exceeds 1 inch (0.083 feet), the design flow rate routed through the strip must be reduced. If this is not feasible, it is not possible to use a filter strip.

Step 3: Calculate design flow velocity through filter strip. The design flow velocity V_{wq} is based on the water quality design flow rate, the width of the filter strip, and the calculated design flow depth from Step 2 using the following equation:

$$V_{wq} = \frac{Q_{wq}}{W d_f} \qquad (6\text{-}11)$$

where V_{wq} = design flow velocity (fps)
W = strip width (ft) (parallel to the edge of pavement)
d_f = water depth (ft).

If V_{wq} exceeds 0.5 feet per second, a filter strip may not be used. Either redesign the site to provide a gentler longitudinal slope for the strip, or select a different WQ facility.

Step 4: Calculate required length of filter strip. Determine the required length L of the filter strip to achieve a desired hydraulic residence time of at least 9 minutes (540 seconds) using the following equation:

$$L = 540 V_{wq} \qquad (6\text{-}12)$$

where L = filter strip length (ft)
V_{wq} = design flow velocity from Step 3 (fps)

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6.3.4.2 DESIGN CRITERIA

Figure 6.3.4.A (p. 6-63) shows typical filter strip details. The most effective filter strips achieve uniform sheet flow under all runoff flow conditions. To achieve proper flow conditions, the following basic design requirements apply.

Drainage Area Restrictions

1. The **longest flowpath** from the area contributing sheet flow to the filter strip shall not exceed 150 feet.
2. The **lateral slope of the contributing drainage** (parallel to the edge of pavement) shall be 2 percent or less.
3. A stepped series of **flow spreaders** installed at the head of the strip may be used to compensate for drainage areas having lateral slopes of up to 4 percent (see Section 6.2.6, p. 6-31, for information on flow spreader designs).
4. The **longitudinal slope of the contributing drainage area** (parallel to the direction of flow entering the filter strip) should be 5 percent or less.
5. Contributing drainage areas with longitudinal slopes steeper than 5 percent should either use a different WQ facility or provide energy dissipation and flow spreading options upslope of the upper edge of the filter strip to achieve flow characteristics equivalent to those meeting the Criteria in items 2 and 4 above.

Filter Strip Geometry and Flow Resistance

1. The **longitudinal slope** of a filter strip (along the direction of flow) shall be between 1 percent minimum and 15 percent maximum.
2. The **lateral slope** of a strip (parallel to the edge of pavement, perpendicular to the direction of flow) shall be less than 2 percent.
3. The **ground surface** at the upper edge of a filter strip (adjacent to the contributing drainage area) shall be at least 1 inch lower than the edge of the impervious area contributing flows.
4. Manning's **roughness coefficient** (n_{wq}) for flow depth calculations shall be 0.35. An exception to this requirement may be made for situations where the filter strip will be mowed weekly in the growing season to consistently provide a grass height of less than 4 inches; in this case, the value of n_{wq} in Equation (6-10) may be set to 0.45. *Note: In filter strip design, a larger* n *value results in a smaller strip size.*

Water Depth and Velocity

1. The **maximum depth** of flow through a filter strip for the WQ design flow shall be 1.0 inch.
2. The **maximum allowable flow velocity** for the water quality design flow V_{wq} shall be 0.5 feet per second.

Flow Spreading and Energy Dissipation

1. Runoff entering a filter strip must not be concentrated. A **flow spreader** shall be installed at the edge of the pavement to uniformly distribute the flow along the entire width of the filter strip.
2. At a minimum, a **gravel flow spreader** (gravel-filled trench) shall be placed between the impervious area contributing flows and the filter strip, and meet the following requirements:
   a) The gravel flow spreader shall be a minimum of 6 inches deep and shall be 18 inches wide for every 50 feet of contributing flowpath.

b) The gravel shall be a minimum of 1 inch below the pavement surface.

Intent: This allows sediment from the paved surface to be accommodated without blocking drainage onto the strip.

c) For strips less than 50 feet, the spreader width may be reduced to a minimum of 12 inches.

d) Where the ground surface is not level, the gravel spreader must be installed so that the bottom of the gravel trench and the outlet lip are level.

e) Along **roadways,** gravel flow spreaders must meet the specification for shoulder ballast given in Section 9-03.9(2). of the current WSDOT/APWA *Standard Specifications for Road, Bridge and Municipal Construction.*. The ballast shall be compacted to 90 percent standard proctor.

Intent: This specification was chosen to meet traffic safety concerns as well as to limit fines to less than 2 percent passing the No.100 sieve.

3. Other flow spreaders (see Section 6.2.6, p. 6-31) may also be used. For filter strip applications, the notched curb spreader and through-curb port spreaders may not be used without also adding a gravel spreader to better ensure that water sheet-flows onto the strip.

4. **Energy dissipaters** are needed in a filter strip if sudden slope drops occur, such as locations where flows in a filter strip pass over a rockery or retaining wall aligned perpendicular to the direction of flow. Adequate energy dissipation at the base of a drop section can be provided by a riprap pad (see Chapter 4, Table 4.2.2.A, for guidance).

Access

Access shall be provided at the **upper edge of a filter strip** to enable maintenance of the inflow spreader throughout the strip width and allow access for mowing equipment.

Soil Amendment

1. Two inches (minimum) of **well-rotted compost** shall be provided for the entire filter strip treatment area to amend the topsoil unless the soil already has an organic content of 10 percent or greater. The compost must be tilled into the underlying native soil to a depth of 6 inches to prevent washing out the compost and avoid creating a defined layer of different soil types that can prevent downward percolation of water.

   a) Compost shall not contain any sawdust, straw, green or under-composted organic matter, or toxic or otherwise harmful materials.

   b) Compost should not contain unsterilized manure because it can leach fecal coliform bacteria into receiving waters.

2. **Soil or sod** with a clay content of greater than 10 percent should be avoided. If there is potential for contamination of the underlying groundwater, the filter strip should be lined with a treatment liner to prevent groundwater contamination. See Section 6.2.4 (p. 6-22) for details on soil liner options.

Planting Requirements

1. **Grass** shall be established throughout the entire treatment area of the filter strip.

2. **Sod** may be used instead of grass seed as long as the entire filter strip area is completely covered with no gaps between sod pieces.

3. Filter strips are subject to drier conditions than biofiltration swales and also may be more vulnerable to erosion than swales. For these reasons, the following permanent **erosion-control grass seed mix** shall be applied at a rate of 80 pounds per acre in filter strips (percentages are by weight):

   40 percent turf-type rye

   40 percent fescue

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10 percent white dutch clover

10 percent colonial bentgrass

4. **Alternate seed mixes** may be used if a horticultural or erosion-control specialist recommends a different mix and if erosion prevention is adequately addressed by other erosion-control measures.
5. Seed may be applied by **hydroseeding or broadcast application**.
6. **Seeding** is best performed in spring (mid-March to June) or fall (late September to October). If seed is applied in the spring or summer, irrigation must be provided to ensure grass survival.
7. Runoff shall be diverted around a filter strip until the grass is established, or an **erosion control blanket** shall be placed over the freshly applied seed mix. See *ESC Standards* (detached Appendix D) for information on erosion control blankets.

Recommended Design Features

Where conditions allow, the following features should be incorporated into a filter strip's design and its corresponding site configuration.

Site Layout and Landscaping

1. Filter strips should be incorporated into the **landscape design** for a site; however, the treatment areas (i.e., grassy areas) should not be fertilized unless needed for healthy grass growth.
2. **Curbs** should be avoided, if possible, at the downslope edge of the contributing area. If curbing is needed, through-curb ports shall be provided (see Section 6.2.6, p. 6-31).
3. If **parking lot wheel stops** are necessary, individual wheel stops should have gaps for water to pass through. The shorter the wheel stops, the better for sheet flow purposes. See Section 6.2.6 (p. 6-31) for requirements.
4. During seeding, slow-release **fertilizers** may be applied to speed the growth of grass. If the filter strip is located in a sensitive lake watershed, low phosphorus fertilizers (such as formulations in the proportion 3:1:3 N-P-K or less) or a slow-release phosphorus formulation such as rock phosphate or bone meal should be used.
5. Filter strips should be well defined on a site and **marked with signs** to prevent future destruction or alteration of the treatment areas. Small at-grade signage is preferred.

Maintenance Features

1. **Irrigation** may be required in the summer months following initial filter strip construction to prevent the filter strip grass from wilting or dying. Site planning should address the need for sprinklers or other means of irrigation.
2. **Flatter slopes** are preferred for filter strips to make grass mowing easier.

Use with Oil Control Facilities

A site providing **oil control** (see the high-use definition in Chapter 1) may employ a filter strip for runoff treatment if a **linear sand filter** (see Section 6.5.4, p. 6-126) is used for oil control. In this situation, the sand filter should be designed so that flows exit the underdrain gravel along the whole length of the trench directly to the filter strip.

Construction Considerations

1. If a filter strip is put into operation before all construction in the contributing drainage catchment has been completed, the strip must be cleaned of sediment and reseeded prior to acceptance by the County. The County will not release financial guarantees if the filter strip is not restored and vigorous grass growth re-established.

2. It is preferable to provide erosion control before construction-phase sediment enters the filter strip. Filter strips are designed to handle only modest sediment loads without frequent maintenance.

Maintenance Considerations

Maintenance considerations, including mowing frequency and sediment removal, are similar to those for biofiltration swales (see page 6-47).

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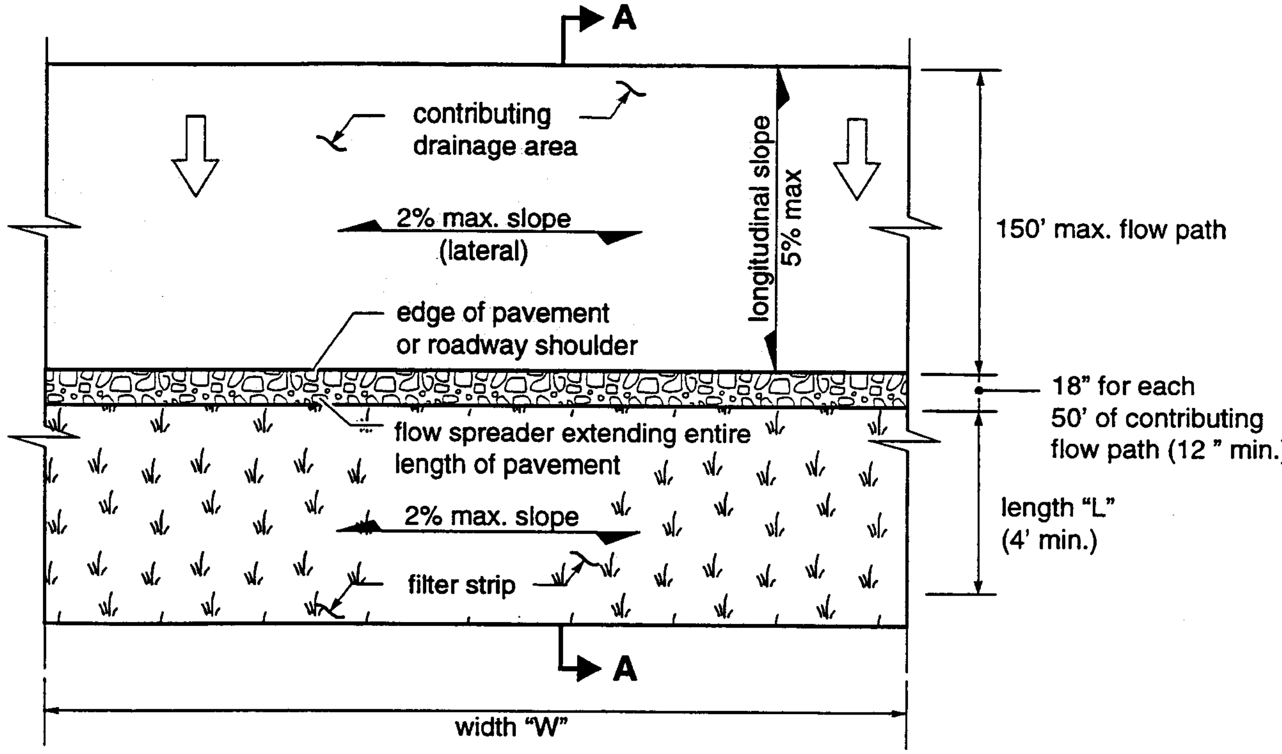
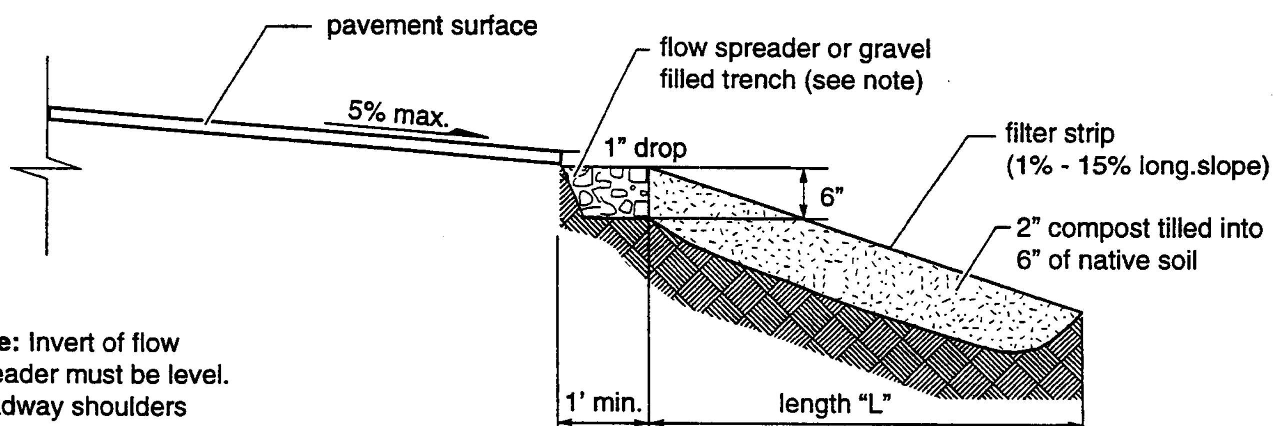
FIGURE 6.3.4.B TYPICAL FILTER STRIP DETAILS



PLAN VIEW
NTS



Note: Invert of flow spreader must be level. Roadway shoulders must use shoulder ballast.

SECTION A-A
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6.3.5 NARROW AREA FILTER STRIPS

This section describes a filter strip design[20] for impervious areas with flowpaths of 30 feet or less that can drain along their widest dimension to grassy areas (see Figure 6.3.4.A, p. 6-57, for definitions of filter strip geometry terms).

The treatment objectives, applications and limitations, design criteria, materials specifications, and construction and maintenance requirements set forth in the basic filter strip design apply to narrow filter strip applications.

If space is available to use the basic filter strip design, that design should be used in preference to the narrow filter strip. However, along roadways with limited right-of-way, or for narrow parking strips, the narrow strip may be used.

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement #8.

6.3.5.1 METHODS OF ANALYSIS

The sizing of a narrow area filter strip is based on the length of flowpath draining to the filter strip and the longitudinal slope of the filter strip itself (parallel to the flowpath).

Step 1: Determine length of flowpath draining to filter strip. Determine the length of the flowpath from the upstream to the downstream edge of the impervious area draining sheet flow to the strip. Normally this is the same as the width of the paved area, but if the site is sloped, the flow path may be longer than the width of the impervious area.

Step 2: Determine average longitudinal slope of filter strip. Calculate the longitudinal slope of the filter strip (along the direction of unconcentrated flow), averaged over the total width of the filter strip. The minimum sizing slope is 2 percent. If the slope is less than 2 percent, use 2 percent for sizing purposes. The maximum allowable filter strip slope is 20 percent. If the slope exceeds 20 percent, the filter strip must be stepped down the slope so that the treatment areas between drop sections do not have a longitudinal slope greater than 20 percent. Drop sections must be provided with erosion protection at the base and flow spreaders to re-spread flows. Vertical drops along the slope must not exceed 12 inches in height. If this is not possible, a different treatment facility must be selected.

Step 3: Determine required length of filter strip. Select the appropriate filter strip length for the flowpath length and filter strip longitudinal slope (Steps 1 and 2 above) **from the graph in Figure 6.3.5.A (p. 6-65).**[21] The filter strip must be designed to provide this minimum length *L* along the entire stretch of pavement draining into it.

To use the graph: Find the **length of the flowpath** on one of the curves (interpolate between curves as necessary). Move along the curve to the point where the **design longitudinal slope** of the filter strip (x-axis) is directly below. Read the filter **strip length** on the y-axis which corresponds to the intersection point.

Example

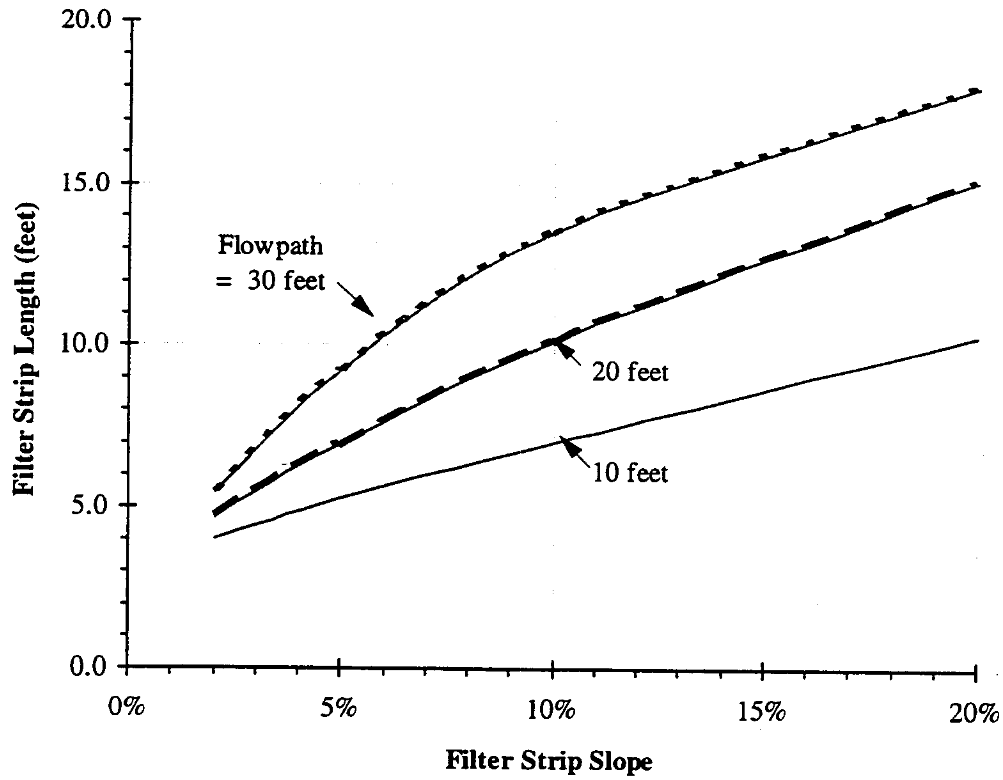
If the length of flowpath through a parking strip is 20 feet and the filter strip will be at 5 percent longitudinal slope, move along the middle curve until it intercepts the 5 percent grid from the x-axis. The required filter strip length is 7 feet (read from the y-axis).

---

[20] This narrow area filter strip design method is included here because technical limitations exist in the basic design method which result in filter strips that are proportionately longer as the contributing drainage becomes narrower (a result that is counter-intuitive). Research by several parties is underway to evaluate filter strip design parameters. This research may lead to more stringent design requirements that would supersede the design criteria presented here.

[21] The filter strip length requirements reflected in Figure 6.3.5.A are scaled from dimensions of biofiltration swale treatment areas for the same slope and flow rate conditions.

FIGURE 6.3.5.A FILTER STRIP LENGTHS FOR NARROW RIGHT-OF-WAY



Note: minimum allowable filter strip length is 4 feet

6.3.5.2 DESIGN CRITERIA

Required and recommended design criteria for narrow area filter strips are the **same as specified for basic filter strips**. Note that for roadway applications, gravel spreaders must meet the specification for shoulder ballast given in Section 9-03.9(2) of the current *Standard Specifications for Road, Bridge and Municipal Construction,* 1994compacted to 90 percent standard proctor.

6.4 WETPOOL FACILITY DESIGNS

This section presents the methods, criteria, and details for analysis and design of wetponds, wetvaults, and stormwater wetlands. These facilities have as a common element a permanent pool of water, the *wetpool*. Each of the wetpool facilities can be combined with a detention or flow control pond in a combined facility. Included are the following specific facility designs:

- Wetponds — Basic and Large, Section 6.4.1 (p. 6-67)
- Wetvaults, Section 6.4.2 (p. 6-80)
- Stormwater Wetlands, Section 6.4.3 (p. 6-86)
- Combined Detention and Wetpool Facilities, Section 6.4.4 (p. 6-92)

The information presented for each facility is organized into the following two categories:

1. **Methods of Analysis:** Contains a step-by-step procedure for designing and sizing each facility. Information used in the procedure is based on available literature but clarified or modified where deficiencies were identified.[22]
2. **Design Criteria:** Contains the details, specifications, and material requirements for each facility.

6.4.1 WETPONDS — BASIC AND LARGE

A *wetpond* is a constructed stormwater pond that retains a permanent pool of water (a "wetpool") at least during the wet season (see the wetpond detail in Figure 6.4.1.B on page 6-78). The volume of the wetpool is related to the effectiveness of the pond in settling particulate pollutants. The following design procedures, requirements, and recommendations cover two wetpond applications, the basic wetpond and the large wetpond. The two sizes are designed for two different levels of pollutant removal.

Applications and Limitations

A wetpond requires a larger area than a biofiltration swale or a sand filter, but it can be integrated to the contours of a site fairly easily. In till soils, the wetpond holds a permanent pool of water that provides an attractive aesthetic feature. In more porous soils, wetponds may still be used, but water seepage from unlined cells could result in a dry pond, particularly in the summer months. Lining with impervious material is one way to deal with this situation.

Wetponds may be single-purpose facilities, providing only water quality treatment, or they may be combined with a detention pond to also provide flow control. If combined, the wetpond can often be stacked under the detention pond with little further loss of development area. See Section 6.4.4 (p. 6-92) for a description of combined WQ and detention facilities.

Wetponds treat water both by gravity settling and by biological uptake of algae and microorganisms. Wetponds can remove some dissolved pollutants such as soluble phosphorus by this uptake mechanism. They are therefore used in the Sensitive Lake Protection menu for phosphorus control in addition to the Basic WQ menu for solids removal. Wetponds work best when the water already in the pond is moved out *en masse* by incoming flows, a phenomena called "**plug flow**." Because treatment works on this displacement principle, the dead storage pool of wetponds may be provided below the groundwater level without interfering unduly with treatment effectiveness. However, if combined with a detention function, the live storage must be above the seasonal high groundwater level.

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how basic and large wetponds can be used to meet Core Requirement #8.

[22] Such modifications were often based on computer modeling using the King County Runoff Time Series (KCRTS) model. Less frequently they were based on bench-scale studies. Back-up studies are listed in Reference Section 5.

6.4.1.1 METHODS OF ANALYSIS

This section describes methods of analysis for the following two wetpond sizes:

- **Basic wetpond** (see below)
- **Large wetpond** (see page 6-71).

❑ BASIC WETPOND

The primary design factor that determines a wetpond's **particulate removal efficiency** is the volume of the wetpool in relation to the volume of stormwater runoff from the *mean annual storm.*[23] The larger the wetpond volume in relation to the volume of runoff, the greater the potential for pollutant removal. Also important are the avoidance of short-circuiting and the promotion of plug flow. *Plug flow* describes the hypothetical condition of stormwater moving through the pond as a unit, displacing the "old" water in the pond with incoming flows. To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm.

Design features that encourage plug flow and avoid dead zones are as follows:

- Dissipating energy at the inlet
- Providing a large length-to-width ratio
- Providing a broad surface for water exchange across cells rather than a constricted area.

Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time.

Wetponds designed using the method below (with the volume = $3V_r$) and the required design criteria in Section 6.4.1.2 are expected to meet the Basic WQ menu goal of 80% TSS removal. The actual performance of a wetpond may vary, however, due to a number of factors, including design features, maintenance frequency, storm characteristics, pond algae dynamics, and waterfowl use.

Procedures for determining a wetpond's dimensions and volume are outlined below.

Step 1: Identify required wetpool volume factor (*f*). A basic wetpond requires a volume factor of 3. This means that the required wetpond volume is 3 times the volume of runoff V_r from the mean annual storm (see Steps 2 and 3).

Step 2: Determine rainfall (*R*) for the mean annual storm. The rainfall for the mean annual storm R is obtained by locating the project site on Figure 6.4.1.A (p. 6-69) and interpolating between isopluvials. Convert to feet for use in Equation (6-13).

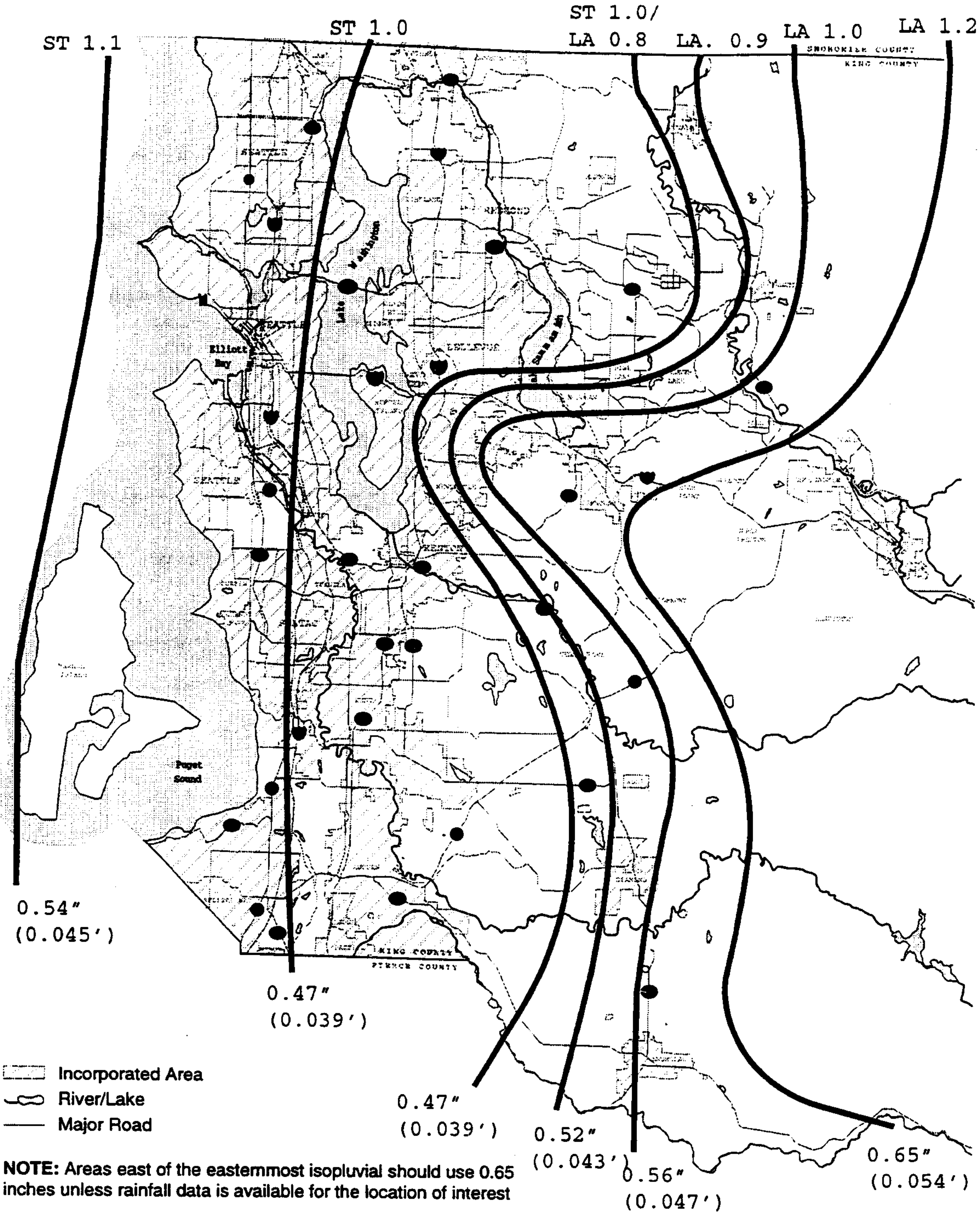
Step 3: Calculate runoff from the mean annual storm (V_r) for the developed site. The runoff volume V_r is the amount of rainfall that runs off a particular set of land covers. To determine V_r, each portion of the wetpond tributary area is assigned to one of four cover types, each having a different runoff coefficient: impervious surface, till grass, till forest, or outwash.

- **Impervious surface** is a compacted surface, such as pavement, gravel, soil, or other hard surfaces, as well as open water bodies. *Note: The effective impervious computations given in Chapter 3, Table 3.2.2.D may be used if desired.*

- **Till grass** is post-development grass or landscaped area and onsite forested land on till soil that are not permanently in sensitive area buffers or covenants. *Till* is soil that does not drain readily and, as a

[23] The *mean annual storm* is a statistically derived rainfall event defined by the U.S. Environmental Protection Agency in "Results of the Nationwide Urban Runoff Program," 1986. It is defined as the annual rainfall divided by the number of storm events in the year. The NURP studies refer to pond sizing using a V_b/V_r ratio: the ratio of the pond volume V_b to the volume of runoff from the mean annual storm V_r. This is equivalent to using a volume factor f times V_r.

FIGURE 6.4.1.A PRECIPITATION FOR MEAN ANNUAL STORM IN INCHES (FEET)



NOTE: Areas east of the easternmost isopluvial should use 0.65 inches unless rainfall data is available for the location of interest

[24] The mean annual storm is a conceptual storm found by dividing the annual precipitation by the total number of storm events per year

result, generates large amounts of runoff. For this application, till soil types include Buckley and bedrock soils, and alluvial and outwash soils that have a seasonally high water table or are underlain at a shallow depth (less than 5 feet) by glacial till. U.S. Soil Conservation Service (SCS) hydrologic soil groups that are classified as till soils include a few B, most C, and all D soils. See Chapter 3 for classification of specific SCS soil types.

- **Till forest** is all permanent onsite forest and/or shrub cover located on till soils that retains the natural understory vegetation and forest duff, irrespective of age, if densities are sufficient to ensure at least 80 percent canopy cover within 5 years. To be counted in this category, forest must be protected as permanent open space. Such areas may be placed in a separate open space tract or may be protected through covenants or conservation easements. Section 5.2.1 has a brief discussion of forested open space under the heading "Rural Residential Projects."
- **Outwash** is soil that infiltrates well and as a result produces small amounts of runoff. SCS hydrologic soil groups classified as outwash soils include all A, most B, and some C soils. See Chapter 3 for classification of specific SCS soil types.

Cover categories are based on existing U.S. Department of Agriculture soil survey data or site specific data where available.

Next, coefficients specific to the four cover types are weighted by the drainage areas and then multiplied by the rainfall R from Step 2 to produce the runoff volume V_r:

$$V_r = (0.9A_i + 0.25A_{tg} + 0.10A_{tf} + 0.01A_o) \times (R/12) \qquad (6\text{-}13)$$

where
V_r = volume of runoff from mean annual storm (cf)
A_i = area of impervious surface (sf)
A_{tg} = area of till soil covered with grass (sf)
A_{tf} = area of till soil covered with forest (sf)
A_o = area of outwash soil covered with grass or forest (sf)
R = rainfall from mean annual storm (inches)

Step 4: Calculate wetpool volume (V_b). Use the results of the previous steps to calculate the required wetpool volume according to the following equation:

$$V_b = f\,V_r \qquad (6\text{-}14)$$

where
V_b = wetpool volume (cf)
f = volume factor from Step 1
V_r = runoff volume (cf) from Step 3

Step 5: Determine wetpool dimensions. Determine the wetpool dimensions satisfying the design criteria outlined below. A simple way to check the volume of each wetpool cell is to use the following equation:

$$V_b = \frac{h(A_1 + A_2)}{2} \qquad (6\text{-}15)$$

where
V_b = wetpool volume (cf)
h = wetpool depth (ft)
A_1 = water quality design surface area of wetpool (sf)
A_2 = bottom area of wetpool (sf)

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Step 6: Design pond outlet pipe and determine primary overflow water surface. The design criteria for wetponds (see Section 6.4.1.2) calls for a pond outlet pipe to be placed on a reverse grade from the pond's wetpool to the outlet structure. Use the following procedure to design the pond outlet pipe and determine the primary overflow water surface elevation:

a) Use the nomographs in Section 4.3 (Figures 4.3.1.B and 4.3.1.C) to select a trial size for the pond outlet pipe sufficient to pass the WQ design flow Q_{wq}.

b) Use Figure 4.3.1.F to determine the critical depth d_c at the outflow end of the pipe for Q_{wq}.

c) Use Figure 4.2.1.G to determine the flow area A_c at critical depth.

d) Calculate the flow velocity at critical depth using continuity equation ($V_c = Q_{wq} / A_c$).

e) Calculate the velocity head V_H ($V_H = V_c^2 / 2g$, where g is the gravitational constant, 32.2 feet per second).

f) Determine the primary overflow water surface elevation by adding the velocity head and critical depth to the invert elevation at the outflow end of the pond outlet pipe (i.e., overflow water surface elevation = outflow invert + d_c + V_H)

g) Adjust outlet pipe diameter as needed and repeat Steps (a) through (e).

❑ LARGE WETPOND

Large wetponds are expected to meet the Sensitive Lake Protection menu goal of 50% total phosphorus removal. The actual performance of a wetpond may vary, however, due to a number of factors. The methods of analysis presented above for basic wetponds apply to large wetponds, except that **Step 1 is modified** as follows:

Step 1: A large wetpond requires a volume factor of 4.5.

6.4.1.2 DESIGN CRITERIA

This section sets forth design criteria for the following:

- **Basic wetpond** (see below)
- **Large wetpond** (see page 6-77).

General wetpond design criteria and concepts are shown in Figure 6.4.1.B (p. 6-78).

❑ BASIC WETPOND

Wetpool Geometry

1. The wetpool shall be divided into **two cells** separated by a baffle or berm.[24] The first cell shall contain between 25 to 35 percent of the total wetpool volume. The baffle or berm volume shall not count as part of the total wetpool volume.

   Intent: The full-length berm or baffle promotes plug flow and enhances quiescence and laminar flow through as much of the entire water volume as possible. Use of a pipe and full-width manifold system to introduce water into the second cell is possible on a case-by-case basis if approved by DDES.

2. Wetponds with wetpool volumes less than or equal to 4,000 cubic feet may be **single celled** (i.e., no baffle or berm is required).

3. **Sediment storage** shall be provided in the first cell. The sediment storage shall have a minimum depth of 1 foot.

4. The **minimum depth of the first cell** shall be 4 feet, exclusive of sediment storage requirements. The depth of the first cell may be greater than the depth of the second cell.

5. The **maximum depth of each cell** shall not exceed 8 feet (exclusive of sediment storage in the first cell). Pool depths of 3 feet or shallower (second cell) shall be planted with emergent wetland vegetation (see **Planting requirements**).

[24] As used here, the term *baffle* means a vertical divider placed across the entire width of the pond, stopping short of the pond bottom. A berm is a vertical divider typically built up from the bottom, or if in a vault, connects all the way to the bottom.

6. Inlets and outlets shall be placed to maximize the flowpath through the facility. The **ratio of flowpath length to width** from the inlet to the outlet shall be at least 3:1. The *flowpath length* is defined as the distance from the inlet to the outlet, as measured at mid-depth. The *width* at mid-depth can be found as follows: width = (average top width + average bottom width)/2.
7. All inlets shall enter the first cell. If there are multiple inlets, the length-to-width ratio shall be based on the average flowpath length for all inlets.

Berms, Baffles, and Slopes

1. A berm or baffle shall extend across the full width of the wetpool, and tie into the wetpond side slopes. If the berm embankments are greater than 4 feet in height, the berm **must be constructed by excavating a key** equal to 50% of the embankment cross-sectional height and width. This requirement may be waived if recommended by a geotechnical engineer for specific site conditions.[25]
2. The **top of the berm may extend** to the **WQ design water surface** or be one foot below the WQ design water surface. If at the WQ design water surface, berm side slopes must be 3H:1V. Berm side slopes may be steeper (up to 2:1) if the berm is submerged one foot.

   Intent: Submerging the berm is intended to enhance safety by discouraging pedestrian access when side slopes are steeper than 3H:1V.
3. If good vegetation cover is not established on the berm, **erosion control measures** should be used to prevent erosion of the berm back-slope when the pond is initially filled.
4. The interior berm or baffle may be a **retaining wall** provided that the design is prepared and stamped by a licensed civil engineer. If a baffle or retaining wall is used, it shall be submerged one foot below the design water surface to discourage access by pedestrians.
5. Criteria for wetpond **side slopes** and **fencing** are given under "General Requirements for WQ Facilities," Section 6.2.3 (p. 6-20).
6. Berm **embankments** shall be the same as for detention ponds (see Section 5.3.1).

Inlet and Outlet

See Figure 6.4.1.B (p. 6-78) for details on the following requirements:

1. The **inlet** to the wetpond shall be **submerged** with the inlet pipe invert a minimum of two feet from the pond bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible.

   Intent: The inlet is submerged to dissipate energy of the incoming flow. The distance from the bottom is set to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.
2. An **outlet structure** shall be provided. Either a Type 2 catch basin with a grated opening (jail house window) or a manhole with a cone grate (birdcage) may be used (see Section 5.3.1.1). No sump is required in the outlet structure for wetponds not providing detention storage. The outlet structure receives flow from the pond outlet pipe. The grate or birdcage openings provide an overflow route should the pond outlet pipe become clogged. Criteria 5 below specifies the sizing and position of the grate opening.
3. The **pond outlet pipe** (as opposed to the structure outlet) shall be back-sloped or have a turn-down elbow, and extend 1 foot below the WQ design water surface. *Note: A floating outlet, set to draw water from 1 foot below the water surface, is also acceptable if vandalism concerns are adequately*

[25] The geotechnical analysis must address situations in which one of the two cells is empty while the other remains full of water. These situations can occur, for example, during pump down of either cell for sediment removal, or when water from the second unlined cell percolates into the ground.

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addressed. **Intent:** The inverted outlet pipe provides for trapping of oils and floatables in the wetpond.

4. The **pond outlet pipe** shall be sized, at a minimum, to pass the WQ design flow. *Note: The highest invert of the outlet pipe sets the **WQ design water surface** elevation.*

5. The **overflow** criteria for single-purpose wetponds are as follows:

   a) The requirement for **primary overflow** as described for flow control ponds is satisfied by either the **grated inlet** to the outlet structure or by a **birdcage** above the pond outlet structure as shown in Figure 5.3.1.C.

   b) The bottom of the grate opening in the outlet structure shall be set at or above the height needed to pass the WQ design flow through the pond outlet pipe (see page 6-70 for sizing details). *Note: The grate invert elevation sets the **overflow water surface** elevation.*

   c) In flow-through ponds, the grated opening shall be sized to pass the 100-year design flow.

6. An **emergency spillway** shall be provided and designed according to the requirements for detention ponds (see Section 5.3.1).

7. A **gravity drain** for maintenance shall be provided if grade allows.

   a) The **drain invert** shall be at least 6 inches below the top elevation of the dividing berm or baffle. Deeper drains are encouraged where feasible, but must be no deeper than 18 inches above the pond bottom.

      Intent: to prevent highly sediment-laden water from escaping the pond when drained for maintenance.

   b) The drain shall be at least 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

      Intent: Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

   Intent: It is anticipated that sediment removal will only be needed for the first cell in the majority of cases. The gravity drain is intended to allow water from the first cell to be drained to the second cell when the first cell is pumped dry for cleaning.

8. Operational access to the valve shall be provided to the finished ground surface.

   a) The valve location shall be accessible and well-marked with one foot of paving placed around the box. It must also be protected from damage and unauthorized operation.

   b) A valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole or vault is required.

9. All metal parts shall be corrosion-resistant. Galvanized materials are discouraged where substitutes are available.

Access and Setbacks

1. The location of the pond relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Section 5.3.1). See Section 6.2.3 (p. 6-20) for typical setback requirements for WQ facilities.

2. Access and maintenance **roads** shall be provided and designed according to the requirements for detention ponds (see Section 5.3.1). Access and maintenance roads shall extend to both the wetpond inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top of the pond. Also see Section 5.3.1, "Access Requirements" for more information on access alternatives.

3. If the **dividing berm** is also **used for access**, it must be built to sustain loads of up to 80,000 pounds.

Signage

1. Signage shall be provided according to the requirements for detention ponds (see Section 5.3.1).
2. If the wetpond is in a lake or sphagnum bog protection area, then signage discouraging feeding of waterfowl shall be provided. The following or similar wording is suggested: "Please don't feed waterfowl. It's not good for them, and their droppings are not good for the lake."

Planting Requirements

1. Planting requirements for detention ponds (see Section 5.3.1.1) also apply to wetponds.

   If the second cell of the wetpond is 3 feet or shallower, the bottom area shall be planted with emergent wetland vegetation. See Table 6.4.1.A (p. 6-75) for recommended emergent wetland plant species for wetponds. **Intent:** Planting of shallow pond areas helps to stabilize settled sediment and prevent resuspension.

   Note: The recommendations in Table 6.4.1.A *are for western Washington only. Local knowledge should be used to adapt this information if used in other areas.*
2. Cattails (Typha latifolia) are not recommended because they tend to crowd out other species, and the dead shoots need to be removed to prevent oxygen depletion in the wetpool.
3. If the wetpond is in a sensitive lake or sphagnum bog protection area, shrubs that form a dense cover shall be planted on slopes above the WQ design water surface on at least three sides. For banks that are berms, no planting is allowed if the berm is regulated by dam safety requirements (see Section 5.3.1). The purpose of planting is to discourage waterfowl use of the pond and to provide shading.[26] Some suitable trees and shrubs include vine maple (*Acer circinatum*), wild cherry (*Prunus emarginata*), red osier dogwood (*Cornus stolonifera*), California myrtle (*Myrica californica*), Indian plum (*Oemleria cerasiformis*), and Pacific yew (*Taxus brevifolia*) as well as numerous ornamental species.

Recommended Design Features

The following design features should be incorporated into the wetpond design where site conditions allow:

1. For wetpool depths in excess of 6 feet, it is recommended that some form of **recirculation** be provided in the summer, such as a fountain or aerator, to prevent stagnation and low dissolved oxygen conditions. A special use permit is needed for a pump or fountain in a County maintained pond.
2. A flow length-to-width ratio greater than the 3:1 minimum is desirable. If the ratio is 4:1 or greater, and a gravity drain for maintenance is provided 12 to 18 inches from the pond bottom, then the **dividing berm is not required**, and the pond may consist of one cell rather than two.
3. A **tear-drop shape**, with the inlet at the narrow end, rather than a rectangular pond is preferred since it minimizes dead zones caused by corners.
4. A small amount of **base flow** is desirable to maintain circulation and reduce the potential for low oxygen conditions during late summer.
5. Evergreen or columnar deciduous **trees along the west and south sides** of ponds are recommended to reduce thermal heating, except that no trees or shrubs may be planted on berms meeting the criteria of dams regulated for safety (see Dam Safety Compliance in Section 5.3.1). In addition to shade, trees and shrubs also discourage waterfowl use and the attendant phosphorus enrichment problems they cause. Trees should be set back so that the branches will not extend over the pond.

   Intent: Evergreen trees or shrubs are preferred to avoid problems associated with leaf drop. Columnar deciduous trees (e.g., hornbeam, Lombardy poplar, etc.) typically have fewer leaves than other deciduous trees.

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[26] Waterfowl are believed to limit use of areas where their view of predator approach paths is blocked. Some suitable native shrubs include vine maple, Indian plum, bitter cherry, red osier dogwood, cascara, and red elderberry. Ornamental hedge plants such as English laurel, privet and barberry are also good choices.

TABLE 6.4.1.A EMERGENT WETLAND PLANT SPECIES RECOMMENDED FOR WETPONDS			
Species	**Common Name**	**Notes**	**Maximum Depth**
INUNDATION TO 1 FOOT			
Agrostis exarata[1]	Spike bent grass	Prairie to coast	to 2 feet
Carex stipata	Sawbeak sedge	Wet ground	
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	to 2 feet
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	to 2 feet
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	to 2 feet
Juncus tenuis	Slender rush	Wet soils, wetland margins	
Oenanthe sarmentosa	Water parsley	Shallow water along stream and pond margins; needs saturated soils all summer	
Scirpus atrocinctus (formerly S. cyperinus)	Woolgrass	Tolerates shallow water; tall clumps	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sagittaria latifolia	Arrowhead		
INUNDATION 1 TO 2 FEET			
Agrostis exarata[1]	Spike bent grass	Prairie to coast	
Alisma plantago-aquatica	Water plantain		
Eleocharis palustris	Spike rush	Margins of ponds, wet meadows	
Glyceria occidentalis	Western mannagrass	Marshes, pond margins	
Juncus effusus	Soft rush	Wet meadows, pastures, wetland margins	
Scirpus microcarpus	Small-fruited bulrush	Wet ground to 18 inches depth	18 inches
Sparganium emmersum	Bur reed	Shallow standing water, saturated soils	
INUNDATION 1 TO 3 FEET			
Carex obnupta	Slough sedge	Wet ground or standing water	1.5 to 3 feet
Beckmania syzigachne[1]	Western sloughgrass	Wet prairie to pond margins	
Scirpus acutus[2]	Hardstem bulrush	Single tall stems, not clumping	to 3 feet
Scirpus validus[2]	Softstem bulrush		
INUNDATION GREATER THAN 3 FEET			
Nuphar polysepalum	Spatterdock	Deep water	3 to 7.5 feet
Nymphaea odorata[1]	White waterlily	Shallow to deep ponds	to 6 feet

Notes:

(1) Non-native species. *Beckmania syzigachne* is native to Oregon. Native species are preferred.

(2) *Scirpus* tubers must be planted shallower for establishment, and protected from foraging waterfowl until established. Emerging aerial stems should project above water surface to allow oxygen transport to the roots.

Primary sources: Municipality of Metropolitan Seattle, *Water Pollution Control Aspects of Aquatic Plants*, 1990. Hortus Northwest, *Wetland Plants for Western Oregon*, Issue 2, 1991. Hitchcock and Cronquist, *Flora of the Pacific Northwest*, 1973.

6. The **number of inlets** to the facility should be limited; ideally there should be only one inlet. The flowpath length should be maximized from inlet to outlet for all inlets to the facility.

7. The **access and maintenance road** could be extended along the full length of the wetpond and could double as playcourts or picnic areas. Placing finely ground bark or other natural material over the road surface would render it more pedestrian friendly.

8. Signage discouraging **feeding of waterfowl** is recommended. Signs entitled "Four reasons not to feed ducks and geese" are available for purchase from the King County Department of Natural Resources.

9. **Stormwater tracts** may be credited to meet recreational space requirements under some circumstances (criteria in KCC 21A.14.180.D) or may sometimes be located in open space set aside through the four to one program. See Section 5.3.1.1 for details.

10. The following design features should be incorporated to **enhance aesthetics** where possible:

    a) Provide pedestrian access to shallow pool areas enhanced with emergent wetland vegetation. This allows the pond to be more accessible without incurring safety risks.

    b) Provide side slopes that are sufficiently gentle to avoid the need for fencing (3:1 or flatter).

    c) Create flat areas overlooking or adjoining the pond for picnic tables or seating that can be used by residents. Walking or jogging trails around the pond are easily integrated into site design.

    d) Include fountains or integrated waterfall features for privately maintained facilities.

    e) Provide visual enhancement with clusters of trees and shrubs. On most pond sites, it is important to amend the soil before planting since ponds are typically placed well below the native soil horizon in very poor soils. Make sure dam safety restrictions against planting do not apply.

    f) Orient the pond length along the direction of prevailing summer winds (typically west or southwest) to enhance wind mixing.[27]

Construction Considerations

1. Sediment that has accumulated in the pond must be removed after construction in the drainage area of the pond is complete (unless used for a liner—see Criteria 2 below). If no more than 12 inches of sediment have accumulated after plat construction, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise. The County will not release maintenance and defect financial guarantees or assume maintenance responsibility for a facility unless it has been cleaned of construction phase sediments.

2. Sediment that has accumulated in the pond at the end of construction may be used as a liner in excessively drained soils if the sediment meets the criteria for low permeability or treatment liners defined in Section 6.2.4 (p. 6-22) and in keeping with guidance given in Table 6.2.4.A (p. 6-23). Sediment used for a soil liner must be graded to provide uniform coverage and thickness.

Maintenance Considerations

1. The pond should be inspected annually. Floating debris and accumulated petroleum products should be removed as needed, but at least annually.

2. Site vegetation should be trimmed as necessary to keep the pond free of leaves and to maintain the aesthetic appearance of the site. Slope areas that have become bare should be revegetated and eroded areas should be regraded prior to being revegetated.

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[27] Wind moving over the surface of standing water can often induce some mixing of surface and near-surface water, replentishing oxygen and reducing stagnant conditions. If the pond is aligned with the prevailing wind direction, this effect can be maximized.

3. Sediment should be removed when the 1-foot sediment zone is full plus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.
4. Water drained or pumped from ponds prior to sediment removal may be discharged to storm drains if it is not excessively turbid (i.e., if water appears translucent when held to light) and if floatable debris and visual petroleum sheens are removed. Excessively turbid water (i.e., water appears opaque when held to light) should be discharged only after the solids have been settled and removed.

❑ LARGE WETPOND

All design criteria for **basic wetponds** shall apply to large wetponds, with the following **modifications:**

1. The wetpool for a large wetpond shall have a volume factor of 4.5.
2. If the project is subject to the Sensitive Lake Protection menu or the Sphagnum Bog Protection menu, the following shall apply:
   a) Shrubs that form a dense cover shall be planted along the top of the wetpond bank on cut slopes. Planting is recommended for bermed slopes, except for berms meeting the criteria of dams regulated for safety (see Dam Safety Compliance in Section 5.3.1). Evergreen trees and shrubs are preferred.

      Intent: Trees and shrubs discourage waterfowl use. Waterfowl tend to avoid areas that are not visually open.

   b) Measures to enhance waterfowl habitat value (e.g., nesting structures) are not allowed.

   c) **Signage** discouraging feeding of waterfowl is required. Signs entitled "Four reasons not to feed ducks and geese" are available for purchase from the King County Department of Natural Resources.
3. **Recommended Design Features:** If joint use of the facility is planned, public fishing or water contact access should be limited to the second cell since the first cell functions to collect and concentrate sediment and attached pollutants.

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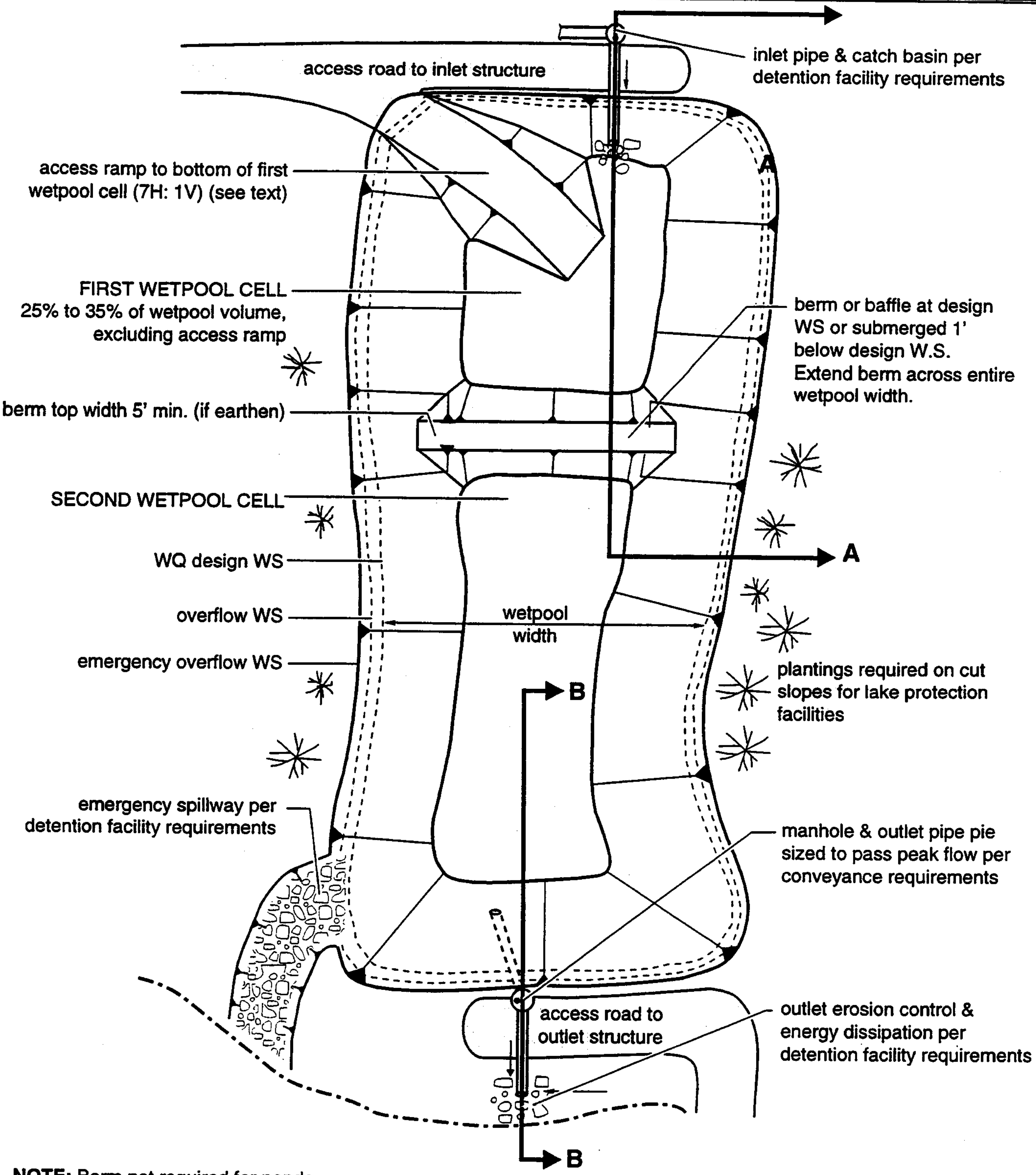
FIGURE 6.4.1.B WETPOND



NOTE: Berm not required for ponds with length to width ratio ≥ 4:1 or if volume less than 4000 c.f.

PLAN VIEW
NTS

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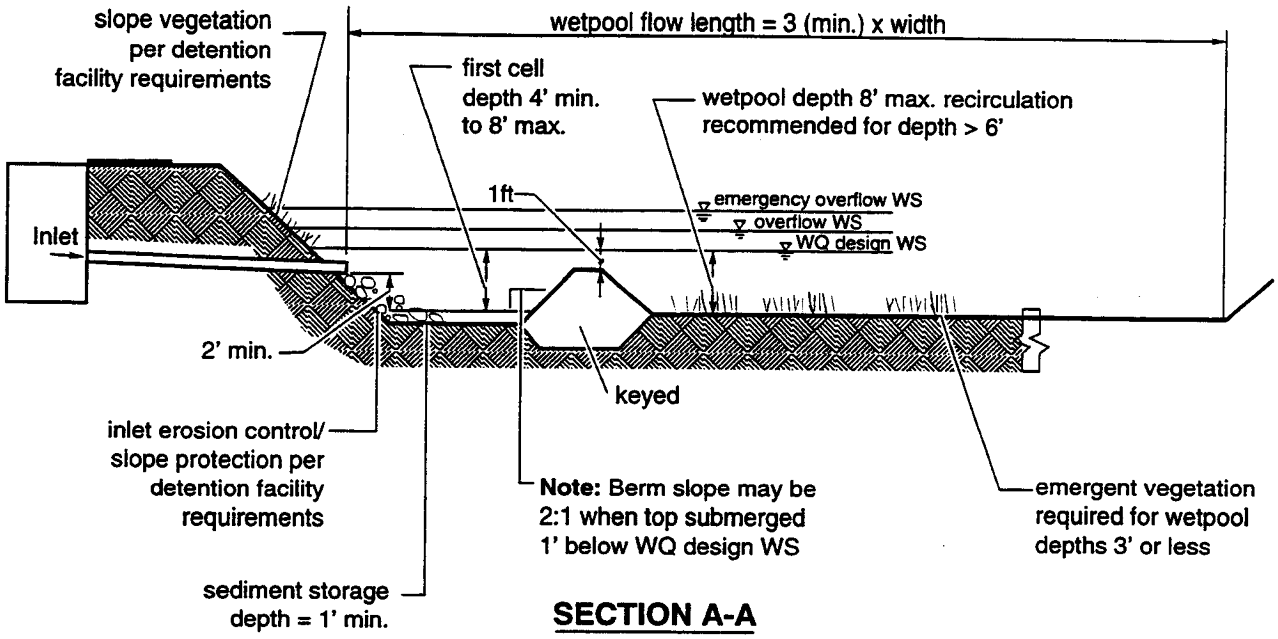
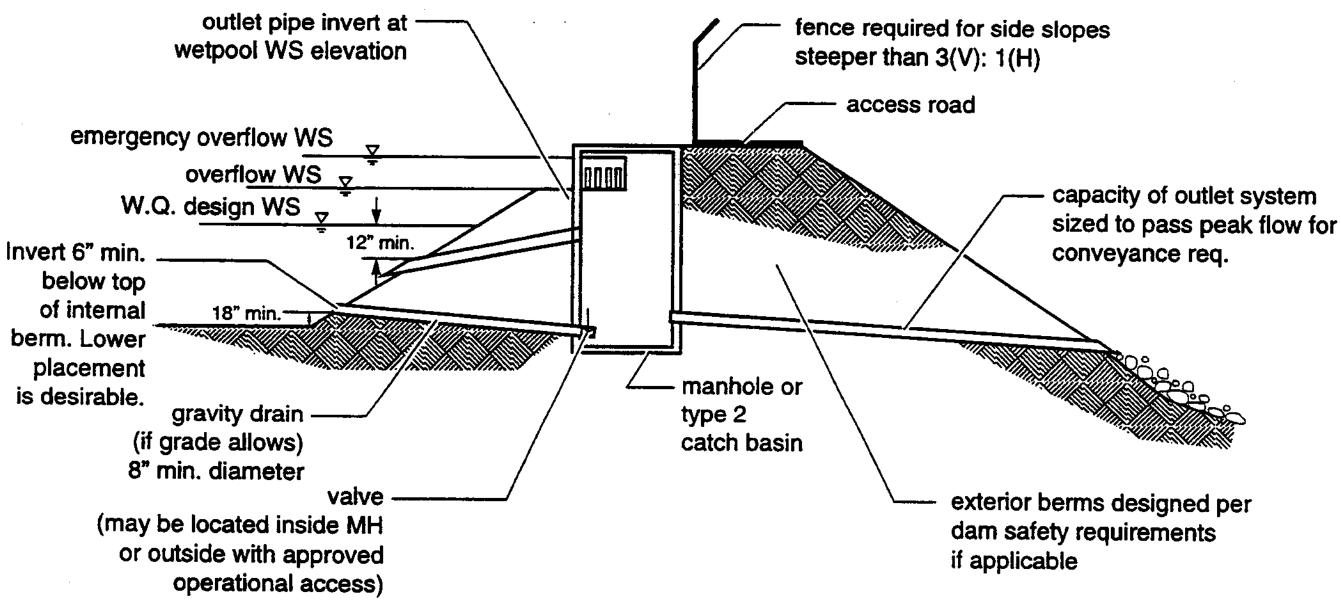
FIGURE 6.4.1.B WETPOND (*CONTINUED*)



SECTION A-A
NTS



SECTION B-B
NTS

NOTE: See detention facility requirements for location and setback requirements.

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6.4.2 WETVAULTS

A *wetvault* is an underground structure similar in appearance to a detention vault, except that a wetvault has a permanent pool of water which dissipates energy and improves the settling of particulate pollutants (see the wetvault details, Figure 6.4.2.A, on page 6-85). Being underground, the wetvault lacks the biological pollutant removal mechanisms, such as algae uptake, present in surface wetponds.

Applications and Limitations

A wetvault may be used in any type or size of development. However, it is most practical in relatively small catchments (less than 10 acres of impervious surface) with high land values because vaults are relatively expensive. Combined detention and wetvaults are allowed; see Section 6.4.4 (p. 6-92).

A wetvault is believed to be ineffective in removing dissolved pollutants such as soluble phosphorus or metals such as copper. There is also concern that oxygen levels will decline, especially in warm summer months, because of limited contact with air and wind. However, the extent to which this potential problem occurs has not been documented.

If oil control is required for a project, the wetvault may be combined with the **baffle oil/water separator** facility (see Section 6.6.2, p. 6-141) to fulfill Special Requirement #5, "Oil Control" (see Option 5, Section 6.1.5, p. 6-14). *Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement #8 and Special Requirement #5.*

6.4.2.1 METHODS OF ANALYSIS

As with wetponds, the primary design factor that determines the removal efficiency of a wetvault is the volume of the wetpool in relationship to the volume of runoff (V_r) from the mean annual storm[28]. The larger the volume, the higher the potential for pollutant removal. Performance is also improved by avoiding dead zones (like corners) where little exchange occurs, using large length-to-width ratios, dissipating energy at the inlet, and ensuring that flow rates are uniform to the extent possible and not increased between cells.

Wetvaults sized using the design methodology below (with a volume of $3V_r$) and following the required design criteria in Section 6.4.2.2 are expected to meet the Basic WQ menu goal of 80% TSS removal.

The methods of analysis for the wetvault are **identical to the methods of analysis for the wetpond.** Follow the procedure specified in Section 6.4.1.1 (p. 6-68) to determine the wetpool volume for the wetvault.

6.4.2.2 DESIGN CRITERIA

In addition to their water quality function, wetvaults may serve a conveyance function, passing flows above the water quality design flow through to the downstream drainage system. When used to convey these flows, vaults must meet the conveyance requirements specified in Chapter 4.

Typical design details and concepts for the wetvault are shown in Figure 6.4.2.A (p. 6-85).

Wetpool Geometry

Same as specified for **wetponds** (see Section 6.4.1.2, p. 6-71) except for the following **two modifications:**

1. **Criterion 3:** The **sediment storage** in the first cell shall be an average of 1 foot. Because of the v-shaped bottom, the depth of sediment storage needed above the bottom of the side wall is roughly proportional to vault width according to the schedule below:

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[28] U.S. Environmental Protection Agency, *Results of the Nationwide Urban Runoff Program*, 1986.

Vault Width	Sediment Depth (from bottom of side wall)
15'	10"
20'	9"
40'	6"
60'	4"

2. **Criterion 5:** The second cell shall be a minimum of 3 feet deep since planting cannot be used to prevent resuspension of sediment in shallow water as it can in open ponds.

Vault Structure

1. Wetvaults shall be designed as flow-through systems.
2. The vault shall be separated into two cells by a **wall** or a **removable baffle.**[29] If a **wall** is used, a 5 foot by 10 foot removable maintenance access must be provided for both cells. If a removable baffle is used, the following criteria apply:
   a) The baffle shall extend from a minimum of 1 foot above the WQ design water surface to a minimum of 1 foot below the invert elevation of the inlet pipe.
   b) The lowest point of the baffle shall be a minimum of 2 feet from the bottom of the vault, and greater if feasible.
3. If the vault is less than 2,000 cubic feet (inside dimensions), or if the length-to-width ratio of the vault pool is 5:1 or greater, and if a gravity drain is provided 12 to 18 inches from the vault bottom, the **baffle or wall** may be omitted and the vault may be one-celled.
4. The two cells of a wetvault should not be divided into additional subcells by **internal walls.** If internal structural support is needed, it is preferred that post and pier construction be used to support the vault lid rather than walls. Any walls used within cells must be positioned so as to lengthen, rather than divide, the flowpath.

   Intent: Treatment effectiveness in wetpool facilities is related to the extent to which plug flow is achieved and short-circuiting and dead zones are avoided. Structural walls placed within the cells can interfere with plug flow and create significant dead zones, reducing treatment effectiveness.
5. The bottom of the first cell shall be sloped toward the inlet. Slope should be between 0.5 percent (minimum) and 2 percent (maximum). The second cell may be level (longitudinally) sloped toward the outlet, with a high point between the first and second cells.
6. The **vault bottom** shall slope laterally a minimum of 5% from each side towards the center, forming a broad "v" to facilitate sediment removal. *Note: More than one "v" may be used to minimize vault depth.*

   Exception: The vault bottom may be flat if **removable panels** are provided over the entire vault. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.
7. The highest point of a **vault bottom** must be at least 6 inches below the outlet elevation to provide for sediment storage over the entire bottom.
8. Provision for passage of flows should the outlet plug shall be provided.
9. Wetvaults may be constructed using **arch culvert sections** provided the top area at the WQ design water surface is, at a minimum, equal to that of a vault with vertical walls designed with an average depth of 6 feet.

   Intent: To prevent decreasing the surface area available for oxygen exchange.

[29] As used here, the term *baffle* means a divider that does not extend all the way to the bottom of the vault, or if a bottom baffle, does not extend all the way to the top of the water surface. A *wall* is used here to mean a divider that extends all the way from near the water surface to the bottom of the vault.

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10. Wetvaults shall conform with the "**Materials**" and "**Structural Stability**" criteria specified for **detention vaults** in Section 5.3.3.

11. Where pipes enter and leave the vault below the WQ design water surface, they shall be **sealed** using a non-porous, non-shrinking grout.

Inlet and Outlet

1. The **inlet** to the wetvault shall be submerged with the inlet pipe invert a minimum of 3 feet from the vault bottom (not including sediment storage). The top of the inlet pipe should be submerged at least 1 foot, if possible.

   Intent: The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Alternative inlet designs that accomplish these objectives are acceptable.

2. Unless designed as an off-line facility, the capacity of the **outlet pipe** and available head above the outlet pipe shall be designed to convey the 100-year design flow for developed site conditions (as described in Section 5.3.4.2) without overtopping the vault. The available head above the outlet pipe must be a minimum of 6 inches.

3. The outlet pipe shall be back-sloped or have tee section, the lower arm of which should extend 1 foot below the WQ design water surface to provide for trapping of oils and floatables in the vault.

4. A **gravity drain** for maintenance shall be provided if grade allows.

   a) The gravity drain should be as low as the site situation allows; however, the **invert** shall be no lower than the average sediment storage depth. At a minimum, the invert shall be 6 inches above the base elevation of the vault side walls.

      Intent: This placement prevents highly sediment-laden water from escaping when the vault is drained for maintenance. A lower placement is allowed than for wetponds since the v-shaped vault bottom will capture and retain additional sediments.

   b) The drain shall be 8 inches (minimum) diameter and shall be controlled by a valve. Use of a shear gate is allowed only at the inlet end of a pipe located within an approved structure.

      Intent: Shear gates often leak if water pressure pushes on the side of the gate opposite the seal. The gate should be situated so that water pressure pushes toward the seal.

   c) Operational access to the valve shall be provided to the finished ground surface. The valve location shall be accessible and well marked with one foot of paving placed around the box. It must also be protected from damage and unauthorized operation.

   d) If not located in the vault, a valve box is allowed to a maximum depth of 5 feet without an access manhole. If over 5 feet deep, an access manhole is required.

Access Requirements

Same as for detention vaults (see Section 5.3.3) except for the following additional requirement for wetvaults:

A minimum of 50 square feet of **grate** shall be provided over the second cell. For vaults in which the surface area of the second cell is greater than 1250 square feet, 4% of the top shall be grated. This requirement may be met by one grate or by many smaller grates distributed over the second cell area. *Note: a grated access door can be used to meet this requirement.*

Intent: The grate allows air contact with the wetpool in order to minimize stagnant conditions which can result in oxygen depletion, especially in warm weather.

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Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Section 5.3.3).

Recommended Design Features

The following design features should be incorporated into wetvaults where feasible, but they are not specifically required:

1. The floor of the second cell should slope toward the outlet for ease of cleaning.
2. The **inlet and outlet** should be at opposing corners of the vault to increase the flowpath.
3. A **flow length-to-width** ratio greater than 3:1 minimum is desirable.
4. **Lockable grates** instead of solid manhole covers are recommended to increase air contact with the wetpool.
5. **Galvanized materials** should be avoided whenever possible.
6. The **number of inlets** to the wetvault should be limited, and the flowpath length should be maximized from inlet to outlet for all inlets to the vault.

Construction Considerations

Sediment that has accumulated in the vault must be removed after construction in the drainage area is complete. If no more than 12 inches of sediment have accumulated after the infrastructure is built, cleaning may be left until after building construction is complete. In general, sediment accumulation from stabilized drainage areas is not expected to exceed an average of 4 inches per year in the first cell. If sediment accumulation is greater than this amount, it will be assumed to be from construction unless it can be shown otherwise. The County will not release maintenance and defect financial guarantees or assume maintenance responsibility for a facility unless it has been cleaned of construction phase sediments.

Maintenance Considerations

1. Accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault. Vault maintenance procedures must meet OSHA confined space entry requirements, which includes clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.
2. Facilities should be inspected annually. Floating debris and accumulated petroleum products should be removed as needed, but at least annually. The floating oil should be removed from wetvaults used as oil/water separators when oil accumulation exceeds one inch.
3. Sediment should be removed when the 1-foot (average) sediment zone is full thus 6 inches. Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.
4. Water drained or pumped from the vault prior to removing accumulated sediments may be discharged to storm drains if it is not excessively turbid (i.e., if water appears translucent when held to light) and if all floatable debris and visual petroleum sheens are removed. Excessively turbid water (i.e., water appears opaque when held to light) should be discharged only after the settleable solids have been removed.

❑ MODIFICATIONS FOR COMBINING WITH A BAFFLE OIL/WATER SEPARATOR

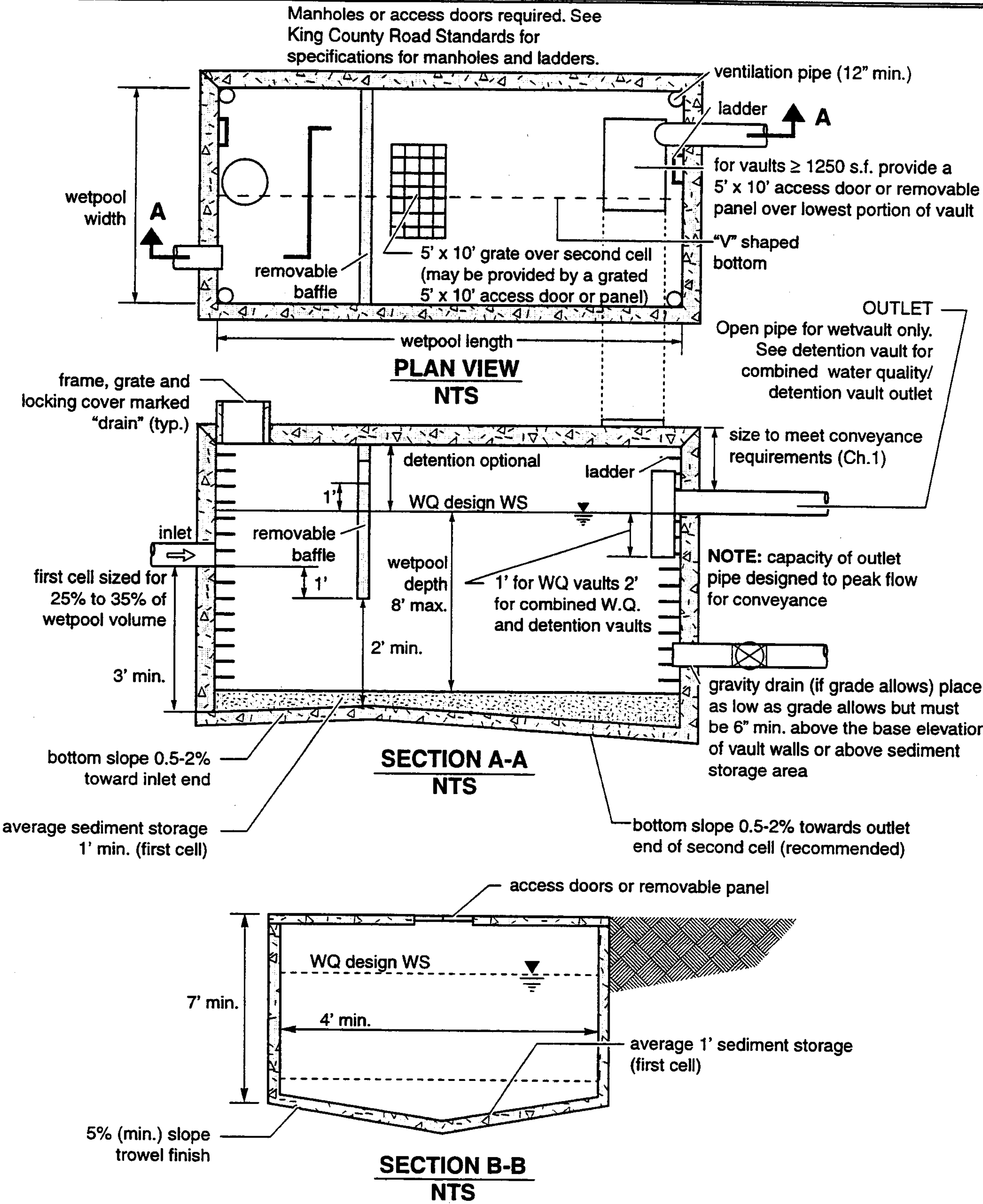
If the project site is a **high-use site** and a wetvault is proposed to meet the Basic WQ menu criteria, the vault may be combined with a baffle oil/water separator (see Section 6.6.2) to meet the requirements of Special Requirement #5 with one facility rather than two. Structural modifications and added design criteria are given below. However, the maintenance requirements for baffle oil/water separators must be adhered to, in addition to those for a wetvault. This will result in more frequent inspection and cleaning than for a wetvault used only for TSS removal. See page 6-150 for information on maintenance of baffle oil/water separators.

1. The sizing procedures for the baffle oil/water separator (p. 6-142) should be run as a check to ensure the vault is large enough. If the oil/water separator sizing procedures result in a larger vault size, increase the wetvault size to match.
2. An **oil retaining baffle** shall be provided in the second cell near the vault outlet. The baffle should not contain a high-flow overflow, or else the retained oil will be washed out of the vault during large storms.
3. The vault shall have a minimum **length-to-width ratio** of 5:1.
4. The vault shall have a design water **depth-to-width** ratio of between 1:3 to 1:2.
5. The vault shall be **watertight** and shall be coated to protect from corrosion.
6. Separator vaults shall have a **shutoff mechanism** on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided.
7. Wetvaults used as oil/water separators must be **off-line** and must bypass flows greater than the WQ design flow.

   Intent: This design minimizes the entrainment and/or emulsification of previously captured oil during very high flow events.

AR 032130

FIGURE 6.4.2.A WETVAULT



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6.4.3 STORMWATER WETLANDS

In land development situations, wetlands are usually constructed for two main reasons: to replace or mitigate impacts when natural wetlands are filled or impacted by development (mitigation wetlands), and to treat stormwater runoff (stormwater treatment wetlands). *Stormwater wetlands* are shallow man-made ponds that are designed to treat stormwater through the biological processes associated with emergent aquatic plants (see the stormwater wetland details in Figure 6.4.3.A, p. 6-90, and Figure 6.4.3.B, p. 6-91).

In King County, wetlands created to mitigate disturbance impacts, such as filling, may not also be used as stormwater treatment facilities. This is because of the different, incompatible functions of the two kinds of wetlands. **Mitigation wetlands** are intended to function as full replacement habitat for fish and wildlife, providing the same functions and harboring the same species diversity and biotic richness as the wetlands they replace. **Stormwater treatment wetlands** are used to capture and transform pollutants, just as wetponds are, and over time the sediment will concentrate pollutants. This is not a healthy environment for aquatic life. Stormwater treatment wetlands are used to capture pollutants in a managed environment **so that they will not reach natural wetlands** and other ecologically important habitats. In addition, vegetation must be harvested and sediment dredged in stormwater treatment wetlands, further interfering with use for wildlife habitat.

In general, stormwater wetlands perform well to remove sediment, metals, and pollutants which bind to humic or organic acids. Phosphorus removal in stormwater wetlands is highly variable.[30]

Applications and Limitations

This stormwater wetland design occupies about the same surface area as wetponds, but has the potential to be better integrated aesthetically into a site because of the abundance of emergent aquatic vegetation. The most critical factor for a successful design is the provision of an **adequate supply of water** for most of the year. Careful planning is needed to be sure sufficient water will be retained to sustain good wetland plant growth. Since water depths are shallower than in wetponds, water loss by evaporation is an important concern. Stormwater wetlands are a good WQ facility choice in areas with **high winter groundwater levels.**

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how this facility can be used to meet Core Requirement #8.

6.4.3.1 METHODS OF ANALYSIS

When used for stormwater treatment, stormwater wetlands employ some of the same design features as wetponds. However, instead of gravity settling being the dominant treatment process, pollutant removal mediated by aquatic vegetation and the microbiological community associated with that vegetation becomes the dominant treatment process. Thus when designing wetlands, water volume is not the dominant design criteria. Rather, factors which affect plant vigor and biomass are the primary concerns.

Stormwater wetlands designed and constructed using the criteria below are expected to meet the Basic WQ menu goal of 80% TSS removal and the Resource Stream Protection goal of 50% total zinc removal.

Steps 1 through 5: Determine the volume of a basic wetpond. Follow Steps 1 through 5 for wetponds (see Section 6.4.1.1, p. 6-68). The volume of a basic wetpond is used as a template for sizing the stormwater wetland.

Step 6: Calculate the surface area of the stormwater wetland. The surface area of the wetland shall be the same as the top area of a wetpond sized for the same site conditions. Calculate the surface area of the stormwater wetland by using the volume from Step 5 and dividing by the average water depth (use 4 feet).

[30] Richardson, C. 1987. "Mechanisms controlling phosphorus retention capacity in freshwater wetlands," *Science*, 228: 1424.

Step 7: Determine the surface area of the first cell of the stormwater wetland. Use the volume determined from Criterion 2 under "Wetland Geometry" (p. 6-87), and a depth of 4 feet.

Step 8: Determine the surface area of the wetland cell. Subtract the surface area of the first cell (Step 7) from the total surface area (Step 6).

Step 9: Determine water depth distribution in the second cell. Decide if the top of the dividing berm will be at the surface or submerged (designer's choice). Adjust the distribution of water depths in the second cell according to Criterion 8 under "Wetland Geometry" below. *Note: This will result in a facility that holds less volume than that determined in Step 5 above. This is acceptable.*

Intent: The surface area of the stormwater wetland is set to be roughly equivalent to that of a wetpond designed for the same site so as not to discourage use of this option.

Step 10: Choose plants. See Table 6.4.1.A (p. 6-75) for a list of plants recommended for wetpond water depth zones, or consult a wetland scientist.

6.4.3.2 DESIGN CRITERIA

Typical details for a **stormwater wetland** are shown in Figure 6.4.3.A (p. 6-90) and Figure 6.4.3.B (p. 6-91).

Wetland Geometry

1. Stormwater wetlands shall consist of two cells, a presettling cell and a wetland cell.
2. The **presettling cell** shall contain a volume equal to the volume of runoff from the mean annual storm (V_r). This is approximately 33 percent of the wetpool volume calculated in Step 5 of "Methods of Analysis," Section 6.4.3.1.
3. The **depth of the presettling cell** shall be between 4 feet (minimum) and 8 feet (maximum).
4. One foot of **sediment storage** shall be provided in the presettling cell.
5. The **wetland cell** shall have an average **water depth** of about 1.5 feet (plus or minus 3 inches).
6. The **"berm"** separating the two cells shall be shaped such that its downstream side gradually slopes to form the second shallow wetland cell (see the section view in Figure 6.4.3.A, p. 6-90). Alternatively, the second cell may be graded naturalistically from the top of the dividing berm (see Criterion 8 below).
7. The **top of berm** shall be either at the WQ design water surface or submerged 1 foot below the WQ design water surface, as with wetponds. Correspondingly, the **side slopes** of the berm must meet the following criteria:
   a) If the top of berm is at the WQ design water surface, the berm side slopes shall be no steeper than 3H:1V.
   b) If the top of berm is submerged 1 foot, the upstream side slope may be up to 2H:1V.[31]
8. Two options (A and B) are provided for **grading the bottom of the wetland cell.** Option A is a shallow, evenly graded slope from the upstream to the downstream edge of the wetland cell (see Figure 6.4.3.A, p. 6-90). Option B is a "naturalistic" alternative, with the specified range of depths intermixed throughout the second cell (see Figure 6.4.3.B, p. 6-91). A **distribution of depths** shall be provided in the wetland cell depending on whether the dividing berm is at the water surface or submerged (see Table 6.4.3.A, below). The maximum depth is 2.5 feet in either configuration.

[31] If the berm is at the water surface, then for safety reasons, its slope must be no greater than 3:1, just as the pond banks must be 3:1 if the pond is not fenced. A steeper slope (2:1 rather than 3:1) is allowed if the berm is submerged in 1 foot of water. If submerged, the berm it is not considered accessible, and the steeper slope is allowed.

TABLE 6.4.3.A DISTRIBUTION OF DEPTHS IN WETLAND CELL			
DIVIDING BERM AT WQ DESIGN WATER SURFACE		DIVIDING BERM SUBMERGED 1 FOOT	
Depth Range (feet)	Percent	Depth Range (feet)	Percent
0.1 to 1	25	1 to 1.5	40
1 to 2	55	1.5 to 2	40
2 to 2.5	20	2 to 2.5	20

Lining Requirements

1. **In infiltrative soils**, both cells of the stormwater wetland shall be lined. To determine whether a low-permeability liner or a treatment liner is required, determine whether the following conditions will be met. If soil permeability will allow sufficient water retention, lining may be waived.
   - The second cell must retain water for at least 10 months of the year.
   - The first cell must retained at least three feet of water year-round.
   - The complete KCRTS precipitation record should be used when establishing these conditions.

   Intent: Many wetland plants can adapt to periods of summer drought, so a limited drought period is allowed in the second cell. This may allow a treatment liner rather than a low permeability liner to be used for the second cell. The first cell must retain water year-round in order for the presettling function to be effective.
2. If a **low permeability liner** is used, a minimum of 18 inches of native soil amended with good topsoil or compost (one part compost mixed with 3 parts native soil) must be placed over the liner. For **geomembrane liners**, a soil depth of 3 feet is recommended to prevent damage to the liner during planting. Hydric soils are not required.
3. The criteria for liners given in Section 6.2.4 (p. 6-22) must be observed.

Inlet and Outlet

Same as for basic wetponds (see page 6-72).

Access and Setbacks

1. Location of the stormwater wetland relative to site constraints (e.g., buildings, property lines, etc.) shall be the same as for detention ponds (see Section 5.3.1). See Section 6.2.3 (p. 6-20) for typical setback requirements for WQ facilities.
2. Access and maintenance **roads** shall be provided and designed according to the requirements for detention ponds (see Section 5.3.1). Access and maintenance roads shall extend to both the wetland inlet and outlet structures. An access ramp (7H minimum:1V) shall be provided to the bottom of the first cell unless all portions of the cell can be reached and sediment loaded from the top. of the wetland side slopes. Also see "Access Requirements" in Section 5.3.1, for more information on access alternatives.
3. If the dividing berm is also used for access, it must be built to sustain loads of up to 80,000 pounds.

Signage

1. Signage shall be provided according to the requirements for detention ponds (see Section 5.3.1).

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2. If the wetland is in a lake or sphagnum bog protection area, then signage prohibiting feeding of waterfowl shall be provided.

Planting Requirements

The wetland cell shall be planted with emergent wetland plants following the recommendations given in Table 6.4.1.A (p. 6-75) or the recommendations of a wetland specialist. *Note: Cattails (Typha latifolia) are not recommended. They tend to escape to natural wetlands and crowd out other species. In addition, the shoots die back each fall and will result in oxygen depletion in the wetpool unless they are removed.*

Construction and Maintenance Considerations

Construction and maintenance considerations are the same as for basic wetponds. Construction of the naturalistic alternative (Option B) can be easily done by first excavating the entire area to the 1.5-foot average depth. Then soil subsequently excavated to form deeper areas can be deposited to raise other areas until the distribution of depths indicated in the design is achieved.

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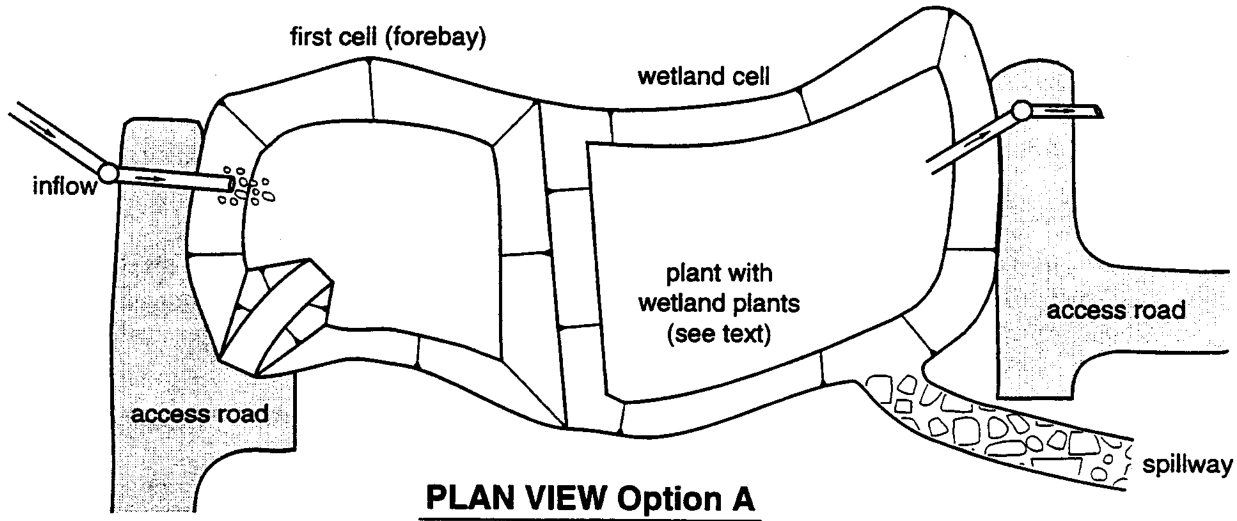
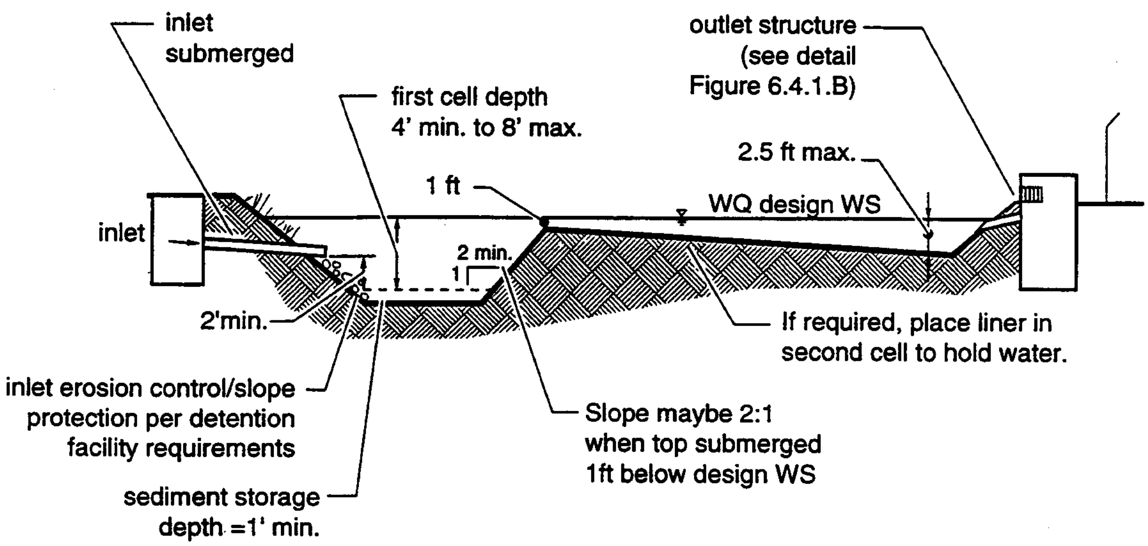
FIGURE 6.4.3.A STORMWATER WETLAND — OPTION A



PLAN VIEW Option A
NTS



SECTION VIEW Option A
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Note: See detention facility requirements for location and setback requirements.

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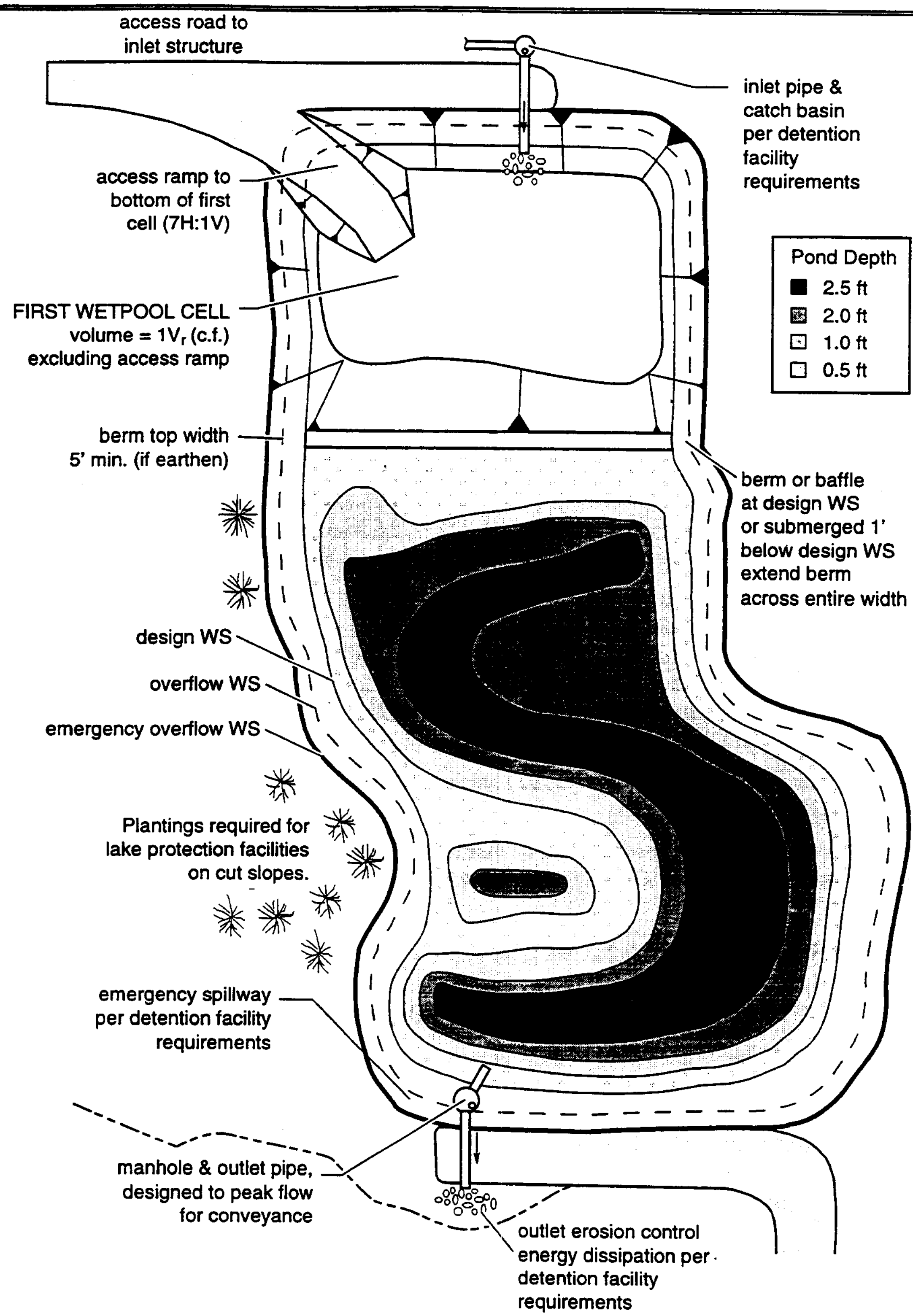
FIGURE 6.4.3.B STORMWATER WETLAND — OPTION B



PLAN VIEW Option B
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6.4.4 COMBINED DETENTION AND WETPOOL FACILITIES

Combined detention and WQ wetpool facilities have the appearance of a detention facility but contain a permanent pool of water as well. The following design procedures, requirements, and recommendations cover differences in the design of the stand-alone WQ facility when combined with detention storage. The following combined facilities are addressed:

- Detention/wetpond (basic and large)
- Detention/wetvault
- Detention/stormwater wetland.

There are two sizes of the combined wetpond, a basic and a large, but only a basic size for the combined wetvault and combined stormwater wetland. The facility sizes (basic and large) are related to the pollutant removal goals stated in the WQ menus. See Section 6.1 (p. 6-3) for more information on the WQ menus and treatment goals.

Applications and Limitations

Combined detention and water quality facilities are very efficient for sites which also have detention requirements. The water quality facility may often be placed beneath the detention facility without increasing the facility surface area. However, the **fluctuating water surface** of the live storage will create unique challenges for plant growth and for aesthetics alike.

The basis for pollutant removal in combined facilities is the same as in the stand-alone WQ facilities. However, in the combined facility, the detention function creates fluctuating water levels and added turbulence. For simplicity, the positive effect of the extra live storage volume and the negative effect of increased turbulence are assumed to balance, and are thus ignored when sizing the wetpool volume.[32] For the combined detention/stormwater wetland, criteria that limit the extent of water level fluctuation are specified to better ensure survival of the wetland plants.

Unlike the wetpool volume, the **live storage component** of the facility should be provided above the seasonal high water table.

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how these combined facilities can be used to meet Core Requirement #8.

6.4.4.1 METHODS OF ANALYSIS

❑ COMBINED DETENTION AND WETPOND (BASIC AND LARGE)

The methods of analysis for combined detention and wetponds are identical to those outlined for wetponds and for detention facilities. Follow the procedure specified in Section 6.4.1.1 (p. 6-68) to determine the wetpool volume for a combined facility. Follow the standard procedure specified in Chapter 5 to size the detention portion of the pond.

❑ COMBINED DETENTION AND WETVAULT

The methods of analysis for combined detention and wetvaults are identical to those outlined for wetvaults and for detention facilities. Follow the procedure specified in Section 6.4.2 (p. 6-80) to determine the wetvault volume for a combined facility. Follow the standard procedure specified in Chapter 5 to size the detention portion of the vault.

[32] Many of the ponds studied in the Nationwide Urban Runoff Program were combined ponds.

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❑ COMBINED DETENTION AND STORMWATER WETLAND

The methods of analysis for combined detention and stormwater wetlands are identical to those outlined for stormwater wetlands and for detention facilities. Follow the procedure specified in Section 6.4.3.1 (p.6-86) to determine the stormwater wetland size. Follow the standard procedure specified in Chapter 5 to size the detention portion of the wetland.

6.4.4.2 DESIGN CRITERIA

❑ COMBINED DETENTION AND WETPOND (BASIC AND LARGE)

Typical design details and concepts for a combined detention and wetpond are shown in Figure 6.4.4.A (p. 6-96). The **detention portion** of the facility shall meet the design criteria set forth in Chapter 5 and sizing procedures in Chapter 3.

Detention and Wetpool Geometry

1. The wetpool and sediment storage volumes shall not be included in the required detention volume.
2. The **"Wetpool Geometry"** criteria for wetponds (see page 6-71) shall apply with the following **modifications/clarifications:**

   a) **Criterion 1:** The **permanent pool** may be made shallower to take up most of the pond bottom, or deeper and positioned to take up only a limited portion of the bottom. Note, however, that having the first wetpool cell at the inlet allows for more efficient sediment management than if the cell is moved away from the inlet. Wetpond criteria governing water depth must, however, still be met. See Figure 6.4.4.B (p. 6-98) for two possibilities for wetpool cell placement.

   Intent: This flexibility in positioning cells is provided to allow for multiple use options, such as volleyball courts in live storage areas in the drier months. Landscape credit can be received subject to criteria in KCC 21A.14.180.D, summarized in "Stormwater Tracts as Recreational or Open Space" in Section 5.3.1.1.

   b) **Criterion 3:** The minimum **sediment storage depth** in the first cell is 1 foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with the detention sediment storage requirement.

Berms, Baffles, and Slopes

Same as for wetponds (see page 6-72).

Inlet and Outlet

The "Inlet and Outlet" criteria for **wetponds** (see page 6-72) shall apply with the following **modifications:**

1. **Criterion 2:** A **sump** must be provided in the outlet structure of combined ponds.
2. The detention flow restrictor and its outlet pipe shall be designed according to the requirements for detention ponds (see Section 5.3.4.2).

Access and Setbacks

Same as for wetponds (see page 6-73).

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Signage

1. Signage shall be provided according to the requirements for detention ponds (see Section 5.3.1).
2. If the wetpond is in a lake or sphagnum bog protection area, signage prohibiting feeding of waterfowl shall be provided.

Planting Requirements

Same as for wetponds (see page 6-74).

❑ COMBINED DETENTION AND WETVAULT

The design criteria for detention vaults and wetvaults must **both** be met, except for the following **modifications or clarifications:**

1. The minimum **sediment storage depth** in the first cell shall average 1 foot. The 6 inches of sediment storage required for detention vaults does not need to be added to this, but 6 inches of sediment storage must be added to the second cell to comply with detention vault sediment storage requirements.
2. The **oil retaining baffle** shall extend a minimum of 2 feet below the WQ design water surface.

   Intent: The greater depth of the baffle in relation to the WQ design water surface compensates for the greater water level fluctuations experienced in the combined vault. The greater depth is deemed prudent to better ensure that separated oils remain within the vault, even during storm events.

Note: If a vault is used for detention as well as water quality control, the facility may not be modified to function as a baffle oil/water separator as allowed for wetvaults on page 6-84. This is because the added pool fluctuation in the combined vault does not allow for the quiescent conditions needed for oil separation.

❑ COMBINED DETENTION AND STORMWATER WETLAND

/stormwater The design criteria for detention ponds and stormwater wetlands must both be met, except for the following **modifications or clarifications:**

1. The **"Wetland Geometry"** criteria for stormwater wetlands (see page 6-87) are modified as follows:

   Criterion 4: The minimum **sediment storage depth** in the first cell is 1 foot. The 6 inches of sediment storage required for detention ponds does not need to be added to this, nor does the 6 inches of sediment storage in the second cell of detention ponds need to be added.

   Intent: Since emergent plants are limited to shallower water depths, the deeper water created before sediments accumulate is considered detrimental to robust emergent growth. Therefore, sediment storage is confined to the first cell which functions as a presettling cell.

2. The "**Inlet and Outlet**" criteria for **wetponds** (see page 6-72) shall apply with the following **modifications:**

   a) **Criterion 2:** A **sump** must be provided in the outlet structure of combined facilities.

   b) The detention **flow restrictor** and its outlet pipe shall be designed according to the requirements for detention ponds (see Section 5.3.4.2).

3. The **"Planting Requirements"** for stormwater wetlands (see page 6-89) are **modified** to use the following plants which are better adapted to water level fluctuations:

   - *Scirpus acutus* (hardstem bulrush) 2 - 6' depth
   - *Scirpus microcarpus* (small-fruited bulrush) 1 - 2.5' depth

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- *Sparganium emersum* (burreed) 1 - 2' depth
- *Sparganium eurycarpum* (burreed) 1 - 2' depth
- *Veronica* sp. (marsh speedwell) 0 - 1' depth

In addition, the shrub *Spirea douglasii* (Douglas spirea) may be used in combined facilities.

Water Level Fluctuation Restrictions: The difference between the WQ design water surface and the maximum water surface associated with the 2-year runoff shall not be greater than 3 feet. If this restriction cannot be met, the size of the stormwater wetland must be increased. The **additional area** may be placed in the first cell, second cell, or both. If placed in the second cell, the additional area need not be planted with wetland vegetation or counted in calculating the average depth.

Intent: This criterion is designed to dampen the most extreme water level fluctuations expected in combined facilities to better ensure that fluctuation-tolerant wetland plants will be able to survive in the facility. It is **not intended** to protect native wetland plant communities and is **not to be applied to natural wetlands.**

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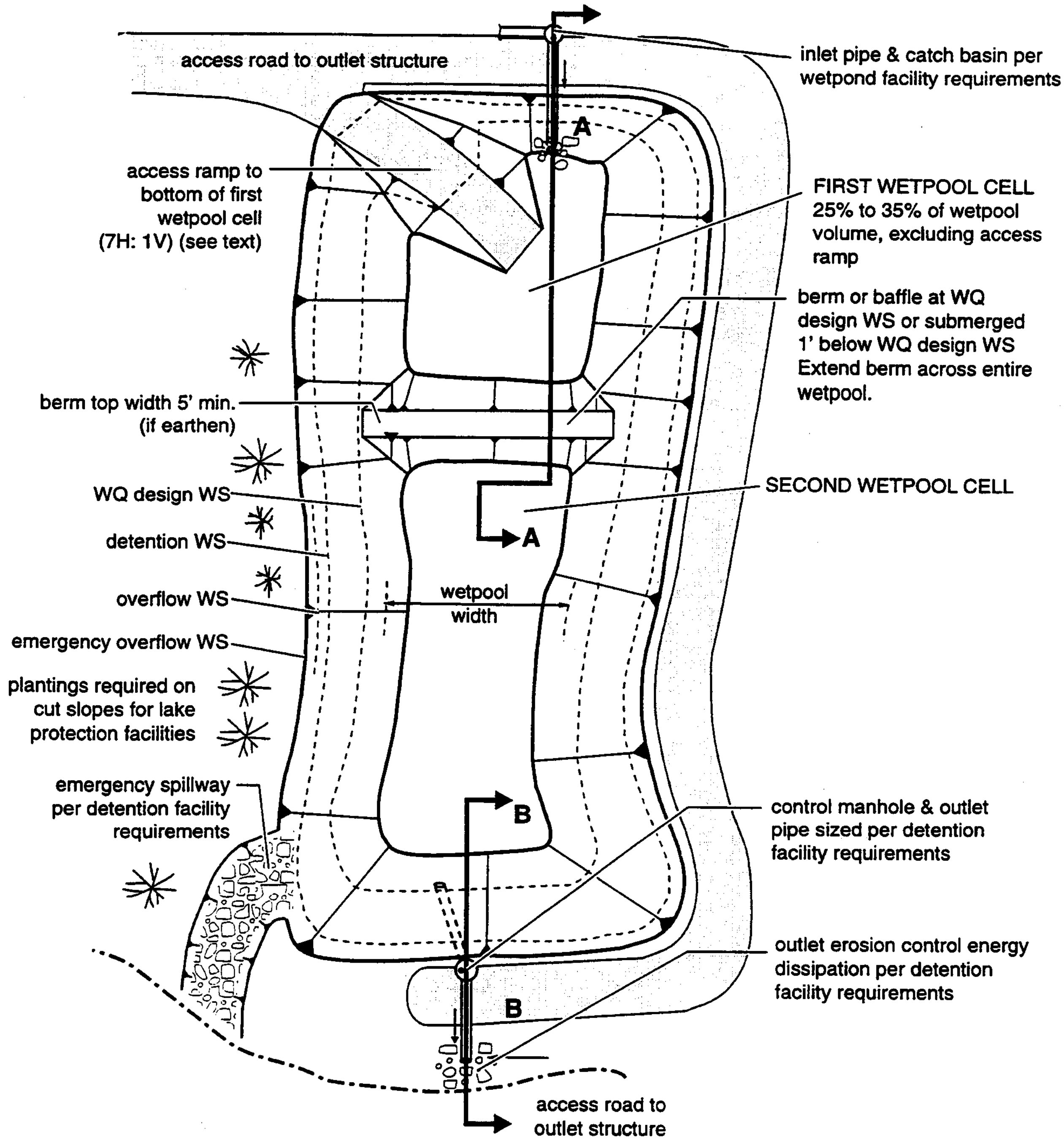
FIGURE 6.4.4.A COMBINED DETENTION AND WETPOND



PLAN VIEW
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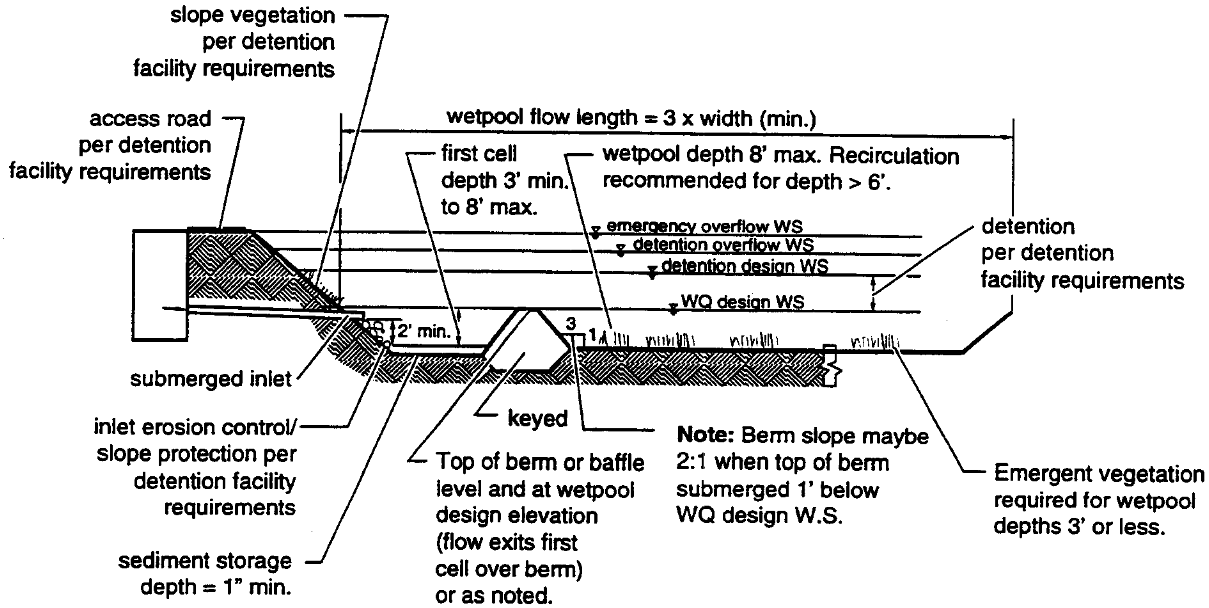
FIGURE 6.4.4.A COMBINED DETENTION AND WETPOND (*CONTINUED*)



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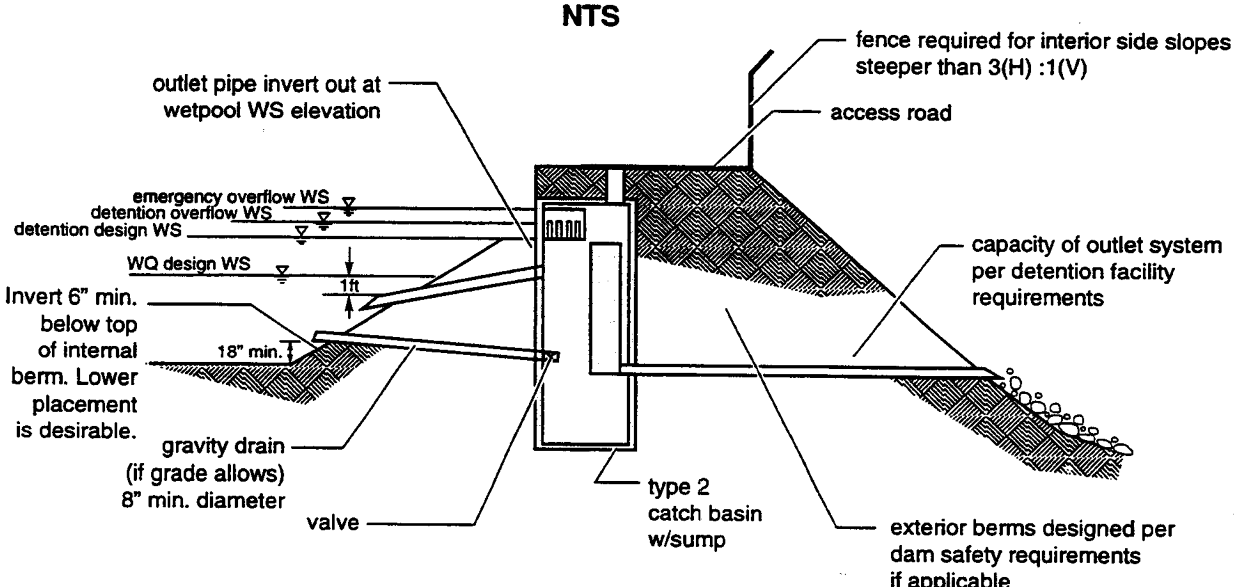

Note: See detention facility requirements for location, interior & exterior sideslopes, and setback requirements.

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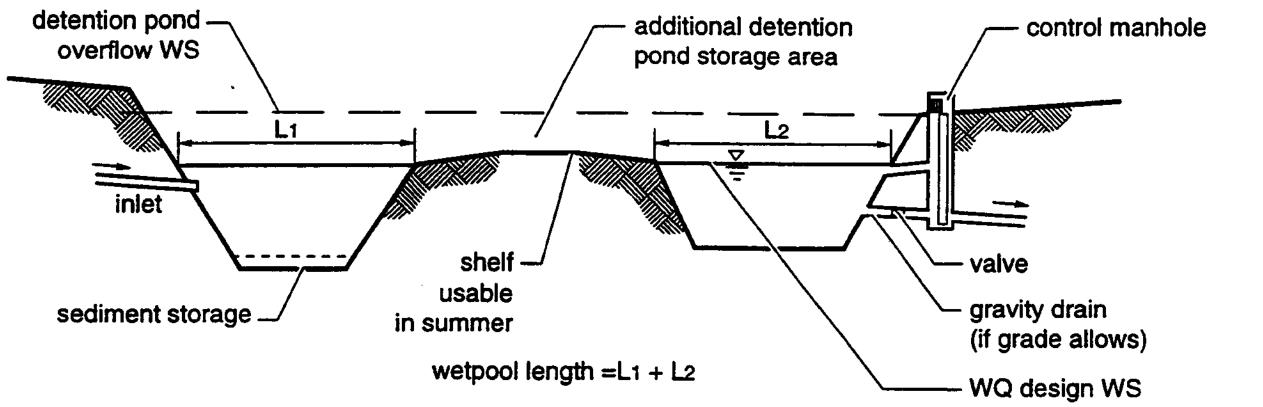
FIGURE 6.4.4.B ALTERNATIVE CONFIGURATIONS OF DETENTION AND WETPOOL AREAS



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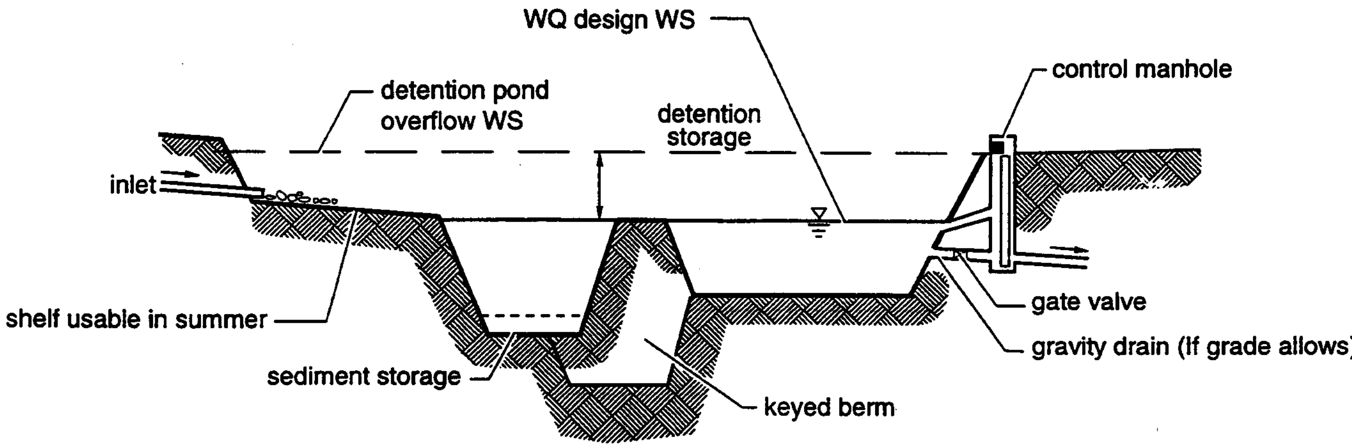

SECTION VIEW
NTS

Note: These examples show how the combined detention/wetpool can be configured to allow for "shelves" for joint use opportunities in dry weather. Other options may also be acceptable.

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6.5 MEDIA FILTRATION FACILITY DESIGNS

This section presents the methods, criteria, and details for analysis and design of sand filters and generic information for leaf compost filters. Specifically, the following specific facility designs are included in this section:

- Sand Filters — Basic and Large, Section 6.5.2
- Sand Filter Vaults, Section 6.5.3
- Linear Sand Filters, Section 6.5.4
- Leaf Compost Filters (LCF), Section 6.5.5

The information presented for each filtration facility is organized into the following categories:

1. **Methods of Analysis:** Contains a step-by-step procedure for designing and sizing each facility. Information used in the procedure is based on available literature, but clarified or modified where deficiencies were identified.[33]
2. **Design Criteria:** Contains the details, specifications, and material requirements for each facility.

6.5.1 GENERAL REQUIREMENTS FOR MEDIA FILTRATION FACILITIES

Presettling Requirement

Filtration facilities are particularly susceptible to clogging. Presettling must therefore be provided before stormwater enters a filtration facility. This requirement may be met by **any of the following:**

1. A water quality facility from the Basic WQ Menu (see Section 6.1.1 for facility options).
2. A presettling pond or vault, which can be integrated as the first cell of the filtration facility, with a treatment volume equal to 0.75 times the runoff from the mean annual storm ($V_r = 0.75$). See Section 6.4.1.1 (p. 6-68) for information on computing V_r. See design requirements below. *Note: For the linear sand filter, use the sediment cell sizing given in the design instead of the above sizing.*
3. A detention pond sized to meet the Level 2 flow control standard.

Other Pretreatment Requirements

1. Sand filters not preceded by a facility that captures floatables, such as a spill control tee, must provide pretreatment to remove **floatable trash and debris** before flows reach the sand bed. This requirement can be met by providing a catch basin with a riser on the inlet to the sand filter (see Figure 6.5.2.C, p. 6-118).
2. For high-use sites, sand filters must be preceded by an **oil control option** from the High-Use menu, Section 6.1.5 (p. 6-14).

Design Criteria For Presettling Cells

1. If water in the presettling cell or upstream WQ facility will be in direct contact with the soil, it must be **lined** per the liner requirements in Section 6.2.4.

   Intent: to prevent groundwater contamination from untreated stormwater runoff in areas of excessively drained soils.

[33] Such modifications were often based on computer modeling using the King County Runoff Time Series (KCRTS) model. Less frequently, they were based on bench-scale studies. Back-up studies are listed in Reference Section 5.

2. The presettling cell shall conform to the following:
   a) The **length-to-width ratio** shall be 3:1. Berms or baffles may be used to lengthen the flowpath.
   b) The **minimum depth** shall be 3 feet; the **maximum depth** shall be 6 feet.
3. Inlets and outlets shall be designed to minimize velocity and reduce turbulence.

6.5.2 SAND FILTERS — BASIC AND LARGE

A *sand filter* operates much like an infiltration pond (see the sand filter detail in Figure 6.5.2.A, p. 6-116). However, instead of infiltrating into native soils, stormwater filters through a constructed sand bed with an underdrain system. Runoff enters the pond and spreads over the surface of the filter. As flows increase, water backs up in the pond where it is held until it can percolate through the sand. The treatment pathway is vertical (downward through the sand) rather than horizontal as it is in biofiltration swales and filter strips. High flows in excess of the WQ treatment goal simply spill out over the top of the pond. Water that percolates through the sand is collected in an underdrain system of drain rock and pipes which directs the treated runoff to the downstream drainage system.

A sand filter removes pollutants by filtration. As stormwater passes through the sand, pollutants are trapped in the small spaces between sand grains or adhere to the sand surface. Over time, soil bacteria will also grow in the sand bed, and some biological treatment may occur. To get better performance from a sand filter, the volume of water spilled over the top should be reduced. Increasing the sand thickness will not dependably improve performance.

The following design procedures, requirements, and recommendations cover two sand filter sizes: a basic size and a large size. The **basic sand filter** is designed to meet the Basic WQ menu goal of 80% TSS removal. The **large sand filter** is expected to meet the Sensitive Lake Protection menu goal of 50% total phosphorus removal.

Applications and Limitations

A sand filter can be used in most residential, commercial, and industrial developments where site topography and drainage provide adequate hydraulic head to operate the filter. **An elevation difference of about 4 feet between the inlet and outlet of the filter is usually needed** to install a sand filter.

Sand filters could be easily integrated into landscape plans as areas for summer sports, such as volleyball. Landscape uses may be somewhat constrained because the vegetation capable of surviving in sand is limited. Trees and shrubs which generate a large leaf fall should be avoided in the immediate vicinity of the filter because leaves and other debris can clog the surface of the filter.

Sand filters are designed to prevent water from backing up into the sand layer (the underdrain system must drain freely). Therefore, a sand filter is more **difficult to install in areas with high water tables** where groundwater could potentially flood the underdrain system. Water standing in the underdrain system will also keep the sand saturated. Under these conditions, oxygen can be depleted, releasing pollutants such as metals and phosphorus that are more mobile under anoxic conditions.

Because the surface of the sand filter will clog from sediment and other debris, this facility **should not be used in areas where heavy sediment loads are expected.** A sand filter should not be used during construction to control sediments unless the sand bed is replaced periodically during construction and after the site is stabilized.

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how basic and large sand filters can be used to meet Core Requirement # 8.

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6.5.2.1 METHODS OF ANALYSIS

This section presents the methods of analysis for both **basic and large sand filters.**

A sand filter is designed with two parts: (1) a **temporary storage reservoir** to store runoff, and (2) a **sand filter bed** through which the stored runoff must percolate. Usually the storage reservoir is simply placed directly above the filter, and the floor of the reservoir pond is the top of the sand bed. For this case, the storage volume also determines the hydraulic head over the filter surface, which increases the rate of flow through the sand.

Two methods are given here to size sand filters: a simple method and a detailed computer modeling method. The **simple method** uses standard values to define filter hydraulic characteristics for determining the sand surface area. This method is useful for planning purposes, for a first approximation to begin iterations in the detailed method, or when use of the detailed computer model is not desired or not available. The simple sizing method **very often results in a larger filter** than the detailed method.

The **detailed routing method** uses the King County Runoff Time Series (KCRTS) computer model to determine sand filter area and pond size based on individual site conditions.[34] Use of the KCRTS design method **very often results in smaller filter sizes** than the simple method, **especially if the facility is downstream of a detention pond**. Both methods include parameters for sizing either a basic or a large sand filter.

Background

There are several variables used in sand filter design which are similar and often confused, even by well-trained individuals. Use of these variables is explained below.

The sand filter design is based on Darcy's law:

$$Q = KiA \tag{6-16}$$

where Q = WQ design flow (cfs)
K = hydraulic conductivity (fps)
A = surface area perpendicular to the direction of flow (sf)
i = hydraulic gradient (ft/ft) for a constant head and constant media depth, computed as follows:

$$i = \frac{h+l}{l} \tag{6-17}$$

where h = average depth of water above filter (ft), defined for this design as $d/2$
d = maximum storage depth above filter (ft)
l = thickness of sand media (ft)

Although it is not seen directly, Darcy's law underlies both the simple and the routing design methods. ***V***, or more correctly, ***1/V***, is the direct input in the sand filter design. The relationship between V and K is revealed by equating Darcy's law and the equation of continuity, $Q = VA$. *Note: When water is flowing into the ground, V is commonly called the **filtration** rate. It is ordinarily measured in a percolation test.*

[34] These flows are roughly equivalent to the WQ design flows used by the Dept. of Ecology in it's 1992 stormwater management manual. The Ecology design flow is based on the peak flow predicted by the SBUH event model for 64% of the 2-year 24-hour rainfall.

Specifically:

$$Q = KiA \quad \text{and} \quad Q = VA$$

so

$$VA = KiA \quad \text{or} \quad V = Ki \qquad (6\text{-}18)$$

Note that $V \neq K$—that is, the filtration rate is not the same as the hydraulic conductivity, but they do have the same units (distance per time). K can be equated to V by dividing V by the hydraulic gradient i, which is defined above in Equation (6-17).

The hydraulic conductivity ***K* does not change with head** nor is it dependent on the thickness of the media, only on the characteristics of the media and the fluid. The hydraulic conductivity of 1 inch per hour (2.315×10^{-5} fps) used in this design is based on bench-scale tests of conditioned rather than clean sand. This design hydraulic conductivity represents the average sand bed condition as silt is captured and held in the filter bed.[35]

Unlike the hydraulic conductivity, the filtration rate ***V* changes with head and media thickness**, although the media thickness is constant in the sand filter design. Table 6.5.2.B on page 6-106 shows values of V for different water depths d (remember, $d = 2h$).

The KCRTS program uses the inverse of the filtration rate, $1/V$, in units of minutes per inch; this is how Darcy's law is expressed in the design. The simple method is also based on $1/V$, but flows and areas are computed for the user in terms of acre equivalents. Thus both the simple and the KCRTS method are based on Darcy's law.

The simple sizing method is different from the KCRTS method because it does not route flows through the filter. It determines the size of the filter based on the simple assumption that inflow is immediately discharged through the filter as if there were no storage volume. An **adjustment factor**–the 0.7 in Equation (6-19)–is applied to compensate for the greater filter size resulting from this method. Even with this adjustment factor, however, the simple method generally produces larger filter sizes than the detailed routing method.

Simple Sizing Method

The simple method has been developed to design sand filters that meet the required treatment volume without performing detailed modeling. Steps for the simple sizing procedure are summarized below.

Step 1: Determine whether a basic or large sand filter is needed. Consult the water quality menus in Section 6.1 (p. 6-3) to determine the size of filter needed, either basic or large.

Step 2: Determine the rainfall region and regional scale factor. Regional scale factors are used to account for differences in rainfall at locations distant from the two gaging locations in King County, Sea-Tac Airport and Landsburg. Refer to the precipitation scaling map in Chapter 3, Figure 3.2.2.A, to determine the scale factor for the project area.

Step 3: Determine maximum depth of water above sand filter. Determine the maximum water storage depth above the surface of the filter. This depth is defined as the depth at which water begins to overflow the reservoir pond, and it depends on site topography and hydraulic constraints. The depth is chosen by the designer.

[35] King County has tested various sand mixes conditioned with simulated stormwater to establish realistic design standards. Tests were conducted under falling head conditions in columns containing 18 inches of sand underlain with a 2-inch layer of washed drain gravel containing a section of 2-inch perforated PVC pipe to simulate the underdrain system. Details are given in Koon, John, "Determination of infiltration rate and hydraulic conductivity for various sand filter media." January 1996.

Step 4: Determine site characteristics. Determine the total number of impervious acres and the total number of grass acres draining to the sand filter. Determine whether the site is on till or outwash soils. Refer to Table 3.2.2.B in Chapter 3 to determine which soil types are considered till and which are considered outwash.

Step 5. Calculate minimum required surface area for sand filter. Determine the sand filter area by multiplying the values in Table 6.5.2.A by the site acreages from Step 4 using the following equation:

$$A_{sf} = 0.7C_s\,(T_iA_i + T_{tg}A_{tg} + T_{tf}A_{tf} + T_{og}A_{og}) \qquad (6\text{-}19)$$

where A_{sf} = sand filter area (sf)
0.7 = adjustment factor to account for routing effect on size
C_s = regional scale factor (unitless) from Step 2
$T_{i,tg,og}$ = tributary area per soil/cover type (acres)
$A_{i,tg,og}$ = filter area per soil/cover type (sf/acre) from Table 6.5.2.A

For depths between the values given in the table, areas can be interpolated. For depths outside the range presented in the table, the detailed routing method must be used.

TABLE 6.5.2.A SAND FILTER AREA INCREMENTS FOR VARIOUS SOIL AND COVER TYPES

Region and Treatment Goal	Maximum Depth above filter (ft)	SOIL AND COVER TYPES[36] [filter area (sf) / tributary area (acre)]		
		A_i Impervious	A_{tg} Till Grass	A_{og} Outwash Grass
Sea-Tac Basic size	6	760	160	140
	3	1140	240	210
	1	1711	360	314
Landsburg Basic size	6	819	180	160
	3	1229	270	235
	1	1844	405	355
Sea-Tac Large size	6	1179	279	250
	3	1769	419	370
	1	2654	629	550
Landsburg Large size	6	1300	300	260
	3	1950	449	395
	1	2926	674	590

Note: Forested areas may be ignored. Vegetated areas other than grass may still be represented as grass for the simple sizing method, or the detailed routing method may be employed using actual cover types.

[36] The values in Table 6.5.2.A were derived as follows. Flows were estimated using the KCRTS model for one acre of the cover types selected in the table. Darcy's law (*Q = Ki A*) was then used to determine sand filter area using this flow *Q*, the hydraulic gradient *i* for the various ponding depths given, and a hydraulic conductivity *k* of 2.3 X 10^{-5} fps (1 inch/hr). The hydraulic gradient *i* was calculated as $(h+l)/l$, where h = the average depth of water above the filter, taken to be the ponding depth *d/2*, and l = the thickness of the sand layer, which is 1.5 feet. The hydraulic conductivity represents a partially plugged sand condition found by bench-scale testing using successive trials with turbid water.

Step 6: Size the underdrain system. The underdrain system is sized to convey the peak filtered flows to the outlet. The design criteria in "Underdrain Systems" (p. 6-110) can be used in lieu of analyzing conveyance capacity for feeder pipes. Strip drains must be analyzed for conveyance per manufacturer's specifications.

The collector pipe (i.e., the pipe collecting flows from the rest of the underdrain system) shall be sized to convey the 2-year, 15-minute peak flow with one foot of head above the invert of the upstream end of the collector pipe. Conveyance capacity can be checked using the "BW" computer program.

Intent: The underdrain must be able to remove standing water from beneath the sand. If standing water remains, the sand will remain saturated. This could cause oxygen depletion and reducing conditions in the sand, allowing some pollutants to become mobile and be released from the filter to downstream receiving waters.

Simple Method Sizing Example

For a site near the city of Snoqualmie with 2 acres of impervious area and 2 acres of outwash grass draining to the sand filter, and 3 feet of head above the filter, the **required sand area** for a **basic size sand filter** would be found as follows:

	Site Areas		Table 6.5.2.A values for Landsburg, basic size		
	2 acres	x	1229 sf/acre	=	2458 sf
+	2 acres	x	235 sf/acre	=	470 sf
				=	2928 sf

Multiply 2928 square feet by the C_s for the Snoqualmie area, which (from Figure 3.2.2.A) is 1.2 times the increments for the Landsburg area. Also, multiply that result by the 0.7 adjustment factor.

2928 sf x 1.2 x 0.7 = 2460 sf

The required sand bed area is therefore **2460 square feet.**

Note: Find the total facility area by adding 3H:1V side slopes for the 3 foot ponding depth plus extra vertical height to convey the 100-year flow. If the total pond depth is 3.5 feet, the sand filter will require a total land area of (50 ft + 10.5 ft) x (50 ft + 10.5 ft) = 3660 square feet, plus access and setback requirements.

Detailed KCRTS Routing Method

The KCRTS routing method allows the designer to optimize filter geometry and sizing to meet specific site conditions. For sand filters located downstream of detention ponds, this method will result in **significantly smaller facilities** than using the simple method described above. The detailed method requires a trial and error solution using KCRTS to route the inflow runoff time series through various sand filter configurations until the amount of runoff that passes through the filter media and is treated meets the treatment objective defined for the facility. Refer to the *KCRTS Computer Software Reference Manual* for general instructions on using the KCRTS program. Steps for the design process, with specific instructions on how to use KCRTS for sand filter sizing, are described below.

Step 1: Determine whether a basic or large sand filter is required. Consult the water quality menus in Section 6.1 (p. 6-3) to determine the size of filter needed. A basic sand filter is sized so that 90% of the runoff volume will pass through the filter, rather than 95% as stated in Section 6.2.1 (p. 6-17) for the WQ design volume. A large sand filter is sized to permit the full 95% of the runoff volume to pass through the filter.[37]

Step 2: Determine rainfall region and regional scale factor. Regional scale factors are used to account for differences in rainfall at various locations in King County. Refer to the precipitation scaling map in Chapter 3, Figure 3.2.2.A, to determine the scale factor for the project area.

Step 3: Create inflow time series. The developed inflow time series is created using the KCRTS program as described in Chapter 3. If the sand filter is upstream of detention, the time series is that of the developed site. If the sand filter is downstream of detention, the time series is that leaving the detention pond.

Note: Sand filters located downstream from detention ponds are significantly smaller than those treating runoff before it is detained. Likewise, sand filters receiving flows from Level 2 detention ponds are smaller than those below Level 1 ponds.

Step 4: Determine the design overflow volume (on-line facilities). The percent of total runoff volume required to pass through the filter was determined in Step 1 (either 90 or 95%). To determine the design overflow volume, multiply the total runoff volume by one minus the percentage (either 0.10 or 0.05). The total runoff volume can be found using the "Compute Volume Discharge" routine found in the "Analysis Tools" module after the inflow time series is created. Detailed instructions for creating the time series can be found in the *KCRTS Computer Software Reference Manual.*[38]

The start and end dates for the reduced runoff time series are as follows:

Start date: 10/1/0

End date: 9/30/8

Note: For most WQ facilities, the designer can chose to design the facility as either on-line (all flow goes through the facility) or off-line (flows above the WQ design flow bypass the facility). An off-line sand filter has a high-flow bypass with an upstream flow splitter designed to bypass flows above 60% of the 2-yr peak discharge using 15-min time steps calibrated to specific site conditions (see Section 6.2.5, p. 6-27, for more information on flow splitter design). The design overflow volume for off-line sand filters is zero, since all flows routed to the filter will be at or below the WQ design flow.

Step 5: Define sand filter modeling parameters. Sand filters can be sized with the "Size a Facility" routine using the infiltration pond option. The following parameters are required for the analysis:

a) Manual Mode: When specifying the filename for the facility, switch the "Design Technique" to manual which allows the user full control of all facility parameters.

b) Side slope: horizontal component of slope (ft/ft) for the pond (above the sand filter)

c) Sand filter area A_{sf}: the surface area of the filter (sf). As a first approximation, it is recommended that the area calculated using the simple sizing method be used. KCRTS refers to this area as the bottom area of the infiltration pond.

d) Maximum water depth d over filter: depth at which runoff begins to overflow the sand filter (ft), referred to in KCRTS as the effective storage depth of the reservoir.

[37] For sand filters, the volume to be treated to meet the Basic menu goal is only 90% (rather than 95%) of the total runoff volume. This is because the sand filter has been documented to provide better than 80% TSS removal, and thus exceeds the treatment goal of the Basic WQ menu. Therefore, less runoff volume can be treated and still meet the basic water quality goal.

[38] Instructions for creating the time series are summarized as follows: **Select** "CREATE a new time series" at the main menu. Enter rainfall region and scale factor (see Figure 3.2.2.A), soil and land cover areas, time step, and data type (reduced record). **Select** "COMPUTE total area." Enter a name for the inflow time series. **Select** "COMPUTE time series." Press F10 to view information created; press "ENTER" to return to main menu. At the main menu, **select** "ENTER analysis tools module." **Select** "COMPUTE volume discharge," and enter the inflow time series name. Enter start date and end date for time series. **Select** "EXTRACT discharge volume." This is the total runoff volume in the time series. **Select** "CONTINUE," and then **select** "RETURN to main menu."

e) Permeable surfaces: bottom only.

f) Riser and orifice information:

- Elevation at 0 stage: 0 is fine for design. This sets a datum adjustment; which if set, the program will display water levels based on relative stage and absolute elevation.
- Riser head: same as the maximum water depth.
- Riser diameter: 12 - 36 inches (must meet the criteria for "Overflow and Bypass Structures," p. 6-108).
- Number of orifices: zero.
- Top of riser: flat.

g) Vertical infiltration: the inverse of the filtration rate *V*, or 1/*V*, and is entered in units of **minutes per inch.** Values for *V* and 1/*V* for various ponding depths are summarized in Table 6.5.2.B (below).

TABLE 6.5.2.B SAND FILTER DESIGN PARAMETERS

	Sand Filter Design Parameters					
Facility ponding depth *d* (ft)	1	2	3	4	5	6
Filtration rate *V* (in/hr)*	1.33	1.67	2.00	2.33	2.67	3.0
1/*V* (min/in)	45	36	30	26	22.5	20

* *Note:* The filtration rate is not used directly but is provided for information. *V* equals the hydraulic conductivity *K* times the hydraulic gradient *i*. The hydraulic conductivity used is 1 inch/hr. The hydraulic gradient = $(h + l) / l$, where $h = d/2$ and l = the sand depth (1.5 ft). See "Background" (p. 6-101) for more information on the definition of terms.

Step 6: Size the sand filter. The KCRTS facility sizing routine is used to design the sand filter as follows:

a) Select "Size a facility" option from the KCRTS main menu.

b) Specify a filename to save the sand filter data.

c) Toggle the "Design Technique" to manual mode.

d) Select "Create a New Detention Facility."

e) Specify an infiltration pond as the facility type, and input the facility specifications determined in Step 5. The primary variable to be adjusted by the designer is the bottom area, which corresponds to the required filter area.

f) Once specified, select the "Save Facility" option.

Step 7: Specify the filename of the Inflow time series.

a) From the main "Facility" menu, select [H] "Edit Inflow Hydrograph List." **AR 032152**

b) Specify the filename of the inflow time series.

c) Select "Return to Main Menu." Since sizing of sand filters in done in manual (rather than automatic) mode, there is no need to complete the setup of the test inflow hydrograph list.

Step 8: Route inflow time series through sand filter and compare volumes. Compare the outflow volume passing through the filter with the required treatment volume. KCRTS can perform the time series routing and the volume comparisons. To set up the volume comparison, perform the following steps:

a) Select [M] " Modify Auto-Analysis," and enter facility outflow name.

b) Toggle the "Volume Calculation" on.

c) Select "Edit Peak/Duration/Volume Information," and specify the same start and end dates specified in Step 4.

d) Return to the main facility design menu and select [A] "Route Time Series."

e) Select "Perform Auto-Analysis." Press F10 to display routing data; press RETURN twice to continue with volume calculation. Press F10 to view the time series outflow volume. This represents the total volume of water which overtopped the facility. Compare the discharge volume with the design discharge volume identified in Step 4.

- If the volume of water spilled exceeded the design outflow volume, increase the bottom area of the facility by selecting [E] "Edit Facility." Repeat this step until the desired performance is achieved.

- If the volume of water spilled is less than the design outflow volume, decrease the bottom area until the outflow and the design outflow match (approximately).

Step 9: Size the underdrain system. The underdrain system is sized to convey the peak filtered flows to the outlet. The design criteria in "Underdrain Systems" (p. 6-110) can be used in lieu of analyzing conveyance capacity for feeder pipes. Strip drains must be analyzed for conveyance per manufacturer's specifications.

The collector pipe (i.e., the pipe collecting flows from the rest of the underdrain system) shall be sized to convey the 2-year, 15-minute peak flow with one foot of head above the invert of the upstream end of the collector pipe. Conveyance capacity can be checked with the "KCBW" computer program.

Intent: The underdrain must be able to remove standing water from beneath the sand. If standing water remains, the sand will remain saturated. This could cause reducing conditions in the sand, allowing some pollutants to become mobile and be released from the filter to downstream receiving waters.

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6.5.2.2 DESIGN CRITERIA

General design concepts and a typical layout of a sand filter are shown in Figure 6.5.2.B (p. 6-116) and Figure 6.5.2.C (p. 6-118).

Sand Filter Geometry

1. **Any shape** sand bed may be used, including circular or free-form designs. *Note: The treatment process is governed by **vertical flow**, so short-circuiting is not a concern as it is in wetponds.*
2. **Sand depth** (*l*) shall be 18 inches (1.5 feet) minimum.
3. **Depth of storage** over the filter media (*d*) shall be 6 feet maximum.

Pretreatment, Flow Spreading, and Energy Dissipation

1. See general presettling and pretreatment requirements for filtration facilities in Section 6.5.1 (p. 6-99).
2. A **flow spreader** shall be installed at the inlet along one side of the filter to evenly distribute incoming runoff across the filter and prevent erosion of the filter surface. See Section 6.2.6 (p. 6-31) for details on flow spreaders.
   a) **If the sand filter is curved or an irregular shape**, a flow spreader shall be provided for a minimum of 20 percent of the filter perimeter.
   b) If the **length-to-width ratio** of the filter is 2:1 or greater, a flow spreader must be located on the longer side and for a **minimum length** of 20 percent of the facility perimeter.
   c) In other situations, use good engineering judgment in positioning the spreader.
3. **Erosion protection** shall be provided along the first foot of the sand bed adjacent to the flow spreader. Geotextile (meeting the specifications in Table 6.5.2.D, page 6-109) weighted with sand bags at 15-foot intervals may be used. Quarry spalls may also be used.

Overflow and Bypass Structures

1. **On-line filters**[39] shall be equipped with **overflows** (primary, secondary, and emergency) in accordance with the design criteria for detention ponds (see Section 5.3.1.1, criteria for "Overflow" and "Emergency Overflow Spillway"). *Note: The primary overflow may be incorporated into the emergency spillway in cases where the spillway discharges into a downstream detention facility, or where overflows can be safely controlled and redirected into the downstream conveyance system.*
2. For **off-line filters**, the outlet structure must be designed to pass the 2-yr peak inflow rate, as determined using KCRTS with 15-minute time steps calibrated to specific site conditions.

   Intent: Overflow capacity is required for low-flow, high-volume storms which may exceed the storage capacity of the filter.
3. To the extent base flow conditions can be identified, **base flow** must be bypassed around the filter to keep the sand from remaining saturated for extended periods of time.

Filter Composition

A sand filter consists of three or four layers:

- Top layer (optional): grass seed or sod grown in sand
- Second layer: sand

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[39] Whether a WQ facility is designed as on-line (all flow going through the facility) or off-line (high flows bypassing the facility) is a choice made by the designer. Section 6.2.5 (p. 6-27) contains information on flow splitters for WQ facilities.

- Third layer: geotextile fabric
- Fourth layer: underdrain system.

Sand Specifications

The sand in a filter shall consist of a medium sand with few fines meeting the size gradation (by weight) given in Table 6.5.2.C. The contractor must obtain a grain size analysis from the supplier to certify that the No. 100 and No. 200 sieve requirements are met. *Note: Many sand mixes supplied locally meet this specification. However, standard backfill for sand drains (as specified in the Washington Standard Specifications 9-03.13) does not meet this specification and should not be used for sand filters.*

TABLE 6.5.2.C SAND MEDIA SPECIFICATIONS

U.S. Sieve Size	Percent passing
U.S. No. 4	95 to 100 percent
U.S. No. 8	70 to 100 percent
U.S. No. 16	40 to 90 percent
U.S. No. 30	25 to 75 percent
U.S. No. 50	2 to 25 percent
U.S. No. 100	Less than 4 percent
U.S. No. 200	Less than 2 percent

Geotextile Materials

Geotextile material requirements are summarized in Table 6.5.2.D.

TABLE 6.5.2.D GEOTEXTILE SPECIFICATIONS

Geotextile Property	Value	Test Method
Grab strength (lbs)	75 (min)	ASTM D4632
Burst strength (psi)	130 (min)	ASTM D3786
Trapezoid tear (lbs)	40 (min)	ASTM D4533
Permeability (cm/sec)	0.2 (min)	ASTM D4491
AOS (sieve size)	#60 - #70	ASTM D4751
Ultraviolet resistance	70 percent or greater	ASTM D4355

Notes:

- Acceptability of geotextile material shall be based on ASTM D-4759.
- Minimum values should be in the weaker principal direction. All numerical values represent minimum average roll value (i.e., test results from any sampled lot shall meet or exceed the minimum values in the table). Stated values are for noncritical and nonsevere applications.

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Underdrain Systems

1. Several **underdrain systems** are acceptable:
   - A central collector pipe with lateral feeder pipes in an 8-inch gravel backfill or drain rock bed
   - A central collector pipe with a geotextile drain strip in an 8-inch gravel backfill or drain rock bed
   - Longitudinal pipes in an 8-inch gravel backfill or drain rock bed, with a collector pipe at the outlet end.

   In smaller installations a single perforated pipe in 8 inches of gravel backfill or drain rock may be adequate.

2. The **maximum perpendicular distance** between any two feeder pipes, or the edge of the filter and a feeder pipe, shall be 15 feet.

   Intent: This spacing is required to prevent the underdrain system from backing up into the sand filter during the early life of the filter when high filtration rates exist.

3. All pipe shall be placed with a **minimum slope** of 0.5 %.

4. The **invert of the underdrain outlet** shall be above the seasonal high groundwater level. The *seasonal high groundwater level* is the highest elevation of groundwater observed.

   Intent: The underdrain must be able to remove standing water from beneath the sand. If standing water remains, the sand will remain saturated. This could cause depletion of dissolved oxygen and reducing conditions in the sand, allowing some pollutants to become mobile and be released from the filter to downstream receiving waters.

5. **Cleanout** wyes with caps or junction boxes shall be provided at both ends of all collector pipes. Cleanouts shall extend to the surface of the filter.

   a) A valve box must be provided for access to the cleanouts.

   b) The cleanout assembly must be water tight to prevent short circuiting of the filter.

   Intent: Caps are required on cleanout wyes to prevent short-circuiting of water into the underdrain system when the pond fills with water.

6. If a **drain strip** is used for lateral drainage, the strip must be placed at the slope specified by the manufacturer but at least at 0.5%. All drain strip must extend to the central collector pipe. Drain strips installations must be analyzed for conveyance because manufactured products vary in the amount of flow they are designed to handle.

7. At least 8 inches of **gravel backfill** must be maintained over all underdrain piping or drain strip, and 6 inches must be maintained on either side to prevent damage by heavy equipment during maintenance. Either drain rock or gravel backfill may be used between pipes or drain strip.

   Note: If drain strip is used, it may be easier to install the central collector pipe in an 8-inch ***trench*** *filled with drain rock, making the cover over the drain strip and the collector pipe the same thickness. In this case the pipe shall be wrapped with geotextile to prevent clogging. Use the same geotextile specification as given in* Table 6.5.2.D (p.6-109).

8. A **geotextile fabric** shall be used between the sand layer and the drain rock or gravel and be placed so that one inch of drain rock or gravel is above the fabric.

   Intent: The position of the geotextile fabric provides a **transition layer** of mixed sand and gravel or rock. A distinct layer of finely textured sand above a coarser one may cause water to pool at the interface and not readily drain downward due to the greater capillary forces in the finer material.

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Underdrain Materials

1. Underdrain **pipe** shall be minimum 6 inch diameter perforated PVC, SDR 35. One acceptable specification for perforations is as follows: 2 rows of holes ($^1/_2$-inch diameter) spaced 6 inches apart longitudinally (max), with rows 120 degrees apart (laid with holes downward). Other drain pipe may be used if it adequately drains the filter.
2. **Drain rock** shall be $1^1/_2$ to $^3/_4$ -inch rock or gravel backfill, washed and free from clay or organic material.
3. If a geotextile drain strip system is used, the attached **geotextile fabric** should not be used, or the fabric side should be positioned away from the sand blanket. Geotextile is already required between the sand and drain rock layers, and must meet the specifications in Table 6.5.2.D (p. 6-109) to avoid clogging the filter prematurely.

Access Roads

An access road shall be provided to the inlet and outlet of a sand filter for inspection and maintenance purposes. Requirements for access roads are the same as for detention ponds (see Section 5.3.1.1, "Design of Access Roads" and "Construction of Access Roads").

Grass Cover

1. **No top soil** may be added to sand filter beds because fine-grained materials (e.g., silt and clay) reduce the hydraulic capacity of the filter.
2. **Growing grass** will require selecting species that can tolerate the demanding environment of the sand bed. Sand filters experience long periods of saturation during the winter wet season, followed by extended dry periods during the summer. Modeling predicts that sand filters will be dry about 60 percent of the time in a typical year. Consequently, vegetation must be capable of surviving drought as well as wetness.
   - The grasses and plants listed in Table 6.5.2.E (below) are good choices for pond sides. They are facultative (i.e., they can tolerate fluctuations in soil water). These species can generally survive approximately 1 month of submersion while dormant in the winter (until about February 15), but they can withstand only about 1 to 2 weeks of submersion after mid-February.
   - The lower portion of Table 6.5.2.E lists grass species that are good choices for the sand filter bottom. They can withstand summer drying and are fairly tolerant of infertile soils. In general, planting a mixture of 3 or more species is recommended. This ensures better coverage since tolerance of the different species is somewhat different, and the best adapted grasses will spread more rapidly than the others. Legumes, such as clover, fix nitrogen and hence can thrive in low-fertility soils such as sands. This makes them particularly good choices for planting the sand filter bed.
3. A **sport-field sod** grown in sand may be used on the sand surface. No other sod may be used due to the high clay content in most sod soils.
4. To prevent overuse that could compact and potentially damage the filter surface, **permanent structures** (e.g., playground equipment or bleachers) are not permitted. Temporary structures or equipment must be removed for filter maintenance.
5. If the sand filter is located in a Sensitive Lake Protection Area, low phosphorus **fertilizers** (such as formulations in the proportion 3: 1: 3 N-P-K or less) or a slow-release phosphorus formulation such as rock phosphate or bone meal should be used.

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TABLE 6.5.2.E RECOMMENDED PLANTS FOR SATURATED AREAS	
RECOMMENDED PLANTS FOR POND SIDES	
Scientific Name	**Common Name**
Agrostis alba	Redtop
Agrostis palustris	Creeping bentgrass
Alopecurus pratensis	Meadow foxtail
Calamagrostis nutkaensis	Pacific reed grass
Glyceria borealis	Northern mannagrass
Holcus lanatus	Common velvet grass
Poa palustris	Fowl bluegrass
Poa pratensis	Kentucky bluegrass
Juncus acuminatus	Tapertip rush
Juncus effusus	Soft rush
RECOMMENDED PLANTS FOR POND BOTTOM (SAND SURFACE)	
Agrostis tenuis	Colonial bentgrass (Highland strain good)
Buchloe dactyloides	Buffalo grass
Festuca elatior	Tall fescue
Festuca elatior "Many Mustang", "Silverado"	Dwarf tall fescues
Festuca rubra	Red fescue
Lolium perenne	Perennial ryegrass
Zoysia tenuifolia	Korean grass
Trifolium repens	White lawn clover
Note: Other grasses may be used if recommended by a horticultural or erosion control specialist for the specific site.	

Recommended Design Features

The following design features should be incorporated into sand filter designs where site conditions allow:

1. A **horticultural specialist** should be consulted for advice on planting.
2. **Seed** should be applied in spring or mid to late fall unless irrigation is provided. If the filter is seeded during the dry summer months, surface irrigation is needed to ensure that the seeds germinate and survive. Seed should be applied at 80 lbs/acre.
3. Slow-release **fertilizers** may be applied to improve germination; however, see requirements above for sensitive lake protection areas.
4. A sand filter can add landscape interest and should be incorporated into the project **landscape design**. Interior side slopes may be stepped with flat areas to provide informal seating with a game or play area below. Perennial beds can be planted above the overflow water surface elevation. However, large shrubs and trees are not recommended because shading limits evaporation and can inhibit drying of the filter surface. In addition, falling leaves and needles can clog the filter surface, requiring more

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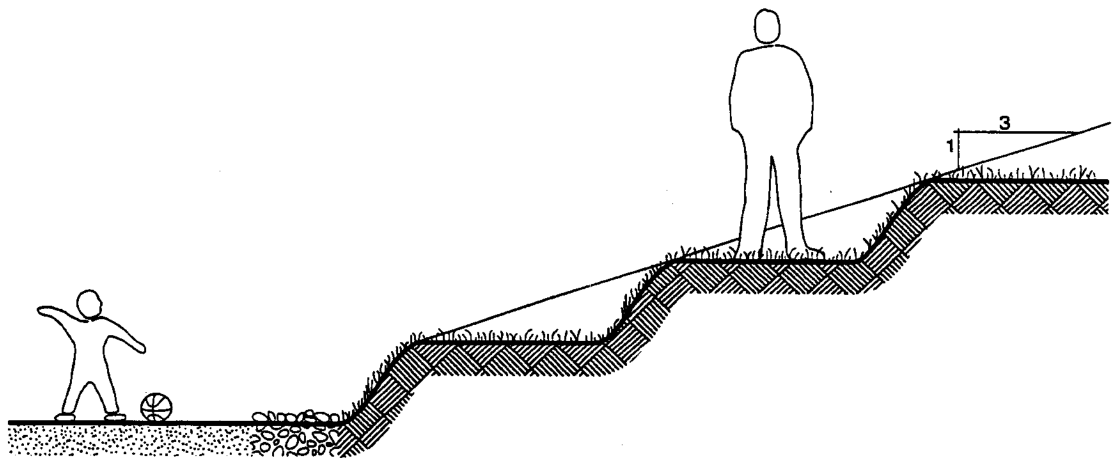
frequent maintenance. *Note: Examples of areas with stepped side slopes can be found at the Ballard Locks in Seattle and at Luther Burbank Park on Mercer Island.*

5. If **recreational use** is intended, such as for a badminton or volleyball play area, the interior side slopes of the filter embankment should be no steeper than 3:1. Drainage tracts may be credited for up to 50 percent of the onsite recreation space requirement under certain conditions. Refer to King County Code 21A.14.180.D for recreation requirements (see Section 5.3.1.2).

FIGURE 6.5.2.A SCHEMATIC OF STEPPED SIDE SLOPES



SECTION
NTS

Construction Considerations

1. If sand filters are put into service before construction of all parcels within the catchment is complete and all disturbed soil in the sand filter catchment has been stabilized, the filter will very likely clog prematurely. If individual lots are not stabilized, the options for **protection from upstream erosion** given in Section 5.4.1 for infiltration ponds may be used.

   Another **alternative** is to install the sand filter pond including full excavation for the filter sand and underdrain layers, delaying placement of the sand and underdrains until the site is stabilized. The partially complete sand filter will then function like a small wetpond. Later, the accumulated sediment should be cleaned and the underdrain and sand layers placed.

   The County will not assume maintenance responsibility or release financial guarantees, however, unless the sand filter is installed per design and functioning properly. If the final sand layer cannot be completed before the typical two-year holding period for financial guarantees, the applicant may elect to pay the County to clean and install the sand when the watershed is stabilized, or may arrange a smaller financial guarantee specifically for completion of the sand filter.

2. **Careful placement of the sand** is necessary to avoid formation of voids within the sand that could lead to short-circuiting, particularly around penetrations for underdrain cleanouts, as well as to prevent damage to the underlying geomembranes and underdrain system. Voids between the trench wall and geotextile fabric should also be avoided.

3. **Over compaction must be avoided** to ensure adequate filtration capacity. Sand is best placed with a low ground pressure tracked bulldozer (4.6 pounds per square inch or less ground pressure). The number of passes over sand fill should be minimized during placement; using large rubber-tired vehicles can minimize ground pressure and compaction.

4. After the sand layer is placed, water settling is recommended. Flood the sand with 10 to 15 gallons of water per cubic foot of sand.

Maintenance Considerations

Sand filters are subject to clogging by fine sediment, oil and grease, and other debris (e.g., trash and organic matter such as leaves). Filters and pretreatment facilities should be inspected every 6 months during the first year of operation. Inspections should also occur immediately following a storm event to assess the filtration capacity of the filter. Once the filter is performing as designed, the frequency of inspection may be reduced to once per year.

During an inspection the following features should be evaluated and maintained as needed:

1. Remove debris and sediment from the pretreatment facility when depth exceeds 12 inches.
2. Remove debris and sediment from the surface of the filter when accumulations exceed 0.5 inches.
3. Observe operation of the overflow and drawdown time in the filter. Frequent overflow through the grated "birdcage" or "jailhouse" window into the outlet structure or slow drawdown are indicators of plugging problems. Under normal operating conditions, a sand filter should completely empty within 9 to 24 hours following a storm event (i.e., after the inflow of runoff to the filter ceases), depending on pond depth. Generally, if the water level over the filter drops at a rate less than $^1/_2$-inch per hour ($V < {}^1/_2$-inch per hour), corrective maintenance is needed. Recommendations for improving sand filter performance are summarized below:
   a) Remove thatch accumulation in grass.
   b) Aerate the filter surface to improve permeability.
   c) Till the filter surface. Two separate passes following a criss-cross pattern (i.e., second pass at right angles to the first) are recommended.
   d) Replace upper 4 to 6 inches of grass and sand.
4. Experience with sand filters used for stormwater treatment in Austin, Texas, has shown that the sand becomes clogged and must be replaced every 4 to 10 years.
5. Rapid drawdown in the filter (i.e., greater than 12 inches per hour) indicates short-circuiting of the filter media. Inspect the cleanouts on the underdrain pipes and along the base of the embankment for leakage.
6. Formation of rills and gullies on the surface of the filter indicates improper function of the inlet flow spreader or poor sand compaction. Check for accumulation of debris on or in the flow spreader, and refill rills and gullies with sand.

Other maintenance practices that should be employed to ensure proper operation of the sand filter are summarized below:

1. Avoid use of excess fertilizers along the bottom or sides of a landscape sand filter.
2. Avoid driving heavy machinery or equipment on the sand filter to minimize compaction of the filter media and prevent the formation of ruts in the surface of the filter that could concentrate or channelize flow.
3. Mow grass as needed, and remove the cut grass from the sand filter.
4. Water the vegetation periodically when needed, especially during the summer dry season.
5. Discourage use of the sand bed by pets by installing signs reminding residents of scoop laws, planting barriers such as barberry, or providing other measures as appropriate.

❑ MODIFICATIONS FOR COMBINING WITH AN INFILTRATION POND

Where an infiltration pond is proposed for flow control, a sand filter (basic or large) may be combined with the infiltration pond by making the following modifications in design criteria:

1. The "**100-year Overflow Conveyance**" requirements for infiltration ponds (see Section 5.4.1) shall apply in place of the "**Overflow and Bypass**" requirements for sand filters.
2. The "**Filter Composition**" criteria are changed to eliminate the requirement for an underdrain system. The fourth layer of the filter becomes the native infiltrative soils.
3. The "**Underdrain System**" and "**Underdrain Materials**" criteria for sand filters are not applied. Water infiltrating through the sand layer need not be collected but may simply continue infiltrating downward into native soils.
4. The sides of the infiltration pond must be provided with a **treatment liner** up to the WQ design water surface elevation, at a minimum. See Section 6.2.4.2 (p. 6-25) for information on liners.

FIGURE 6.5.2.B SAND FILTER WITH LEVEL SPREADER

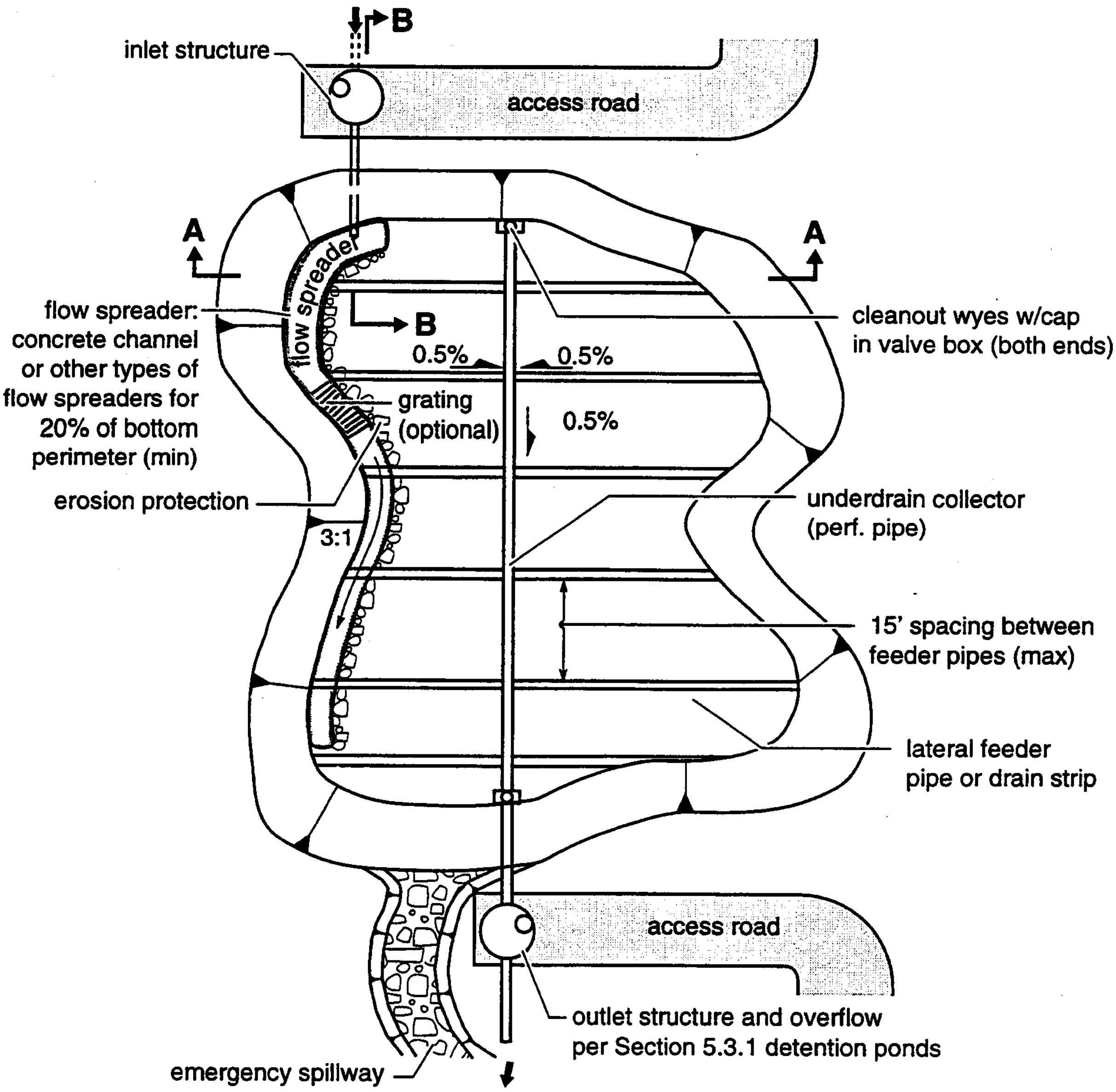


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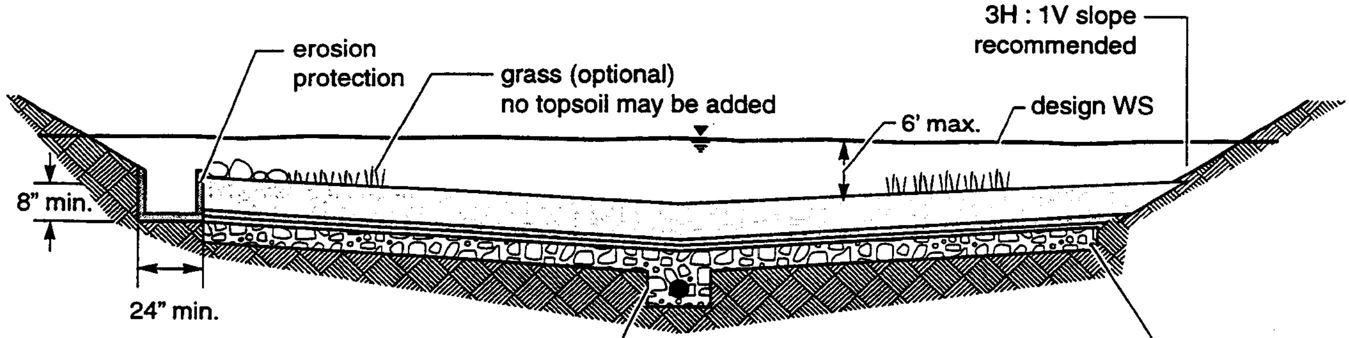
FIGURE 6.5.2.B SAND FILTER WITH LEVEL SPREADER (*CONTINUED*)



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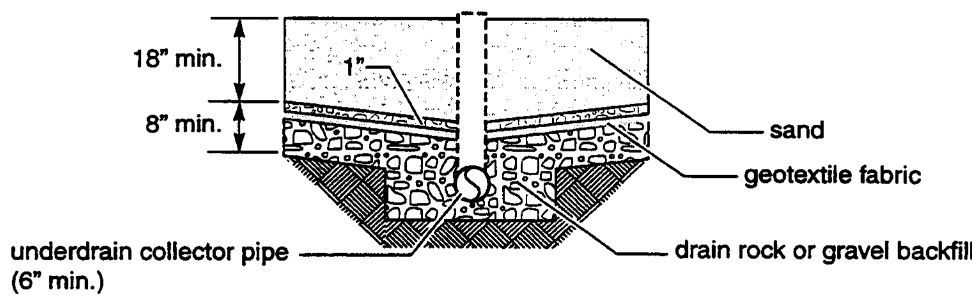

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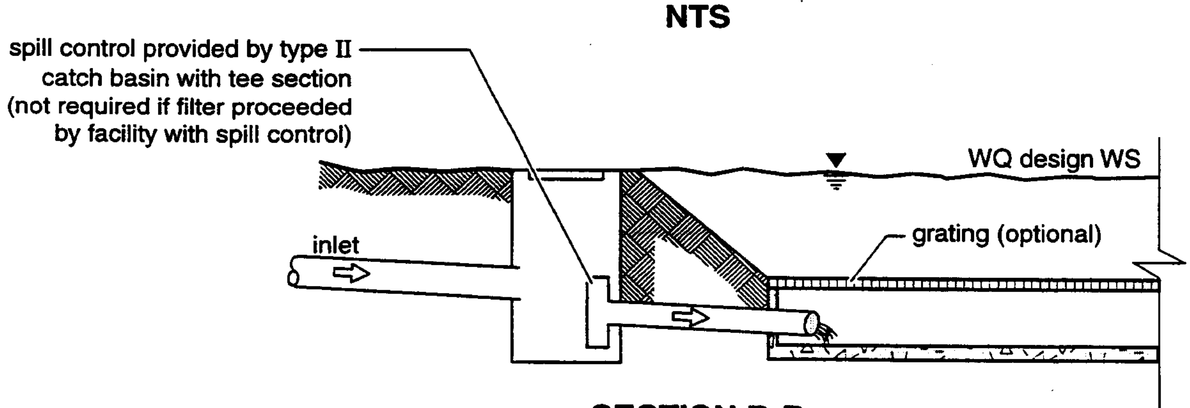

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FIGURE 6.5.2.C SAND FILTER WITH PRETREATMENT CELL

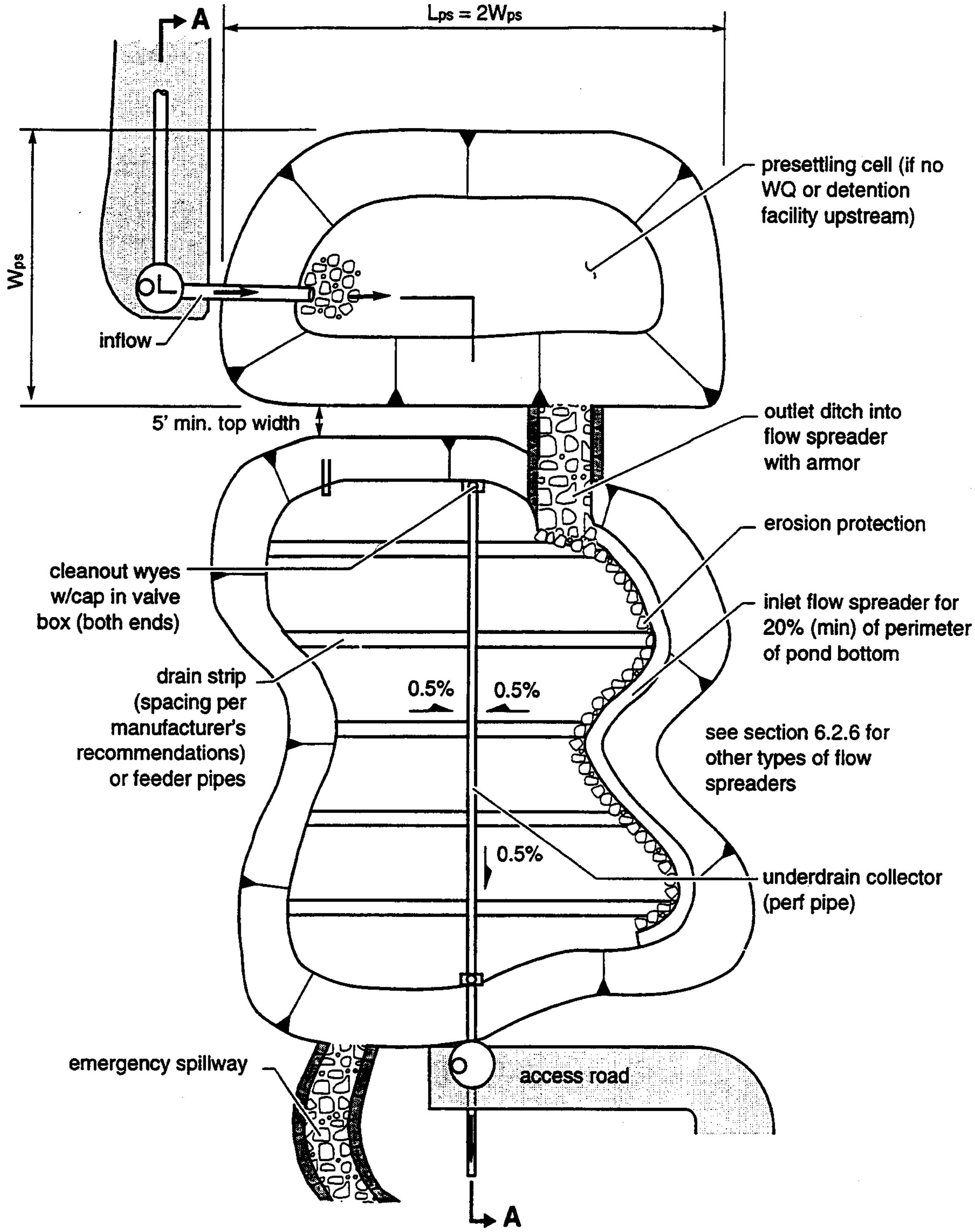

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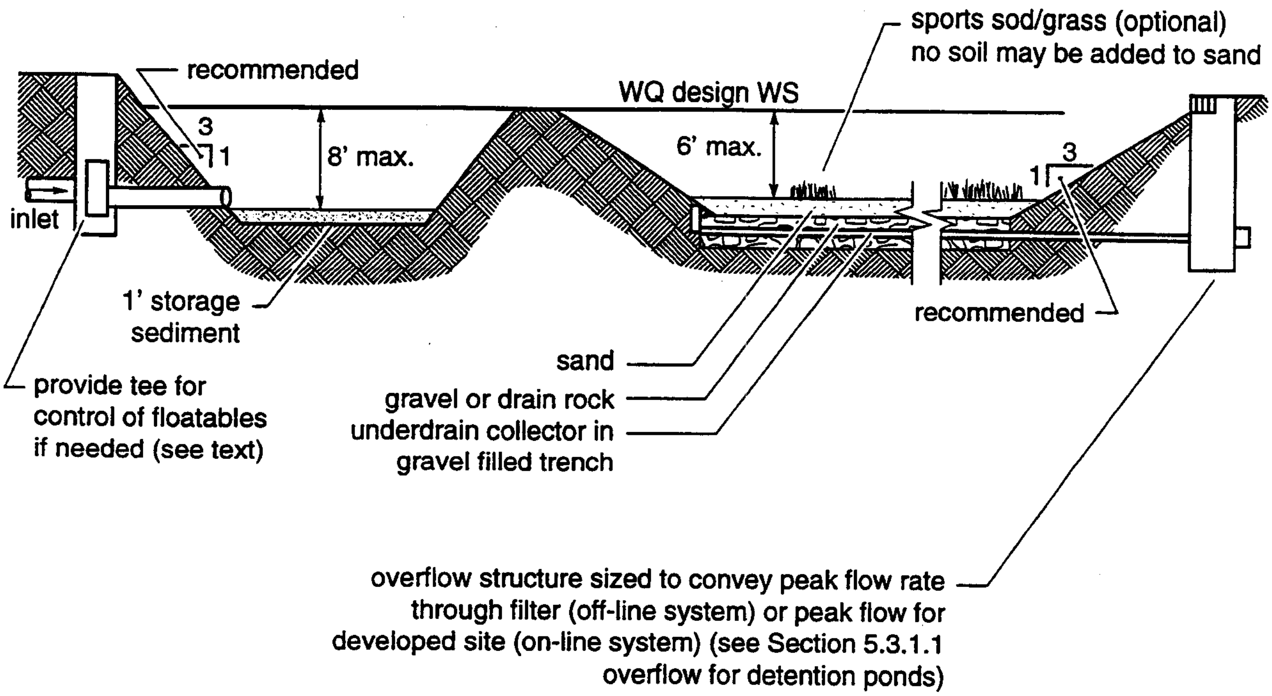
FIGURE 6.5.2.C SAND FILTER WITH PRETREATMENT CELL (*CONTINUED*)



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6.5.3 SAND FILTER VAULTS

A *sand filter vault* is similar to an open sand filter except that the sand layer and underdrains are installed below grade in a vault. Like a sand filter, a sand filter vault can be sized as either a basic or a large facility to meet different water quality objectives. The **basic sand filter vault** is designed to meet the Basic WQ menu goal of 80% TSS removal for the water quality design flow. The **large sand filter vault** is expected to meet the Sensitive Lake Protection menu goal of 50% total phosphorus removal.

Applications and Limitations

A sand filter vault can be used on **sites where space limitations preclude the installation of above ground facilities**. In highly urbanized areas, particularly on redevelopment and infill projects, a vault is a viable alternative to other treatment technologies that require more area to construct.

Like sand filters, sand filter vaults are **not suitable for areas with high water tables** where infiltration of groundwater into the vault and underdrain system will interfere with the hydraulic operation of the filter. Soil conditions in the vicinity of the vault installation should also be evaluated to identify special design or construction requirements for the vault.

It is desirable to have an **elevation difference of 4 feet between the inlet and outlet** of the filter for efficient operation. Therefore, site topography and drainage system hydraulics must be evaluated to determine whether use of an underground filter is feasible.

Because the surface of a sand filter vault is prone to clogging from sediment and other debris, this facility **should not be used in areas where heavy sediment loads are expected.**

Refer to the WQ menus, Section 6.1 (p. 6-3), for information on how sand filter vaults can be used to meet Core Requirement #8.

6.5.3.1 METHODS OF ANALYSIS

The **methods of analysis** for basic and large sand filter vaults are identical to the methods described for basic and large sand filters. Follow the procedures described in Section 6.5.2.1 (p. 6-100).

6.5.3.2 DESIGN CRITERIA

In addition to their water quality function, sand filter vaults may serve a conveyance function, passing flows above the water quality design flow through to the downstream drainage system. When used to convey these flows, vaults must meet the conveyance requirements specified in Chapter 4.

General **design concepts** for sand filter vaults are shown in Figure 6.5.3.A (p. 6-124).

Sand Filter Geometry

Same as for sand filters (see page 6-108).

Pretreatment, Flow-Spreading, and Energy Dissipation

1. See general presettling and pretreatment requirements for filtration facilities, Section 6.5.1, p. 6-99.
2. A **flow spreader** shall be installed at the inlet to the filter bed to evenly distribute incoming runoff across the filter and prevent erosion of the filter surface.
3. For **vaults with presettling cells**, the presettling cells shall be constructed so that the **divider wall** extends from the floor of the vault to the WQ design water surface and is water tight
4. The flow spreader shall be positioned so that the **top of the spreader** is no more than 8 inches above the top of the sand bed (and at least 2 inches higher than the top of the inlet pipe if a pipe and manifold distribution system is used). See Section 6.2.6 (p. 6-31) for details on flow spreaders. For

vaults with presettling cells, a **concrete sump-type flow spreader** (see Figure 6.2.6.B, p. 6-34) shall be built into or affixed to the divider wall. The sump shall be a minimum of 1 foot wide and extend the width of the sand filter. The downstream lip of the sump shall be no more than 8 inches above the top of the sand bed.

5. Flows may enter the sand bed by **spilling over the top of the wall into a flow spreader pad**, or alternatively a **pipe and manifold system** may be designed and approved at the discretion of DDES to deliver water through the wall to the flow spreader. *Note: Water in the first or presettling cell is dead storage. Any pipe and manifold system designed must retain the required dead storage volume in the first cell, minimize turbulence, and be readily maintainable.*

6. If a pipe and manifold system is used, the **minimum pipe size** shall be 8 inches. Multiple inlets are recommended to minimize turbulence and reduce local flow velocities.

7. **Erosion protection** shall be provided along the first foot of the sand bed adjacent to the spreader. Geotextile weighted at the corners with sand bags, quarry spalls, or other suitable erosion control may be used.

Overflow and Bypass Structures

Same as for sand filters (see page 6-108).

Filter Composition

The filter bed shall consist of three layers as follows:

- Top layer: sand
- Second layer: geotextile fabric
- Third layer: underdrain system.

Sand Specifications and Geotextile Materials

Same as for sand filters (see page 6-109).

Underdrain Systems and Underdrain Materials

Same as for sand filters (see page 6-110).

Vault Structure

1. Sand filter vaults are typically designed as on-line (flow-through) systems with a flat bottom under the filter bed.

2. If a presettling cell is provided, the **cell bottom** may be longitudinally level or inclined toward the inlet. To facilitate sediment removal, the bottom shall also slope from each side towards the center at a minimum of 5%, forming a broad "v". *Note: More than one "v" may be used to minimize cell depth.*

   Exception: The bottom of the presettling cell may be flat rather than v-shaped if **removable panels** are provided over the entire presettling cell. Removable panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel.

3. One foot (average) of **sediment storage** must be provided in the presettling cell.

4. Where pipes enter and leave the presettling cell below the WQ design water surface, they shall be **sealed** using a non-porous, non-shrinking grout.

5. If an **oil retaining baffle** is used for control of floatables in the presettling cell, it must conform to the following:

   a) The baffle shall extend from 1 foot above to 1 foot below the WQ design water surface (minimum requirements) and be spaced a minimum of 5 feet horizontally from the inlet.

b) Provision for passage of flows in the event of plugging shall be provided.

c) An access opening and ladder shall be provided on both sides of the baffle into the presettling cell.

6. Sand filter vaults shall conform with the "**Materials**" and "**Structural Stability**" criteria specified for **detention vaults** in Section 5.3.3.

7. The **arch culvert sections** allowed for wetvaults **may not be used** for sand filter vaults. Free access to the entire sand bed is needed for maintenance.

Access Requirements

Same as for **detention vaults** (see Section 5.3.3) except for the following **modifications:**

1. For facilities maintained by King County, **removable panels** must be provided over the entire sand bed. Panels shall be at grade, have stainless steel lifting eyes, and weigh no more than 5 tons per panel. Concrete bridge decking or industrial decking are options. If within the roadway, the panels must meet the traffic loading requirements of the King County road standards.

2. A minimum of 24 square feet of **ventilation grate** must be provided for each 250 square feet of sandbed surface area. Grates may be located in one area if the sand filter is small, but placement at each end is preferred. Small grates may also be dispersed over the entire sand bed.

   Intent: Grates are important to allow air exchange above the sand. Poor air exchange will hasten anoxic conditions which may result in release of pollutants such as phosphorus and metals and cause objectionable odors.

Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Section 5.3.3).

Recommended Design Features

The following design features should be incorporated into sand filter vaults where feasible but are not specifically required:

1. The **floor of the presettling cell** should be **sloped toward the inlet** to allow for sediment accumulation and ease of cleaning.

2. A **geotextile fabric** is recommended over the sand bed to make sand bed maintenance easier. If used, the geotextile should be a flexible, high-permeability, three-dimensional matrix of the kind commonly used for erosion control. Sand bags should be used at 10 to 15 foot intervals to hold the geotextile in place.

3. **Additional grates** are recommended instead of solid panels to increase air contact with the sand bed.

4. **Vault entry** is subject to OSHA requirements for confined spaces, including clearly marking entrances. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

Construction Considerations

Same as for sand filters (see page 6-113) plus, upon completion of installation, the vault should be thoroughly cleaned and flushed prior to placement of sand and drain rock.

Maintenance Considerations

Maintenance considerations for sand filter vaults are similar to those described in Section 6.5.2 (p. 6-100) for sand filters. Note, however, that confined space entry procedures should be followed when entering a vault. Even though some surface ventilation is provided for sand filter vaults, precautions are still warranted.

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❑ MODIFICATIONS FOR COMBINING WITH AN INFILTRATION VAULT

Where an infiltration vault is proposed for flow control, a sand filter vault (basic or large) may be combined with the infiltration facility by making the following modifications in design criteria:

1. The **"100-year Overflow Conveyance"** requirements for infiltration ponds (see Section 5.4.1) shall apply in place of the **"Overflow and Bypass"** requirements for sand filter vaults.
2. The **"Filter Composition"** criteria are changed to eliminate the requirement for an underdrain system. The third layer of the filter becomes the native infiltrative soils.
3. The **"Underdrain System"** and **"Underdrain Materials"** criteria for sand filter vaults are not applied. Water infiltrating through the sand layer need not be collected but may simply continue infiltrating downward into native soils.
4. **"Access requirements"** for grating may be reduced at the discretion of the design and review engineers.

   Intent: when water infiltrates into the soil directly without being collected by an underdrain system, the concern for pollutant release diminishes. Ventilation for odor control is, then, the only concern.

FIGURE 6.5.3.A SAND FILTER VAULT

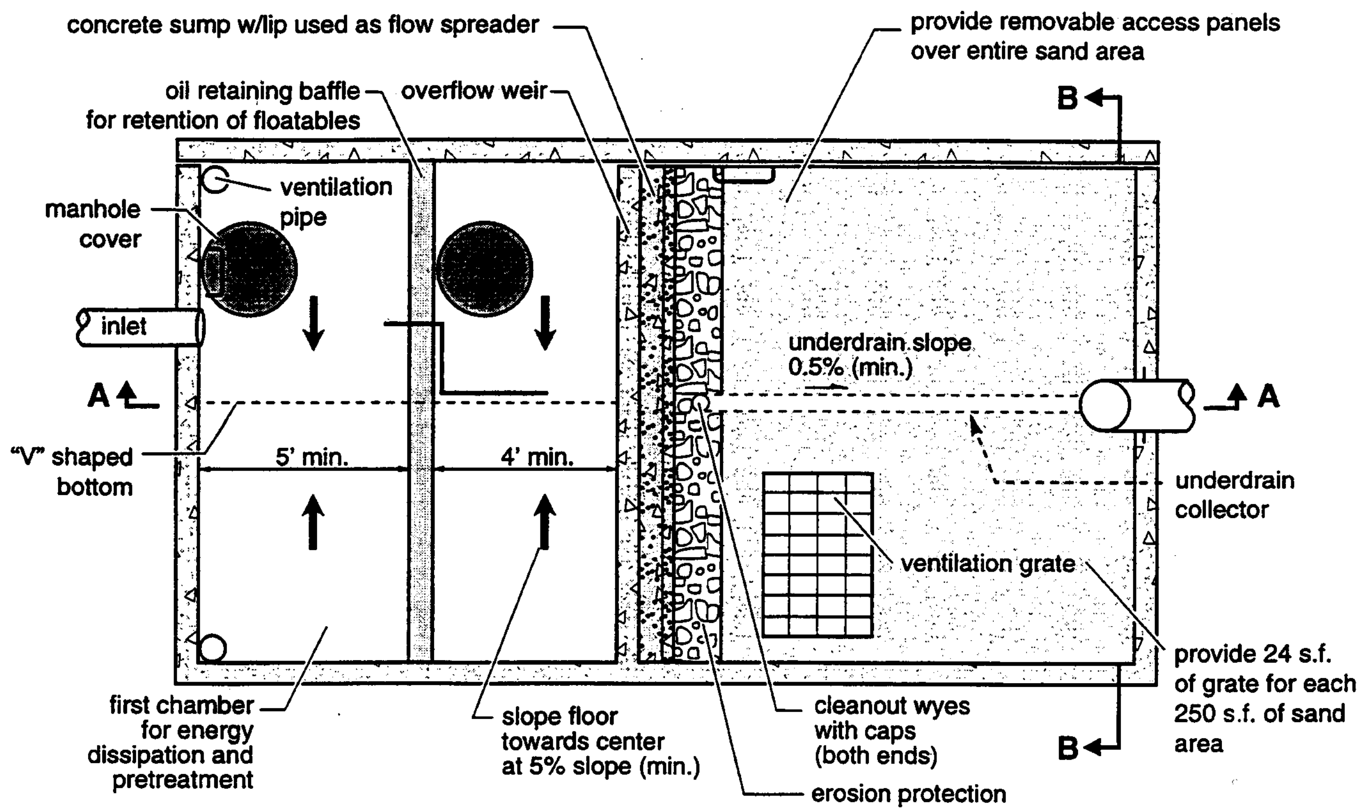

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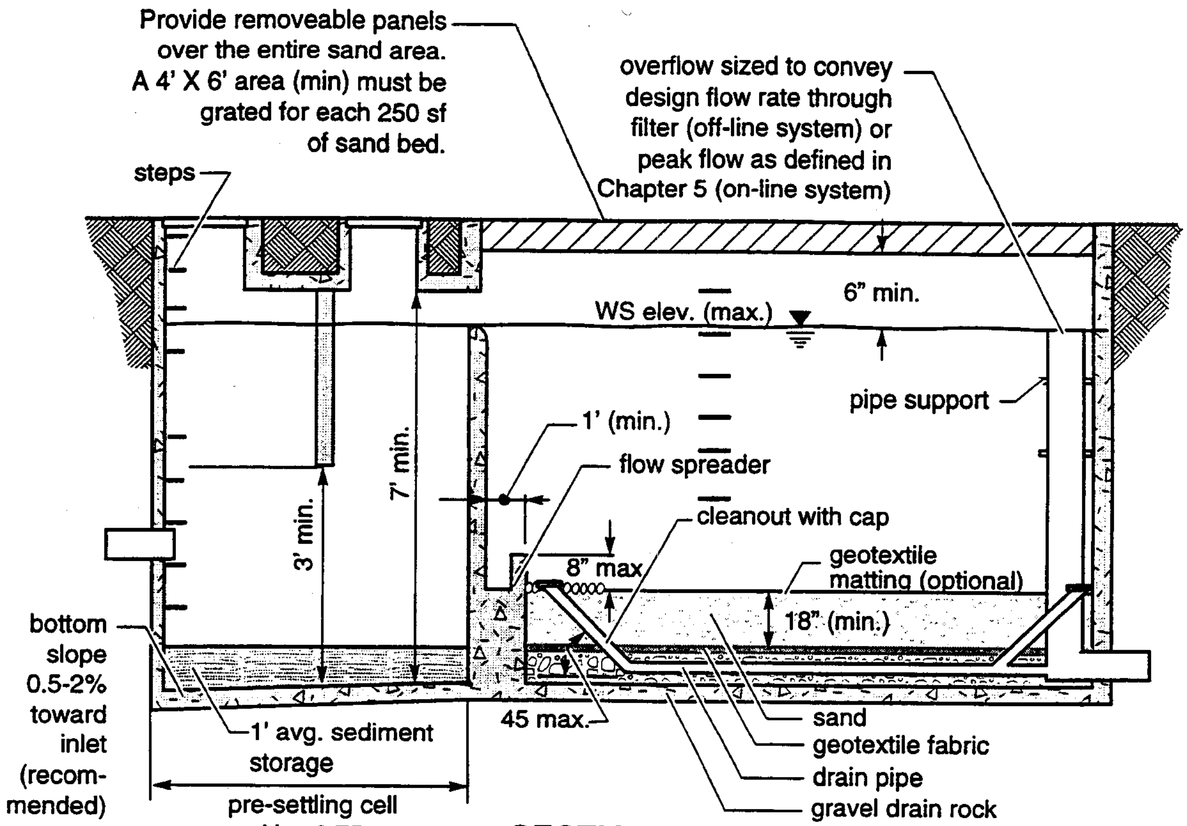
FIGURE 6.5.3.A SAND FILTER VAULT (*CONTINUED*)



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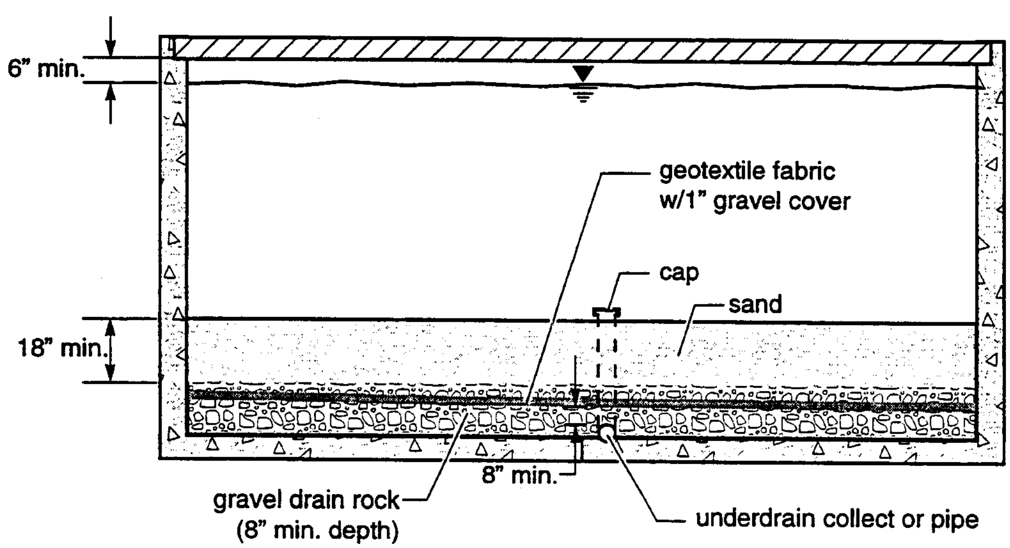

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6.5.4 LINEAR SAND FILTERS

Linear sand filters are typically long, shallow, rectangular vaults. The vaults consist of two cells or chambers, one for settling coarse sediment from the runoff and the other containing sand. Stormwater flows into the second cell via a weir section that also functions as a flow spreader to distribute the flow over the sand. The outlet consists of an underdrain pipe system that connects to the storm drain system. As with other sand filters, linear filters come in two sizes, basic and large. The **basic linear sand filter** is designed to meet the Basic WQ menu goal of 80% TSS removal for the water quality design flow. The **large linear sand filter** is expected to meet the Sensitive Lake Protection menu goal of 50% total phosphorus removal.

Applications and Limitations

The linear sand filter is used for stormwater flows for two different treatment purposes:

1. To provide basic or second-tier water quality treatment, and
2. To treat runoff from high-use sites (i.e., sites generating higher than typical concentrations of oil and grease).

Linear sand filters are **best suited for treating small drainages** (less than 5 acres), particularly long, narrow areas. The goal is to keep linear sand filters fairly shallow and narrow in width. A linear sand filter can be located along the perimeter of a paved impervious surface or can be installed downstream of a filter strip where additional treatment is needed. If used for oil control, the filter should be located upstream from the main water quality treatment facility (i.e., wetpond, biofiltration swale, or combined detention and wetpond).

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how linear sand filters can be used to meet Core Requirement # 8 or Special Requirement #5.

6.5.4.1 METHODS OF ANALYSIS

A linear sand filter is sized based on the infiltration rate of the sand and the amount of runoff draining to the facility. The filter is sized to infiltrate the sand filter design flow without significant ponding above the sand. The sizing methods specified below are for both the basic and large linear sand filter.

Step 1: Identify the size of sand filter needed, either basic or large. Consult the water quality menus, Section 6.1 (p. 6-3) to determine which size is needed. A basic linear sand filter is sized to permit 90 percent of the runoff volume to pass through the filter. A large linear sand filter allows 95 percent of the volume to pass through the filter. For oil control purposes, use the basic sand filter size.

Step 2: Determine the rainfall region and regional scale factor. Regional scale factors are used to account for differences in rainfall at locations distant from the two gaging locations in King County, Sea-Tac Airport and Landsburg. Refer to the precipitation scaling map in Chapter 3, Figure 3.2.2.A, to determine the scale factor for the project area.

Step 3: Determine site characteristics. Determine the total number of impervious acres and the total number of grass acres draining to the sand filter. Determine whether the site is on till or outwash soils. Refer to Table 3.2.2.B in Chapter 3 to determine which soil types are considered till and which are considered outwash.

Step 4: Calculate the minimum required surface area for the linear sand filter. Determine the sand filter area by multiplying the values in Table 6.5.4.A (p.6-127) by the site acreages from Step 3 using the following equation:

$$A_{sf} = 0.7\ C_s\,(T_i A_i + T_{tg} A_{tg} + T_{tf} A_{tf} + T_{og} A_{og}) \qquad (6\text{-}20)$$

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where A_{sf} = sand filter area (sf)
0.7 = adjustment factor to account for routing effect on size
C_s = regional scale factor (unitless) from Step 2
$T_{i,tg,\ og}$ = tributary area per soil/cover type (acres)
$A_{i,tg,\ og}$ = filter area per soil/cover type (sf/acre) from Table 6.5.4.A.

The values in Table 6.5.4.A (below) are identical to those in Table 6.5.2.A for the simple sizing method but are repeated below for convenience. For depths less than 1 foot, the detailed routing method must be used.

Linear sand filters may also be sized using the detailed routing procedure of Section 6.5.2.1 (p. 6-100). It is expected that filters designed with the detailed routing method would be narrower than those sized using Table 6.5.4.A.

TABLE 6.5.4.A
LINEAR SAND FILTER AREA INCREMENTS FOR SEA-TAC AND LANDSBURG

		Soil/Cover Types [filter area (sf) / tributary area (acres)]		
Region and Treatment Goal	**Max. Water Depth (ft)**	A_i **Impervious**	A_{tg} **Till grass**	A_{og} **Outwash grass**
SeaTac Basic	1	1711	360	314
Landsburg Basic	1	1844	405	355
SeaTac Large	1	2654	629	550
Landsburg Large	1	2926	674	590

Step 5: Size the sediment cell. The sediment cell width should be set after the sand filter width is determined. Use Table 6.5.4.B below to set the width of the sediment cell. If another WQ facility precedes the sand filter, the sediment cell may be waived.

TABLE 6.5.4.B SEDIMENT CELL WIDTH, LINEAR SAND FILTER

If Sand filter width is:	Width of sediment cell should be:
1 to 2 feet	12 inches
2 to 4 feet	18 inches
4 to 6 feet	24 inches
Over 6 feet	One-third of sand cell width

Example

A site in the White Center area has 1 acre of impervious area and 0.2 acres of till grass draining to the sand filter (1 foot of head above the filter). The designer wants to install a linear sand filter along a 200-foot parking area. The required sand area for a basic size linear sand filter would be found as follows:

Site Areas		Table 6.5.4.A values for SeaTac, basic size		
1 acres	x	1711 sf/acre	=	1711 sf
+ 0.2 acres	x	360 sf/acre	=	72 sf
			=	1783 sf

Multiply 1783 square feet by the C_s for the White Center area, which (from Figure 3.2.2.A) is 1.0 times the SeaTac area increments. Also multiple that result by the 0.7 adjustment factor.

1783 sf x 1.0 x 0.7 = 1248 sf

The required sand bed area is therefore **1248 square feet.** Divide 1248 square feet by 200 feet, the length of the filter for the site, to get a required sand bed width of 6.2 feet. The sediment cell would be one-third of 6.2 feet, or about 2 feet.

Note: To save space, the designer could cover the sand filter with grating that would bear traffic load and use the space for parking. The designer could also hire an engineer to perform the KCRTS detailed routing method. With this method, the sand bed width could be reduced to about 5 feet.

For background on the derivation of numbers in Table 6.5.4.A, refer to the "Background" discussion (p. 6-101) for the sand filter.

6.5.4.2 DESIGN CRITERIA

Linear sand filter details are shown in Figure 6.5.4.A (p. 6-130).

Geometry, Sizing, and Overflow

1. A linear sand filter shall consist of **two cells** or chambers, a sediment cell and a sand bed cell, divided by a low divider wall. If the sand filter is preceded by another WQ facility, and the flow enters the sand filter as sheet flow, the sediment cell may be waived.
2. Stormwater may enter the sediment cell by sheet flow or via a piped inlet.
3. **Minimum inside width** of the sand filter cell shall be 1 foot. **Maximum width** shall be 15 feet.
4. The **divider wall** must be level and extend 12 inches (max) above the sand bed.
5. The **sand filter bed** shall be 12 inches deep. An 8-inch layer of **drain rock with perforated drainpipe** shall be installed beneath the sand layer.
6. The **drainpipe** shall have a minimum diameter of 6 inches and be wrapped in **geotextile** and sloped 0.5 % (min) to drain.
7. For design, the **maximum depth of ponding** over the sand shall be 1 foot.
8. If separated from traffic areas, a linear sand filter may be **covered or open**, but if covered, the cover must be removable for the entire length of the filter. Covers must be grated if flow to the filter is from sheet flow.

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9. A linear sand filter shall have an **emergency overflow route**, either surface overland, tightline, or other structure for safely controlling the overflow, and shall meet the conveyance requirements specified in Chapter 1.

Structure Specifications

1. A linear sand filter vault shall be concrete (precast/prefabricated or cast-in-place). The concrete must conform to the "**Material**" requirements for **detention vaults** in Section 5.3.3.
2. At the discretion of DDES, the sediment cell may be made of materials other than concrete, provided water can be evenly spread for uniform delivery into the sand filter cell.
3. Where linear sand filters are located in traffic areas, they must meet the "**Structural Stability**" requirements specified for **detention vaults** in Section 5.3.3. The sediment cell shall have a **removable grated cover** that meets HS-25 traffic loading requirements. The cover over the sand filter cell may be either solid or grated.

Sand Specifications

Same as for sand filters (see Table 6.5.2.C, p. 6-109).

Geotextile Materials

Same as for sand filters (see Table 6.5.2.D, p. 6-109).

Underdrain Materials

Same as for sand filters (see page 6-111).

Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Section 5.3.3).

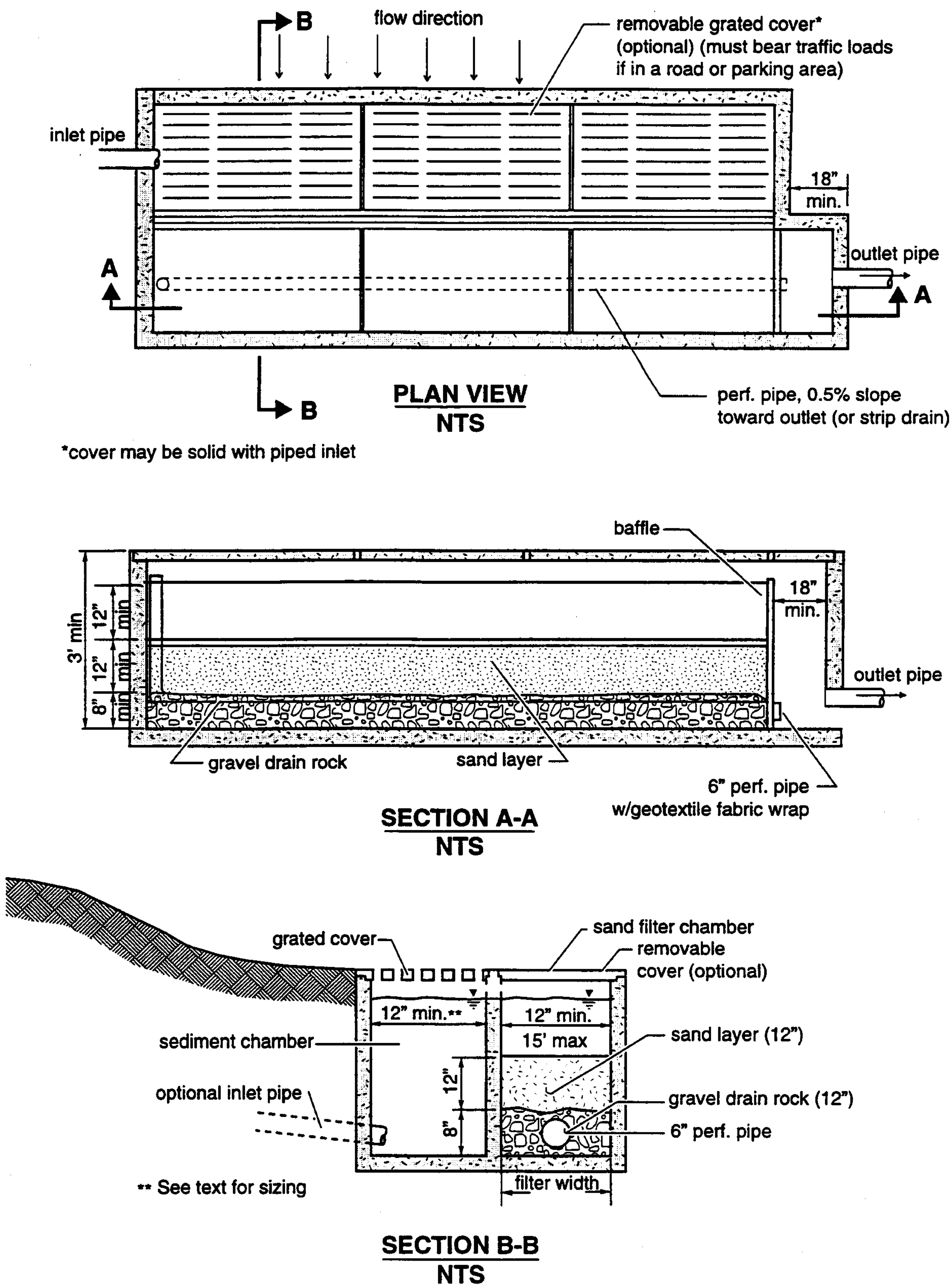
Construction Considerations

If put into service before the site is stabilized, placement of the sand layer should be delayed, and the linear sand filter may be used with the gravel layer only. The gravel layer must be replaced and the vault cleaned when the site is stabilized and the sand bed installed. King County will not assume maintenance responsibility or release financial guarantees until the final installation is complete.

Maintenance Considerations

Maintenance considerations for linear sand filters are similar to those for basic sand filters (see Section 6.5.2.2) except sediment should be removed from the sediment cell when the depth exceeds 6 inches.

FIGURE 6.5.4.A LINEAR SAND FILTER



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6.5.5 LEAF COMPOST FILTERS (LCF)

The process and apparatus of treating stormwater runoff by passing the runoff through a bed of leaf compost material is patented by W & H Pacific, Inc., (Patent Number 5,322,629) and marketed by Stormwater ™ Management, a company based in Portland, Oregon. A LCF removes pollutants through filtration, ion exchange, adsorption, and microbial degradation. Figure 6.5.5.A (p. 6-133) gives a schematic representation of a leaf compost filter.

Applications and Limitations

A leaf compost filter may be used as a second water quality facility in a stream protection treatment train (per Table 6.1.3.A, p. 6-11) or a bog protection treatment train (per Table 6.1.4.A, p. 6-13). Leaf compost filters are especially effective in situations where removal of metal contaminants is desired. **LCFs may not be used as stand-alone facilities** until more experience is gained with the system, particularly with potential for plugging or blinding and maintenance requirements.

Stormwater ™ Management has developed two basic types of compost filter: a vault style employing canisters filled with compost and an open unit with a long bed of compost. The vault unit is typically used in situations where space is limited, and the open unit is typically used to treat high volume runoff.

Consult the water quality menus in Section 6.1 (p. 6-3) for specific information on how a LCF can be used to meet Core Requirement # 8.

6.5.5.1 METHODS OF ANALYSIS

Compost filter sizing is based on the water quality design flow (see Section 6.2.1, p. 6-17). Since the process and the compost are patented, Stormwater ™ Management personnel will configure a leaf compost filter based on the design flow provided and specific site characteristics. In King County, the WQ design flow should be based on the KCRTS modeled flows, described in Chapter 3, rather than on other flow-estimation methods. An accurate description of land use and potential sediment and pollutant loading sources shall also be provided to Stormwater ™ Management personnel, who consider these factors in sizing. The typical size of the drop-in unit can be estimated based on the water quality design flow in Table 6.5.5.A (below).

TABLE 6.5.5.A TYPICAL DROP-IN FILTER VAULT SIZES BASED ON DESIGN FLOW

Design Flow (cfs)	Vault Size
up to 0.15	6' x 8'
0.16 to 0.28	6' x 12'
0.29 to 0.46	8' x 14'
0.46 to 0.64	8' x 18'
greater than 0.64	multiple drop-in filters

6.5.5.2 DESIGN CRITERIA

Figure 6.5.5.A (p. 6-133) illustrates the general configuration of a typical canister-style LCF unit using standard precast concrete vaults.

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General

Vaults used for a LCF shall conform with the "**Materials**" and "**Structural Stability**" requirements specified for detention vaults (see Section 5.3.3).

Pretreatment

This manual limits use of a LCF to the second or third facility in a treatment train. If used in another situation, an approved adjustment is required (see Section 1.4). Providing adequate pretreatment and performance monitoring are key to obtaining an adjustment approval. See Section 6.5.1, p. 6-99 for general pretreatment requirements.

Access Requirements

1. Unobstructed **access must be provided over the entire compost filter bed** by either access doors or removable panels to allow for removal and replacement of the bed. Removable panels, if used, shall be at grade, have stainless steel lifting eyes, and weight no more than 5 tons per panel.
2. Access to the **inflow and outlet cells** must also be provided.
3. **Ladder access** is required when vault height exceeds 4 feet.
4. **Locking lids** shall be provided as specified for detention (see Section 5.3.3).

Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Section 5.3.3).

Construction Considerations

Installation of a leaf compost filter shall follow the manufacturer's recommended procedures.

Maintenance Requirements

Maintenance needs vary from site to site based on the type of land use activity, implementation of source controls, and weather conditions. Leaf compost filters shall be inspected quarterly or at a frequency recommended by the supplier. Inspection and maintenance shall include the following:

1. The operation and maintenance instructions from the manufacturer shall be kept along with an inspection and maintenance log. The **maintenance log** shall be available for review by County inspectors.
2. **Routine maintenance** shall include inspecting for debris, vegetation, and sediment accumulation, flushing the underdrain, and removing or replacing compost media.
3. **Sediment** shall be removed when the accumulation causes the infiltration capacity to drop below the design flow rate of 2 to 2.2 gpm/sf. *Note: Instructions are available from the manufacturer for testing infiltration capacity.*
4. The **compost media** should be replaced at least once a year or when infiltration capacity is unrecoverable. Sediment removal and/or compost media replacement may require a vactor truck.
5. Media shall be disposed of in accordance with applicable regulations, including the Seattle-King County Department of Public Health solid waste regulations (Title 10) and state dangerous waste regulations (WAC 173-303). In most cases, compost media may be disposed of as solid waste.

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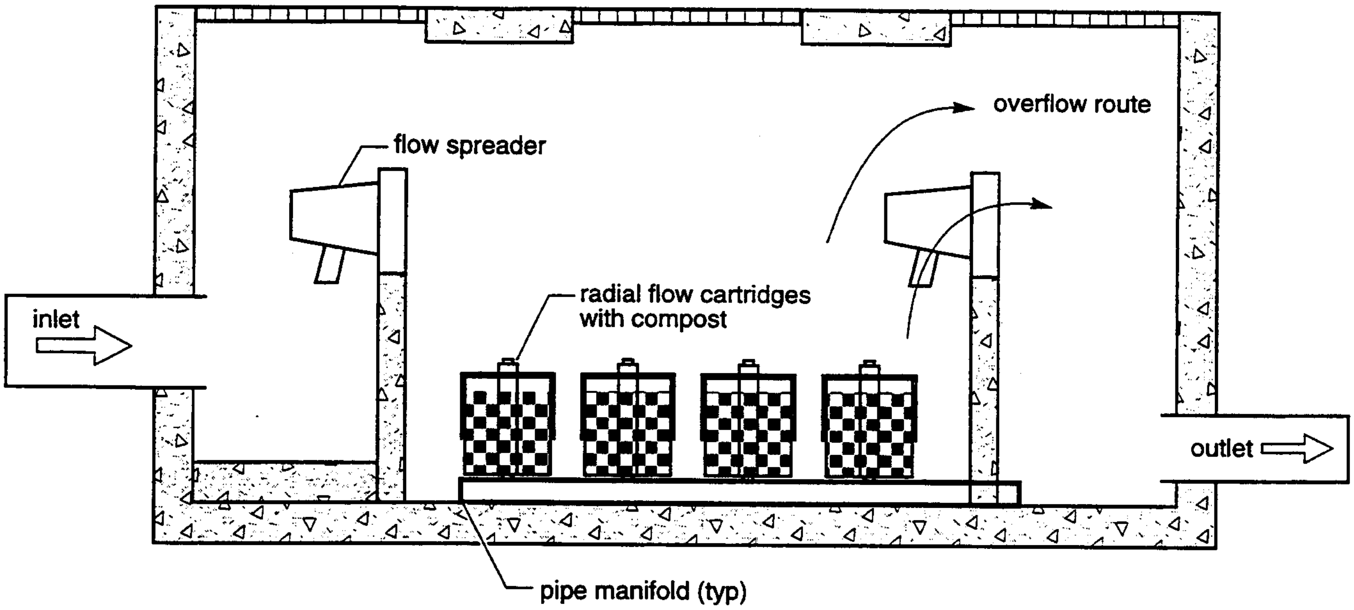
FIGURE 6.5.5.A LEAF COMPOST FILTER, SCHEMATIC



U.S. Patent No. 5,322,629

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6.6 OIL CONTROL FACILITY DESIGNS

This section presents the methods, criteria, and details for oil control facilities that are not discussed in other sections. Included are the following facility designs:

- Catch basin inserts, Section 6.6.1
- Oil/water separators, Section 6.6.2

Other oil control facilities include wetvaults, with minor modifications (see Section 6.4.2, p. 6-80), and linear sand filters (see Section 6.5.4, p. 6-126). Non-facility options include parking lot washing with proper disposal of wash water and compliance with a NPDES permit that already addresses oil control. More information on non-structural options can be found in the High-Use menu, Section 6.1.5 (p. 6-14).

The information presented for each facility is organized into the following two categories:

1. **Methods of Analysis:** Contains a step-by-step procedure for designing and sizing each facility. Information used in the procedure is based on available literature, but clarified or modified where deficiencies were identified.[40]
2. **Design Criteria:** Contains the details, specifications, and material requirements for each facility.

6.6.1 CATCH BASIN INSERTS

A *catch basin insert* is a device installed underneath a catch basin inlet that treats stormwater through filtration, settling, absorption, adsorption, or a combination of these mechanisms. Catch basin inserts vary greatly in form, some being rectangular, tray-like structures, some more like oil absorbent bags or pillows. Figure 6.6.1.A (p. 6-140) presents a schematic representation of a catch basin insert.

King County, in conjunction with other local agencies, has tested several catch basin inserts and found performance and removal rates to be highly variable, depending upon system configuration, pollutant particle size and concentration, and maintenance frequency. Because performance varies widely among the different devices, King County has developed a set of **performance criteria** that the devices must satisfy to be used for oil control pursuant to Special Requirement #5. Table 6.6.1.A (p. 6-136) lists the performance criteria and describes the tests to be used to evaluate whether a device meets the criteria.

Water Quality Treatment Objectives

The catch basin inserts manufactured to date typically have been configured to remove sediment, pollutants adsorbed to sediment, and oil and grease. The inserts described here **are intended to capture total petroleum hydrocarbons** (TPH) for use in new or redeveloped high-use sites (see Chapter 1 for information on high-use sites). Devices meeting the design criteria outlined in Table 6.6.1.A (p. 6-136) should provide oil and grease removals comparable to those of other high-use treatment options. However, catch basin inserts provide little if any spill protection and do not meet spill-containment requirements unless the catch basin in which they are installed has a tee section.

While the inserts described here are focused on treating TPH, catch basin inserts **can also be configured with other sorbents to remove specific pollutants**. Owners proposing to use catch basin inserts to treat specific pollutants should obtain assistance from King County's business outreach program or from another pollution control agency such as the Department of Ecology.

Catch basin inserts also **may be used for sediment control during construction**, as described in Appendix D. In some instances, particularly for redevelopment projects at high-use sites, existing catch basins may first be equipped with inserts for sediment control during construction and then be reconfigured (e.g., changing treatment media) to treat TPH following completion of construction activities.

[40] Such modifications were often based on computer modeling using the King County Runoff Time Series (KCRTS) model. Less frequently they were based on bench-scale studies. Back-up studies are listed in Reference Section 5.

TABLE 6.6.1.A
PERFORMANCE CRITERIA AND EVALUATION METHODS FOR CATCH BASIN INSERTS

	Criteria	Methods of Evaluation
1	Insert has ability to treat the water quality design flow for a minimum of 6 weeks under typical high-traffic conditions (in the Seattle area, this flow rate is approximately 0.042 cfs (19 gpm) for a drainage area of 5,000 square feet).	Subject the system to the maximum flow rate when new, and again after 4 and 6 weeks deployment. All flow must pass through the treatment area without short-circuiting or bypass.
2	Insert has ability to create a positive seal around grate to prevent low-flow bypass.	Install and observe unit under low-flow conditions. All flow must pass through the treatment area.
3	Media system functions so that its surface does not become plugged or blinded shortly after deployment and cause stormwater to bypass media before full use of media is realized.	Inspect media after 4 and 6 weeks deployment. If filtration rate as tested in Method #1 above has been compromised and media still can absorb oil, clogging is a problem.
4	Medium resists water saturation and maintains oil-absorbing properties for a minimum of 6 weeks under constantly wet conditions.	Examine media after 4 and 6 weeks deployment for signs of water saturation or degradation. Media in acceptable condition should still absorb oil and repel water.
5	Insert has means of preventing floating oil from escaping the unit. This requirement will be waived for inserts designed to be used with a tee section or down-turned elbow.	Inspect the insert for the presence of an under-over weir at the high-flow relief. If this or some comparable device exists, it is assumed that free oils will be retained.
6	Insert has means of preventing oil-soaked media from escaping the unit.	When the insert is new, and again after 4 to 6 weeks deployment, subject it to the peak flow rate (defined under Criterion #7) and observe whether media escapes.
7	Insert has ability to pass high flows without causing excessive ponding; no ponding to occur for the 25-year peak flow rate (in Seattle this rate is approximately 43 gpm for a drainage area of 5,000 square feet).	Close off all filtration surfaces with plastic sheeting and subject the insert to the required flow. No ponding around the drain inlet should occur for the 25-year peak rate.
8	Manufacturer provides complete installation and maintenance instructions.	Verify that instructions include information on the following: • Installation • Creating an adequate seal • Removal (including safety considerations) • Cleaning and replacement • Decant and disposal of liquid wastes • Media disposal guidance
	Desirable Features	**Methods of Evaluation**
1	Insert has high-flow bypass to prevent resuspension and washout.	Subject the insert to the flow rate calculated for Criterion #1, and then gradually increase the flow. Only the designed flow rate should pass through the treatment surfaces.
2	Service contract is provided.	There is no method for evaluating service contracts. Service contracts are listed as a desirable feature because they may offer greater assurance of regular system maintenance and, consequently, treatment reliability.

Note: The evaluation tests assume the use of suitable oil-absorbing/adsorbing media (see "Material Requirements," p. 6-138).

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Applications and Limitations

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how catch basin inserts can be used to meet Special Requirement #5. Note that catch basin inserts **shall not be in a public road right-of-way maintained by King County**. This is because the County does not have the resources needed to maintain catch basin inserts as frequently as needed for effective operation.

Catch basin inserts may be used to meet the oil control requirements for new or redevelopment high-use sites. The minimal space requirements, planning and engineering needs, and implementation time make catch basin inserts particularly attractive for redevelopment projects. The initial cost investment may be much lower than that of comparable oil treatment options. However, long-term costs associated with the **more frequent maintenance required** for catch basin inserts may offset some of the initial cost savings. Applicants considering catch basin inserts are encouraged to investigate maintenance costs associated with a particular device. Costs for maintaining catch basin inserts are on the order of $10 to $100 per unit per month, assuming monthly media replacement. The use of a catch basin insert may be limited by drainage area, available space inside the catch basin, availability of maintenance personnel or services, and access.

Catch Basin Interior Space

Pipe stub-outs, misaligned inlet frames, and shallow drainage systems limit the use of catch basin inserts for redevelopment. Therefore, an applicant considering catch basin inserts for a redevelopment project must ensure that the devices are physically compatible with existing catch basins and will achieve the desired performance.

Availability of Maintenance Staff or Services

To be effective, a catch basin insert must be maintained at a frequency recommended by the manufacturer, but at least monthly (the cycle may be extended up to six weeks depending upon local conditions; see "Maintenance Requirements" on p. 6-139). Because of the importance of regular maintenance, **owners using catch basin inserts will be required to keep a maintenance log** that specifies when the facilities were cleaned or replaced; the log must be available for review by County inspectors. Commercial maintenance services for facilities like catch basin inserts are increasingly available. Applicants intending to use catch basin inserts should include maintenance in a routine program such as grounds maintenance or contract with a commercial service.

Applicants planning to use a catch basin insert should also **consider the weight of candidate devices** and whether the insert must be completely lifted out of the catch basin to be maintained. Some of the inserts currently produced are heavy and may require two people or machinery, such as a forklift, to perform routine maintenance.

6.6.1.1 METHODS OF ANALYSIS

Catch basin inserts require little design or analysis but must meet the design criteria listed in the following section.

6.6.1.2 DESIGN CRITERIA

Figure 6.6.1.A (p. 6-140) illustrates the general configuration of a catch basin insert. Catch basin inserts must meet the criteria outlined below.

General

1. Catch basin inserts shall not be used to satisfy Special Requirement #5 if they will be installed in a **public road right-of-way** and maintained by King County; another option from the High-Use menu must be used instead.
2. The **total maximum tributary area** for catch basin inserts should not exceed 5,000 square per unit for new development projects. This limit is based on a target of treating 90 percent of the runoff

volume. For a 5,000 square foot impervious area in the Seattle region, this flow is approximately 19 gallons per minute (gpm), or 0.04 cubic feet per second for the WQ design flow.[41] The total maximum tributary area shall not exceed 7,000 square feet per unit for redevelopment projects.

3. If a manufacturer develops a catch basin insert that is proven to effectively treat flow rates higher than 20 gpm (0.045 cubic feet per second) without releasing previously trapped material (in accordance with Performance Criteria #1, #5, and #6 listed in Table 6.6.1.A, p. 6-136), King County may allow specific catch basin inserts to drain areas larger than 5,000 square feet.
4. A catch basin insert for a new development project shall be **designed to fit with a standard grate**, as specified in the *King County Road Standards* (see *KCRS* Nos. 41 and 42). If the insert is installed in an existing catch basin, **the insert shall be demonstrated to fit properly** so that there is a positive seal around the grate to prevent low-flow bypass. The maximum height of the grate above the top of the frame, with the insert installed, shall not exceed 3/16 inch, and the grate should be non-rocking.
5. Catch basin inserts shall be accessible as needed for maintenance and should not be limited by continuous vehicle parking.

Pretreatment

While no pretreatment is required with a catch basin insert, the use of the source control BMPs described in the *King County Stormwater Pollution Control Manual* (available from DNR) will decrease maintenance needs. **Catch basin inserts may not be used in place of source control best management practices.**

Material Requirements

1. A catch basin insert must be fitted with **oil-absorbent/adsorbent filter media**, to be changed at least monthly (October to June) and whenever the filter media surface is covered with sediment. **Acceptable sorbent media** include wood fiber products such as *Absorbent W* or *SuperSorb*, whole fibrous moss (need not be sphagnum), or *Petrolok*; these media have been investigated by the County and found to retain captured oil fairly effectively. *Streamguard*™ polymer (currently distributed by Foss Environmental) was also tested using the same method established by the County and found to achieve acceptable oil retention. Other products which absorb oil without significant release are also acceptable.[42] Other polypropylene-based products are expected to be acceptable, although none but the Streamguard™ polymer have been investigated to date.
2. **Unacceptable filter media**. Cedar Grove compost was tested and found unacceptable for oil retention. Compost from CFS Treatment Systems, Inc., who produce a patented leaf compost, was also tested. Although it performed fairly well, it did not retain oil as well as the other products tested. Therefore, CFS leaf compost should not be used in catch basin inserts for oil control. Other materials that are unsuitable for use in catch basin inserts include Fuller's or diatomaceous earth and kitty litter.
3. To minimize the generation of solid waste and the consumption of natural resources, systems constructed of or using **recycled products are preferred**. Reusable filter materials should be refreshed according to the manufacturer's instructions.

Construction Requirements

1. Installation of a catch basin insert for a new or redevelopment project shall follow the manufacturer's recommended procedures. The insert should be installed in the catch basin after the site has been paved or stabilized (for new development) or after completion of construction (for a redevelopment site that is already paved).

[41] Testing by King County indicates that few of the devices tested could continue to meet treatment requirements at flow rates in excess of about 20 gpm. In addition, due to the very short contact time and potential for flushing previously trapped materials, treatment would be compromised at higher flow rates.

[42] Criteria used for acceptable absorbent materials are that a completely oil-saturated sample of the material does not release more than 10 mg/L of total petroleum hydrocarbon in any two minute period when flushed with tap water (running at a rate of 0.3 to 0.5 gpm) for 10 consecutive minutes.

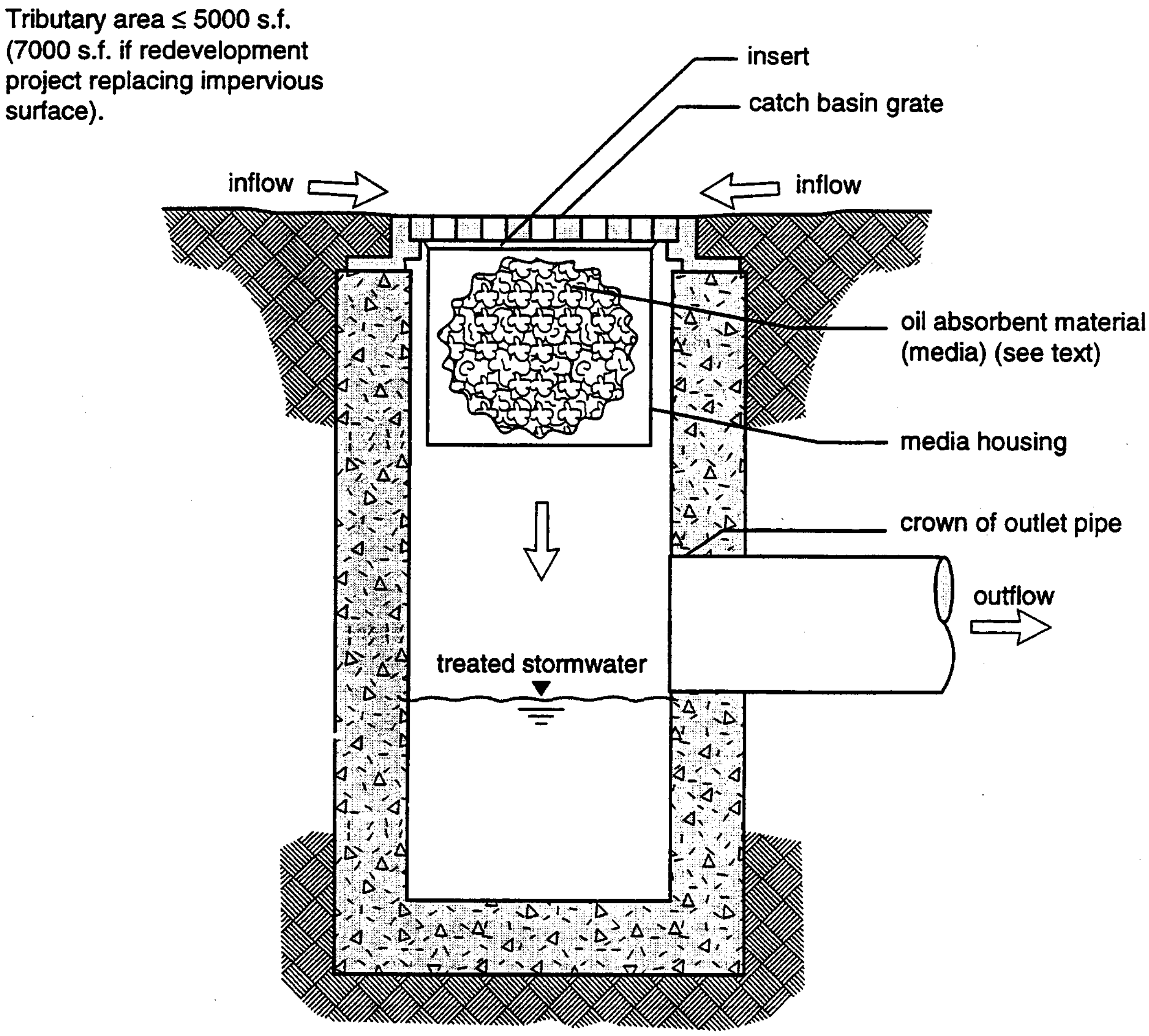
2. If a catch basin insert is **used for sediment control during construction**, it should be reconfigured in accordance with the manufacturer's recommendations. When used for sediment control, the insert should be inspected at least weekly and maintained if needed (see Appendix D for information on using the insert for sediment control).

Maintenance Requirements

Catch basin insert systems require more frequent maintenance than other oil treatment systems. While maintenance requirements of individual units may be relatively minor, the need for diligence and the potentially large number of units required in place of other more typical oil treatment systems make sound maintenance planning essential to the successful use of these devices. Therefore, the following provisions are necessary for proper maintenance:

1. A **declaration of covenant** must be recorded allowing King County to inspect facilities (see Reference Section 8E for wording).
2. Maintenance needs vary from site to site based on the type of land use activity, implementation of source controls, and weather conditions. Catch basin inserts should be **maintained at a frequency recommended by the manufacturer**, but at least monthly during the wet season (October through April) and once every 2 months during the remainder of the year. *Note: During the first wet season, it is recommended that inspection be carried out every other week to determine whether a shorter maintenance cycle is needed for the particular site.*
3. Maintenance shall include full replacement or renewal of oil absorbent/adsorbent material. In addition, when maintaining the insert, the catch basin sump should be inspected for sediment accumulation. Sediment should be removed if the depth of sediment in the sump is greater than 0.5 feet. **An inspection and maintenance log shall be kept onsite** and made available to County inspectors on an as-needed basis. At a minimum, the maintenance log shall include the following information: date, type of maintenance performed, names of persons performing the work, and signature. Persons conducting maintenance activities should wear rubber gloves for health and safety protection while handling used filter media.
4. The **operation and maintenance instructions** from the catch basin insert manufacturer shall be kept with the maintenance log. Manufacturer's instructions should include installation, removal (including safety instructions), cleaning and replacement (including a practical means of determining when the unit is in need of service), and media disposal guidance (including decanting of liquid wastes).
5. Owners should follow the manufacturer's instructions for **dewatering filter media**, which vary depending on the type of unit. Generally, catch basin inserts that drain by gravity can be dewatered in place during dry weather. If an owner is unable to perform monthly maintenance because there has not been sufficient dry weather, the maintenance period may be extended up to an additional two weeks. If by the end of the additional two weeks there has been insufficient dry weather to allow dewatering, the owner shall make other arrangements for dewatering the filter media. Such arrangements could include use of a commercial service, dewatering the insert in a watertight container, or other methods meeting environmental regulations. Media shall be disposed of in accordance with applicable regulations, including the Seattle-King County Department of Public Health solid waste regulations (Title 10) and State dangerous waste regulations (WAC 173-303). In most cases, dewatered filter media may be disposed of as solid waste.

FIGURE 6.6.1.A SCHEMATIC OF CATCH BASIN INSERT



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6.6.2 OIL/WATER SEPARATORS

Oil/water separators rely on passive mechanisms that take advantage of oil being lighter than water. Oil rises to the surface and can be periodically removed. The two types of oil/water separators typically used for stormwater treatment are the baffle type or API (American Petroleum Institute) oil/water separator and the coalescing plate oil/water separator.

Baffle oil/water separators baffle Baffle use vaults that have multiple cells separated by baffles extending down from the top of the vault (see Figure 6.6.2.D on page 6-151 for schematic details). The baffles block oil flow out of the vault. Baffles are also commonly installed at the bottom of the vault to trap solids and sludge that accumulate over time. In many situations, simple floating or more sophisticated mechanical oil skimmers are installed to remove the oil once it has separated from the water.

Coalescing plate separators are typically manufactured units consisting of a baffled vault containing several inclined corrugated plates stacked and bundled together (see Figure 6.6.2.E on page 6-152 for schematic details). The plates are equally spaced (typical plate spacing ranges from $^1/_4$-inch to 1 inch) and are made of a variety of materials, the most common being fiberglass and polypropylene. Efficient separation results because the plates reduce the vertical distance oil droplets must rise in order to separate from the stormwater. Once they reach the plate, oil droplets form a film on the plate surface. The film builds up over time until it becomes thick enough to migrate upward under the influence of gravity along the inclined plate. When the film reaches the edge of the plate, oil is released as large droplets which rise rapidly to the surface, where the oil accumulates until the unit is maintained. Because the plate pack increases treatment effectiveness significantly, coalescing plate separators can achieve a specified treatment level with a smaller vault size than a simple baffle separator.

Oil/water separators are meant to treat stormwater runoff from more intensive land uses, such as high-use sites, and facilities that produce relatively high concentrations of oil and grease. Although baffle separators historically have been used to remove larger oil droplets (150 microns or larger), they can also be sized to remove smaller oil droplets. Both separators can be used to meet a **performance goal of 10 to 15 mg/L** by designing the unit to removal oil particles 60 microns and larger.

Applications and Limitations

Oil/water separators are designed to remove free oil and are not generally effective in separating oil that has become either chemically or mechanically emulsified and dissolved in water. Therefore, it **is desirable for separators be installed upstream of facilities and conveyance structures that introduce turbulence and consequently promote emulsification**. Emulsification of oil can also result if surfactants or detergents are used to wash parking areas that drain to the separator. Detergents should not be used to clean parking areas unless the wash water is collected and disposed of properly (usually to the sanitary sewer).

Oil/water separators are **best located in areas where the tributary drainage area is nearly all impervious, and a fairly high load of petroleum hydrocarbons is likely to be generated.** Oil/water separators are not recommended for areas with very dilute concentrations of petroleum hydrocarbons since their performance is not effective at low concentrations. Excluding unpaved areas helps to minimize the amount of sediment entering the vault, reducing the need for maintenance. A unit that fails and ceases to function can release previously trapped oil to the downstream receiving water, both in release from the oily sediments and from entrainment of surface oils.

Wetvaults may also be modified to function as baffle oil/water separators (see design criteria for wetvaults, Section 6.4.2.2, p. 6-80).

Consult the water quality menus in Section 6.1 (p. 6-3) for information on how baffle and coalescing plate oil/water separators can be used to meet Special Requirement # 5.

6.6.2.1 METHODS OF ANALYSIS

Background

Generally speaking, in most oil and water mixtures the degree of oil/water separation that occurs is dependent on both the time the water is detained in the separator and the oil droplet size. The sizing methods in this section are based on Stokes' law:

$$V_T = \frac{g(d_p - d_c)D_o^2}{18\mu} \tag{6-21}$$

where
- V_T = rise velocity of oil droplet
- g = gravitational constant
- d_p = density of droplet to be removed
- d_c = density of carrier fluid
- D_o = diameter of oil droplet
- μ = absolute viscosity of carrier fluid

1. The basic assumptions inherent in Stokes' law are: (1) flow is laminar, and (2) the oil droplets are spherical.

Traditional baffle separators are designed to provide sufficient hydraulic residence time to permit oil droplets to rise to the surface. The residence time T_r is mathematically expressed as follows:

$$T_r = \frac{V}{Q} \tag{6-22}$$

where
- V = effective volume of the unit or container, or $A_s \times H$, where
- A_s = surface area of the separator unit, and
- H = height of water column in the unit

- Q = hydraulic capacity or flow through the separator

The time required for the oil droplet to rise to the surface within the unit is found by the relation:

$$T_T = \frac{H}{V_T} \tag{6-23}$$

where V_T = rise velocity of the oil droplet

The oil droplet rises to the water surface if the residence time in the separator is at least equal to the oil droplet rise time. This can be expressed as follows:

$$T_r = T_T$$

By substituting terms and simplifying:

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$$V_T = \frac{Q}{A_s} \tag{6-24}$$

where A_s = surface area of the separator unit

The ratio in Equation (6-24) is designated as the surface overflow rate or loading rate. It is this rate that governs the removal efficiency of the process and predicts whether an oil droplet will be removed by the separator.

Method for Baffle Separators

Design steps for the baffle separator are summarized below:

Step 1: Determine the WQ design flow (Q). The facility is sized based on the WQ design flow (see Section 6.2.1, p. 6-17). The separator **must be designed as an off-line facility**. That is, flows higher than the WQ design flow must bypass the separator.

Step 2: Calculate the minimum vertical cross-sectional area. Use the following equation:

$$A_c = \frac{Q}{V_H} \tag{6-25}$$

where A_c = minimum cross-sectional area (sf)
Q = water quality design flow (cfs)
V_H = design horizontal velocity (fps)

Set the horizontal velocity V_H equal to 15 times the oil droplet's rise rate V_T. A **design rise rate of 0.033 feet per minute shall be used** unless it is demonstrated that conditions of the influent or performance function warrant the use of an alternative value. Using the 0.033 feet per minute rise rate results in V_H = 0.008 fps (= 0.495 fpm).

Step 3: Calculate the width and depth of the vault. Use the following equation:

$$D = \frac{A_c}{W} \tag{6-26}$$

where D = maximum depth (ft)
W = width of vault (ft)
and where A_c is from Step 2 above.

The computed depth D must meet a depth-to-width ratio r of between 0.3 and 0.5 (i.e., $0.3 \leq D/W \leq 0.5$).
Note: $D = (r A_c)^{0.5}$ and
$W = D/r$ and
r = the depth-to-width ratio

Step 4: Calculate the length of the vault. Use the following equation:

$$L = FD\left(\frac{V_H}{V_T}\right) \tag{6-27}$$

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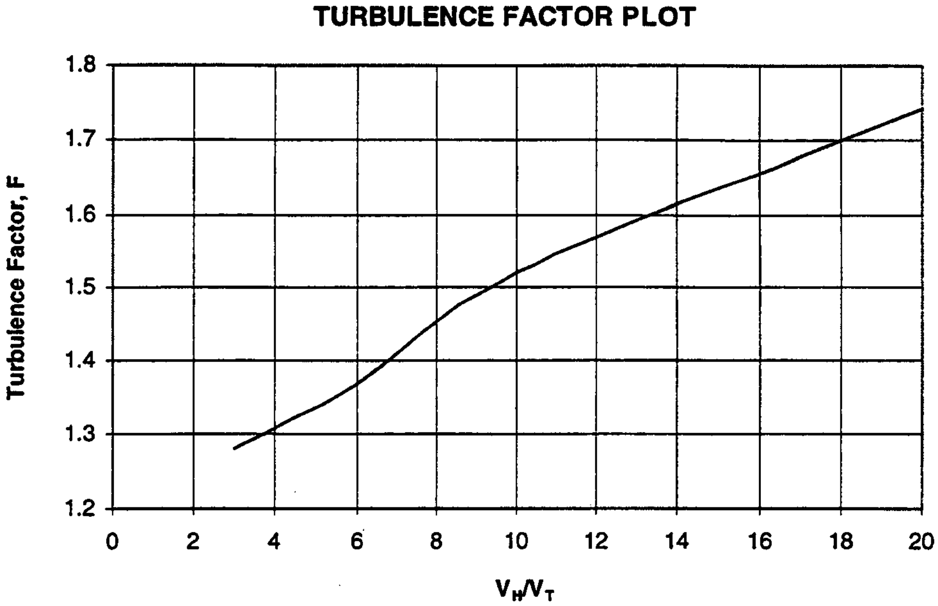
where L = length of vault (ft)

F = turbulence and short-circuiting factor (unitless, see Figure 6.6.2.A)
V_H = horizontal velocity (ft/min)
V_T = oil droplet rise rate (ft/min)
D = depth (ft)

The turbulence factor F should be selected using a V_H/V_T ratio of 15, so $F = 1.64$.

Therefore Equation (6-27) becomes: $L = 1.65 \times 15 \times D$

FIGURE 6.6.2.A TURBULENCE FACTOR PLOT



Step 5: Check the separator's length-to-width ratio. The length L of the vault must be at least 5 times its width in order to minimize effects from inlet and outlet disturbances. The length of the forebay shall be approximately $L/3$.

Step 6: Compute and check that the minimum horizontal surface area (A_H) criterion is satisfied. This criterion is expressed by the following equation:

$$A_H = \left(\frac{1.65Q}{0.33}\right) \leq LW \tag{6-28}$$

Step 7: Compute and check that the horizontal surface area of the vault forebay. This area must be greater than 20 square feet per 10,000 square feet of tributary impervious area. The length of the forebay ($L/3$) may be increased to meet this criterion without having to increase the overall length of the vault.

Step 8: Design the flow splitter and high-flow bypass. See Section 6.2.5 (p. 6-27) for information on flow splitter design.

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Method for Coalescing Plate Separators

Coalescing plate separators are designed using the same basic principles as baffle separators. The major difference is that in the baffle separator, horizontal separation is related only to water surface area, while in the coalescing plate separator, horizontal separation is related to the sum of the plan-areas of the plates. The treatment area is increased by the sum of the horizontal projections of the plates being added, and is referred to as the plate *effective separation area.*

The basic procedure for designing a coalescing plate separator is to determine the effective separation area required for a given design flow. The specific vault sizing then depends on the manufacturer's plate design. The specific design, analysis, configuration, and specifications for coalescing plates are empirically based and variable. Manufacturers' recommendations may be used to vary the recommendations given below.

Step 1: Determine the WQ design flow. The coalescing plate oil/water separator must be sized based on the WQ design flow (see Section 6.2.1, p. 6-17). The separator **must be designed as an off-line facility**; flows higher than the WQ design flow must bypass the separator.

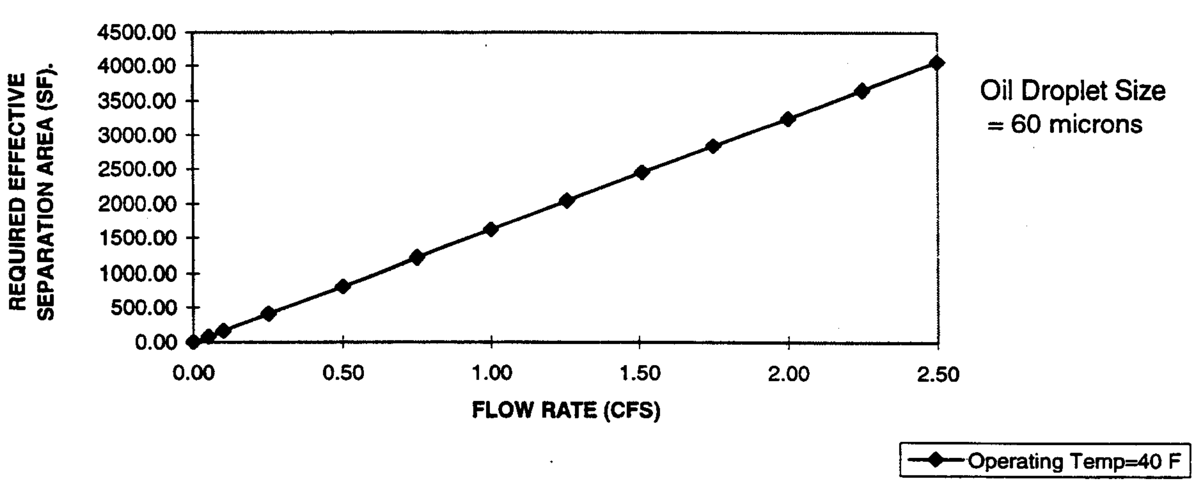
Step 2: Calculate the plate minimum effective separation area (A_h). A_h is found using the following equation:

$$A_h = \frac{60Q}{0.00386\left(\frac{S_w - S_o}{\mu}\right)} \qquad (6\text{-}29)$$

where
S_w = specific gravity of water = 1.0
S_o = specific gravity of oil = 0.85
μ = absolute viscosity of water (poises); use 0.015674 for temp = 39° F
Q = water quality design flow rate (cfs)
A_h = required effective (horizontal) surface area of plate media (sf).

Equation (6-29) is based on an oil droplet diameter of 60 microns. A graphical relation of Equation (6-29) is shown in Figure 6.6.2.B below. This graph may be used to determine the required effective separation surface area of the plate media.

FIGURE 6.6.2.B EFFECTIVE SEPARATION SURFACE VS FLOW RATE



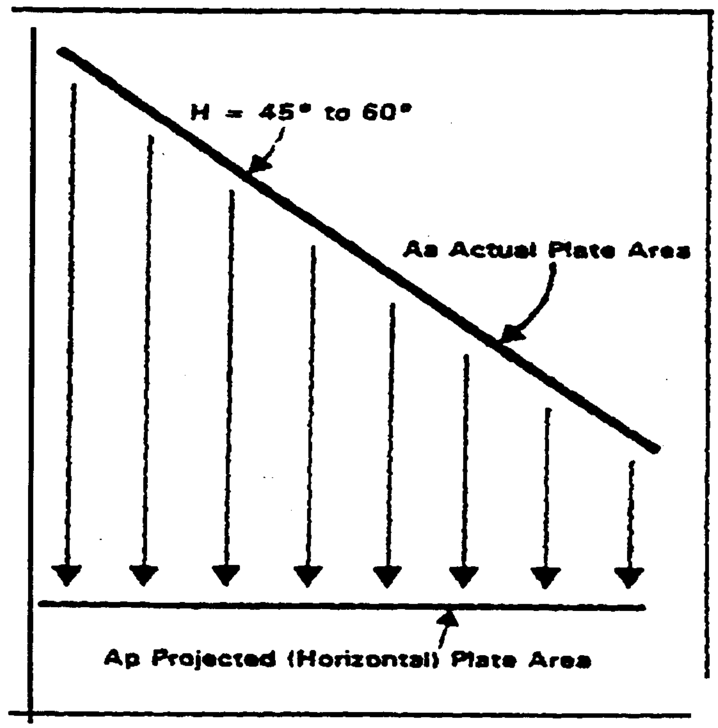
Step 3: Calculate the collective projected surface area (A_p). A key design step needed to assure adequate performance of the separator unit is to convert the physical plate area (the surface area of the plates if laid flat) into the effective (horizontal) separation surface area A_h (calculated in step 2). The effective separation surface area A_h is based on the collective projected horizontal surface area A_p of the plates where the plates are inclined, rather than their laid flat.

$$A_h = A_p = A_a (\cos H) \tag{6-30}$$

where A_a = actual collective plate area of the plate configuration (sf)
H = angle of the plates to the horizontal (degree)

This equation is represented graphically in Figure 6.6.2.C below. The designer should make sure that the manufacturer sizes the oil/water separator using the projected surface area rather than the actual plate area. *Note: For this method, only the **lower plate surface** may be counted as effective separation surface, regardless of manufacturer's claims.*

FIGURE 6.6.2.C PROJECTED HORIZONTAL PLATE AREA FOR COALESCING PLATE OIL/WATER SEPARATOR



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Step 4: Check with specific separator manufacturers. Check with specific manufacturers to choose a separator that provides the required actual collective plate area calculated in Step 3, and meets the other design criteria given in the next section, p. 6-147. The specific vault design will depend upon each manufacturer's design. The geometric configuration and dimensions of the plate pack as well as the vault design are variable and flexible depending on each manufacturer's product.

Table 6.6.2.A (p. 6-147) provides approximate vault sizes for rough planning purposes. In reality, various manufacturer's have quite different designs, both for the plate packs themselves as well as for forebay and afterbays. In addition, standard pre-cast vault dimensions vary with each manufacturer. These various

factors can greatly affect the volume of vault needed to provide a given effective separation area. The numbers in Table 6.6.2.A should, then, be considered "order of magnitude" estimates only.

TABLE 6.6.2.A
APPROXIMATE COALESCING PLATE OIL/WATER SEPARATOR VAULT DIMENSIONS*

Area of Effective Separation (square feet)	Approximate vault volume required (cubic feet) for plates with 1/2 inch spacing and inclined 60 degrees from horizontal (cubic feet)
100	150
200	240
300	330
600	530
1,200	890
2,400	1150
3,200	2090
4,800	2640

* *Order of magnitude estimates for planning purposes only. Actual vault volumes vary considerably depending on separator design features and pre-cast vault dimensions.*

6.6.2.2 DESIGN CRITERIA

Details for a typical baffle oil/water separator are shown in Figure 6.6.2.D (p. 6-151). **Other designs** and configurations of separator units and vaults are allowed, including above ground units. However, they must produce equivalent treatment results and treat equivalent flows as conventional units.

General Siting

1. Oil/water separators **must be installed off-line**, bypassing flows greater than the WQ design flow.
2. When a separator is required, it **shall precede other water quality treatment facilities** (except wetvaults). It may be positioned either upstream or downstream from flow control facilities, since there are both advantages and disadvantages with either placement.
3. In moderately pervious soils where **seasonal groundwater** may induce flotation, buoyancy tendencies shall be balanced by ballasting or other methods as appropriate.
4. Any **pumping devices** shall be installed downstream of the separator to prevent oil emulsification in stormwater.

Vault Structure — General

The following criteria apply to both baffle and coalescing plate separators:

1. Separator vaults shall be **watertight**. Where pipes enter and leave a vault below the WQ design water surface, they shall be sealed using a non-porous, non-shrinking grout.
2. Separator vaults shall have a **shutoff mechanism** on the outlet pipe to prevent oil discharges during maintenance and to provide emergency shut-off capability in case of a spill. A valve box and riser shall also be provided according to the design criteria for wetponds (see "Inlet and Outlet Criteria," Section 6.4.1.2, p. 6-71).

Vault Structure — Baffle Separators

In addition to the above general criteria, the following criteria apply specifically to baffle separators:

1. Baffle separators shall be divided into **three compartments**: a forebay, an oil separation cell, and an afterbay. The **forebay** is primarily to trap and collect sediments, encourage plug flow, and reduce turbulence. The **oil separation cell** traps and holds oil as it rises from the water column, and it serves as a secondary sediment collection area. The **afterbay** provides a relatively oil-free cell before the outlet, and it provides a secondary oil separation area and holds oil entrained by high flows.
2. The **length of the forebay** shall be approximately 1/3 to 1/2 of the length of the vault, *L*. In addition, the **surface area of the forebay** must be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator.
3. A **removable flow-spreading baffle**, extending from the surface to a depth of up to 1/2 the vault depth (D) is recommended to spread flows.
4. The **removable bottom baffle** (sediment-retaining baffle) shall be a minimum of 24 inches (see Figure 6.6.2.D, p. 6-151), and located at least 1 foot from the oil-retaining baffle. A "window wall" baffle may be used, but the area of the window opening must be at least three times greater than the area of the inflow pipe.
5. A **removable oil retaining baffle** shall be provided and located approximately 1/4 *L* from the outlet wall or a minimum of 8 feet, whichever is greater (the 8-foot minimum is for maintenance purposes). The oil-retaining baffle shall extend from the elevation of the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.
6. Baffles may be fixed rather than removable if additional entry ports and ladders are provided so that both sides of the baffle are accessible by maintenance crews.
7. Baffle separator vaults shall have a minimum **length-to-width ratio** of 5.
8. The **design water depth** (*D*) shall be no deeper than 8 feet unless approved by DDES. Depths greater than 8 feet may be permitted on a case-by-case basis, taking into consideration the potential for depletion of oxygen in the water during the warm summer months.
9. Baffle separator vaults shall have a **design water depth-to-width** ratio of between 0.3 and 0.5.

Vault Structure — Coalescing Plate Separators

In addition to the above general criteria, the following criteria apply specifically to coalescing plate separators:

1. Coalescing plate separators shall be divided by baffles or berms into **three compartments**: a forebay, an oil separation cell which houses the plate pack, and an afterbay. The **forebay** controls turbulence and traps and collects debris. The **oil separation cell** captures and holds oil. The **afterbay** provides a relatively oil-free exit cell before the outlet.
2. The **length of the forebay** shall be a minimum of 1/3 the length of the vault, *L* (but 1/2 *L* is recommended). In addition, it is recommended that the **surface area of the forebay** be at least 20 square feet per 10,000 square feet of tributary impervious area draining to the separator. In lieu of an attached forebay, a separate grit chamber, sized to provide be at least 20 square feet per 10,000 square feet of tributary impervious area, may precede the oil/water separator.
3. An **oil-retaining baffle** shall be provided. If maintained by the County, the baffle must be a minimum of 8 feet from the outlet wall (for maintenance purposes). For large units, a baffle position of 0.25*L* from the outlet wall is recommended. The oil-retaining baffle shall extend from the water surface to a depth of at least 50% of the design water depth. Various configurations are possible, but the baffle shall be designed to minimize turbulence and entrainment of sediment.

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4. A bottom **sediment-retaining baffle** shall be provided upstream of the plate pack. The minimum height of the sludge-retaining baffle shall be 18 inches. Window walls may be used, but the window opening must be a minimum of three times greater than the area of the inflow pipe.

5. It is recommended that entire space between the sides of the plate pack and the vault wall be filled with a solid but light-weight removable material such as a **plastic or polyethylene foam** to reduce short-circuiting around the plate pack. Rubber flaps are not effective for this purpose.

6. If a separator will be maintained by King County, the **separator plates** shall meet the following requirements:

   a) Plates shall be inclined at 45° to 60° from the horizontal. This range of angles exceeds the angle of repose of many solids and therefore provides more effective droplet separation while minimizing the accumulation of solids on the individual plates.

   b) Plates shall have a minimum plate spacing of 1/2-inch and have corrugations.

   c) Plates shall be securely bundled in a plate pack so that they may be removed as a unit.

   d) The plate pack shall be a minimum of 6 inches from the vault bottom.

   e) There should be 1 foot of head space between the top of the plate pack and the bottom of the vault cover.

Inlet and Outlet

1. The **inlet shall be submerged.** A tee section may be used to submerge the incoming flow and must be at least 2 feet from the bottom of the tank and extend above the WQ design water surface.

   Intent: The submerged inlet is to dissipate energy of the incoming flow. The distance from the bottom is to minimize resuspension of settled sediments. Extending the tee to the surface allows air to escape the flow, thus reducing turbulence. Alternative inlet designs that accomplish these objectives are acceptable.

2. The **vault outlet pipe** shall be sized to pass the WQ design flow before overflow (using the pipe sizing methods in Chapter 4). The vault outlet pipe shall be back-sloped or have a tee extending 1 foot above and below the WQ design water surface to provide for secondary trapping of oils and floatables in the wetvault. *Note: The invert of the outlet pipe sets the WQ design water surface elevation.*

Material Requirements

1. All **metal parts shall be corrosion-resistant.** Zinc and galvanized materials are to be avoided when substitutes are available because of aquatic toxicity potential. Painting metal parts for corrosion resistance is not allowed due to lack of longevity.

2. **Vault baffles** shall be concrete, stainless steel, fiberglass reinforced plastic, or other acceptable material and shall be securely fastened to the vault.

3. **Gate valves**, if used, shall be designed for seating and unseating heads appropriate for the design conditions.

4. For coalescing plate separators, **plate packs** shall be made of fiberglass, stainless steel or polypropylene.

Access Requirements

Same as for **detention vaults** (see Section 5.3.3) except for the following **modifications:**

1. Access to **each compartment** is required. If the length or width of any compartment exceeds 50 feet, an additional access point for each 50 feet is required.

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2. Access points for the **forebay and afterbay** shall be positioned partially over the inlet or outlet tee to allow visual inspection as well as physical access to the bottom of the vault.
3. For **coalescing plate separators**, the following also apply:
   a) Access to the **compartment containing the plate pack** shall be a removable panel or other access able to be opened wide enough to remove the entire coalescing plate bundle from the cell for cleaning or replacement. Doors or panels shall have stainless steel lifting eyes, and panels shall weigh no more than 5 tons per panel.
   b) A **parking area or access pad** (25-foot by 15-foot minimum) shall be provided near the coalescing plate bundles to allow for their removal from the vault by a truck-mounted crane or backhoe, and to allow for extracting accumulated solids and oils from the vault using a vactor truck.

Access Roads, Right of Way, and Setbacks

Same as for detention vaults (see Section 5.3.3).

Recommended Design Features

1. A **gravity drain** for maintenance is recommended if grade allows. The drain invert should be at a depth equal to the depth of the oil retaining baffle. Deeper drains are encouraged where feasible.
2. The recommended design features for wetvaults should be applied.
3. If large amounts of oil are likely to be captured, a bleed-off pipe and separate waste oil tank can be located adjacent to the vault to channel separated oils into the tank. This improves the overall effectiveness of the facility, especially if maintenance is only annually. It also improves the quality of the waste oil recovered from the facility.

Construction Considerations

1. Construction of oil/water separators should follow and conform to the manufacturer's recommended construction procedures and installation instructions as well as Chapter 7 of the *King County Road Standards*. Where the possibility of vault flotation exists, the vault shall be properly anchored in accordance with the manufacturer's recommendations or an engineer's design and recommendations.
2. Particular care must be taken when inserting coalescing plate packs in the vault so as not to damage or deform the plates.
3. Upon completion of installation, the oil/water separator shall be thoroughly cleaned and flushed prior to operating.

Maintenance Considerations

1. Oil/water separators must be cleaned regularly to ensure that accumulated oil does not escape from the separator. Separators should be cleaned by November 15 of each year to remove accumulation during the dry season. They must also be cleaned after spills of polluting substances such as oil, chemicals, or grease. Vaults must also be cleaned when inspection reveals any of the following conditions:
   a) Oil accumulation in the oil separation compartment equals or exceeds 1 inch, unless otherwise rated for greater oil accumulation depths recommended by the specific separator manufacturer.
   b) Sediment deposits in the bottom of the vaults equals or exceeds 6 inches in depth.
2. For the first several years, oil/water separators should be checked on a quarterly basis for proper functioning and to ensure that accumulations of oil, grease, and solids in the separator are at acceptable levels. Effluent from the vault shall also be observed for an oil sheen to ensure that oil concentrations are at acceptable levels and that expected treatment is occurring. Separators should also be inspected after large storm events (about 2 inches in 24 hours).

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3. Access to separators shall be maintained free of all obstructions, and units shall be readily accessible at all times for inspection and maintenance.
4. Maintenance personnel entering oil/water separator vaults should follow the state regulations pertaining to confined space entry, if applicable.

FIGURE 6.6.2.D BAFFLE OIL/WATER SEPARATOR

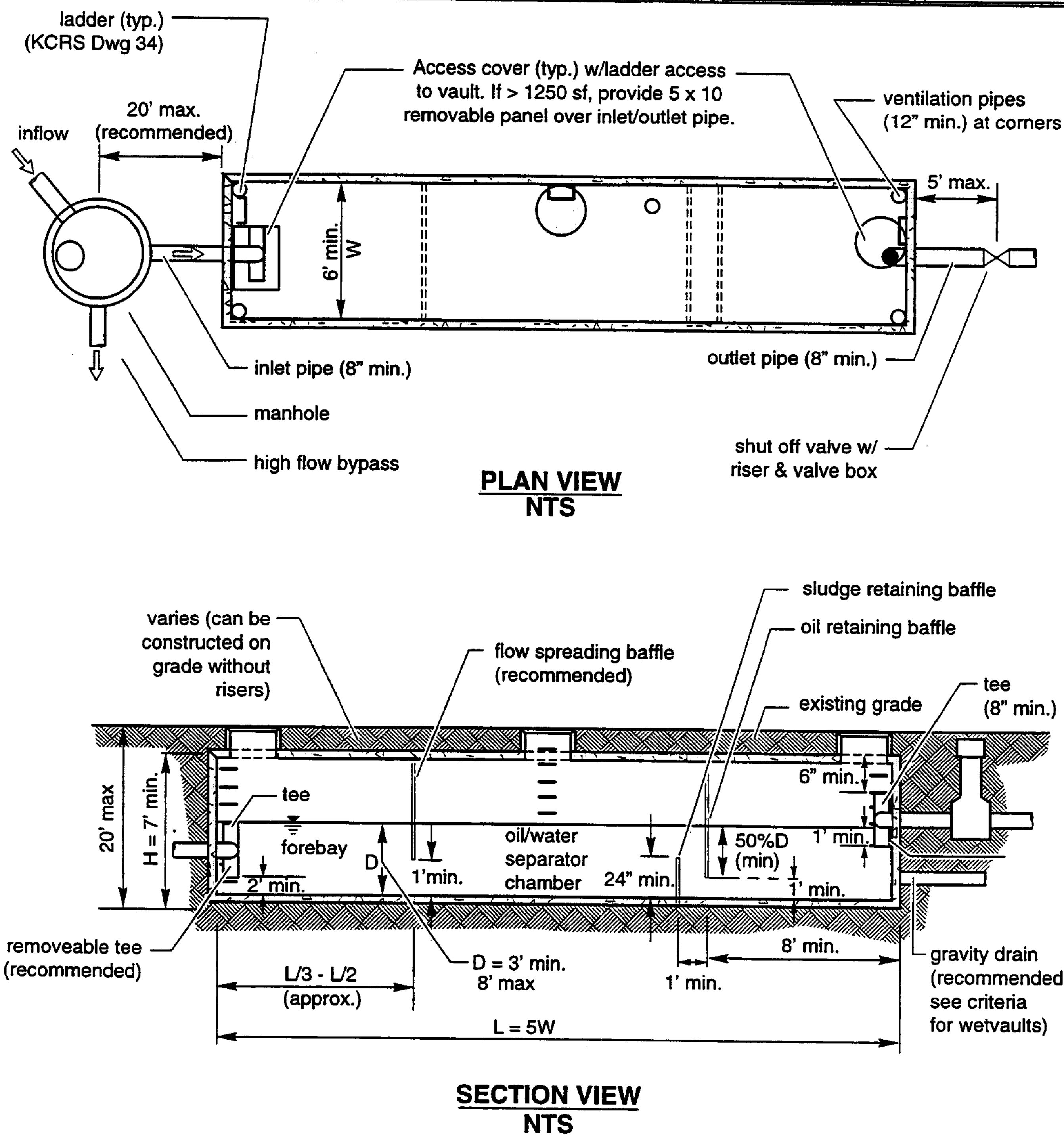

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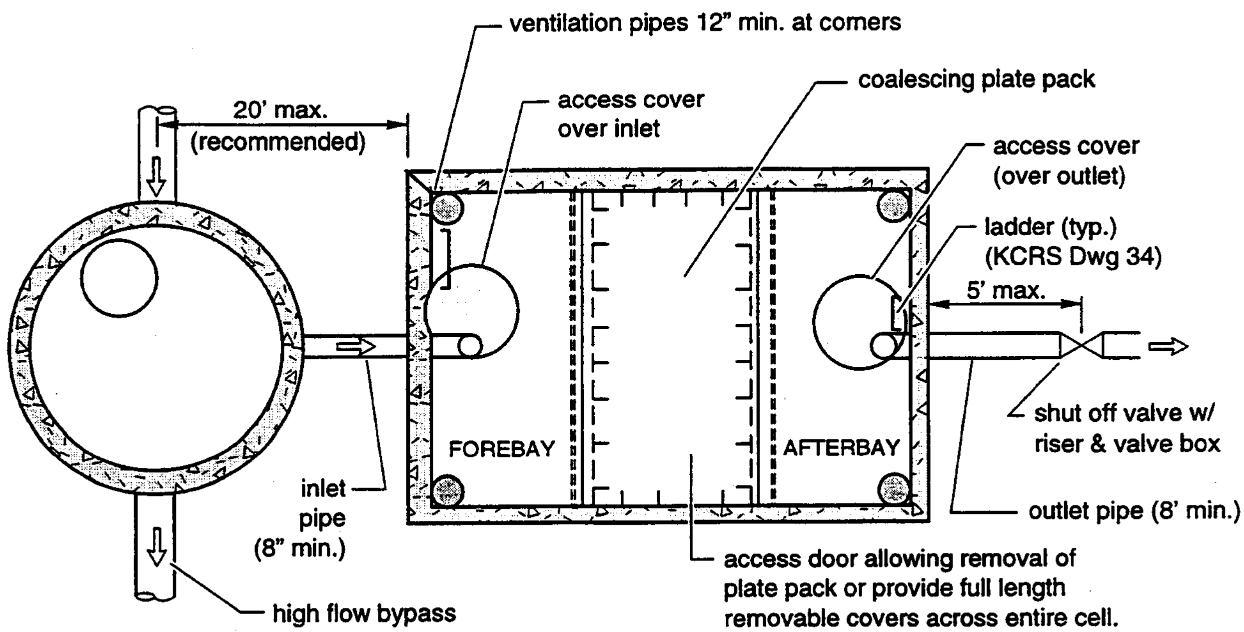
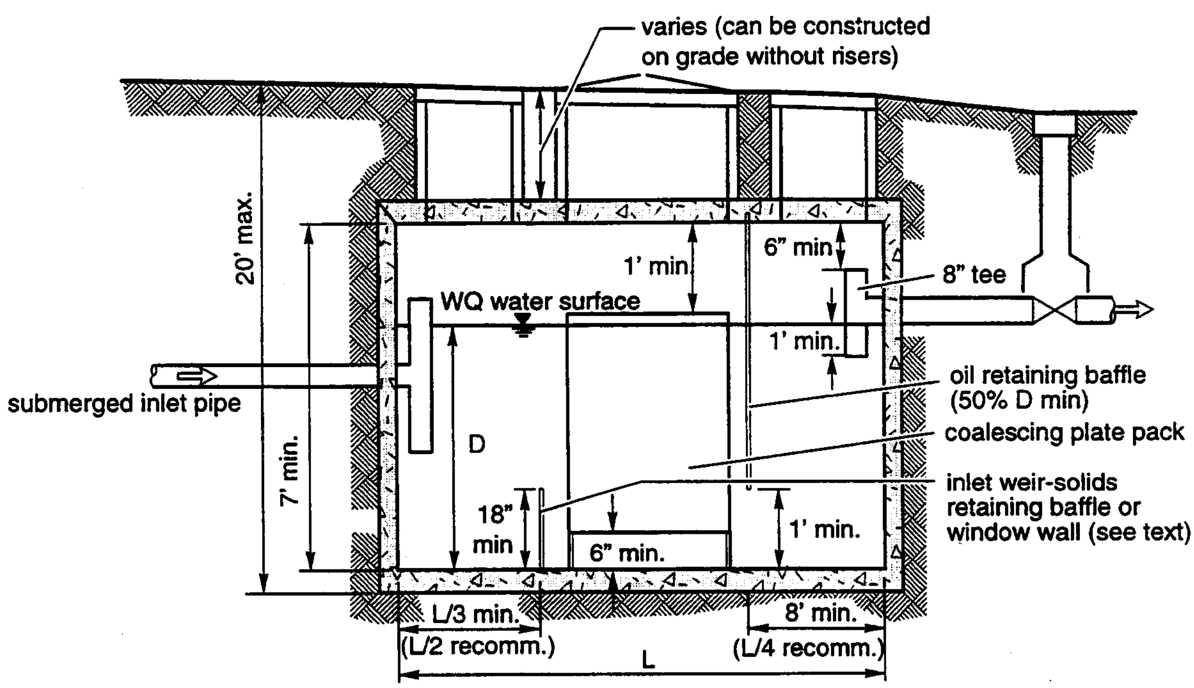
FIGURE 6.6.2.E COALESCING PLATE OIL/WATER SEPARATOR



PLAN VIEW
NTS



SECTION VIEW
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Definitions

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DEFINITIONS

Note: The following terms are provided for reference and use with this manual. They shall be superseded by any other definitions for these terms adopted by ordinance.

Acceptable discharge point means an enclosed drainage system (i.e., pipe system, culvert, or tightline) or open drainage feature (e.g., ditch, channel, swale, stream, river, pond, lake, or wetland) where concentrated runoff can be discharged without creating a significant adverse impact.

Adjustment means a department approved variation in the application of the requirements of K.C.C. 9.05.050 and the *Surface Water Design Manual* to a particular project in accordance with K.C.C. 9.05.050C. The term adjustment replaces "variance" which had been used in prior editions of the *Surface Water Design Manual.*

Alkalinity is a measure of the acid neutralizing capacity of water; the ability of a solution to resist changes in pH by neutralizing acidic input.

Alluvial soils are soils found in valley bottoms; they are generally fine-grained and often have a high seasonal water table.

Anadromous fish means fish that ascend rivers from the sea for breeding.

Applicant means a property owner or a public agency or public or private utility which owns a right-of-way or other easement or has been adjudicated the right to such an easement pursuant to RCW 8.12.090, or any person or entity designated or named in writing by the property or easement owner to be the applicant, in an application for a development proposal, permit, or approval.

Appurtenances means machinery, appliances, or auxiliary structures attached to a main structure, but not considered an integral part thereof, for the purpose of enabling it to function.

Aquifer means a geologic stratum containing groundwater that can be withdrawn and used for human purposes.

As-built drawings means engineering plans which have been revised to reflect all changes to the plans which occurred during construction.

Back-up system means a retention/detention facility where inflows are routed through the control structure before entering the facility; they are "backed up" into the facility by the flow restrictor.

Backwater means water upstream from an obstruction which is deeper than it would normally be without the obstruction.

Baffle means a device to deflect, check or regulate flow.

Base flood means a flood having a one percent chance of being equaled or exceeded in any given year; also referred to as the 100-year flood. The base flood is determined for existing conditions, unless a basin plan including projected flows under future developed conditions has been completed and adopted by King County, in which case these future flow projections shall be used. In areas where the Flood Insurance Study includes detailed base flood calculations, those calculations may be used until projections of future flows are completed and approved by King County.

Base flood elevation means the water surface elevation of the base flood. It shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD).

Basin means a drainage area which drains either to the Cedar, Green, Snoqualmie, Skykomish, or White rivers, or the drainage areas which drain directly to Puget Sound. Basin also means any area draining to a point of interest.

Basin plan means a plan and all implementing regulations and procedures including but not limited to capital projects, public education activities, land use management regulations adopted by ordinance for managing surface and storm water management facilities, and features within individual subbasins.

Berm means a constructed barrier of compacted earth.

Best management practices (BMP) means those practices which provide the best available and reasonable physical, structural, managerial, or behavioral activity to reduce or eliminate pollutant loads and/or concentrations leaving the site.

Biofiltration swale is a long, gently sloped, vegetated ditch designed to filter pollutants from stormwater. Grass is the most common vegetation, but wetland vegetation can be used if the soil is saturated.

Blanket adjustment means an adjustment established by the County that can be applied routinely or globally to all projects where appropriate. Blanket adjustments are usually based on a previously approved adjustment and can be used to effect minor changes or corrections to the design requirements of this manual, or to add new designs and methodologies to this manual.

Blind, blinding means to severely reduce the ability of a normally infiltrative media to pass water, usually by plugging with sediment or debris.

BMPs means best management practices.

Bollard means a post used to prevent vehicular access. A bollard may or may not be removable.

BSBL means building setback line.

Buffer means a) a designated area adjacent to and a part of a steep slope or landslide hazard area which protects slope stability, attenuation of surface water flows, and landslide hazards reasonably necessary to minimize risk; or b) a designated area adjacent to or a part of a stream or wetland that is an integral part of the stream or wetland ecosystem. The critical functions of a riparian buffer (those associated with an aquatic system) include shading, input of organic debris and coarse sediments, uptake of nutrients, stabilization of banks, interception of fine sediments, overflow during high water events, protection from disturbance by humans and domestic animals, maintenance of wildlife habitat, and room for variation of aquatic system boundaries over time due to hydrologic or climatic effects. The critical functions of terrestrial buffers include protection of slope stability, attenuation of surface water flows from storm water runoff and precipitation, and erosion control.

Building setback line means a line measured parallel to a property, easement, drainage facility, or buffer boundary that delineates the area (defined by the distance of separation) where buildings or other obstructions are prohibited (including decks, patios, outbuildings, or overhangs beyond 18 inches). Wooden or chain link fences and landscaping are allowable within a building setback line. In this manual the minimum building setback line shall be 5 feet.

Catch basin insert means a device installed underneath a catch basin inlet which can use either gravity or various sorbent materials to remove pollutants from stormwater. When used with sorbent material, catch basin inserts are primarily for oil removal.

Catch line means the point where a severe slope intercepts a different, more gentle slope.

Cation exchange capacity means the quantity of ammonium cations in a dry mass saturated with ammonium acetate that can be displaced by a strong solution of NaCl, measured in milliequivalents per gram or 100 grams. The test is usually performed at neutral pH (Freeze & Cherry, *Groundwater*, 1979).

Channel means a long, narrow excavation or surface feature that conveys surface water and is open to the air.

Channel, constructed means a channel or ditch constructed to convey surface water; also includes reconstructed natural channels.

Channel, natural means a) a channel which has occurred naturally due to the flow of surface waters; b) a channel that, although originally constructed by human activity, has taken on the appearance of a natural channel including a stable route and biological community.

Clearing means the and removal of vegetation by manual, mechanical, or chemical methods.

Closed depression means an area which is low-lying and either has no surface water outlet, or has such a limited outlet that during storm events the area acts as a retention basin, with more than 5000 square feet of water surface area at overflow elevation.

Coal Mine Hazard Area means an area underlain by abandoned mine workings such as adits, tunnels, drifts, and air shafts, or where mine tailings are present.

Compensatory storage means new excavated storage volume equivalent to the flood storage capacity eliminated by filling or grading within the flood fringe. Equivalent shall mean that the storage removed shall be replaced by equal volume between corresponding one foot contour intervals that are hydraulically connected to the floodway through their entire depth.

Construct or modify means to install a new drainage pipe/ditch or make improvements to an existing drainage pipe/ditch (for purposes other than routine maintenance, repair, or emergency modifications, and excluding driveway culverts installed as part of single-family residential building permits) that either serve to concentrate previously unconcentrated surface and storm water runoff or serve to increase, decrease, and/or redirect the conveyance of surface and storm water runoff.

Conveyance means a mechanism for transporting water from one point to another, including pipes, ditches, and channels.

Conveyance system means the ~~natural and constructed~~ drainage facilities and features, both natural and constructed, which collect, contain, and provide for the flow of surface and storm water from the highest points on the land down to a receiving water. The natural elements of the conveyance system include swales and small drainage courses, streams, rivers, lakes, and wetlands. The constructed elements of the conveyance system include gutters, ditches, pipes, channels, and most flow control and water quality treatment facilities.

Critical depth means the depth which minimizes the specific energy E of the flow.

Critical Drainage Area means an area where the Department of Natural Resources (DNR) has determined that additional drainage controls (beyond those in this manual) are needed to address a severe flooding, drainage, and/or erosion condition which poses an imminent likelihood of harm to the welfare and safety of the surrounding community. Critical Drainage Areas (CDAs) are formally adopted by administrative rule under the procedures specified in KCC 2.98. When CDAs are adopted, they are inserted in Reference Section 3 of this manual and their requirements are implemented through Special Requirement #1 (see Section 1.3.1).

Critical flow means flow at the critical depth and velocity.

Culvert means pipe or concrete box structure which drains open channels, swales, or ditches under a roadway or embankment typically with no catch basins or manholes along its length.

Cut slope means a slope formed by excavating overlying material to connect the original ground surface with a lower ground surface created by the excavation. A cut slope is opposed to a bermed slope, which is constructed by importing soil to create the slope.

DDES means the Department of Development and Environmental Services.

Dead storage means the volume available in a depression in the ground below any conveyance system, or surface drainage pathway, or outlet invert elevation that could allow the discharge of surface and storm water runoff.

Dedication of land means setting aside and assigning ownership for a portion of a property for a specific use or function.

Depression storage means the amount of precipitation that is trapped in depressions on the surface of the ground.

Design engineer means the licensed civil engineer who prepares the analysis, design, and engineering plans for an applicant's permit or approval submittal.

Detention means release of surface and storm water runoff from the site at a slower rate than it is collected by the drainage facility system, the difference being held in temporary storage.

Detention facility is a facility that collects water from developed areas and releases it at a slower rate than it enters the collection system. The excess of inflow over outflow is temporarily stored in a pond or a vault and is typically released over a few hours or a few days.

Determination of Non-Significance (DNS) means the written decision by the responsible official of the lead agency that a proposal is not likely to have a significant adverse environmental impact per the SEPA process, and therefore an EIS is not required.

Development means any activity that requires a permit or approval, including but not limited to a building permit, grading permit, shoreline substantial development permit, conditional use permit, special use permit, zoning variance or reclassification, subdivision, short subdivision, Urban Planned Development, binding site plan, site development, or right-of-way use permit.

Direct discharge means undetained discharge from a proposed project to a major receiving water.

Discharge means runoff, excluding offsite flows, leaving the proposed development through overland flow, built conveyance systems, or infiltration facilities.

Dispersed discharge means release of surface and storm water runoff from a drainage facility system such that the flow spreads over a wide area and is located so as not to allow flow to concentrate anywhere upstream of a drainage channel with erodible underlying granular soils or the potential to flood downstream properties.

Ditch means a constructed channel with its top width less than 10 feet at design flow.

Diversion means a change in the natural discharge location or runoff flows onto or away from an adjacent downstream property. See Core Requirement #1.

DNS means Determination of Non-Significance.

Drainage refers to the collection, conveyance, containment, and/or discharge of surface and storm water runoff.

Drainage area means an area draining to a point of interest.

Drainage basin means an area draining to a point of interest.

Drainage channel means a drainage pathway with well-defined bed and banks indicating frequent conveyance of surface and storm water runoff.

Drainage course means a pathway for watershed drainage often characterized by wet soil vegetation and often intermittent in flow.

Drainage easement means a legal encumbrance that is placed against a property's title to reserve specified privileges for the users and beneficiaries of the drainage facilities contained within the boundaries of the easement.

Drainage facility means a constructed or engineered feature that collects, conveys, stores or treats surface and storm water runoff. Drainage facilities shall include but not be limited to all constructed or engineered streams, pipelines, channels, ditches, gutters, lakes, wetlands, closed depressions, flow control or water quality treatment facilities, erosion and sedimentation control facilities, and other drainage structures and appurtenances that provide for drainage.

Drainage pathway means the route that surface and storm water runoff follows downslope as it leaves any part of the site.

Drainage review means an evaluation King County staff of a proposed project's compliance with the drainage requirements in the *Surface Water Design Manual.*

Dry Season means May 1 to September 30.

Easement means the legal right to use a parcel of land for a particular purpose. It does not include fee ownership, but it may restrict the owner's use of the land.

Effective impervious fraction is the fraction of actual total impervious area connected to a drainage system. These figures should be used in the absence of detailed surveys or physical inspection (e.g., via pipe, channel, or short sheet flow path).

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EIS means Environmental Impact Statement.

Embankment means a structure of earth, gravel, or similar material raised to form a pond bank or foundation for a road.

Energy dissipater means any means by which the total energy of flowing water is reduced. In stormwater design, it is usually a mechanism that reduces velocity prior to, or at, discharge from an outfall in order to prevent erosion. Energy dissipaters include rock splash pads, drop manholes, concrete stilling basins or baffles, and check dams.

Energy gradient means the slope of the specific energy line (i.e., the sum of the potential and velocity heads).

Engineering plan means a plan prepared and stamped by a professional civil engineer that depicts improvements proposed for a particular site. An engineering plan contains a Technical Information Report and Site Improvement Plans, which are described in detail in Chapter 2 of the *Surface Water Design Manual.*

Engineering review means an evaluation by the Department of Development and Environmental Services (or its successor agency) of a proposed project's compliance with the drainage requirements in the *Surface Water Design Manual* and with other King County requirements.

Enhancement means an increase in ecological functions and value, desirability, or attractiveness of an environmental feature.

Environmental Impact Statement (EIS) means a document that discusses the likely significant adverse impacts of a proposal, ways to lessen the impacts, and alternatives to the proposal. It is required by the national and state environmental policy acts when projects are determined to have the potential for significant environmental impact.

Equivalent area means the area tributary to the receiving water body equal to or less than the shortest, straight-line distance from the receiving water body (or regional facility) to the farthest point of the proposed project.

Erodible granular soils means soil materials that are easily eroded and transported by running water, typically fine or medium grained sand with minor gravel, silt, or clay content. Such soils are commonly described as Everett or Indianola series soil types in the SCS classification. Also included are any soils showing examples of existing severe stream channel incision as indicated by unvegetated streambanks standing over two feet high above the base of the channel.

Erosion means detachment and transport of soil or rock fragments by water, wind, ice, etc.

Erosion and sediment control means any temporary or permanent measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave the site.

Erosion Hazard Areas means those areas of King County containing soils which, according to the USDA Soil Conservation Service, King County Soils Survey dated 1973 and any subsequent revisions or additions thereto, may experience severe to very severe erosion hazard. The group of soils includes Alderwood gravely sandy loan (AgD), Alderwood-Kitsap (AkF), Beausite gravelly sandy loam (BeD and BeF), Kitsap silt loam, (KpD), Ovall gravelly sandy loam (OvP and OvF), Ragnar fine sandy loam (Rad), Ragnar-Indianola Association (RdE), River Wash (Rh), and Coastal Beaches (Cb), when they occur on slopes of 15% or steeper.

Eutrophic means a condition of a water body in which excess nutrients, particularly phosphorous, stimulates the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen. Thus, less dissolved oxygen is available to other aquatic life.

Eutrophication refers to the process where excess nutrients in water lead to excessive growth of aquatic plants.

Evapotranspiration is the collective term for the processes of evaporation and plant transpiration by which water is returned to the atmosphere as a vapor.

Exceedance probability is the probability that the flow will be equaled or exceeded in any given year.

Existing conditions are the conditions of drainage, vegetation, and impervious cover at the time of analysis.

Existing offsite conditions are the conditions of drainage, vegetation, and impervious cover offsite, including any problems recorded or observed in the study area (except on the proposed project site), at the time of analysis (see "existing site conditions").

Existing site conditions depend on what, if any, land conversion activity has occurred on the site since May 1979 when King County first required flow control on developments adding more than 5,000 square feet of new impervious surface. If a permit has been obtained since May 1979 for any land conversion activity which included the addition of more than 5,000 square feet of new impervious surface, then *existing site conditions* are those created by the site improvements and drainage facilities constructed per the approved permits and engineering plans. Otherwise, *existing site conditions* are those that existed prior to May 1979 as determined from aerial photographs and, if necessary, on knowledge of individuals familiar with the area. The intent is to mitigate unaddressed impacts created by site alterations/improvements, such as clearing, which have occurred since May 1979 (see Core Requirement #3). *Note: Air photos flown in 1979 are available for viewing at the map counter of the King County Department of Transportation and at DDES.*

Experimental design adjustment means an adjustment used for proposing new designs or methods which are different from those in this manual, which are not uniquely site specific, and for which data sufficient to establish functional equivalence do not exist.

FEMA means Federal Emergency Management Agency

FEMA floodway is a distinct floodway definition that describes the limit to which encroachment into the natural conveyance channel can cause one foot or less rise in water surface elevation.

Fertilizer means any material or mixture used to supply one or more of the essential plant nutrient elements.

Filter strip means a grassy area with gentle slopes which treats stormwater runoff from adjacent paved areas before it concentrates into a discrete channel.

Financial guarantee means a form of financial security posted to ensure timely and proper completion of improvements in compliance with the project's engineering plan, to ensure compliance with the King County Code, and/or to warranty materials, workmanship of improvements and design. Financial guarantees include assignments of funds, cash deposit, surety bonds, and/or other forms of financial security acceptable to or required by the Director of DDES. The terms "performance guarantee," "drainage facilities restoration and site stabilization guarantee," and "defect and maintenance guarantee" are considered subcategories of financial guarantee. The term "financial guarantee" replaces the term "bond" which had been used in prior editions of the *Surface Water Design Manual.*

FIRM means Flood Insurance Rate Map.

Flood fringe means that portion of the floodplain outside of the floodway which is covered by floodwaters during the base flood; it is generally associated with standing water rather than rapidly flowing water.

Flood Hazard Areas means those areas of King County subject to inundation by the base flood; these areas include but are not limited to streams, lakes, wetlands, and closed depressions.

Flood Insurance Rate Map (FIRM) is the official map on which the Federal Insurance Administration has delineated flood hazard areas, floodways, and risk premium zones.

Flood Insurance Study means the official report provided by the Federal Insurance Administration that includes flood profiles and the FIRM.

Floodplain means the total area subject to inundation by the base flood including the flood fringe and floodway.

Flood-proofing means adaptations to ensure that a structure is substantially impermeable to the passage of water below the flood protection elevation, and that it resists hydrostatic and hydrodynamic loads and effects of buoyancy.

Flood protection elevation means an elevation that is one foot above the base flood elevation.

Flood protection facility means any levee, berm, wall, enclosure, raised bank, revetment, constructed bank stabilization, or armoring that is commonly recognized by the community as providing significant protection to a property from inundation by floodwaters.

Flood routing means an analytical technique used to compute the effects of system storage and system dynamics on the shape and movement of flow; represented by a hydrograph.

Floodway means the channel of the river or stream and those portions of the adjoining floodplains which are reasonably required to carry and discharge the base flood flow. The portions of the adjoining floodplains which are considered to be "reasonably required" are defined by the County flood hazard regulations.

Flow control BMPs are simple methods and designs for dispersing and reducing runoff from developed areas.

Flow control facility means a drainage facility designed to mitigate the impacts of increased surface and storm water runoff generated by site development pursuant to the drainage requirements in KCC Chapter 9.04. Flow control facilities are designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold runoff a short period of time and then release it to the conveyance system.

Flow duration means the aggregate time that peak flows are at or above a particular flow rate of interest (e.g., the amount of time over the last 40 years that peak flows were at or above the 2-year flow rate).

Flow frequency is the inverse of the probability that the flow will be equaled or exceeded in any given year (the *exceedance probability*). For example, if the exceedance probability is 0.01, or 1 in 100, that flow is referred to as the 100-year flow.

Flowpath means the route that surface and storm water runoff follows between two points of interest.

Flow-through system means a retention/detention facility where inflows are routed through the storage facility before discharge through the flow restrictor.

Freeboard means the vertical distance between the design water surface elevation and the elevation of the structure or facility which contains the water.

Full build-out conditions assumes that the tributary area is developed to its full zoning potential except where there are existing sensitive areas, open space tracts, and/or native growth protection easements/covenants.

Full Drainage Review means the basic evaluation required by KCC 9.04.030 of a proposed project's compliance with the full range of core and special requirements in Chapter 1 of this manual. This review addresses the impacts associated with adding new impervious surface and changing land cover on typical sites. Full Drainage Review is required for any proposed project that would not be eligible or subject to one of the drainage reviews which targets certain types of projects.

Geologist means a person who has earned a degree in geology from an accredited college or university or who has equivalent educational training, and who has at least five years of experience as a practicing geologist or four years of experience and at least two years post-graduate study, research, or teaching. The practical experience shall include at least three years work in applied geology and landslide evaluation, in close association with qualified practicing geologists or geotechnical professional/civil engineers.

Geomorphically significant flow is a flow capable of moving sediment.

Geotechnical engineer means a practicing geotechnical/civil engineer licensed as a professional Civil Engineer with the State of Washington who has at least four years of professional employment as a geotechnical engineer in responsible charge, including experience with landslide evaluation.

Groundwater means underground water usually found in aquifers. Groundwater usually originates from infiltration. Wells tap the groundwater for water supply uses.

Gully means a channel caused by the concentrated flow of surface and stormwater runoff over unprotected erodible land.

Habitat means the specific area or environment in which a particular type of plant or animal lives and grows.

Hardpan means a cemented or compacted and often clay-like layer of soil that is impenetrable by roots.

Harmful pollutant means a substance that has adverse effects to an organism including death, chronic poisoning, impaired reproduction, cancer, or other effects.

High infiltration rates are those in excess of 9 inches per hour as measured by the EPA method or the double ring infiltrometer method (ASTM D 3385). These will typically be course sand or gravel soil with low silt content.

High-use site means a commercial or industrial site that (1) has an expected average daily traffic (ADT) count equal to or greater than 100 vehicles per 1,000 square feet of gross building area; (2) is subject to petroleum storage or transfer in excess of 1,500 gallons per year, not including delivered heating oil; or (3) is subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons net weight (trucks, buses, trains, heavy equipment, etc.). Also included is any road intersection with a measured ADT count of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway, excluding projects proposing primarily pedestrian or bicycle use improvements.

Horton overland flow is a runoff process whereby the rainfall rate exceeds the infiltration rate, and the excess precipitation flows downhill over the soil surface.

Hydraulically connected means connected through surface flow or water features such as wetlands or lakes.

Hydraulic gradient means slope of the potential head relative to a fixed datum.

Hydrograph means a graph of runoff rate, inflow rate, or discharge rate past a specific point over time.

Hydrologic cycle means the circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hydrologic soil groups means a soil characteristic classification system defined by the U.S. Soil Conservation Service in which a soil may be categorized into one of four soil groups (A, B, C, or D) based upon infiltration rate and other properties.

Impervious surface means a hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development; and/or a hard surface area which causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled, macadam, or other surfaces which similarly impede the natural infiltration of surface and storm water runoff. Open, uncovered flow control or water quality treatment facilities shall not be considered impervious surfaces (see also "new impervious surface").

Impoundment means a natural or man-made containment for surface water.

Improvement means those structures commonly provided when land is converted from its natural to a developed state. Examples include roads (with or without curbs or gutters), sidewalks, crosswalks, parking lots, water mains, sanitary and storm sewers, drainage facilities, street trees, and other appropriate items.

Infiltration facility means a drainage facility designed to use the hydrologic process of water soaking into the ground (commonly referred to as percolation) to dispose of surface and storm water runoff.

Ingress/egress means the points of access to and from a property.

Inlet means a form of connection between the surface of the ground and a channel or pipe for the admission of surface and stormwater runoff.

Inlet control is a flow condition where the flow is governed by the culvert's inlet geometry.

Interflow is near-surface groundwater that moves laterally through the soil horizon following the hydraulic gradient of underlying relatively impermeable soils. When interflow is expressed on the surface, it is called a *spring* or *seepage*.

KCAS means King County Aerial Survey.

KCRS means *King County Road Standards,* which are available from the King County Department of Transportation Map Counter.

Lake means an area permanently inundated by water in excess of two meters (7 ft) deep and greater than twenty acres in size as measured at the ordinary high water mark.

Lake management plan means a plan describing the lake management recommendations and requirements adopted by ordinance and/or public rule for managing water quality within individual lake basins.

Landscape management plan means a King County approved plan for defining the layout and long-term maintenance of landscaping features to minimize the use of pesticides and fertilizers, and reduce the discharge of suspended solids and other pollutants.

Landslide means episodic downslope movement of a mass of soil or rock; includes but is not limited to rockfalls, slumps, mudflows, and earthflows.

Landslide Hazard Areas means those areas of King County subject to a severe risk of landslide as defined in KCC 21A.24, including the following:

1. Any area with a combination of:
   - Slopes steeper than 15%;
   - Impermeable soils, such as silt and clay, frequently interbedded with granular soils, such as sand and gravel; and
   - Springs or groundwater seepage;
2. Any area which has shown movement during the Holocene epoch, 10,000 years ago to the present, or which is underlain by mass wastage debris from that epoch;
3. Any area potentially unstable as a result of rapid stream incision, stream bank erosion or undercutting by wave action;
4. Any area which shows evidence of, or is at risk from, snow avalanches, or
5. Any area located on an alluvial fan, presently subject to or potentially subject to inundation by debris flows or deposition of stream-transported sediments.

Landslide Hazard Drainage Areas are specially mapped where the County has determined that overland flows from new projects will pose a significant threat to health and safety because of their close proximity to SAO-defined landslide hazard areas that are on slopes greater than 15% (a delineation of the known SAO landslide hazard areas can be found in King County's *Sensitive Areas Map Folio).* Such areas are delineated on the Landslide Hazard Drainage Areas map adopted with this manual.

Large Site Drainage Review means the evaluation required by KCC 9.04.030 for development proposals that are large and/or involve resources or problems of special sensitivity or complexity. Because of the large size and complexities involved, there is usually a greater risk of significant impact or irreparable damage to sensitive resources. Such proposals often require a more definitive approach to drainage requirements than that prescribed by the core and special requirements in Chapter 1. Large Site Drainage Review entails preparation of a master drainage plan (MDP) or limited scope MDP which is reviewed and approved by DDES.

Leachable materials, wastes, or chemicals are those substances which, when exposed to rainfall, measurably alter the physical or chemical characteristics of the rainfall runoff; examples include erodible soil, uncovered process wastes, manure, fertilizers, oily substances, ashes, kiln dust, garbage dumpster leakage, etc.

Leaf compost filter is a patented treatment device which uses a specially prepared and patented compost product to remove pollutants from stormwater.

Level pool routing is the basic technique of storage routing used in King County for sizing and analyzing detention storage and determining water levels for ponding water bodies. The level pool routing technique is based on the continuity equation: Inflow - Outflow = Change in storage.

Licensed civil engineer means a person registered with the State of Washington as a professional engineer in civil engineering.

Lowest floor means the lowest enclosed area (including basement) of a structure. An area other than a basement area that is used solely for parking of vehicles, building access, or storage is not considered a building's lowest floor, provided that the enclosed area meets all of the structural requirements of the flood hazard standards.

Major receiving water means a large receiving water that has been determined by King County to be safe for direct discharge of surface and storm water runoff subject to the restrictions on such discharges set forth in Core Requirement #3 (see "direct discharge").

MDNS means a Mitigated Determination of Non-Significance per SEPA (see "DNS" and "Mitigation").

Mass wasting means the movement of large volumes of earth material downslope.

AR 032207

Master Drainage Plan (MDP) means a comprehensive drainage control plan usually prepared during the Large Site Drainage Review process, and intended to prevent significant adverse impacts to the natural and man-made drainage system, both on and offsite.

Mean annual storm means a statistically derived rainfall event derived by dividing the annual rainfall in an area by the number of storm events per year, as defined by the Nationwide Urban Runoff Program studies (U.S. Environmental Protection Agency, "Results of the Nationwide Urban Runoff Program," 1986).

Metals means elements, such as mercury, lead, nickel, zinc and cadmium, that are of environmental concern because they do not degrade over time. Although many are necessary nutrients, they are sometimes magnified in the food chain, and they can be toxic to life in high enough concentrations.

Mitigation means the reduction of a potential impact by the use of any or all of the following actions that are listed in descending order of preference (KCC 21.04):

1. Avoiding the impact altogether by not taking a certain action or parts of an action
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation, by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts
3. Rectifying the impact by repairing, rehabilitating, or restoring the affected sensitive area
4. Reducing or eliminating the impact over time by preservation or maintenance operations during the life of the development proposal
5. Compensating for the impact by replacing, enhancing, or providing substitute sensitive areas
6. Monitoring the impact and taking appropriate corrective measures.

Modified Site Improvement Plan means a limited or simplified "Site Improvement Plan" used for some projects in targeted review and/or where major improvements are not proposed.

Monitor means to systematically and repeatedly measure something in order to track changes.

Monitoring means the collection and analysis of data by various methods for the purposes of understanding natural systems and features, evaluating the impacts of development proposals on the biological, hydrologic, and geologic elements of such systems, and assessing the performance of mitigation measures imposed as conditions of development.

National Pollutant Discharge Elimination System (NPDES) means the part of the federal Clean Water Act which requires point source discharges to obtain permits. These permits, referred to as NPDES permits, are administered by the Washington State Department of Ecology.

Native Growth Protection Easements (NGPE) means an easement granted to the County for the protection of native vegetation within a sensitive area or its associated buffer. The NGPE shall be recorded on the appropriate documents of title and filed with the King County Records and Election Division. This term was used prior to December 1990, but has since been replaced with "sensitive area"; all references to sensitive areas in this manual shall also apply to native growth protection easements.

Natural channel (see "channel, natural")

Natural discharge area means an onsite area tributary to a single natural discharge location.

Natural discharge location means the location where runoff leaves the project site under existing site conditions.

Natural onsite drainage feature means a natural swale, channel, stream, closed depression, wetland, or lake.

New conveyance system elements are those that are proposed to be constructed where there are no existing constructed conveyance elements.

New impervious surface means the addition of a hard or compacted surface such as pavement, gravel, dirt, or roofs, or the addition of a more compacted surface such as the paving of pre-existing dirt or gravel.

NGPE means Native Growth Protection Easement.

AR 032208

NGVD means National Geodetic Vertical Datum (see "base flood elevation").

Normal depth means the depth of uniform flow. This is a unique depth of flow for any combination of channel characteristics and flow conditions. Normal depth is found from Manning's equation.

NPDES means National Pollutant Discharge Elimination System.

Nutrient means one of the essential chemicals needed by plants or animals for growth. Excessive amounts of nutrients can lead to degradation of water quality and excessive algae growth. Some nutrients can be toxic at high concentrations.

Offsite means any area lying upstream of the site that drains onto the site and any area lying downstream of the site to which the site drains.

Offsite flows means runoff conveyed to a proposed project from adjacent properties.

Oil/water separator means a vault, usually underground designed to provide a quiescent environment to separate oil from water. Floatables (e.g., styrofoam) are also removed.

One-year capture zone means the surface area overlying the portion of the aquifer which contributes water to the well within a one year period.

Onsite means the site that includes the proposed development (see "site").

Ordinary high water mark means the mark that will be found by examining the bed and banks of a stream and ascertaining where the presence and action of waters are so common and usual, and so long maintained in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation. In any area where the ordinary high water mark cannot be found, the line of mean high water shall substitute. In any area where neither can be found, the channel bank shall be substituted. In braided channels and alluvial fans, the ordinary high water mark or substitute shall be measured so as to include the entire stream feature.

Orifice means an opening with closed perimeter (usually sharp-edged) and of regular form in a plate, wall, or partition through which water may flow, generally used for the purpose of measurement or control of such water.

Outfall is a point where collected and concentrated surface and storm water runoff is discharged from a pipe system or culvert.

Outlet control is a flow condition where the flow is governed by a combination of inlet geometry, barrel characteristics, and tailwater elevation.

Outwash soils are soils formed from highly permeable sands and gravels.

Overtopping means to flow over the limits of a containment or conveyance element.

Permeable soils means soil materials with a sufficiently rapid infiltration rate so as to greatly reduce or eliminate surface and storm water runoff.

Perviousness means related to the size and continuity of void spaces in soils; related to a soil's infiltration rate.

Pesticide is any substance (usually chemical) used to destroy or control organisms; includes herbicides, insecticides, algaecides, fungicides, and others. Many of these substances are manufactured and are not naturally found in the environment. Others, such as pyrethrum, are natural toxins which are extracted from plants and animals.

pH means a measure of the alkalinity or acidity of a substance found by measuring the concentration of hydrogen ions in the substance. The pH scale ranges from 1 to 14 with 1 being highly acidic, 14 highly basic, and 7 neutral. Most natural waters in King County are slightly acidic having a pH of around 6.5.

Physiographic means characteristics of the natural physical environment (including hills).

Pipe system are networks of storm drain pipes, catch basins, manholes, inlets, and outfalls designed and constructed to convey surface water.

Plat means a map or representation of a subdivision showing the division of a tract or parcel of land into lots, blocks, streets, or other divisions and dedications.

Point discharge means the release of collected and/or concentrated surface and storm water runoff from a pipe, culvert, or channel.

Point of compliance is the location where detention performance standards are evaluated. In most cases, the point of compliance is the outlet of the proposed detention facility where, for example, 2- and 10-year discharges must match predevelopment 2- and 10-year peak flow rates.

Pollution-generating impervious surface means an impervious surface considered to be a significant source of pollutants in surface and storm water runoff.. Such surfaces include those subject to vehicular use or storage of erodible or leachable materials, wastes, or chemicals, and which receive direct rainfall or the run-on or blow-in of rainfall. Thus, a covered parking area would be included if runoff from uphill could regularly run through it or if rainfall could regularly blow in and wet the pavement surface. Metal roofs are also considered pollution-generating impervious surface unless they are treated to prevent leaching.

Pollution-generating pervious surface means a non-impervious surface with vegetative ground cover subject to use of pesticides and fertilizers. Such surfaces include, but are not limited to, the lawn and landscaped areas of residential or commercial sites, golf courses, parks, and sports fields.

Porosity means the property of having pores (small openings) that allow the passage of water.

Preapplication means the meeting(s) and/or form(s) used by applicants for some development permits to present initial project intentions to the Department of Development and Environmental Services or its successor agency. Preapplication does not mean application.

Preapplication adjustment means an adjustment that can be requested prior to permit application. It is useful for when an adjustment decision is needed to determine if a project is feasible, or when the approval conditions must be known to determine if a project is viable before funding a full application. The approval of preapplication adjustments is tied by condition to the project proposal presented at a preapplication meeting with DDES.

Project means any proposed action to alter or develop a site which may also requires drainage review.

Project site means that portion of a property or properties subject to proposed project improvements including those required by this manual.

R/D means retention/detention facility, another term for flow control facility.

Reach means a length of channel with uniform characteristics.

Receiving waters means bodies of water or surface water systems receiving water from upstream man-made or natural systems.

Recharge means the flow to groundwater from the infiltration of surface and stormwater runoff.

Redevelopment project means a project that proposes to add, replace, and/or alter exterior impervious surface (for purposes other than routine maintenance, resurfacing, regrading, or repair) on a site that is already substantially developed (has 35% or more of existing impervious surface coverage.)

Regional detention facility means a stormwater quantity control structure designed to prevent or correct the existing or future surface water runoff problems of a basin or subbasin as defined by the King County Department of Natural Resources (DNR).

Regional scale factor is a geographically variable multiplier applied to the flow time series to account for the variations in rainfall amounts, and hence runoff, between the project site and the rainfall station (Landsburg or Sea-Tac).

Release rate means the computed peak rate of surface and storm water runoff from a site.

Replaced impervious surface means any existing impervious surface proposed to be removed down to bare soil or base course, and replaced with pollution-generating impervious surface, excluding impervious surface removed for the sole purpose of installing utilities.

Resource stream means a stream section mapped and rated by King County as being a regionally significant stream reach that harbors significant concentrations of fish for some period in their life cycle.

Retention means the process of collecting and holding surface and storm water runoff with no surface outflow.

Retention/detention facility (R/D) means a type of drainage facility designed either to hold water for a considerable length of time and then release it by evaporation, plant transpiration, and/or infiltration into the ground, or to hold surface and storm water runoff for a short period of time and then release it to the surface and storm water conveyance system.

Retrofitting means the renovation of an existing structure or facility to meet changed conditions or to improve performance.

Riparian means pertaining to the banks of rivers and streams, and sometimes also wetlands, lakes, or tidewater.

Riprap means a facing layer or protective mound of stones placed to prevent erosion or sloughing of a structure or embankment due to the flow of surface and storm water runoff.

Runoff means water originating from rainfall and other precipitation that is found in drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow groundwater. As applied in this manual, it also means the portion of rainfall or other precipitation that becomes surface flow and interflow.

Runoff files refers to a database of continuous flows presimulated by HSPF.

Runoff Files Method is a hydrologic modeling tool for western King County to produce results (design flows, detention pond sizing, etc.) comparable to those obtained with the U.S. Environmental Protection Agency's HSPF model but with significantly less effort. This is achieved by providing the user with a set of 15 minute and hourly time series files of unit area land surface runoff ("runoff files") presimulated with HSPF for a range of land cover conditions and soil types within King County.

Run-on or blow-in of rainfall means stormwater from uphill that could regularly run through an area, or rainfall that could regularly be blown in and wet the pavement surface.

Rural residential development means proposed plats or short plats in rural residential zoning (RA) per KCC 21A.12. These development proposals lie generally outside the Urban Growth Area and create large (greater than 2.5 acre) lots.

Rural residential project means any project occurring on properties zoned RA-2.5, RA-5, RA-10, and RA-20 per KCC 21A.12.

Salmonid means a member of the fish family Salmonidae. In King County salmonid species include Chinook, Coho, chum, sockeye, and pink salmon; cutthroat, rainbow, and brown trout and steelhead; Dolly Varden, brook trout, char, kokanee, and whitefish.

Sand filter is a depression or basin with the bottom made of a layer of sand. Stormwater is treated as it percolates through the sand layer and is discharged via a central collector pipe.

SAO means Sensitive Areas Ordinance.

Scour means erosion of channel banks due to excessive velocity of the flow of surface and stormwater runoff.

SCS means Soil Conservation Service, U.S. Department of Agriculture.

SCS Method means a hydrologic analysis based on the Curve Number method (*National Engineering Handbook* - Section 4: Hydrology, August 1972).

Seasonal high groundwater level means the highest elevation attained by groundwater, as measured by piezometers or wells, during any calendar year.

Sediment means fragmented material which originates from weathering and erosion of rocks or unconsolidated deposits, and which is transported by, suspended in, or deposited by water.

Sedimentation means the depositing or formation of sediment.

Sensitive area means the area delineated on a site which contains wetlands, streams, steep slopes, hazard areas, landslide hazard areas, and their required buffers. Sensitive areas are recorded as tracts or sensitive area notice on titles.

Sensitive Areas Ordinance (SAO) means the King County Ordinance and rules that identify environmentally sensitive areas (coal mine, erosion, flood, landslide, seismic, steep slope, and volcanic hazard areas, and streams, wetlands, and protective buffers) and supplement the development requirements contained in the various use classifications in the King County Code by providing for additional controls.

Sensitive area setback area means the area delineated on a site which contains wetlands, streams, steep slopes, hazard areas, landslide hazard areas, and their required buffers. This term was used from November 1990 through December 1995. References to sensitive areas in this manual shall also apply to sensitive area setback areas.

Sensitive area steep slope means a steep slope (generally over 40%) that meets the definition of a steep slope as defined in KCC Chapter 21A.24, "Environmentally Sensitive Areas."

Sensitive area tract means a separate tract that is created to protect the sensitive area and its buffer, and whose ownership is assigned as provided in KCC 21A.24.

Sensitive lake means a lake that has proved to be particularly prone to eutrophication; the County gives this designation when an active input plan has been adopted to limit the amount of phosphorous entering the lake.

SEPA means State Environmental Policy Act.

Shared facility means a drainage facility designed to meet one or more of the requirements of KCC 9.04.050 for two or more separate projects contained within a basin as defined in KCC 9.04.020. Shared facilities usually include shared financial commitments.

Sheet erosion means the relatively uniform removal of soil from an area without the development of conspicuous water channels.

Sheet flow means relatively uniform flow over plane surfaces without the concentration of water into conspicuous channels.

Shoreline development means the proposed projects regulated by the Shoreline Management Act. Usually this includes the construction over water or within a shoreline zone (generally 200 feet landward of the water) of structures such as buildings, piers, bulkheads, and breakwaters, including environmental alterations such as dredging and filling, or any project which interferes with public navigational rights on the surface waters.

Shredded wood mulch means a mulch made from shredded tree trimmings, usually from trees cleared on site and stockpiled until needed. It must be free of garbage and weeds and may not contain excessive resin, tannin, or other material detrimental to plant growth.

Siltation means the process by which a river, lake, or other water body becomes clogged with sediment. Silt can clog gravel beds and prevent successful survival of salmon eggs.

Single family residential project means a project that constructs or modifies a single family dwelling unit and/or makes related onsite improvements, such as driveways, roads, outbuildings, play courts, etc., or a project that creates single family residential lots such as a plat or short plat.

Site means the legal boundaries of the parcel or parcels of land for which an applicant has or should have applied for authority from King County to carry out a development activity, including any drainage improvements required by this manual.

Site improvement plan consists of all the plans, profiles, details, notes and specifications necessary to construct road, drainage structure and off-street parking improvements. A **Modified Site Improvement Plan** means a limited or simplified "Site Improvement Plan" used for some projects in targeted review and/or where major improvements are not proposed.

Slope means the gradient in feet (vertical) per feet (horizontal) or expressed as percent. Side slopes of drainage facilities are usually referred to with the horizontal dimension first (as in 3H:1V).

Sloughing means the sliding of overlying material. Sloughing has the same effect as caving, but it usually occurs when the bank or an underlying stratum is saturated or scoured.

AR 032212

Small site drainage plans are a simplified form of site improvement and erosion/sediment control plans (without a technical information report) which can be prepared by a non-engineer from a set of pre-engineered design details. Small site drainage plans are only allowed for projects in Small Site Drainage Review.

Small Site Drainage Review is a simplified alternative to Full Drainage Review (as required by KCC 9.04.030) for small residential building and subdivision projects that add ten thousand square feet or less of new impervious surface. The core and special requirements applied under Full Drainage Review are replaced with simplified small site requirements which can be applied by a non-engineer.

Soil bioengineering means a method of soil or land stabilization that uses living plant material selected for the specific site situation as the major structural or engineering component of the stabilization.

Soil permeability means the ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil.

Soil scientist means a person who has earned a degree in soil science, agronomy, or hydrogeology from an accredited college or university, or who has equivalent educational training and has at least five years of experience, or who has four years of experience and at least two years of post-graduate study. Two years of experience must be in the State of Washington with local soil types.

Soil stabilization means the use of measures such as rock lining, vegetation, or other engineering structures to prevent the movement of soil when loads are applied to the soil.

Sole-source aquifer means an aquifer that is the only source of drinking water for a given community and that is so designated by the U.S. Environmental Protection Agency.

Specific energy means the total energy within any system with respect to the channel bottom; equal to the potential head plus velocity and pressure heads.

Sphagnum bog wetlands are unique wetlands having a predominance of sphagnum moss creating a substrate upon which a distinctive community of plants is established. Some of these include *ledum groenlandicum* (Labrador tea), *Kalmia occidentalis* (bog laurel), *Drosera rotundifolia* (sundew), and *Vaccinium oxycoccos* (cranberry). Stunted evergreen trees are also sometimes present. In addition to a distinctive plant community, the water chemistry of sphagnum wetlands is also unique. It is characterized by acidic waters (pH 3 to 5.5), low nutrient content, low alkalinity, and a buffering system composed predominantly of organic acids. In the Puget Sound area, mature sphagnum bog wetlands are typically very old, often dating back thousands of years.

Spill control device means a Tee section or turn down elbow designed to retain a limited volume of pollutant that floats on water, such as oil or antifreeze. Spill control devices are passive and must be followed by clean-up activity for the spilled pollutant to actually be removed.

State Environmental Policy Act (SEPA) means the Washington State law intended to minimize environmental damage. SEPA requires that state agencies and local governments consider environmental factors when making decisions on activities, such as development proposals over a certain size and comprehensive plans. As part of this process, environmental documents are prepared and opportunities for public comment are provided.

Steep slope means those areas in King County on slopes 40% or steeper within a vertical elevation change of at least ten feet. A slope is delineated by establishing its toe and top, and is measured by averaging the inclination over at least ten feet of vertical relief. For the purpose of this definition:

1. The *toe* of a slope is a distinct topographic break in slope which separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the toe of a steep slope is the lowermost limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet; AND

2. The *top* of a slope is a distinct topographic break in slope which separates slopes inclined at less than 40% from slopes 40% or steeper. Where no distinct break exists, the top of a steep slope is the uppermost limit of the area where the ground surface drops ten feet or more vertically within a horizontal distance of 25 feet.

Storage routing a method to account for the attenuation of peak flows passing through a detention facility or other storage feature.

Storm drains means the enclosed conduits that transport surface and storm water runoff toward points of discharge (sometimes called storm sewers).

Storm drain system refers to the system of gutters, pipes, streams, or ditches used to carry surface and storm water from surrounding lands to streams, lakes, or Puget Sound.

Stormwater means water originating from rainfall and other precipitation that ultimately flows into drainage facilities, rivers, streams, ponds, lakes, and wetlands, or flows from springs and seeps, as well as shallow groundwater. As applied in this manual, it is synonymous with the codified term, "surface and storm water."

Stormwater wetland means a wetland constructed, often in areas of upland soil, for the purpose of treating stormwater. When created in upland soils, stormwater wetlands are not considered waters of the State if they are regularly maintained. In King County, stormwater wetlands cannot currently be used to mitigate for impacts to an existing natural wetland.

Stream means an area where surface waters produce a defined channel or bed. A defined channel or bed is an area which demonstrates clear evidence of the passage of water and includes, but is not limited to, bedrock channels, gravel beds, sand and silt beds, and defined-channel swales. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, storm water runoff devices, or other entirely artificial watercourses unless they are used by salmonids or used to convey streams naturally occurring prior to construction. Those topographic features that resemble streams but have no defined channels (e.g., swales) shall be considered streams when hydrologic and hydraulic analyses done pursuant to a development proposal predict formation of a defined channel after development.

Stream classification means the following stream classification which applies to all streams within King County:

- Class 1 streams are all streams inventoried as Shorelines of the State under King County's Shoreline Master Program, KCC Title 25, pursuant to RCW Chapter 90:58.
- Class 2 streams are all streams smaller than Class 1 streams that flow year-round during years of normal rainfall, or those that are used by salmonids.
- Class 3 streams are streams that are intermittent or ephemeral during years of normal rainfall and are not used by salmonids.

Structure means a catch basin or manhole in reference to a storm drainage system or as defined in KCC zoning code 21A.

Stub-out means a length of pipe provided for future connection to the storm drainage system.

Subbasin means a) a drainage area which drains to a watercourse or waterbody named and noted on common maps and which is contained within a basin as defined in KCC 9.04.020; b) a drainage basin or area which is part of a larger drainage basin or area.

Subcritical flow means flow at depths greater than the critical depth.

Subject to vehicular use as used in the definition of pollution-generating impervious surface, means regularly used by motor vehicles; the surface may be paved or unpaved. The following are considered *regularly-used surfaces*: roads, unvegetated road shoulders, bike lanes within the traveled lane of a roadway, driveways, parking lots, unfenced firelanes, diesel equipment storage yards, and airport runways. The following are not considered regularly-used surfaces: road shoulders primarily used for emergency parking, paved bicycle pathways, bicycle lanes adjacent to unpaved or paved road shoulders primarily used for emergency parking, fenced firelanes, and infrequently used maintenance access roads.

Supercritical flow means flow at depths less than the critical depth.

Surface and storm water means water originating from rainfall and other precipitation that ultimately flows into drainage facilities, rivers, streams, springs, seeps, ponds, lakes, and wetlands as well as shallow groundwater.

Surface and storm water management system means drainage facilities and any other natural features which collect, store, control, treat, and/or convey surface and storm water.

Surface flow means flow that travels overland in a dispersed manner (sheet flow), or in natural channels or streams or constructed conveyance systems.

Surface Water Design Manual means the manual (and supporting documents as appropriate) describing surface and storm water design and analysis requirements, procedures, and guidance which has been formally adopted by rule under the procedures specified in KCC 2.98. The *Surface Water Design Manual* will be available from the King County Department of Development and Environmental Services or the Department of Natural Resources.

Swale means a shallow drainage conveyance with relatively gentle side slopes, generally with flow depths less than one foot.

SWM means the former Surface Water Management Division of the King County Department of Natural Resources.

Targeted Drainage Review means an evaluation required by KCC 9.04.030 for certain types of proposed projects where drainage review is abbreviated to address only those requirements that would apply to those projects. Projects subject to this type of drainage review are typically small-site proposals or other small projects that have site-specific or project-specific drainage concerns that must be addressed by a licensed civil engineer or DDES review staff.

Temporary Erosion and Sedimentation Control means any temporary measures taken to reduce erosion, control siltation and sedimentation, and ensure that sediment-laden water does not leave the site.

TESC means Temporary Erosion and Sedimentation Control.

Threshold discharge area means onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within 1/4-mile downstream (as determined by the shortest flowpath). The purpose of this definition is to clarify how the thresholds of this manual are applied to project sites with multiple discharge points.

Tightline means a continuous length of pipe which conveys water from one point to another (typically down a steep slope) with no inlets or collection points in between.

Tightline system is typically a continuous length of pipe used to convey flows down a steep or sensitive slope with appropriate energy dissipation at the discharge end.

Till means a layer of poorly sorted soil deposited by glacial action; in the King County area, till typically has a high silt content (see Section 3. 2.2.1 for a description of soil groups).

Time of concentration is the time it takes runoff to travel overland (from the onset of precipitation) from the most hydraulically distant location in the drainage basin to the point of discharge.

Total phosphorous (TP) means a naturally occurring element essential for plant growth. Total phosphorous includes both dissolved and particulate phases of phosphorous. Excess phosphorous can cause excess algae growth in lakes and streams, resulting in aesthetic problems and threats to aquatic life.

Total suspended solids (TSS) means that portion of the solids carried by stormwater that can be caught on a standard glass filter. Additional pollutants such as metals and organics are often associated with the finer portion of the solids.

Toxic means poisonous, carcinogenic, or otherwise directly harmful to life.

Tract means a legally created parcel of property designated for special non-residential and non-commercial uses.

Travel time means the estimated time for surface water to flow between two points of interest.

Treatment train is a combination of two or more treatment facilities connected in series (i.e., the design water volume passes through each facility in turn).

Tributary means a drainage feature that collects water and conveys it to another drainage feature (e.g., a drainage channel is tributary to a stream into which it flows).

Tributary area means the geographical area (not constrained by property boundaries) that drains to the point of concern.

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Undisturbed buffer means a zone where development activity, including logging and the construction of utility trenches, roads, and/or surface and storm water drainage facility systems, shall not occur.

Undisturbed low gradient uplands means forested land that is sufficiently large and flat to infiltrate surface and storm runoff without allowing the concentration of water on the surface of the ground.

Urban residential development means proposed plats or short plats in urban residential zoning per KCC 21.A12. These development proposals generally lie within the Urban Growth Area and create small (generally less than 10,000 square foot) lots.

Water quality treatment facility means a drainage facility designed to reduce pollutants once they are already contained in surface and storm water runoff. Water quality treatment facilities are the structural component of best management practices (BMPs); when used singly or in combination, WQ facilities reduce the potential for contamination of surface and/or ground waters.

Watershed means the geographic region from which water drains toward a central collector such as a stream, river, lake, or salt water.

Wetpool refers to the volume of water more or less permanently contained in a pond or vault. The volume of water in a wetpool is normally lost only through natural processes such as evaporation, evapotranspiration, or slow infiltration into the ground.

Wetpond and **wetvault** mean drainage facilities for water quality treatment that contain a permanent pool of water. They are designed to optimize water quality by providing long retention times (on the order of a week or more) to settle out particles of fine sediment to which pollutants such as heavy metals adsorb, and to allow biologic activity to occur that metabolizes nutrients and organic pollutants. For wetvaults, the permanent pool of water is covered by a lid which blocks sunlight from entering the facility, limiting light-dependent biologic activity.

Wetland means an area inundated or saturated by ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (U.S. Army Corps of Engineers Regulation 33 CFR 328.3 (1988)). Wetlands in King County include all area waterward from the wetland edge. Where the vegetation has been removed, a wetland shall be determined by the presence of hydric soils, as well as other documentation of the previous existence of wetland vegetation such as aerial photographs.

Wetland edge means the line delineating the outer edge of a wetland established by using the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (January 10, 1989), jointly published by the U. S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, and the U.S. Soil Conservation Service.

Wetland Rating System means the wetland rating system (outlined below) which is based upon the King County Wetlands Inventory (1983) and the U.S. Fish and Wildlife Service's *Classification of Wetlands and Deepwater Habitats of the United States*, FWS/OBS-79/31 (December 1979):

1. Class 1 wetlands are those assigned the Unique/Outstanding #1 rating in the inventory, or uninventoried wetlands which meet any one of the following criteria:

   a) Presence of species recognized by the federal government or State of Washington as endangered or threatened, or the presence of critical or outstanding potential habitat for those species

   b) Wetlands having 40% to 60% open water in dispersed patches with two or more classes of vegetation

   c) Wetlands equal to or greater than ten acres in size which have three or more wetland classes, one of which is open water

   d) Presence of plant associations of infrequent occurrence. These include, but are not limited to, estuarine systems and bogs.

2. Class 2 wetlands are those assigned the Significant #2 rating in the inventory, or uninventoried wetlands which meet any of the following criteria:

   a) Wetlands greater than one acre in size

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b) Wetlands less than or equal to one acre in size which have three or more wetland classes

c) Wetlands less than or equal to one acre in size which have a forested wetland class

d) Wetlands which have present heron rookeries or raptor nesting trees.

3. Class 3 wetlands are those assigned the Low Concern #3 rating in the inventory, or uninventoried wetlands less than or equal to one acre in size which have two or fewer wetland classes.

Wet Season means October 1 to April 30.

Zero-rise floodway is a floodway definition based upon the limit to which encroachment can occur without detectable water surface elevation or energy grade line changes. Zero-rise floodways are assumed to include the entire 100-year floodplain until King County approves a detailed study which defines a zero-rise floodway.

Zinc one of several metals of concern in the aquatic environment. Used in the Resource Stream Protection menu as an indicator of a whole range of metals found in urban runoff.

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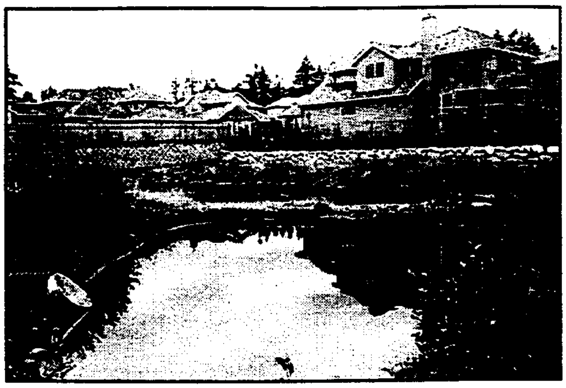
Appendices

APPENDICES



KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

APPENDIX A

MAINTENANCE REQUIREMENTS FOR PRIVATELY MAINTAINED DRAINAGE FACILITIES

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APPENDIX A

MAINTENANCE STANDARDS FOR PRIVATELY MAINTAINED DRAINAGE FACILITIES

NO. 1 - DETENTION PONDS

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic foot per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size office garbage can). In general, there should be no visual evidence of dumping.	Trash and debris cleared from site.
	Poisonous Vegetation	Any poisonous or nuisance vegetation which may constitute a hazard to County personnel or the public.	No danger of poisonous vegetation where County personnel or the public might normally be. (Coordination with Seattle-King County Health Department)
	Pollution	Oil, gasoline, or other contaminants of one gallon or more or any amount found that could: 1) cause damage to plant, animal, or marine life; 2) constitute a fire hazard; or 3) be flushed downstream during rain storms.	No contaminants present other than a surface film. (Coordination with Seattle/King County Health Department)
	Unmowed Grass/ Ground Cover	If facility is located in private residential area, mowing is needed when grass exceeds 18 inches in height. In other areas, the general policy is to make the pond site match adjacent ground cover and terrain as long as there is no interference with the function of the facility.	When mowing is needed, grass/ground cover should be mowed to 2 inches in height. Mowing of selected higher use areas rather than the entire slope may be acceptable for some situations.
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordination with Seattle/King County Health Department)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site.
	Tree Growth	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access, leave trees alone.	Trees do not hinder maintenance activities. Selectively cultivate trees such as alders for firewood.
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion.	Slopes should be stabilized by using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
Pond Dikes	Settlements	Any part of dike which has settled 4 inches lower than the design elevation.	Dike should be built back to the design elevation.
Emergency Overflow/Spillway	Rock Missing	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. Rip-rap on inside slopes need not be replaced.	Replace rocks to design standards.

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NO. 2 - INFILTRATION

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Poisonous Vegetation	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Pollution	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Unmowed Grass/ Ground Cover	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Rodent Holes	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Insects	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
Storage Area	Sediment	A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. If two inches or more sediment is present, remove.	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
	Sheet Cover (If Applicable)	Sheet cover is visible and has more that three 1/4-inch holes in it.	Sheet cover repaired or replaced.
	Sump Filled with Sediment and Debris (If Applicable)	Any sediment and debris filling vault to 10% of depth from sump bottom to bottom of outlet pipe or obstructing flow into the connector pipe.	Clean out sump to design depth.
Filter Bags	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Replace filter bag or redesign system.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Replace gravel in rock filter.
Side Slopes of Pond	Erosion	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
Emergency Overflow Spillway	Rock Missing	See "Ponds" Standard No. 1	
Settling Ponds and Vaults	Sediment	Remove when 6" or more.	

Note: Sediment accumulation of more than .25 inches per year may indicate excessive erosion is occurring upstream of the facility or that conveyance systems are not being properly maintained. The contributing drainage area should be checked for erosion problems or inadequate maintenance of conveyance systems if excessive sedimentation is noted in an infiltration facility.

Check twice a year during first 2 years of operation; once a year thereafter. Clean manholes/catch basins, repair damaged inlets/outlets, clean trash racks.

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NO. 3 - CLOSED DETENTION SYSTEMS (PIPES/TANKS)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point with debris and sediment	Vents free of debris and sediment
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for ½ length of storage vault or any point depth exceeds 15% of diameter. Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than ½ length of tank.	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any crack allowing material to be transported into facility	All joint between tank /pipe sections are sealed
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of it's design shape	Tank/ pipe repaired or replaced to design.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than ½ inch of thread (may not apply to self-locking lids.)	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying 80lbs of lift. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	King County Safety Office and/or maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks.	Ladder meets design standards allows maintenance person safe access.
Catch Basins		See "Catch Basins" Standards No. 5	See "Catch Basins" Standards No. 5

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NO. 4 - CONTROL STRUCTURE/FLOW RESTRICTOR

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Distance between debris build-up and bottom of orifice plate is less than 1-1/2 feet.	All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall and outlet pipe structure should support at least 1,000 lbs of up or down pressure.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards..
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole		See "Closed Detention Systems" Standards No. 3	See "Closed Detention Systems' Standards No. 3
Catch Basin		See "Catch Basins" Standards No. 5	See 'Catch Basins" Standards No. 5

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NO. 5 - CATCH BASINS

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris (Includes Sediment)	Trash or debris of more than 1/2 cubic foot which is located immediately in front of the catch basin opening or is blocking capacity of the basin by more than 10%	No Trash or debris located immediately in front of catch basin opening.
		Trash or debris (in the basin) that exceeds 1/3 the depth from the bottom of basin to invert the lowest pipe into or out of the basin.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
		Deposits of garbage exceeding 1 cubic foot in volume	No condition present which would attract or support the breeding of insects or rodents.
	Structure Damage to Frame and/or Top Slab	Corner of frame extends more than 3/4 inch past curb face into the street (If applicable).	Frame is even with curb.
		Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (intent is to make sure all material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab.	Frame is sitting flush on top slab.
	Cracks in Basin Walls/ Bottom	Cracks wider than 1/2 inch and longer than 3 feet, any evidence of soil particles entering catch basin through cracks, or maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Cracks wider than 1/2 inch and longer than 1 foot at the joint of any inlet/ outlet pipe or any evidence of soil particles entering catch basin through cracks.	No cracks more than 1/4 inch wide at the joint of inlet/outlet pipe.
	Sediment/ Misalignment	Basin has settled more than 1 inch or has rotated more than 2 inches out of alignment.	Basin replaced or repaired to design standards.

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NO. 5 - CATCH BASINS (*CONTINUED*)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Fire Hazard	Presence of chemicals such as natural gas, oil and gasoline.	No flammable chemicals present.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Pollution	Nonflammable chemicals of more than 1/2 cubic foot per three feet of basin length.	No pollution present other than surface film.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by on maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying 80 lbs. of lift; intent is keep cover from sealing off access to maintenance.	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)		Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

NO. 6 DEBRIS BARRIERS (E.G., TRASH RACKS)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed.
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier clear to receive capacity flow.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Repair or replace barrier to design standards.

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NO. 7 - ENERGY DISSIPATERS

Maintenance Components	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance is Performed.
External:			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Replace rocks to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/ flushed so that it matches design.
	Not Discharging Water Properly	Visual evidence of water discharging at concentrated points along trench (normal condition is a "sheet flow" of water along trench). Intent is to prevent erosion damage.	Trench must be redesigned or rebuilt to standards.
	Perforations Plugged.	Over 1/2 of perforations in pipe are plugged with debris and sediment.	Clean or replace perforated pipe.
	Water Flows Out Top of "Distributor" Catch Basin.	Maintenance person observes water flowing out during any storm less than the design storm or its causing or appears likely to cause damage.	Facility must be rebuilt or redesigned to standards.
	Receiving Area Over-Saturated	Water in receiving area is causing or has potential of causing landslide problems.	No danger of landslides.
Internal:			
Manhole/ Chamber	Worn or Damaged Post. Baffles, Side of Chamber	Structure dissipating flow deteriorates to 1/2 or original size or any concentrated worn spot exceeding one square foot which would make structure unsound.	Replace structure to design standards.
	Other Defects	See "Catch Basins" Standard No. 5	See "Catch Basins" Standard No. 5

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NO. 8 - FENCING

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Missing or Broken Parts	Any defect in the fence that permits easy entry to a facility.	Parts in place to provide adequate security.
	Erosion	Erosion more than 4 inches high and 12-18 inches wide permitting an opening under a fence.	No opening under the fence that exceeds 4 inches in height.
Wire Fences	Damaged Parts	Post out of plumb more than 6 inches.	Post plumb to within 1-1/2 inches.
		Top rails bent more than 6 inches.	Top rail free of bends greater than 1 inch.
		Any part of fence (including post, top rails, and fabric) more than 1 foot out of design alignment.	Fence is aligned and meets design standards.
		Missing or loose tension wire.	Tension wire in place and holding fabric.
		Missing or loose barbed wire that is sagging more than 2-1/2 inches between posts.	Barbed wire in place with less than 3/4 inch sag between post.
		Extension arm missing, broken, or bent out of shape more than 1 1/2 inches.	Extension arm in place with no bends larger than 3/4 inch.
	Deteriorated Paint or Protective Coating	Part or parts that have a rusting or scaling condition that has affected structural adequacy.	Structurally adequate posts or parts with a uniform protective coating.
	Openings in Fabric	Openings in fabric are such that an 8-inch-diameter ball could fit through.	No openings in fabric.

NO. 9 - GATES

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Damaged or Missing Members	Missing gate or locking devices.	Gates and Locking devices in place.
		Broken or missing hinges such that gate cannot be easily opened and closed by a maintenance person.	Hinges intact and lubed. Gate is working freely.
		Gate is out of plumb more than 6 inches and more than 1 foot out of design alignment.	Gate is aligned and vertical.
		Missing stretcher bar, stretcher bands, and ties.	Stretcher bar, bands and ties in place.
	Openings in Fabric	See "Fencing" Standard No. 8	See "Fencing" Standard No. 8

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NO. 10 - CONVEYANCE SYSTEMS (PIPES & DITCHES)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Pipes	Sediment & Debris	Accumulated sediment that exceeds 20% of the diameter of the pipe.	Pipe cleaned of all sediment and debris.
	Vegetation	Vegetation that reduces free movement of water through pipes.	All vegetation removed so water flows freely through pipes.
	Damaged	Protective coating is damaged; rust is causing more than 50% deterioration to any part of pipe.	Pipe repaired or replaced.
		Any dent that decreases the cross section area of pipe by more than 20%.	Pipe repaired or replaced.
Open Ditches	Trash & Debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet of ditch and slopes.	Trash and debris cleared from ditches.
	Sediment	Accumulated sediment that exceeds 20 % of the design depth.	Ditch cleaned/ flushed of all sediment and debris so that it matches design.
	Vegetation	Vegetation that reduces free movement of water through ditches.	Water flows freely through ditches.
	Erosion Damage to Slopes	See "Ponds" Standard No. 1	See "Ponds" Standard No. 1
	Rock Lining Out of Place or Missing (If Applicable).	Maintenance person can see native soil beneath the rock lining.	Replace rocks to design standards.
Catch Basins		See "Catch Basins: Standard No. 5	See "Catch Basins" Standard No. 5
Debris Barriers (e.g., Trash Rack)		See "Debris Barriers" Standard No.6	See "Debris Barriers" Standard No. 6

NO. 11 - GROUNDS (LANDSCAPING)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Weeds (Nonpoisonous)	Weeds growing in more than 20% of the landscaped area (trees and shrubs only).	Weeds present in less than 5% of the landscaped area.
	Safety Hazard	Any presence of poison ivy or other poisonous vegetation.	No poisonous vegetation present in landscaped area.
	Trash or Litter	Paper, cans, bottles, totaling more than 1 cubic foot within a landscaped area (trees and shrubs only) of 1,000 square feet.	Area clear of litter.
Trees and Shrubs	Damaged	Limbs or parts of trees or shrubs that are split or broken which affect more than 25% of the total foliage of the tree or shrub.	Trees and shrubs with less than 5% of total foliage with split or broken limbs.
		Trees or shrubs that have been blown down or knocked over.	Tree or shrub in place free of injury.
		Trees or shrubs which are not adequately supported or are leaning over, causing exposure of the roots.	Tree or shrub in place and adequately supported; remove any dead or diseased trees.

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NO. 12 - ACCESS ROADS/ EASEMENTS

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash and debris exceeds 1 cubic foot per 1,000 square feet i.e., trash and debris would fill up one standards size garbage can.	Roadway free of debris which could damage tires.
	Blocked Roadway	Debris which could damage vehicle tires (glass or metal).	Roadway free of debris which could damage tires.
		Any obstruction which reduces clearance above road surface to less than 14 feet.	Roadway overhead clear to 14 feet high.
		Any obstruction restricting the access to a 10 to 12 foot width for a distance of more than 12 feet or any point restricting access to less than a 10 foot width.	Obstruction removed to allow at least a 12 foot access.
Road Surface	Settlement, Potholes, Mush Spots, Ruts	When any surface defect exceeds 6 inches in depth and 6 square feet in area. In general, any surface defect which hinders or prevents maintenance access.	Road surface uniformly smooth with no evidence of settlement, potholes, mush spots, or ruts.
	Vegetation in Road Surface	Weeds growing in the road surface that are more than 6 inches tall and less than 6 inches tall and less than 6 inches apart within a 400-square foot area.	Road surface free of weeds taller than 2 inches.
	Modular Grid Pavement	Build-up of sediment mildly contaminated with petroleum hydrocarbons.	Removal of sediment and disposal in keeping with Health Department recommendations for mildly contaminated soils or catch basin sediments.
Shoulders and Ditches	Erosion Damage	Erosion within 1 foot of the roadway more than 8 inches wide and 6 inches deep.	Shoulder free of erosion and matching the surrounding road.
	Weeds and Brush	Weeds and brush exceed 18 inches in height or hinder maintenance access.	Weeds and brush cut to 2 inches in height or cleared in such a way as to allow maintenance access.

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NO. 13- WATER QUALITY FACILITIES

A.) Biofiltration Swale

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Biofiltration swale	Sediment Accumulation on Grass Layer	Sediment depth exceeds 2-inches	No sediment deposits on grass layer of the bio-swale, which would impede filtration of runoff.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Vegetation is mowed or nuisance vegetation is eradicated, such that flow not impeded. Grass should be mowed to a height between 4 inches and 9 inches.
	Inlet Outlet Pipe	Inlet/ outlet pipe clogged with sediment and/ or debris.	No clogging or blockage in the inlet and outlet piping.
	Trash and Debris Accumulation	Trash and debris accumulated in the bio-swale.	Trash and debris removed from bioswale.
	Erosion/ Scouring	Where the bio-swale has eroded or scoured the bottom due to flow channelization, or higher flows.	Bioswale should be re-graded and re-seeded to specification, to eliminated channeled flow. Overseeded when bare spots are evident.

NO. 13- WATER QUALITY FACILITIES (*CONTINUED*)

B.) Grasslined Filter Strips

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Filter Strip	Sediment Accumulation on Grass Layer	Sediment depth exceeds 2 inches.	No sediment deposits on grass layer of the filter strip, which would impede filtration runoff.
	Vegetation	When the grass becomes excessively tall (greater than 10-inches); when nuisance weeds and other vegetation starts to take over.	Vegetation is mowed or nuisance vegetation is eradicated, such that flow not impeded. Grass should be mowed to a height between 4 inches and 9 inches.
	Trash and Debris Accumulation	Trash and debris accumulated on the filter strip.	Trash and Debris removed from filter.
	Erosion/ Scouring	Where the filter strip has eroded or scoured due to flow channelization, or higher flows.	Strip should be re-graded and re-seeded specification, to eliminate channeled flow. Overseeded when bare spots are evident.
	V-Notch Pipe Weir	When the V-Notch pipe becomes damaged or clogged with sediment/ debris.	Cleaned and properly functioning weir, such that flows uniformly spread.

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C.) Wetponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Wetpond	Vegetation	Vegetation such as grass and weeds need to be mowed when it starts to impede aesthetics of pond. Mowing is generally required when height exceeds 18-inches. Mowed vegetation should be removed from areas where it could enter the pond, either when the pond level rises, or by rainfall runoff.	Vegetation should be mowed to 4 to 5 inches in height. Trees and bushes should be removed where they are interfering with pond maintenance activities.
	Trash and Debris	Accumulation that exceeds 1 CF per 1000-SF of pond area.	Trash and debris removed from pond.
	Inlet/ Outlet Pipe	Inlet/ Outlet pipe clogged with sediment and/ or debris material.	No clogging or blockage in the inlet and outlet piping.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds the depth of sediment zone plus 6-inches, usually the first cell.	Removal of sediment from pond bottom.
	Oil Sheen on Water	Prevalent and visible oil sheen.	Removal of sediment from pond bottom.
	Erosion	Erosion of the pond's side slopes and/ or scouring of the pond bottom, that exceeds 6-inches, or where continued erosion is prevalent.	Slopes should be stabilized by using proper erosion control measures, and repair methods.
	Settlement of Pond Dike/ Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or inspector determines dike/ berm is unsound.	Dike/ berm is repaired to specifications.
	Rock Window	Rock window is clogged with sediment.	Window is free of sediment and debris.
	Overflow Spillway	Rock is missing and soil is exposed at top of spillway or outside slope.	Replace rocks to specifications.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

D.) Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Wetvault	Trash/ Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/ outlet, (includes floatables and non-floatables).	Trash and debris removed from vault.
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom that exceeds the depth of the sediment zone plus 6-inches.	Removal of sediment from vault.
	Damaged Pipes	Inlet/ outlet piping damaged or broken and in need of repair.	Pipe repaired and/ or replaced.
	Access Cover Damaged/ Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
	Vault Structure Damaged	Vault: Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/ inspection personnel determines that the vault is not structurally sound.	No cracks wider than 1/4-inch at the joint of the inlet/ outlet pipe. Vault is determined to be structurally sound.
	Baffles	Baffles corroding, cracking, warping and/ or showing signs of failure as determined by maintenance/ inspection staff.	Repair or replace baffles to specifications.
	Access Ladder Damage	Ladder is corroded or deteriorated, not functioning properly, missing rungs, has cracks and/ or misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

E.) Sand Filters

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Above Ground	Sediment Accumulation on Grass Layer	Sediment depth exceeds 1/2-inch.	No sediment deposit on grass layer of sand filter which would impede permeability of the filter section.
	Trash and Debris Accumulations	Trash and debris accumulated on sand filter bed.	Trash and debris removed from sand filter bed.
	Sediment/ Debris in Yard Drains/ Clean-Outs]	When the yard drain CB's and clean-out become full or partially plugged with sediment and/ or debris.	Sediment, material from the CB's and clean-outs removed.
	Vegetation	When the grass becomes excessively tall (greater than 6-inches); when nuisance weeds and other vegetation starts to take over.	Vegetation is mowed or nuisance vegetation is eradicated, such that flow is not impeded.
	Sand Filter Media	Drawdown of water through the sand filter media, takes longer than 24-hours, and/ or flow through the overflow pipes occurs frequently.	Usually requires replacement of top 6 to 12-inches of media. May require replacement of entire sand filter section, depending on section.
	Prolonged flows	Sand is saturated for prolonged periods of time (several weeks) and does not dry out between storms due to continuous base flow or prolonged flows from detention facilities.	Limit the low, continuous flows to a small portion of the facility by using a low wooden divider or slightly depressed sand surface.
	Short Circuiting	When flows become concentrated over the sand filter rather than dispersed.	Flow and percolation of water through the sand filter is uniform and dispersed across the filter section.
	Erosion Damage to Slopes	Erosion over 2-inches deep where cause of damage is prevalent or potential for continued erosion is evident.	Slopes should be stabilized by using proper erosion control measures.
	Rock Pad Missing or Out of Place	Soil beneath the rock is visible.	Replace or rebuild the rock pad to design specifications.
	V-Notch Pipe Weir	When the V-Notch pipe becomes damaged or clogged with sediment/ debris.	Clean and properly functioning weir, such that flows uniformly spread.
	Damaged Pipes	Any part of the piping that is crushed or deformed more than 20% or any other failure to the piping.	Pipe repaired or replaced.
Below Ground Vault.	Sediment Accumulation on Sand Media Section	Sediment depth exceeds 1/2-inch.	No sediment deposits on sand filter section, which would impede permeability of the filter section.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in vault bottom.	No sediment deposit in the first chamber of the vault.
	Trash/ Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/ outlet, floatables and non-floatables	Trash and debris removed from vault, and inlet/ outlet piping.
	Sediment in Drain Pipes/ Yard Drains/ Cleanouts	When drain pipes, cleanouts, and yard drains become full with sediment and/ or debris.	Remove the material from the facilities.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

E.) Sand Filters (Continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground Vault (Continued)	Short Circuiting	When seepage/ flow occurs along the vault walls and corners.	Sand filter media section re-laid and compacted along perimeter of vault to form a semi-seal.
	Vertical Riser Pipes	Plugged, failure due to cracking deformation. Flows tend to back-up in first chamber of the vault.	Clean out the riser pipe; replace pipe as needed.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and/ or replaced.
	Access Cover Damaged/ Not Working	Cover cannot be opened, one person cannot open the cover, corrosion/ deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damaged; Includes Cracks in Walls, Bottom, Damage to Frame and/ or Top Slab.	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/ inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
		Cracks wider than 1/2-inch at the joints of any inlet/ outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than 1/4-inch wide at the joint of the inlet/ outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/ or showing signs of failure as determined by maintenance/ inspection person.	Repair or replace baffles to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, missing rungs, cracks, and misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

F.) Leaf Compost Filters

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Above Ground Open Swale	Sediment accumulation on Geo-Textile/ media	Sediment depth exceeds 0.25-inches.	No sediment deposits on fabric layer which would impede permeability of the fabric.
	Trash and debris accumulations	Trash and debris accumulated on compost filter bed.	Trash and debris removed from compost filter bed.
	Sediment/ debris in drain/ yard drains/ clean-outs.	When the yard drain CB's and clean-outs become full of sediment and/ or debris.	Remove the accumulated material from the facility.
	Vegetation	Vegetation impending flow through section, or encroaching into compost media.	Vegetation is mowed or eradicated such that flow is no longer impeded.
	Leaf Compost Media	Drawdown of water through the leaf compost, takes longer than 12-hours, and/ or flow through the overflow pipes occurs frequently.	Replace media with new to design specifications, in addition to replacing fabric.
	Short-Circuiting	When Channeled flow occurs over the leaf media; and where flow perks through the media at the baffles.	Flow is uniform over the entire width of the media section, and concentrated percolation does not occur at the baffle walls. Media needs to be graded and re-set at the baffles to form a seal. Weir plate may need to be adjusted in addition.
	Erosion Damage to Slopes	Eroded damage over 2-inches deep where cause of damage is prevalent or potential for continued erosion is prevalent.	Slopes should be stabilized by using proper erosion control measures.
	Damaged Geo-Textile Fabric.	When fabric is torn, deteriorated, raveled, etc.	Fabric replaced as necessary.
	Rock Pad Missing or out of place	Soil beneath the pad is visible.	Replace or rebuild the rock pad to design standards.
	Damaged Pipes	Any part of the pipe system that is crushed, damage due to corrosion, and/ or settlement.	Pipe repaired or replaced.
	V-Notch Weir Assemblies	Flow is not being uniformly spread over filter media.	Clean, repair or replace the weir systems.
Below Ground Vault	Sediment Accumulation on Geo-Textile/ Media.	Sediment depth exceeds 0.25-inches.	No sediment deposits on fabric layer which would impede permeability of the fabric and compost media.
	Sediment Accumulation in Vault	Sediment depth exceeds 6-inches in first chamber.	No sediment deposits in vault bottom of first chamber.
	Trash/ Debris Accumulation	Trash and debris accumulated on compost filter bed.	Trash and debris removed from the compost filter bed.
	Sediment in Drain Pipes/ Yard Drains/ Clean-Outs	When drain pipes, clean-outs, yard drains become full with sediment and/ or debris.	Remove the accumulated material from the facilities.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

F.) Leaf Compost Filter (Continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Below Ground	Leaf Compost Media	Drawdown of water through the leaf compost, takes longer than 12-hours, and/ or overflow occurs frequently.	Replace media with new compost to specifications, in addition to replacing fabric.
	Short Circuiting	When seepage occurs along the vault wall and corners occur.	Percolation of water occurs along the walls and corners and not through the media section. Media needs to be re-set along the vault wall and corners to form a semi-seal.
	Plugged/ Damaged Elbows	Flow tends to backup unusually high in the first chamber of the vault.	Clean out the elbow fittings and/ or replace if damaged.
	Damaged Geo-Textile Fabric	Fabric is torn, deteriorated, raveled, etc.	Fabric replaced as necessary.
	Rock Pad Missing or Out of Place	Soil beneath the pad is visible.	Replace or rebuild the rock pad to design standards.
	Damaged Pipes	Any part of the pipes that are crushed, damaged due to corrosion and/ or settlement.	Pipe repaired and/ or replaced.
	Access Cover Damaged/ Not Working	Cover cannot be opened, one person cannot open the cover, corrosion/ deformation of cover.	Cover repaired to proper working specifications or replaced.
	V-Notch Weir Assemblies	Flow does not spread uniformly over filter media by weir section.	Clean, repair and/ or replace the weir plate section, or adjust height.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/ or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/ inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
	Baffles	Baffles corroding, cracking warping, and/ or showing signs of failure as determined by maintenance/ inspection person.	Repair or replace baffles to specification.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than 1/4-inch wide at the joint of the inlet/ outlet pipe.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

G.) Infiltration Ponds

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Infiltration Pond	Vegetation	Vegetation such as grass and weeds needs to be mowed when it starts to impede infiltration function. Mowing is generally required when height exceeds 12 inches.	Vegetation should be mowed to 2-inches in height. Trees and bushes should be removed where they impact the infiltrating area of the pond.
	Sand Filter Layer	Sand filter layer has sediment deposits that exceeds 1/2-inch or the infiltration rate of the sand layer is less than 2 in/ hr.	Remove sediment and top layer of sand, and replace in kind per specification.
	Sediment Accumulation in Pond Bottom	Sediment accumulations in pond bottom that exceeds 1/2-inch in depth or percolation test of the pond indicates facility is only working at 90% of it's design percolation rate.	Removal of sediment from pond bottom.
	Trash and Debris	Accumulation that exceeds 1-CF per 1,000-SF of pond area.	Trash and Debris removed from pond.
	Inlet/ Outlet Pipe	Inlet/ outlet pipe clogged with sediment and/ or debris material.	No clogging or blockage in the inlet and outlet piping.
	Erosion	Erosion of the pond's side slope and/ or scouring of the pond bottom, that exceeds 2-inches, or where potential for continued erosion is prevalent.	Slopes should be stabilized by using proper erosion control measures and repair methods.
	Sediment of Pond Dike/ Berm	Any part of these components that has settled 4-inches or lower than the design elevation, or where potential for continued erosion is prevalent.	Slopes should be stabilized by using proper erosion control measures and repair methods.
	Rock Window	Rock window is clogged with sediment.	Window is free of sediment and debris.
	Overflow Spillway	Rock is missing and soil is exposed	Replace rocks to specifications.
Infiltration Vault/ Tank	Sediment Accumulation in Vault	Tanks: Sediment depth exceeds 6-inches in depth.	No sediment deposits in tank bottom.
	Trash and Debris Accumulation	Trash and debris accumulated in tank, vault or connecting pipe. Includes floatables and non-floatables.	Trash and debris removed from each facility.
	Access Cover Damaged/ Not Working	Cover cannot be opened or removed, especially by one person.	Cover repaired or replaced to proper working specifications or replaced.
	Tank or Vault Structure Damaged	Tank: Joints between tank sections failing, such that leakage occurs and. or material being washed through into facility; or maintenance/ inspection person determines the tank is not structurally sound.	Tank replaced or repaired to design specifications.

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NO. 13 - WATER QUALITY FACILITIES (*CONTINUED*)

G.) Infiltration Ponds (*Continued*)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Infiltration Vault/ Tank	Tank or Vault Structural Damage	Vault: Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance inspection personnel determines that the vault is not structurally sound.	Tank replaced or repaired to design specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, missing rungs, has cracks and/ or misaligned.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel.

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NO. 14 - OIL CONTROL FACILITIES

A.) Oil/ Water Separators

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed.
API Type OWS	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with out thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth.	No sediment deposits on vault bottom which would impede flow through the vault and separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulation in vault, or pipe inlet/ outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/ outlet piping.
	Oil Accumulation	Oil accumulations that exceed 1-inch, at the surface of the water	Extract oil from vault by vactoring. Disposal in accordance with state and local rules and regulations.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired or replaced.
	Access Cover Damaged/ Not Working	Cover cannot be opened, one person cannot open the cover, corrosion/ deformation of cover.	Cover repaired to proper working specifications or replaced.
	Vault Structure Damage- Includes Cracks in Walls Bottom, Damage to Frame and/ or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/ inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
	Baffles	Baffles corroding, cracking, warping and/ or showing signs of failure as determined by maintenance/ inspection person.	Repair or replace baffles to specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
		Cracks wider than 1/2-inch at the joint of any inlet/ outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than 1/4-inch wide at the joint of the inlet/ outlet pipe.
CPS-Type OWS	Monitoring	Inspection of discharge water for obvious signs of poor water quality.	Effluent discharge from vault should be clear with no thick visible sheen.
	Sediment Accumulation	Sediment depth in bottom of vault exceeds 6-inches in depth and/ or visible signs of sediment on plates.	No sediment deposits on vault bottom and plate media, which would impede flow through the vault and separation efficiency.
	Trash and Debris Accumulation	Trash and debris accumulated in vault, or pipe inlet/ outlet, floatables and non-floatables.	Trash and debris removed from vault, and inlet/ outlet piping.
	Oil Accumulation	Oil accumulation that exceeds 1-inch at the water surface.	Extract oil from vault by vactoring methods. Clean coalescing plates by thoroughly rinsing and flushing. Should be no visible oil depth on water.

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NO. 14 - OIL CONTROL FACILITIES (*CONTINUED*)

A.) Oil/ Water Separators (Continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
	Damaged Coalescing Plates	Plate media broken, deformed, cracked and/ or showing signs of failure.	Replace that portion of media pack or entire plate pack depending on severity of failure.
	Damaged Pipes	Inlet or outlet piping damaged or broken and in need of repair.	Pipe repaired and or replaced.
	Baffles	Baffles corroding, cracking, warping and/ or showing signs of failure as determined by maintenance/ inspection person.	Repair or replace baffles to specifications.
	Vault Structure Damage- Includes Cracks in Walls, Bottom, Damage to Frame and/ or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance inspection personnel determines that the vault is not structurally sound.	Vault replaced or repaired to design specifications.
	Access Ladder Damaged	Ladder is corroded or deteriorated, not functioning properly, missing rungs, cracks, and misaligned.	Ladder replaced or repaired and meets specifications, and is safe to use as determined by inspection personnel.
		Cracks wider than 1/2-inch at the joint of any inlet/ outlet pipe or any evidence of soil particles entering the vault through the walls.	No cracks more than 1/4-inch wide at the joint of the inlet/ outlet pipe.

B.) Catch Basin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Catch Basin	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/ or unit.	No sediment cap on the insert media and it's unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/ restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Inspection	Inspection of media insert is required.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert-Water Saturated	Catch basin insert is saturated with water, which no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	General	Regular interval replacement due to typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

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KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

APPENDIX B

MASTER DRAINAGE PLAN OBJECTIVE, CRITERIA AND COMPONENTS, AND REVIEW PROCESS

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APPENDIX B

MASTER DRAINAGE PLAN OBJECTIVE, CRITERIA AND COMPONENTS, AND REVIEW PROCESS

Objective

The objective of the Master Drainage Plan (MDP) is to propose specific drainage control systems that will prevent significant adverse impacts to the site's natural hydrologic system and to existing and planned off-site drainage systems and resources. Although this is also the objective of the Surface Water Design Manual (SWDM) generally, the County allows smaller-scale projects to rely more heavily on the "cookbook" approach of the Core and Special Requirements specified in the Manual. Land use alterations from larger scale projects have a higher potential to result in resource and flooding impacts if the "cookbook" standards miss their mark. These larger project, then, are required to take a more detailed, site-specific look at drainage resources and associated management issues.

Larger projects are seen to entail more risk to receiving waters (including groundwater) for two reasons: (a) the relatively large area of the subbasin which is developed and (b) the shorter than typical time frame in which that development occurs. If the same area were developed as smaller parcels, rather than as a large site, development would normally be staggered over a longer period of time. This longer time frame allows a certain "grace" period for problems to be identified and corrective actions incorporated into later development proposals. Not only are formal drainage complaints called in to the County a source of information, but the SEPA public review process accompanying permit review offers an avenue for existing drainage problems to be made known. This longer time frame and input from the affected public offers certain safeguards that any problems resulting from application of the more general drainage planning approach specified in the SWDM are dealt with before additional development in the subbasin proceeds.

Some of the impacts that MDPs would be expected to address include the following:

1. Increase in flow rates and/or volumes that would result in flooding along the natural and/or constructed drainage system, or that would aggravate existing flooding problems, either on-site or downstream.
2. Increase of flow rates and/or volumes, both on- and off-site that would de-stabilize the existing geomorphic balance of the natural drainage systems. Examples would include an increase in the rate or frequency of streambank erosion resulting in bank/slope failures along stream corridors, and downstream sedimentation reducing channel capacity.
3. Alteration of natural topography and/or native vegetation that would result in unstable soil conditions, slopes, or embankments.
4. Alteration of natural hydrologic features or provision of site improvements that would reduce the functional ability of the subbasin to preserve water quality and quantity and/or in-stream and other aquatic habitat values.
5. Alteration of ground water/interflow that would adversely change downstream base flows and/or impair existing water rights.

Criteria

The proposed drainage plan, impact analysis and mitigation measures shall be supported by detailed technical analyses and reports as part of the MDP. In addition to the engineering plans, the MDP shall include appropriate geotechnical investigations, water quality and aquatic habitat analysis, and hydrologic computer modeling (see Section 3.2 in Chapter 3). The report shall also include maintenance and operation provisions for the existing natural drainage system and any on-site drainage facilities. Specific maintenance plans and agreements, identifying maintenance responsibilities, must be provided for any facility privately maintained.

The hydrologic and hydraulic analysis of the site, basin, and downstream system shall be done using the methods described in this Manual. Exceptions are for plans required to prepare hydrologic models using rainfall and stream gage data. Any upstream contributing systems or sub-basins shall be analyzed for both existing and future development conditions (as shown in the latest adopted Community Plan, the King County Comprehensive Plan, or other land use maps). Any agreements, contracts or work scopes for the MDP or monitoring plan are also considered a component of the MDP. Specific requirements and the order for submittal of the various components are given in a detached document entitled: *Master Drainage Planning for Large Site Developments - Process and Requirements*, May 1995

Components of Master Drainage Plans

The MDP consists of several components. These components are typically presented in a drainage plan developed using an approved hydrological model, special reports and studies to identify impacts, mitigation measures to reduce impacts, a technical report containing engineering analyses such as the off-site and flood plain analyses, and a post-development monitoring plan. The drainage plan shall provide a comprehensive analysis of existing and proposed surface and subsurface water quantity and quality conditions for both on- and off-site systems. Off-site systems may include upstream and downstream hydrology. Upstream analysis shall include the total drainage area contributing to the site. Downstream analysis shall extend to an acceptable receiving body of water.

Technical elements

At a minimum, specific technical elements of the MDP include the following:

a) A conceptual or preliminary plan of the proposed drainage collection and flow control systems, based upon accurate field topographic mapping and geologic data, should be provided, along with appropriate cross-sections and details necessary to identify drainage system elements.

b) All assumptions, parameters, and input data used in the hydrologic model. Input and output files from hydrologic and/or hydraulic computer models shall be included as an appendix.

c) Hydraulic performance data (stage, storage, discharge) for all elements of the hydrologic system, whether existing or proposed, including lakes, ponds, and wetlands. This data shall be used to route inflow hydrographs to produce outflow hydrographs.

d) Flow data for all existing and proposed conveyance facilities, including streams, swales, pipes, and ditches which will support the proposed system.

e) Floodplain analysis identifying flows, velocities, and extent of flooding for the existing and proposed conditions. Other backwater analysis required to determine existing and proposed conveyance capacity within the MDP and downstream of the MDP.

f) Erosion analysis of on-site and downstream open-drainage systems, identifying flows, velocities, areas of existing and future deposition and channel erosion, and characterization of sediment.

g) Geotechnical analysis of the site and proposed improvements which specifically addresses soils and slope stability for proposed lakes/ponds, road alignments, channel/ravine conditions, building setbacks from steep slopes, vegetative preservation and controls, existing and proposed drainage facilities, and downstream system stability.

h) Ecological analysis to include the physical and biological features of the streams, lakes, wetlands and swales. The features identified shall be keyed to the map produced in Item (2)(b), below.

i) Method and conceptual design for maintaining existing flow regimes in any swales/ravines that may be altered by the development.

j) Method, conceptual design, and location of water quality compensating facilities that may be necessary to replace naturally occurring "biofiltration" functions of site vegetation, i.e. provision and/or preservation of vegetated swales.

k) Description of maintenance design features and provisions that will ensure reliable and long-term facility operation.

l) Provide construction phasing plan that will ensure stormwater/erosion control during development of individual subbasins.

m) Establish a stream flow/rainfall gauging and stream cross section monitoring plan that will document any changes in the levels of flooding, erosion, and sedimentation, and identify responsible parties for necessary mitigation.

Mapping requirements

Mapping for the MDP must be of adequate scale and detail for accurate definition and location of all system elements, both on-site and off-site, and must provide support for hydrologic model characterization. In general, the following are required:

a) Delineation of sub-basins of appropriate size/land use for computer model characterization and hydraulic analysis of all tributary flows.

b) Location and size of all existing and proposed hydrologic features and facilities in the basins. This includes lakes, ponds, wetlands, swales, streams, pipes, and culverts.

c) Overall plan/profile and cross-sections of conveyance systems and identification of the floodplain and floodway and frequency of flooding for existing and developed conditions.

d) Identify areas of in-stream erosion, sedimentation and/or unstable slopes.

e) Identify site soils for use in hydrologic modeling and preliminary analysis for controlling erosion during construction.

f) Identify upstream and downstream habitat condition, i.e., spawning, rearing, and transport areas; pools, riffles, and other in-stream habitat features; and species and populations observed. Locations shall be keyed to the map produced in Item (2)(b), above.

g) Identify general required building setbacks, clearing limits and Native Growth Protection Easements in areas of steep slopes and drainage features.

Review Process

Master Drainage Plans (MDPs) are submitted directly to the Department of Development and Environmental Services Division (DDES) for review. They must, however, be a part of a permit application that has been filed with DDES (see Section 1.1.1). The MDP process should commence concurrently with the SEPA process.

King County has prepared MDP guidelines entitled: *Master Drainage Planning for Large Site Developments - Process and Requirements*, May 1995, which provide technical guidance to implement the requirements of Section 1.3.3 and this Appendix B. The *MDP Guidelines* may be obtained by contacting DDES.

Prior to commencing preparation of the MDP, the applicant and design engineer (including the team that includes other design professionals such as geotechnical engineers and/or biologists, etc.) should request a MDP pre-application meeting for general information followed by a scoping meeting with DDES in order to coordinate the requirements for the hydrologic modeling and other special analysis which may be required. At these meetings, the applicant should present an outline for the proposed MDP that includes a description of the proposed project, a schedule for preparation of the MDP, and a description of any known environmental or regulatory issues related to the proposal.

DDES will review the components of the MDP as submitted, in a timely manner. The fees for review of the MDP will be determined from resources (consultant, staff, equipment) required and will be billed to the applicant by King County. Review fees shall be paid by the applicant to King County prior to receiving MDP plan approval.

Following approval in concept of all of the MDP components, the applicant will submit four complete final MDP packages to DDES for approval. Three copies will be kept by DDES, and one copy will be returned to the applicant for their records.

Questions regarding the MDP review process should be directed to DDES.

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SURFACE WATER DESIGN MANUAL

APPENDIX C (detached)

SMALL SITE DRAINAGE REQUIREMENTS

AR 032246

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SURFACE WATER DESIGN MANUAL

APPENDIX D (detached)

EROSION AND SEDIMENTATION CONTROL STANDARDS

AR 032247

Reference

REFERENCE

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

Note:

Although some of the materials in this Reference section may have been adopted by administrative rule or by ordinance, the administrative rule that adopted the Surface Water Design Manual has not formally adopted any of the materials in this section. All of the papers, forms, notes, equations, symbols, maps and other materials herein are for reference only.

King County assumes no responsibility for the completeness or current status of the materials contained in this section. It is the sole responsibility of each applicant to insure that the most current materials are used in preparing a permit application for their proposed project. Copies of these materials are available from DNR or DDES.

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REFERENCE 1

AREA SPECIFIC DRAINAGE REVIEW THRESHOLDS

REFERENCE 1

AREA SPECIFIC DRAINAGE REVIEW THRESHOLDS

The following are area specific drainage review thresholds from Section 1.1.1. Areas subject to Drainage Review Threshold #4 are mapped on the Landslide Hazard Drainage Area map included with the Design Manual. Drainage Review Threshold #5 is applied to areas designated as Critical Drainage Areas as listed below and detailed in Reference Section 3. Drainage Review Threshold #6 is applied to the rural zoned portions of the respective basin/community plan area. Zoning maps are available at DDES.

DRAINAGE REVIEW THRESHOLD #4

Drainage review is required for projects adding more than 2,000 square feet of new impervious surface and draining to an SAO defined landslide hazard area, as shown on the Landslide Drainage Area map with this manual.

DRAINAGE REVIEW THRESHOLD #5

Critical Drainage Areas

No additional thresholds.

DRAINAGE REVIEW THRESHOLD #6

KCC 16.82.150(C) Areal Clearing Limits in Rural Areas

Drainage review is required if clearing more than 35% of the site or 7,000 square feet, whichever is greater. Flow control is required for projects clearing more than 35% of the site, per the conditions of KCC 16.82.150(c) in the rural-zoned areas of the following basin and community plans:

- Bear Creek Basin
- Bear Creek Community Planning Area
- East Sammamish Community Planning Area
- Issaquah Creek Basin

Notes:
1. The complete text of KCC 16.82.150 is included in Reference Section 2-A.
2. The effective date of current KCC 16.82.150 is August 18, 1997. However, areal clearing limits have been in effect in these areas per the respective Basin and/or Community Plan requirements.

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REFERENCE 2

AREA SPECIFIC DRAINAGE REQUIREMENTS

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REFERENCE 2-A

AREA SPECIFIC CLEARING RESTRICTIONS

Maximum Clearing Limits for areas subject to KCC 16.82.150(c) Areal Clearing Limits in Rural Areas

AREA DESCRIPTION		MAXIMUM ALLOWABLE CLEARING General	w/ Flow Control#
• Bear Creek Basin		35%	60%
• Bear Creek Community Planning Area		35%	60%
• East Sammamish Community Planning Area		35%	60%
• Issaquah Creek Basin		35%	60%
• May Creek Basin		35%	60%
• Soos Creek Basin	RSRA streams *	65%	65%
• Soos Creek Basin	non-RSRA streams*	80%	80%

Maximum clearing allowed with flow control facility per Core Requirement #3.
* Single Family residential building permits on individual lots are exempt in Soos Creek.

Area Specific Seasonal Clearing Restrictions KCC 16.82.150(D)

- Bear Creek Community Planning Area
- Northshore Community Planning Area
- East Sammamish Community Planning Area
- Soos Creek Basin
- Hylebos Creek Basin

Area Specific P-Suffix Clearing and Grading Restrictions

AREA DESCRIPTION	P-SUFFIX #
• Soos Creek Community Planning Area	SC P3
• Soos Creek Basin in Tahoma/Raven Heights Community Planning Area	TR-P44

Notes:
1. The complete text of KCC 16.82.150, SC-P3, and TR-P44 is included in this section.
2. The effective date of these updates is August 18, 1997. However, areal clearing restrictions have been in effect in these areas per the respective Basin and/or Community Plan requirements.

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KCC-16.82.150 (Effective September 1, 1998)

Ordinance 9614, Section 103, as amended, and K.C.C. 16.82.150 are hereby amended as follows:

Clearing standards.

A. For clearing and grading permits issued under this chapter, the current clearing standards contained in this section and in the following regulations shall apply:

1. The Sensitive Areas Code, K.C.C. chapter 21A.24, and its adopted administrative rules;
2. Property-specific development standards pursuant to K.C.C. chapter 21A.38;
3. Critical drainage area designations identified by adopted administrative rule; and
4. Wildlife habitat corridors pursuant to K.C.C. chapter 21A.14.

B. Within sensitive areas designated pursuant to K.C.C. chapter 21A.24, uses shall be limited to those specified in that chapter. Within any other areas subject to clearing restrictions referenced or contained in this section, the following uses are allowed under a clearing permit:

1. Timber harvest in accordance with a timber harvest management plan and clearing permit approved by the department of development and environmental services or a successor agency. That department shall promulgate administrative rules specifying the contents of, and the submittal requirements and approval criteria for, timber harvest management plans in consultation with the department of natural resources prior to any permit approvals for timber harvest within these tracts or easements;

2. Passive recreation uses and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar uses that do not require permanent structures, provided that cleared areas and/or areas of compacted soils associated with these uses and facilities do not exceed eight percent of the area of the tract or easement. Within wildlife habitat corridors, trail widths shall be the minimum allowed under adopted trail standards and no other recreation uses shall be permitted in the one hundred fifty foot minimum width of the corridor;

3. Utilities and utility easements, including surface water facilities, provided that such uses are within or adjacent to existing road or utility easements whenever possible. Within wildlife habitat corridors, existing or multiple utility uses within established easements shall be allowed within the one hundred fifty foot minimum width of the corridor. Development of new utility corridors shall

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be allowed within wildlife habitat corridors only when multiple uses of existing easements are not feasible and the utility corridors are sited and developed using county-approved best management practices to minimize disturbance; and

4. Removal of dangerous and or damaged trees.

C. For the RA (Rural Area) zoned areas in either the Bear Creek Basin, Issaquah Creek basin, the Soos Creek basin, the May Creek basin, the East Sammamish Community Planning Area or the Bear Creek Community Planning Area:

1. Clearing shall be limited to a maximum of thirty-five percent of the lot or plat area or the amount legally cleared prior to the effective date of any clearing regulations in effect at the time of the clearing, whichever is greater, except under conditions specified below:

a. Clearing shall be limited to a maximum of sixty percent of the lot or plat area if the approved permit requires flow control and water quality facilities in accordance with standards set forth in the applicable adopted basin plan and the King County Surface Water Design Manual;

b. In the Soos Creek basin, clearing shall be limited to a maximum of eighty percent of the lot or plat area, except in designated Regionally Significant Resource Areas where clearing shall be limited to a maximum of sixty-five percent of the lot or plat area. Buffers for all sensitive areas designated under K.C.C. Title 21A and sensitive areas except for submerged lands may be counted towards meeting the requirement. Building permits for single-family residential building on individual lots shall be exempt from the clearing limit in the Soos Creek basin;

c. Clearing required for the construction of access, utilities and septic systems to serve any lots 1.25 acres or smaller in size shall not be counted towards the thirty-five percent maximum clearing standard;

d. On individual lots smaller than twenty thousand square feet, up to seven thousand square feet may be cleared; and

e. Clearing standards for Urban Planned Developments and Mineral zoned properties will be determined through their own designated review processes.

2. For subdivisions and short subdivisions, portions of the plat that are required to remain uncleared shall be retained in one or more open space tracts, with all developable lots sited on the portions of the plat approved to be cleared. Sensitive areas designated under K.C.C. Title

21A shall be recorded separately from tracts mandated by this regulation, but may be counted towards meeting these requirements. Tracts mandated by this regulation may be retained by the subdivider, conveyed to residents of the subdivision, or conveyed to a third party. Open space tracts shall be shown on all property maps and shall be protected by covenants, approved by the county, that restrict their uses to those listed in K.C.C. 16.82.150B. All open space tracts established pursuant to this regulation shall be clearly marked with at least one sign per buildable lot adjoining the tract indicating that the tract is permanent, dedicated open space.

3. For individual lots, the clearing limits shall be applied at the time of building permit application unless the lot is within a subdivision that has been approved with other conditions to meet the standard established in paragraph C2. In cases where conditions are applied to the subdivision, individual lots shall be exempt from the clearing restrictions in paragraph C1. The uses and restrictions on the uncleared portions of individual lots shall be those specified in K.C.C. 16.82.150B. Sensitive areas designated under K.C.C. Title 21A may be counted towards meeting requirements on individual lots.

4. The subdivision or permitting of building on parcels that are cleared in violation of the regulations in effect at the time of the clearing shall be subject to conditions requiring the restoration of trees and understory vegetation on at least sixty-five percent of the plat or lot, or, where applicable, on the percentage of the site that was to remain uncleared under paragraph C1. A restoration plan shall be required of permit applicants, and shall be subject to the approval of the department of development and environmental services. That department shall prepare administrative rules regarding the review and approval of restoration plans in consultation with the department of natural resources before approving subdivision or building permits for parcels cleared in violation of applicable clearing regulations. The administrative rules shall also specify when a restoration plan will be deemed sufficient to forego the six year moratorium on permitting authorized in K.C.C. 16.82.140.

5. In the Bear Creek basin and the Bear Creek Community Planning Area, the requirements of paragraphs C1 through C4 shall be modified or waived by the director for proposed projects that meet the following conditions:

a. The project shall consist of one or more of the following uses:

1. Government services listed in K.C.C. 21A.08.060,

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2. Educational services listed in K.C.C. 21A.08.050,

3. Parks as listed in K.C.C. 21A.08.040 when located adjacent to an existing or

proposed school,

4. Libraries listed in K.C.C. 21A.08.040, and

5. Road projects;

b. The project site shall not be located in a designated regionally significant resource area except for utility corridors that can demonstrate no feasible alternative;

c. The project shall clear the minimum necessary to accommodate the proposed use which includes all the allowed ballfields, playfields, other facilities, and spaces proposed by the public agency to carry out its public function; and

d. The project shall meet the on-site flow control and water quality standards set forth in the applicable adopted basin plan and the Surface Water Design Manual.

The modification or waiver shall not exempt the project from any other code provisions which may apply. The director's decision may be appealed to the zoning and subdivision examiner pursuant to K.C.C. chapter 20.24, provided that any such appeal must be consolidated with an appeal, if any, heard by the examiner on the merits of the proposed project.

6. In the Issaquah Creek basin, the Soos Creek basin and the East Sammamish Community Planning Area, the following standards shall apply:

a. In the regionally significant resource areas, except for utility corridors that can demonstrate no feasible alternative, the requirements of paragraphs C1 through C4 shall apply; and

b. In areas outside of the regionally significant resource areas, projects that consist of one or more of the uses identified in C5(a)(1) to (4) shall be exempt from the requirements of paragraphs C1 through C4.

B. Construction projects can be a significant contributor of pollution to streams and wetlands. Therefore, from October 1 through March 31, in the Bear Creek Community Planning Area, the Northshore Community Planning Area, the East Sammamish Community Planning Area and the Soos Creek and Hylebos Creek basins:

1. Clearing and grading shall only be permitted if shown to the satisfaction of the director that silt-laden runoff exceeding standards in the King County Surface Water Design Manual will be prevented from leaving the construction site through a combination of the following:

a. site conditions including vegetative coverage, slope, soil type and proximity to receiving waters;

b. limitations on activities and the extent of disturbed areas; and

c. proposed erosion and sedimentation control measures.

2. The director shall set forth in writing the basis for approval or denial of clearing or grading during this period.

3. Clearing and grading will be allowed only if there is installation and maintenance of an erosion and sedimentation control plan approved by the department which shall define any limits on clearing and grading or specific erosion and sediment control measures required during this period. Alternate best management practices may be approved or required on-site by the inspector.

4. If, during the course of construction, silt-laden runoff exceeding standards in the King County Surface Water Design Manual leaves the construction site or if clearing and grading limits or erosion and sediment control measures shown in the approved plan are not maintained, a notice of violation shall be issued.

5. If the erosion and sediment control problem defined in the violation is not adequately repaired within twenty-four hours of the notice of violation, then a notice and order may be issued by the inspector to install adequate erosion and sediment control measures to stop silt-laden runoff from leaving the site. The notice and order may also require the contractor to discontinue any further clearing or grading, except for erosion and sediment control maintenance and repair, until the following March 31.

6. The following activities are exempt from the seasonal clearing and grading requirements of this subsection:

a. Routine maintenance and necessary repair of erosion and sediment control facilities;

b. Routine maintenance of public facilities or existing utility structures as provided by K.C.C. 21A.24.050B;

c. Activities where there is one hundred percent infiltration of surface water runoff within the site in approved and installed erosion and sedimentation control facilities;

d. Typical landscaping activities of existing single family residences that do not require a permit;

e. Class I, II III and IV Special forest practices;

f. Mineral extraction activities on sites with approved permits; and

g. Public agency response to emergencies that threaten the public health, safety and welfare.

Soos Creek, SC-P3 (Effective. August 18, 1997)

Clearing and Grading

As a general rule, the vegetation on a development site should be retained as long as possible to reduce impacts. Even after construction has begun, permanent retention of as much of the native vegetation as possible is important and contributes to mitigating the adverse impacts. Native vegetation is adapted to the conditions of the Northwest including summer drought, winter temperatures, insect pests, and diseases. Native vegetation provides food, shelter, and breeding sites to which local wildlife has adapted.

Temporary erosion control and drainage facilities are required to be in place prior to any clearing on a plat. Once the roads and utilities have been constructed and the plat has received final approval, the construction of individual homesites begins. The cumulative sedimentation from the construction of a number of single family homes without erosion control can be significant. Generally, individual single family residential homes fall below the threshold for drainage and erosion control plans pursuant to the Surface Water Design Manual. As a result, erosion and sedimentation control are needed for individual development.

In addition, tighter controls should be placed on the clearing that occurs during the platting process. Under present conditions, sites are often completely cleared very early in the development process, sometimes long before there are any building permits issued for a site. During the time between clearing and site development, substantial erosion and sedimentation can occur. Until there is a need to remove the existing vegetation for construction, the forest should remain in order to protect surface and ground water quality, and to provide wildlife habitat. When construction does occur, the surface water management facilities should be installed first, in order to control the increased surface water flows that will occur when the site is cleared.

Commercial property should not be cleared until after approval of an individual site plan. This delay will allow for integrating the existing vegetation and trees on site into the overall landscape design.

Policy NR-7 states:

NR-7_Clearing and grading should be limited to all short plats, plats, and commercial projects to protect water quality, limit surface water runoff and erosion and maintain wildlife habitat and visual buffers.

The following areawide P-suffix conditions implement policy NR-7. These conditions shall apply throughout the Soos Creek planning area. The conditions shall expire automatically upon the effective date of an adopted Countywide clearing ordinance.

1. Subdivisions, Short Subdivisions and PUDs. The following conditions apply only to applications for subdivisions, short subdivisions and PUDs. Deviations from these standards may be allowed based on a special study prepared by a qualified forester with expertise in windthrow or tree disease.

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a. Lot clearing during road and utility construction. The building envelope on each buildable lot shall be identified on the engineering plans. The following table specifies the maximum size of the building envelope based on actual average lot size:

- Lot Size (in sq. ft.) Building Envelope
- Greater than 15,000 – 5,000 sq. ft.
- 9,001-15,000 – 35% of lot size
- 5,000-9,000 – 45% of lot size
- Less than 5,000 – 55% of lot size

Except as provided in subsection 1.b., the clearing of building envelopes shall occur at the same time as the clearing for roads and utilities. The clearing limits for each building envelope shall be clearly marked or flagged on each lot and inspected prior to any clearing. Erosion and sedimentation controls shall be instituted on the building envelopes as required by the Surface Water Design Manual. The vegetation remaining after initial clearing of the building envelope may be preserved or cleared as deemed appropriate by the permittee of the residential building permit for that lot after its approval and issuance.

b. Lot-by-lot clearing. In subdivisions, short subdivisions and PUDs served by on-site septic systems, clearing on individual lots shall be postponed until the approval and issuance of the individual residential building permit for each lot. No clearing on the individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

In subdivisions, short subdivisions and PUDs served by sewers, the applicant may opt to postpone clearing on individual building lots until the approval and issuance of the individual residential building permits for each lot. Under this option, no clearing on individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

Ordinance 12824
Effective Date August 18, 1997

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Tahoma-Raven Heights, TR-P44 *(Effective. August 18, 1997)*

Clearing and Grading

As a general rule, the vegetation on a development site should be retained as long as possible to reduce impacts. Even after construction has begun, permanent retention of as much of the native vegetation as possible is important and contributes to mitigating the adverse impacts. Native vegetation provides food, shelter, and breeding sites to which local wildlife has adapted.

Temporary erosion control and drainage facilities are required to be in place prior to any clearing on a plat. Once the roads and utilities have been constructed and the plat has received final approval, the construction of individual homesites begins. The cumulative sedimentation from the construction of a number of single family homes without erosion control can be significant. Generally, individual single family residential homes fall below the threshold for drainage and erosion control plans pursuant to the Surface Water Design Manual. As a result, erosion and sedimentation control are needed for individual development.

In addition, tighter controls should be placed on the clearing that occurs during the platting process. Under present conditions, sites are often completely cleared very early in the development process, sometimes long before there are any building permits issued for a site. During the time between clearing and site development, substantial erosion and sedimentation can occur. Until there is a need to remove the existing vegetation for construction, the forest should remain in order to protect surface and ground water quality, and to provide wildlife habitat. When construction does occur, the surface water management facilities should be installed first, in order to control the increased surface water flows that will occur when the site is cleared.

Commercial property should not be cleared until after approval of an individual site plan. This delay will allow for integrating the existing vegetation and trees on site into the overall landscape design.

The following P-suffix conditions implement policy BW-3 of the Soos Creek Basin Plan:

BW-3–Clearing: Rural Densities. For new subdivisions with densities less than one unit/acre, undisturbed indigenous vegetation should be retained on the area set aside as required wetland and stream buffers, whichever is greater. In addition, the following conditions and exemptions apply:

a. Whenever possible, the undisturbed area should retain vegetation in large contiguous area rather than isolated patches, strips, or individual trees. Trees are the preferred vegetation to be included in the tract, shrubs are second preference, and grasslands are least preferable.

b. Criteria should be developed to allow exemptions for trees that pose a hazard to structures.

c. Forest practices within forest zones and crop production within agricultural zones would be exempt.

d. The undisturbed area should be fenced or clearly marked with permanent signs.

e. Vegetated portions of wetlands should not be included in the tract.

These conditions shall apply in the portions of the Soos Creek Basin covered by the Tahoma/Raven Heights Communities Plan. The conditions shall expire automatically upon the effective date of an adopted countywide clearing ordinance.

Subdivisions, Short Subdivisions and PUDs: The following conditions apply only to applications for subdivisions, short subdivisions and PUDs. Deviations from these standards may be allowed based on a special study prepared by a qualified forester with expertise in windthrow or tree disease.

2. Lot clearing during road and utility construction: The building envelope on each buildable lot shall be identified on the engineering plans. The following table specifies the maximum size of the building envelope based on actual average lot size: (Building envelope being the total dimensions of the structure including width, depth and height).

   a. Lot Size (in sq. ft.) — Building Envelope
   b. Greater than 15000 — 5000 sq. ft.
   c. 9001-15000 — 35% of lot size
   d. 5000-9000 — 45% of lot size
   e. Less than 5000 — 55% of lot size

   Except as provided in subsection 1.b., the clearing of building envelopes shall occur at the same time as the clearing for roads and utilities. The clearing limits for each building envelope shall be clearly marked or flagged on each lot and inspected prior to any clearing. Erosion and sedimentation controls shall be instituted on the building envelopes as required by the Surface Water Design Manual. The vegetation remaining after initial clearing of the building envelope may be preserved or cleared as deemed appropriate by the permitted of the residential building permit for that lot after its approval and issuance.

3. Lot-by-lot clearing: In subdivisions, short subdivisions and PUDs served by on-site septic systems, clearing on individual lots shall be postponed until the approval and issuance of the individual residential building permit for each lot. No clearing on the individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

In subdivisions, short subdivisions and PUDs served by sewers, the applicant may opt to postpone clearing on individual building lots until the approval and issuance of the individual residential building permits for each lot. Under this option, no clearing on individual building lots shall occur during the construction of roads and utilities except that necessary to accommodate cuts and fills due to topography and road design. Erosion and sedimentation control plans shall be designed through buildout including sediment pond sizing. All building permits shall have erosion control measures consistent with the Surface Water Design Manual standards.

Ordinance 12824 Effective Date August 18, 1997

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REFERENCE 2B

ADOPTED BASIN AND LAKE MANAGEMENT PLANS AREA SPECIFIC CONVERSIONS

Drainage Requirements

New methods have been adopted by King County as the runoff control requirements for development since the adoption of the following basin plans. These methods are detailed in the Surface Water Design Manual. The table below identifies the new standards that provide the equivalent level of protection as the recommendations in the Basin Plan (except when noted in the amended standard). These new standards are to be used in place of the original recommendations. See the original Basin Plan language for details on the standard and the conditions for when it is applied; but apply the amended standard using the normal application methods detailed in the Design Manual including safety factors and thresholds unless specifically directed otherwise in this table.

Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
BEAR CREEK BASIN PLAN		
BW-2: Onsite Detention Standards - General Basinwide Standard	Match pre-developed 2- and 10-year peak flows (SBUH 24-hr)[b]	Level 1 Flow Control (KCRTS)[c d] - Match pre-developed 2- and 10-year peak flow rates
BW-2: Onsite Detention Standards - Steep Slope Standard	Release the 2-year peak flow at 50% of the forested 2-year peak flow; the 10-year at the forested 2-year; and the 100-year at the forested 10 year (SBUH 24-hr) *NOTE: Ordinance adopting the basin plan deleted this standard*	Not applicable.
BW-2: Onsite Detention Standards - Stream Protection Standard	Release the 2-year peak flow at 50% of the pre-developed 2-year peak flow; the 10-year at the pre-developed 2-year; and the 100-year at the pre-developed 10 year (SBUH 24-hr) *NOTE: Ordinance adopting the basin plan revised standard as follows: Match pre-developed flow durations between 50% of the 2-year through the 50-year flows (continuous flow model or, when cannot, use SBUH 24-hr method stated above)*	Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows
BW-2: Onsite Detention Standards - Master Plan Development Standard	Match pre-developed flow durations between 50% of the 2-year through the 50-year flows (continuous flow model)	Level 2 Flow Control (KCRTS)

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
BEAR CREEK BASIN PLAN (cont.)		
BW-3: Clearing Limits	All development is limited on allowable clearing to between 10% and 25% of the project area *NOTE: Ordinance 12015 implementing basin plan revised standard as follows:* *1) Applies only in rural zoned areas;* *2) Area cleared is limited to 35%.*	All development in the rural zone can only clear up to 35% of the project area. Note: small lots may exceed this limit for infrastructure necessary to service lot (including septic drainfields)
BW-3: Clearing Limits - Waiver	Waive limits if release all flows up to the 10-year peak at 70% of the pre-developed 2-year peak flow (SBUH 24-hr). Note: in Upper Bear Creek, waiver only allows clearing up to 65% *NOTE: Ordinance adopting the basin plan revised standard as follows:* *1) Waiver applies only to urban zoned lands (except MPD area);* *2) Rural small lots can exceed limits for septic drainfields without detention required* *Ordinance 12015 implementing basin plan further revised standard to allow waiver only up to 60% everywhere clearing limit is applied*	In areas with clearing limits, projects applying the Level 2 Flow Control (KCRTS) can clear up to 60%. Note: small lots may exceed this limit for infrastructure necessary to service lot (including septic drainfields) without detention required
BW-5: Hillside Drainage Restrictions	Site reviews are to minimize drainage impacts on potentially erodable soils *NOTE: Ordinance adopting the basin plan revised standard as follows: Drainage plans are to minimize impacts on potentially erodable soils through use of tightlines or comparable techniques*	- Meet K.C.C. 21A.24.310.E if applicable; OR - Meet conveyance requirements for tightlines in CR #4; OR - Meet outfall and conveyance requirements (CR #4) and conduct downstream analysis (CR #2) for adequate channel capacity and protection (see Design Manual Section 4.3.7) which may require Level 2 Flow Control (KCRTS) or tightlining.
CW-5: Infiltration - High Densities	Industrial, Commercial and Multifamily 1)cannot infiltrate runoff, 2) must line stormwater facilities, and 3) requires biofiltration or pretreatment prior to discharge *NOTE: Ordinance adopting the basin plan revised standard as follows: 1)requires commercial land best management practices, 2) must identify location of and risk to water supply wells in offsite analysis, and 3) cannot infiltrate pipeline discharges and outdoor toxics storage areas*	Meet the following conditions: - Source Controls: Special Requirement #4 - Implement specific required BMPs for activities covered in the Stormwater Pollution Control Manual - Offsite analysis to include location of and risk to wells - Groundwater protection requirements for infiltration and lining in Design Manual - Water Quality Controls: Core Requirement #8
CW-5: Infiltration – Low Densities	Residential must infiltrate where feasible and comply with Special Requirement #5	- Infiltration required for roof drainage in appropriate soils - Groundwater protection requirements for infiltration facilities

Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
EAST LAKE SAMMAMISH BASIN PLAN		
BW-1: Basinwide Onsite Detention Standard	Match pre-developed 2- and 10-year peak flows (modified SBUH 7-day)[e]	Level 1 Flow Control (KCRTS) - Match pre-developed 2- and 10-year peak flow rates
BW-2: Stream Protection Onsite Detention Standard	Match pre-developed flow durations between 50% of the 2-year event through 50-year event, and match the 100-year peak flow by either using: 1) Use continuous model such as HSPF[f]; or 2) Release the 2-year peak flow at 50% of the pre-developed 2-year flow; the 10-year at the pre-developed 2-year, and the 100-year at the predeveloped 10-year (SBUH 24-hr)	Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows.
BW-3.A.4: Ravine Protection Standard	Retain all runoff onsite to maximum extent feasible	Infiltration of runoff required in granular soils per Design Manual Section 5.4. Downspout infiltration required in granular soils and in allowable soil conditions when feasible to fit trench lengths onsite. If infiltration not feasible, downspout dispersion trenches required when minimum flow paths can be met onsite or into adjacent open space.
BW-3.A.5: Ravine Protection Standard - Pipeline Areas	Surface runoff that leaves the site shall be conveyed down western slope of basin via continuous pipeline.	Meet conveyance requirements for tightlines in Core Requirements (CR) #4.
BW-3.A.6: Ravine Protection Standard - Water Quality	Meet goals of Lake Sammamish Water Quality plan - water quality requirements met by infiltration or other methods of on-site retention, if feasible	Sensitive Lake Treatment Standard (CR #8).
BW-3.A.7: Ravine Protection Standard - Pipeline Discharges	Discharge must be non-erosive (direct to lake or stable from discharge to lake)	Meet outfall and conveyance requirements (CR #4) and conduct downstream analysis (CR #2) for adequate channel capacity and protection.
BW-3.A.9: Ravine Protection Standard - Alternative Standard	Meet BW-2 when not required to build or connect to a pipeline and cannot achieve 100% infiltration.	Meet Level 2 Flow Control (KCRTS) when not required to build or connect to a pipeline and cannot achieve 100% infiltration.
BW-3.B.3: Relationship to Other Drainage Codes - Variances	Variance not needed for pipeline discharges that are not at the natural location (CR #1).	Variance required to review proposal but applicant to request and receive fee waiver per Design Manual Section 1.4.3.
BW-5: Wetland Management Area Protection - Detention Standards (refer to T-2, PL-2, MH-5 & LJ-3)	Meet BW-2 Stream Protection Standard if in wetland subbasin	Meet Level 2 Flow Control (KCRTS) if in wetland subbasin.

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	**Previously Adopted Basin Plan Standard**	**Amended Standard[a]**
EAST LAKE SAMMAMISH BASIN PLAN (cont.)		
BW-5: Wetland Management Area Protection - Infiltration (refer to I-2)	Infiltrate all runoff up to and including the 25-year event	Infiltration of runoff required in granular soils per Design Manual up to and including the post-developed 25-year peak flow rate (KCRTS). Downspout infiltration required in granular soils and in allowable soil conditions when feasible to fit trench lengths onsite. If infiltration not feasible, downspout dispersion trenches required if minimum flow paths can be met onsite or into adjacent open space.
BW-9: Water-Quality Design Standards	Use the most effective combination of soil infiltration, wet R/D ponds, constructed wetland treatment, biofilters, alum treatment of stormwater ponds, and dry ponds with biofilters until new requirements are developed for the basin.	Sensitive Lake Treatment Standard (CR #8).
BW-26: Seasonal Clearing and Grading Limits - Waiver	Waive October 1 to March 31 limits outside of Wetland Management Areas and the Pine and Beaver Lake watersheds if: 1) no significant silt-laden runoff leaves the construction site; and 2) approved erosion and sediment control plan, installed and maintained	Waive limits if Department of Development and Environmental Services (DDES) determines that implementation of ESC requirements (CR #5) will not result in significant silt-laden runoff leaving the construction site and are properly installed and maintained throughout the limit period.
PH-2; MH-2: Baseflow Maintenance	Evaluate suitability of soils for infiltration. Runoff from new impervious surfaces retained onsite to maximum extent feasible. Limit impervious surface to 35% coverage on all non-infiltrative soils. For subdivisions and short subdivisions with non-infiltrative soils; 25% of development shall remain undisturbed and set aside as NPGE.	- Infiltration of runoff required in granular soils per Design Manual Section 4.5. Downspout infiltration required in granular soils and in allowable soil conditions when feasible to fit trench lengths onsite. If infiltration not feasible, downspout dispersion trenches required if flow paths can be met onsite or into adjacent open space. - For non-infiltrative areas of development, impervious surface limited to 35% coverage. - For subdivisions and short subdivisions with non-infiltrative soils; 25% of development shall remain undisturbed and set aside per K.C.C. 21A.24.130.
PH-3; MH-3: Reduced Onsite Detention	Direct discharge into Lake Sammamish without detention allowed after appropriate water quality treatment	- Meet CR #8 requirements. - Direct discharge allowed when criteria for direct discharge exemption in CR #3 is met.
LJ-4: Protection of Laughing Jacobs Lake Floodplain	Floodplain analysis required if development within 10 vertical feet of ordinary high water mark.	Floodplain/Floodway Delineation (Special Requirement #2) required if development within 10 vertical feet of ordinary high water mark.

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
EAST LAKE SAMMAMISH BASIN PLAN (cont.)		
LJ-6: Ravine-Top Clearing and Drainage Standards	Meet appropriate detention standard and convey discharge via tightline to base of ravine. Discharge to stream with adequate energy dissipation.	- Meet conveyance requirements for tightlines, outfall and conveyance in CR #4.
CP-58; CP-59: Pine Lake Phosphorus Control	All known, available and reasonable methods of prevention, control, and treatment for phosphorus control. Current standards are: 1) infiltration to and including the 25-year event, 2) where soils unsuitable, swale or constructed wetland combined with sand filter, or 3) updated Design Manual requirement for phosphorus control	Sensitive Lake Treatment Standard (CR #8).
BLMP: Beaver Lake Phosphorus Control	All known and reasonable treatment for phosphorus control to achieve 80% reduction in total phosphorus (above background levels).	Beaver Lake Management Plan requirements per Special Requirement #1 and K.C.C. 9.08.120.B
ISSAQUAH CREEK BASIN PLAN		
BW-1: Flow Reduction On-Site Retention/ Detention Standard	1) Match pre-developed 2- and 10-year peak flows (modified SBUH 7-day); 2) Release the 2-year peak flow at 50% of the pre-developed 2-year flow; the 10-year at the pre-developed 2-year, and the 100-year at the predeveloped 10-year (SBUH 24-hr); or 3) Use continuous model such as HSPF	Level 1 Flow Control (KCRTS) - Match pre-developed 2- and 10-year peak flow rates
BW-2: Erosion Protection On-Site Retention/Detention Standard (refer to UI-1, MI-1, MD-1, NF-3,	Match pre-developed flow durations between 50% of the 2-year event through 50-year event, and match the 100-year peak flow by either using: 1) Use continuous model such as HSPF; or 2) Release the 2-year peak flow at 50% of the pre-developed 2-year flow; the 10-year at the pre-developed 2-year, and the 100-year at the predeveloped 10-year (SBUH 24-hr)	Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows.
BW-19: Water Quality Treatment Design Standards	Meet the lake protection water quality treatment requirement for 50% phosphorous removal.	Sensitive Lake Treatment Standard (CR #8)
UI-2: Standards and Performance Goals - MDP Requirements	All development requiring a Master Drainage Plan (MDP) shall meet specified requirements in the recommendation	Recommendation applies as stated per Special Requirement #1.

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
ISSAQUAH CREEK BASIN PLAN (cont.)		
EF-2 & NF-2: Factors for Evaluation of Master Planned Developments - MDP Requirements	All development requiring a MDP shall meet specified requirements in the recommendation	Recommendation applies as stated per Special Requirement #1.
NF-3: Wetland 7 Management Area Protection - Detention Standards	Meet BW-2 Stream Protection Standard if in wetland subbasin	Meet Level 2 Flow Control (KCRTS) if in wetland subbasin.
NF-3: Wetland Management Area Protection - Infiltration	Maximize infiltration potential of all conveyance, detention, and discharge facilities through perforated conveyance pipes and discharge dispersal into undisturbed vegetation	Infiltration required in suitable soils per Design Manual. Downspout dispersal, infiltration or perforated stout design required where feasible. Discharge in dispersal trenches where possible. Conveyance systems designed as perforated pipe systems where above seasonal water table.
T-2: Site Development Requirements - Pipeline Areas	All development requiring a MDP shall convey any discharges down the steep reaches of Cougar and Squeak Mountains to the valley floor via continuous pipeline.	Meet conveyance requirements for tightlines in Core Requirements (CR) #4. Meet outfall and conveyance requirements (CR #4) and conduct downstream analysis (CR #2) from pipeline outfall for adequate channel capacity and protection.
T-2: Site Development Requirements - Erosion and Sediment Control	A stringent erosion and sediment control plan should be initiated to minimize construction-related erosion	Meet all wet season requirements prior to commencing construction (CR#5). Note: seasonal clearing limits may be applicable on some portions of the site.
T-2: Site Development Requirements - MDP Approval	Any MDP approval shall be contingent on completion of downstream flood control and drainage project deemed essential by SWM and the City of Issaquah	Recommendation applies as stated per Special Requirement #1.
CEDAR RIVER BASIN PLAN		
BW-3.3: Wetland Management Area Protection - Detention Standards (refer to M6, P2-P5 & P7)	Meet Level 2 or Level 3 R/D if in wetland subbasin (see BW-19)	Meet Level 2 or Level 3 Flow Control (KCRTS) if in wetland subbasin (see BW-19)
BW-3.4: Wetland Management Area Protection - Roof Downspout Infiltration	Infiltrate roof downspouts where practical	Downspout infiltration required in granular soils and in allowable soil conditions per Design Manual Section 5.4.when feasible to fit trench lengths onsite.
BW-12.1: Water-Quality Treatment Standards - Basic Treatment Areas	Apply water quality treatment BMPs having a goal of 80 % removal of total suspended solids (TSS)	Basic Water Quality Standard (CR #8) - 80% average annual removal of total suspended solids (TSS)
BW-12.2a: Water-Quality Treatment Standards - Sphagnum Bog Wetland Treatment Areas	Apply sphagnum bog protection BMPs having a goal of protecting bogs by controlling nutrients, alkalinity and pH	Sphagnum Bog Protection Standard (CR #8) - total phosphorus reduction 50%, total nitrate+nitrite reduction 40%, pH below 6.5 and alkalinity below 10 mg/L.

Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
CEDAR RIVER BASIN PLAN (cont.)		
BW-12.2b: Water-Quality Treatment Standards - Sensitive Lake Treatment Areas	Apply lake protection BMPs having a goal of 50% annual average total phosphorous removal	Sensitive Lake Protection Standard (CR #8) - 50% average annual removal of total phosphorous
BW-12.2a: Water-Quality Treatment Standards - RSRA Stream Reaches	Apply stream protection BMPs having a goal of 50% reduction of total zinc	Resource Stream Protection Standard (CR #8) - 50% reduction of total zinc
BW-17: Aquifer Protection and Base Flow Maintenance (Sections 2 & 3)	Protect aquifer recharge and stream base flows by infiltration runoff whenever feasible; protect aquifer water quality by reducing introduction of pollutants into drainage waters.	Meet the following conditions: - Infiltration required in suitable soils per Design Manual (see BW-21) - Source Controls: Special Requirement #4 : Implement specific required BMPs for activities covered in the Stormwater Pollution Control Manual - Groundwater protection requirements for infiltration and lining in Design Manual - Water Quality Controls: Core Requirement #8
BW-19a: Retention/ Detention Standards - Level 0	In identified areas Level 1 R/D can be waived if a regional facility has capacity or direct discharge is possible *Note: Ordinance adopting the basin plan revised the standard as follows: waiver allowed only when will not result in aggravation or creation of a significant drainage or water quality problem*	In identified areas, projects may qualify for the Discretionary Exemption for Infill Projects or the Direct Discharge Exemption in Core Requirement (CR) #3: Flow Control
BW-19b: Retention/ Detention Standards - Level 1: 2/10 Peak Flow Frequency	Match pre-developed 2- and 10-year peak flows by using either: 1) KCRTS; or 2) modified SBUH 7-day method	Level 1 Flow Control (KCRTS) - Match pre-developed 2- and 10-year peak flow rates
BW-19c: Retention/ Detention Standards - Level 2: Peak Flow Duration Control	Match pre-developed flow durations between 50% of the 2-year event through 50-year event by either using: 1) KCRTS; or 2) Release the 2-year peak flow at 50% of the pre-developed 2-year flow; the 10-year at the pre-developed 2-year, and the 100-year at the pre-developed 10-year (SBUH 24-hr)	Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
CEDAR RIVER BASIN PLAN (cont.)		
BW-19c: Retention/ Detention Standards - Level 3: Lake and Wetland Peak Stage Frequency and Duration	Match pre-developed flow durations between 50% of the 2-year event through 50-year event, and match the 100-year peak flow by either using: 1) KCRTS; or 2) Release the 2-year peak flow at 50% of the pre-developed 2-year flow; the 10-year at the pre-developed 2-year, and the 100-year at the pre-developed 10-year (SBUH 24-hr; safety factor 40%)	Level 3 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows and release the post-developed 100-year flow at the pre-developed 100-year
BW-19d: Retention/ Detention Standards - Level 4: Special Requirements	Runoff will be designed to achieve specific goals such as pre-disturbance streamflow characteristics	Projects in these catchments shall be subject to Large Site Drainage Review (Design Manual Section 1.1.2.4)
BW-20.1: Ravine Protection Standard - On-Site Retention	Retain all runoff onsite to maximum extent feasible	Infiltration of runoff required in granular soils per Design Manual Section 5.4. Downspout infiltration required in granular soils and in allowable soil conditions when feasible to fit trench lengths onsite. If infiltration not feasible, downspout dispersion trenches required when minimum flow paths can be met onsite or into adjacent open space.
BW-20.2: Ravine Protection Standard - Pipeline Areas	1) Surface runoff that leaves the site shall be conveyed downslope to the valley floor via continuous pipeline, if feasible. 2) Discharge that is not direct to the Cedar River shall meet Level 1 Peak Flow Control 3) Discharge must be non-erosive (direct to lake or stable from discharge to lake)	Meet the Landslide Hazard Drainage Area Requirements (Design Manual Section 1.2.3.2) - Meet conveyance requirements for tightlines in Core Requirements (CR) #4. - Meet Level 1 Flow Control (KCRTS) when not direct discharge to Cedar River - Meet outfall and conveyance requirements (CR #4) and conduct downstream analysis (CR #2) for adequate channel capacity and protection.
BW-20.3: Ravine Protection Standard - Enhanced R/D	Meet Level 2 Peak Flow Duration Control when not required to build or connect to a pipeline and cannot achieve 100% infiltration.	Meet Level 2 Flow Control (KCRTS) when not required to build or connect to a pipeline and cannot achieve 100% infiltration.
BW-20: Relationship to Other Drainage Codes - Variances	Variance not needed for pipeline discharges that are not at the natural location (CR #1).	Variance required to review proposal but applicant to request and receive fee waiver per Design Manual Section 1.4.3.
BW-21: Infiltration as a Stormwater Mitigation Treatment	Project designs shall maximize the use of on-site stormwater retention and infiltration	- Infiltration required in suitable soils per Design Manual Section 5.4. Downspout infiltration required in granular soils and in allowable soil conditions when feasible to fit trench lengths onsite. Downspout dispersion or infiltrated stubouts where infiltration not possible. Discharge in dispersal trenches when possible. Conveyance systems designed as perforated pipe systems where above seasonal water table.

Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
SOOS CREEK BASIN PLAN		
BW-2: Onsite Detention Standards - General Basinwide Standard	Match pre-developed 2- and 10-year peak flows (SBUH 24-hr)	Level 1 Flow Control (KCRTS) - Match pre-developed 2- and 10-year peak flow rates
BW-2a: Onsite Detention Standards - Reduced Detention Standard. (Also referred to as AS3, AS8, & AS14)	Match pre-developed 2-year peak flows (SBUH 24-hr) except where flooding problems are expected.	Level 1 Flow Control (KCRTS) unless project meets direct discharge requirements for the lakes designated as major receiving bodies into which the subcatchment drains.
BW-2b: Onsite Detention Standards - Little Soos Standard. (Also referred to as AS6)	Match pre-developed 2-, 10- and 100-year peak flows (SBUH 24-hr)	Level 1 Flow Control (KCRTS)
BW-2c: Onsite Detention Standards - Soosette Increased Detention Standard. (Also referred to as AS18)	Release all flows up to the 100-year peak flow at 70% of the pre-developed 2-year peak flow (SBUH 24-hr)	Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows
BW-2d: Onsite Detention Standards - Covington Center Standard. (Also referred to as AS5)	No subdivision or non-single-family construction permits until Master Drainage Plan (MDP) adopted. Covington MDP adopted in 1992.	Meet Covington MDP conditions in KCC 20.14.025.
CW-5: Infiltration - High Densities	Industrial, Commercial and Multifamily 1)cannot infiltrate runoff, 2) must line stormwater facilities, and 3) requires biofiltration or pretreatment prior to discharge	Meet the following conditions: - Groundwater protection requirements for infiltration and lining in Design Manual - Water Quality Controls: Core Requirement #8
CW-5: Infiltration - Low Densities	Residential must infiltrate where feasible and comply with Special Requirement #5	Meet the following conditions: - Infiltration required for roof drainage in appropriate soils - Groundwater protection requirements for all infiltration Note: previous standard applied to all residential development
HYLEBOS CREEK BASIN PLAN		
BW-1: Basinwide Onsite Detention Standard	Match pre-developed 2- and 10-year peak flows (modified SBUH 7-day)	Level 1 Flow Control (KCRTS) - Match pre-developed 2- and 10-year peak flow rates

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
BW-3: Stream Protection Onsite Detention Standard	Match pre-developed flow durations and peaks between 50% of the 2-year event through 50-year event, and match the 100-year peak flow by: 1) Use continuous model such as HSPF; or 2) Release the 100-year peak flow at 70% of the pre-developed 2-year flow (SBUH 24-hr) *NOTE: Ordinance adopting the basin plan revised standard 2) as follows: Release the 2-year peak flow at 50% of the pre-developed 2-year flow; the 10-year at the pre-developed 2-year, and the 100-year at the pre-developed 10-year*	Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows
BW-9: Seasonal Clearing and Grading Limits - Exemption	Exempt from October 1 to March 31 limits if: 1) infiltrate 100% of surface runoff; 2) approved erosion and sediment control plan, installed and maintained; and 3) disturbed soil areas left unworked for more than 12 hours covered. *NOTE: Ordinance adopting the basin plan revised standard as follows: Meet all Temporary Erosion and Sediment Control requirements best management practices (BMPs)*	Meet ESC requirements: Core Requirement (CR) #5 (including wet season requirements) and the following additional conditions: 1) no significant silt-laden runoff leaving the construction site, and 2) all BMPs are properly installed and maintained throughout
BW-10.2: Hillslope Development and Drainage Restrictions	Surface runoff flowing towards landslide hazard areas or slopes that are 40% or greater shall be conveyed down slope via continuous pipeline unless directed to stable receiving areas as determined by downstream analysis. *NOTE: Ordinance adopting the basin plan deleted this standard*	Not Applicable
BW-17.3: BMP Programs for Control of Nonpoint Source Pollutants - Commercial and Industrial Uses	Implement BMPs specific to the nature of activity involved.	Obtain and comply with permit from the National Pollution Discharge Elimination System (NPDES) Stormwater Permit program; OR Implement specific required BMPs for activities covered in the Stormwater Pollution Control Manual.
BW-17.5: BMP Programs for Control of Nonpoint Source Pollutants - Agricultural Uses	Implement BMPs specific to the nature of activity involved.	Implement and maintain a farm management plan approved by the King Conservation District; OR Implement specific required BMPs for activities covered in the Stormwater Pollution Control Manual.

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Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
HYLEBOS CREEK BASIN PLAN (cont.)		
BW-20: Stormwater Infiltration Limitations	Evaluate suitability of soils for infiltration. Runoff from new rural and low- to moderate-density land uses infiltrated to extent possible. Infiltration not allowed in high-density areas of multifamily or commercial land uses. *NOTE: Ordinance adopting the basin plan revised standard as follows: Infiltration allowed in multifamily, commercial and industrial when commercial BMPs in place.*	Meet the following conditions: - Infiltration required in suitable soils per Design Manual. - Source Controls: Special Requirement #4 - Implement specific required BMPs for activities covered in the Stormwater Pollution Control Manual - Groundwater protection requirements for infiltration and lining in Design Manual - Water Quality Controls: CR #8
NS-1: Reduced Onsite Detention	Direct discharge into Puget Sound without detention allowed after appropriate water quality treatment	- Meet CR #8 requirements. - Direct discharge allowed when criteria for direct discharge exemption in CR #3 is met.
COVINGTON MASTER DRAINAGE PLAN		
Since the adoption of Covington Master Drainage Plan (MDP), the state has revised the water quality standards for toxic metals. The MDP was developed to address, among other issues, measured violations of the old copper standards. Plan recommendations for standards and retrofits designed to address total copper loadings to streams have different results on dissolved copper loadings (the new water quality standard). Monitoring studies were conducted to define dissolved copper concentrations in stormwater runoff, groundwater and streams within in the MDP area. Based on the monitoring results, the table below identifies the new standards and projects that will provide the level of protection needed to meet the MDP's stated goals. See the Original MDP language for details on the standard.		
SW-1: System Configuration – subbasin drainage analysis	All development in area designated in Figure V-4 (Attachment C, Ordinance 10293) shall: - reduce copper loadings by constructing lower density development than allowed; - provide a groundwater study which proves flows from site do not migrate to Little Soos Creek; or - runoff from site is conveyed to a location where surface or groundwater flow is away from Little Soos Creek.	Repealed - no additional requirements in the designated area.
SW-2: Surface Water Facilities – Infiltration: Pretreatment	Infiltration from development or redevelopment with greater than 5000 ft^2 of impervious surface requires lined wetpond and bioswale treatment prior to infiltration.	Infiltration from development or redevelopment with greater than 5000 ft^2 of impervious surface shall meet groundwater protection requirements for infiltration and lining in the Design Manual.
SW-2: Surface Water Facilities – Infiltration: Water Supply Wells	Development proposals must identify domestic water supply wells within 1 mile and assess human health risk from infiltration and implement appropriate mitigation measures.	Developments shall submit an offsite analysis (Core Requirement #2) that identifies the location of domestic water supply wells within a 1 mile radius of proposed infiltration facilities, and, if any wells are present, assess the human health risk and recommend appropriate measures to mitigate identified health risks.

Adopted Revisions to Apply in Place of Basin Plan Recommendations		
Basin Plan Recommendation	Previously Adopted Basin Plan Standard	Amended Standard[a]
COVINGTON MASTER DRAINAGE PLAN (cont.)		
SW-3: Surface Water Facilities - Surface Detention	All development in areas where infiltration to groundwater is not feasible (Attachment 2, Ordinance 10293) shall match predeveloped stream hydrographs by providing stormwater detention of four-acre inches of detention storage volume per impervious acre developed.	All development in areas where infiltration to groundwater is not feasible (Attachment 2, Ordinance 10293) shall apply the Level 2 Flow Control (KCRTS) - Match pre-developed flow durations between 50% of the 2-year through the 50-year flows
SC-2 Commercial /Industrial Best Management Practices	Structural elements of the DOE Storm Water Management Manual BMP guidelines for commercial and industrial businesses are required, where appropriate, for new or redevelopment.	- All commercial and industrial new and redevelopment shall meet Special Requirement #4: Source Controls; AND - Obtain and comply with permit from the National Pollution Discharge Elimination System (NPDES) Stormwater Permit program; OR - Implement specific required BMPs for activities covered in the Stormwater Pollution Control Manual
LAKE MANAGEMENT PLANS		
Cottage Lake Management Plan	See plan recommendations.	Sensitive Lake Protection Standard (CR#8)
Beaver Lake Management Plan	See plan recommendations.	Beaver Lake Management Plan requirements per Special Requirement #1 and K.C.C. 9.08.120.B. A goal of 80% removal of new phosphorous to be achieved through application of all known and reasonable technologies.
Lake Twelve Management Plan	Plan recommends development of a weed harvesting program.	Basic Water Quality Standard (CR#8)
Lake Desire Management Plan	See plan recommendations.	Sensitive Lake Protection Standard (CR#8)
Lake Sawyer Management Plan	Pending.	Sensitive Lake Protection Standard (CR#8)
Lake Sammamish WQ Management Plan	See plan recommendations.	Sensitive Lake Protection Standard (CR#8)

[a] These standards are to be applied to development scenarios when required by and as implemented through the King County Surface Water Design Manual.
[b] Santa Barbara Urban Hydrograph hydrologic method.
[c] King County Runoff Time Series hydrologic method adopted in the King County Surface Water Design Manual.
[d] An HSPF continuous hydrologic model with regionalized parameters listed in the King County Surface Water Design Manual may be substituted for KCRTS.
[e] Santa Barbara Urban Hydrograph hydrologic method modified by King County to use a seven day rainfall distribution.
[f] Hydrologic Simulation Program-FORTRAN continuous flow simulation model.

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REFERENCE 2C

P-SUFFIX CONVERSION SUMMARY MATRIX

(BASED ON ADOPTED ORDINANCES 96-260, 261, AND 263)

This matrix lists, by planning area, each original p-suffix condition and briefly indicates how each was impacted by this ordinance package. Drainage related conditions have been bolded for easier reference. Other development related conditions may have affect drainage design. The complete text and maps for the following drainage related special district overlays and p-suffix conditions are located at the end of this section.

- SO-140 Ground Water Protection SDO
- SO-160 Urban Aquifer Protection SDO
- SO-180 Wetland Management Area SDO
- SO-190 Erosion Hazards Near Sensitive Water Bodies SDO
- SO-200 Heron Habitat Protection Area SDO
- SO-210 Urban Stream Protection Area SDO
- SO-220 Significant Trees SDO
- SO-230 Floodplain Density SDO

ORD.#	PRE-CON P#	DESCRIPTION	ACTION	NEW REG#	REPEAL RATIONALE/ NOTES
BEAR CREEK					
8846	BCP-P2	Stream Corridors	Repealed		Covered, KCC21A.24 and KCC21A.24.360
8846	**BCP-P3**	**Animal Fencing**	**Retained**	**BC-P22**	
8846	**BCP-P4**	**Bear/Evans Creek Basin Construction Controls**	**Repealed**		**Surface Water Design Manual Standard Requirements**
8846	BCP-P6	Heritage Sites	Repealed		Covered, Landmarks Code 20.62
8846	BCP-P8	SR-520 Intersection with Redmond Way	Repealed		Condition met
		(Road Corridor: Woodinville-Duvall)	Retained	BC-P2	
		(Road Corridor: Avondale)	Retained	BC-P3	
		(Road Corridor: NE Novelty Hill)	Retained	BC-P4	
		(Road Corridor: NE 128th Way)	Retained	BC-P5	
		(Road Corridor: NE Union Hill)	Retained	BC-P6	
		(Road Corridor: 216th Ave NE)	Repealed		Project Completed
		(Commercial Area: Avondale Road)	Retained	BC-P8	
		(Commercial Area: NE Woodinville-Duvall)	Retained	BC-P9	
		(Commercial Area: 236th Ave NE)	Retained	BC-P10	
		(Commercial Area: I-P and M-P)	Retained	BC-P11	
8846	**BCP-P9**	**Bear Creek Valley Stream Corridors**	**Repealed**		**Covered, KCC21A.24.360(A) and (E) and KCC21A.24.200**
8846	**BCP-P10**	**Environmentally Sensitive Areas**	**Repealed**		**Covered, KCC21A.24.120**
8846	BCP-P11	Neighborhood Centers	Multiple	BC-P12	
		(Avondale Corner)	Multiple	BC-P13	
		(Redmond Fall City Road)	Multiple	BC-P14	
12170-19-4	BCP-P12	Ring Hill	Retained	BC-P16	

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ORD-#	PRE-CON P#	DESCRIPTION	ACTION	NEW REG#	REPEAL RATIONALE / NOTES
12093	BCP-P13	Novelty Hill Master Plan Developments/ Urban Planned Developments (Blakely Ridge)	Retained	BC-P17	
12601	BCP-P14	Novelty Hill Master Plan Developments/ Urban Planned Developments Area P-suffix Conditions (Northridge)	Retained	BC-P21	
2487	BCP-2487	119-74P (2487)	Multiple	BC-P20	
5752	BCP-5752	107-81R (5752)	Multiple	BC-P18	
7868	BCP-7868	115-85R (7868)	Multiple	BC-P19	
10033	BCP-10033	L90RZ026 (10033)	Repealed		Multiple
EAST KING COUNTY					
11653-83	EKC-P1	Comprehensive Plan Amendment Process	Repealed		Condition met
11653-92A	EKC-P2	Parcel Number 041909-9033, NB-P	Repealed		Condition met
12061	EKC-P3	Alpental Map Amendment Study	Retained	EK-P3	
EAST SAMMAMISH					
10847	ESP-P2	Grand Ridge Clustering	Retained	ES-P2	
10847	ESP-P3	Wildlife Corridor/Urban Separator	Repealed	ES-P20	
10847	ESP-P4	Klahanie Village Affordable Housing	Retained	ES-P3	
10847	**ESP-P6**	**Wetland 7 and North Fork Issaquah Creek Valley**	**Repealed**		**Covered, KCC21A.12.030 (B19) and Issaquah Basin Plan (see Reference Section 2-B)**
10847	ESP-P8	Klahanie Community Business Center Design Requirements	Retained	ES-P4	
10847	ESP-P9	Northwest Pipeline	Retained	ES-P5	
10847	ESP-P10	Farmlands Preservation Clustering	Retained	ES-P6	
10847	ESP-P12	Beaverdam Rural Deed Restrictions	Retained	ES-P7	
10847	ESP-P13	Beaverdam Golf Course Restrictions	Retained	ES-P8	
10847	ESP-P14	Historic Preservation	Repealed		Covered, Landmarks Code 20.62
10847	**ESP-P15**	**East Lake Sammamish Basin Wetland Management Areas**	**Replaced**	**SO-180**	**Wetland Management Area SDO**
10847	**ESP-P16**	**Grand Ridge Rural Development Requirements**	**Multiple**	**ES-P9**	**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10847	**ESP-P17**	**Pine Lake Watershed**	**Replaced**	**SR-15-1 KCC-16.82.150D**	**Sensitive Lake Treatment Standard (CR #8) and KCC-16.82.150 (D) (see Reference Section 2-A).**
10847	**ESP-P18**	**Beaver Lake Watershed**	**Repealed**		**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10847	**ESP-P19**	**Surface Water Retention/ Detention Requirements**	**Replaced**	**SR-15-2**	**Flow Control Application Map and CR#3: Flow Control**
10847	**ESP-P20**	**Seasonal Clearing and Grading Restrictions**	**Replaced**	**KCC-16.82.150D**	**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10847	**ESP-P21**	**Panhandle and Monohan Subbasins**	**Replaced**	**SO-190**	**Erosion Hazards Near Sensitive Areas SDO and Landslide Hazard Drainage Area Requirements and Applications Map.**

ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE / NOTES
10847	**ESP-P22**	**Vegetation Retention in Rural Areas - Areawide**	**Replaced**	**KCC-16.82.150C**	**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10847	ESP-P23	Pine Lake Medical/Dental Clinic Properties	Repealed		Condition met
10847	ESP-P24	Bush Lane Subarea Development Requirement	Repealed		Floodplain study already required under existing code
10847	ESP-P25	Plateau Properties	Multiple	ES-P11	
10847	ESP-P26	J. Swerda Property	Repealed		Multiple
11653-107	ESP-P27	Grand Ridge	Retained	ES-P12	
12061-4-1A	ESP-P28	Ravenholt 4 to 1	Retained	ES-P13	
12061-4-1B	ESP-P29	Marshall 4 to 1	Retained	ES-P14	
11747-A	ESP-P30	Aldarra Property	Retained	ES-P15	
6497	ESP-6497	134-80R (6497)	Retained	ES-P16	
11935	ESP-11935	L95RZ001 (11935)	Multiple	ES-P17	
12531	ESP-P31	Issaquah Employment Center	Retained	ES-P18	
12531	ESP-P32	Emmerson 4 to 1	Retained	ES-P19	
ENUMCLAW					
9499	ENP-P1	Historic Sites	Repealed		Covered, Landmarks Code 20.62
9499	**ENP-P3**	**Green River Gorge and Valley Walls**	**Replaced**	**SR-15-3**	**Landslide Hazard Drainage Area Requirements. Also addressed KCC21.24.280**
9499	ENP-P5	Enumclaw Airport Area	Replaced	SO-150	Aviation Facilities SDO
9499	ENP-P6	Weyerhaeuser Mill	Retained	EN-P1	
9499	ENP-P7	Skieens Property	Repealed		Covered, KCC21A.12.030 (9a)
9499	ENP-P8	Enumclaw Landfill	Repealed		Covered, WAC 173-304-407
7375	ENP-7375	231-85R (7375)	Repealed		Covered, KCC21A.24
FEDERAL WAY					
7746	FWP-P1	Office Park Concept Gets Definite Direction	Repealed		
7746	FWP-P2	W28-22-4:(RS7200 to RD3600-P)	Repealed		Annexed to Federal Way
		(RS7200 to RM2400-P)	Repealed		Annexed to Federal Way
		(RS7200 to BC-P)	Repealed		Annexed to Federal Way
		(RS7200 and RM900 to BC-P)	Repealed		Annexed to Federal Way
		(SR to CG-P)	Retained	FW-P5	
		(SR pot. BC to CG-P)	Retained	FW-P6	
		(SR to BC-P)	Retained	FW-P7	
		(RS7200 to BC-P)	Repealed		Annexed to Federal Way
		(BC to CG-P)	Repealed		Annexed to Federal Way
		(RM900 to CG-P)	Repealed		Annexed to Federal Way
7746	FWP-P3	E28-22-4	Multiple	FW-P11	
7746	FWP-P4	W34-22-4	Repealed		Covered, KCC21A.24.320, KCC21A.14.230-.250
7746	FWP-P5	E34-22-4	Repealed		Covered, KCC21A.24.320, KCC21A.14.230-.250
7746	FWP-P6	E3-21-4	Multiple	FW-P12	
7746	FWP-P7	E9-21-4	Multiple	FW-P13	
7746	FWP-P8	W10-21-4	Multiple	FW-P14	
		(SR to RM2400-P)	Retaind	FW-P15	
		(SR to BN-P)	Retained	FW-P16	
7746	FWP-P9	W15-21-4	Multiple	FW-P17	
7746	FWP-P10	W28-21-4	Multiple	FW-P18	
		(SR to CG-P)	Retained	FW-P19	
7746	FWP-P11	W33-21-4	Repealed		Covered, 234-88 PUD adopted

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ORD #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE/ NOTES
7746	FWP-P12	E33-21-4	Repealed		Multiple
663	FWP-633	P70-27 (633)	Repealed		Condition met
3953	FWP-3953	264-75R (3953)	Multiple	FW-P21	
4560	FWP-4560	201-78R (4560)	Repealed		Condition met
4589	FWP-4589	230-79R (4589)	Repealed		Bond expired
4812	FWP-4812	263-79R (4812)	Multiple	FW-P22	
4867	FWP-4867	208-80R (4867)	Multiple	FW-P23	
5114	FWP-5114	235-80R (5114)	Repealed		Annexed to Federal Way
5144	FWP-5144	257-80R (5144)	Multiple	FW-P25	
5171	FWP-5171	270-79R (5171)	Repealed		Covered, KCC12.88.105-.110
6005	FWP-6005	248-81R (6005)	Repealed		Covered, KC Road Standards
6059	FWP-6059	218-82R (6059)	Repealed		Expired
6074	FWP -6074	222-82R (6074)	Repealed		Covered, KCC16.04.052
6151	FWP-6151	223-82R (6151)	Retained	FW-P26	
6275	FWP-6275	236-82R (6275)	Repealed		Time limited condition
7087	FWP-7087	230-84R (7087)	Repealed		Condition met
7653	FWP-7653	209-86R (7653)	Multiple	FW-P27	
8825	FWP-8825	228-88R (8825)	Repealed		Covered, KCC21A.16
9095	FWP-9095	213-89R (9095)	Repealed		Covered, KCC21A.16
9189	FWP-9189	208-87R (9189)	Multiple	FW-P28	
GREEN RIVER					
6468	GRN-6468	254-75R (6468)	Repealed		Multiple
7821	GRN-7821	224-86R (7821)	Multiple	GR-P1	
8375	GRN-8375	119-87R (8375)	Multiple	GR-P2	
HIGHLINE					
5453	HLP-P1	E9-23-4; O-P, R-48-P	Multiple	HL-P1	
5453	HLP-P2	W4-23-4; R-12-P	Repealed		Covered, KCC16.04.052
5453	HLP-P3	W9-23-4; R-18-P	Repealed		Covered, KCC16.04.052
3313	HLP-3313	225-77R (3313)	Multiple	HL-P2	
3424	HLP-3424	226-77R (3424)	Multiple	HL-P3	
3643	HLP03643	270-77R (3643)	Retained	HL-P4	
3744	HLP-3744	204-77R (3744)	Repealed		Multiple
3779	HLP-3779	284-77R (3779)	Multiple	HL-P5	
4094	HLP-4094	287-78R (4094)	Multiple	HL-P6	
4885	HLP-4885	208-79R (4885)	Multiple	HL-P7	
8858	HLP-8858	233-88R (8858)	Multiple	HL-P8	
8863	HLP-8863	223-88R (8863)	Repealed		Multiple
8866	HLP-8866	224-88R (8866)	Repealed		Multiple
11271	HLP-11271	222-89R (11271)	Multiple	HL-P9	
NEWCASTLE					
6422	NCP-P1	Historic Sites	Repealed		Covered, Landmarks Code 20.62
6422	**NCP-P2**	**Grazing Animal Access to May Creek and its Tributaries**	**Retained**	**NC-P21**	
6422	NCP-P3	Permanent Open Space in Reserve Tracts Created under the SC Zone	Repealed		Covered, KCC21A.12.030 (17) and 21A.14.050. Zoning now R-1 and RA-5.
6422	NCP-M	Cougar Mountain Subarea Master Plan Development	Retained	NC-P1	
12170-18	NCP-P4	Eastgate Congregational Church	Retained	NC-P12	
6422	NCP-P5	W 18-24-6: RS-7200 to RD-3600-P	Multiple	NC-P13	
6422	NCP-P6	E10-23-5: RM-1800 to RT 2400-P; E 15-23-5: S-R, Potential RM-1800, and S-R to RT-2400-P	Retained	NC-P14	Sidewalk Requirement
6422	NCP-P7	RM-900 to RM-900-P	Retained	NC-P15	W 12-23-5: Use Limit
6422	NCP-P8	S-R (potential RM-900) to S-R (15,000) (potential C-G-P)	Multiple	NC-P16	W 12-23-5: Mini-warehouse storage only

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ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE / NOTES
6422	NCP-P9	S-R to SC-P (South of Renton - Issaquah Road/S.R. No. 900, Unclassified Use Permit 217-77)	Multiple	NC-P17	E 12-23-5: Landscaping Conditions
6422	NCP-P10	S-E to S-E-P	Multiple	NC-P18	W 7-23-6: Further Subdivision Limit
6422	NCP-P11	G to SC-P (Potential Q-M)	Multiple	NC-P19	M: Landscaping Conditions
3239	NCP-3239	107-77R (3239)	Multiple	NC-P20	
3501	NCP-3501	151-77R (3501)	Multiple	NC-P2	
4703	NCP-4703	156-79R (4703)	Repealed		Multiple
4915	NCP-4915	121-80R (4915)	Repealed		Multiple
5184	NCP-5184	301-79R (5184)	Multiple	NC-P4	
5346	NCP-5346	102-81R (5346)	Multiple	NC-P5	
5378	NCP-5378	120-79R (5378)	Multiple	NC-P3	
5854	NCP-5854	145-81R (5854)	Multiple	NC-P6	
5985	NCP-5985	114-82R (5985)	Multiple	NC-P7	
6671	NCP-6671	106-83R (6671)	Multiple	NC-P8	
6696	NCP-6966	116-84R (6696)	Repealed		Covered, KCC21A.24
7328	NCP-7328	113-85R (7328)	Repealed		Multiple
8718	NCP-8718	112-88R (8718)	Retained	NC-P9	
8796	NCP-8796	108-88R (8796)	Repealed		Multiple
9656	NCP-9656	117-89R (9656)	Multiple	NC-P10	
10781	NCP-10781	123-89R (10781)	Multiple	NC-P11	
NORTHSHORE					
10703	**NSP-P1**	**Special Stormwater Retention/Detention Requirements**	**Replaced**	**SR-15-4**	**See Flow Control Application Map and CR#3: Flow Control**
10703	**NSP-P2**	**Seasonal Clearing Restrictions**	**Replaced**	**KCC-16.82.150D**	**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10703	**NSP-P3**	**Natural Resource Protection Area**	**Replaced**	**SO-200**	**Heron Habitat Protection Area SDO**
10703	**NSP-P4**	**Significant Vegetation Retention**	**Replaced**	**SO-220**	**Significant Tree SDO**
10703	NSP-P5	Pedestrian Circulation (Multifamily)	Repealed		Covered, KCC21A - Pedestrian Circulation Standards
10703	NSP-P6	Kingsgate Fireflow Requirements	Repealed		Covered, KCC21A.28.130
10703	NSP-P7	SR-522 Access Restriction	Repealed		Covered, KC Road Standards, 2.02
10703	NSP-P8	Kenmore and Woodinville Right-of-Way Dedication/Improvements	Multiple	NS-P1	
10703	NSP-P9	Neighborhood Collector Improvements	Repealed		Covered KC Road Standards 2.02 and 2.03
10703	NSP-P10	Pedestrian Oriented Area	Replaced	SO-050	Pedestrian-Oriented Commercial Development SDO
10703	NSP-P11	Office/Civic Core	Retained	NS-P2	
10703	NSP-P12	Pedestrian Linkages	Retained	NS-P3	
10703	NSP-P13	Office Only Requirements	Repealed		Current Zoning is O. Also covered, KCC21A.38.050.
10703	NSP-P14	Mixed-Use Pedestrian Oriented Area	Multiple	NS-P4	
10703	NSP-P15	Sammamish River Industrial Design Requirements	Repealed		Incorporated - Woodinville
10703	NSP-P16	Hollywood Neighborhood Center Design Requirements	Repealed		Incorporated - Woodinville
10703	NSP-P17	Sammamish River Valley Access Restrictions	Replaced	SO-120	Agricultural Production Buffer SDO
10703	NSP-P18	Agricultural Impact Areas	Repealed		Incorporated - Woodinville
10703	NSP-P19	Recreational Policy	Retained	NS-P22	

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ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE/ NOTES
10703	NSP-P20	Commercial Use Limitations - North Juanita Community Business Center	Retained	NS-P5	
10703	NSP-P21	STR 5-26-5: TL 9019	Retained	NS-P6	
10703	NSP-P22	STR 22-26-5: TL 9053, 9080, 9042, 9027: STR 27-26-5: TL 9002	Retaind	NS-P7	
10703	NSP-P23	STR 27-26-5: TL 9065, 9069	Retained	NS-P8	
10703	NSP-P24	STR 12-26-4: TL 416410-220 and 0215	Retained	NS-P9	
10703	NSP-P25	STR 11-26-4: TL 9001, 9137, 9020, 9016, 9165 STR 12-26-4: TL 416410-0310, 0305, 0300, 0295, 0290, 0285, 0275, 0270	Multiple	NS-P10	
10703	NSP-P26	STR 25-26-4: TL 607650-0101	Repealed		
10703	NSP-P27	STR 22-26-5: TL 9021	Retained	NS-P12	
10703	NSP-P28	STR 16-26-5	Repealed		Incorporated - Woodinville
10703	NSP-P29	STR 10-26-5	Repealed		Incorporated - Woodinville
10703	NSP-P30	STR 20-26-5	Retained	NS-P20	
10703	NSP-P31	STR 17-26-5	Repealed		All parcels now have O zoning.
10703	NSP-P32	Harbor Village Development and Marina	Multiple	NS-P13	
10703	NSP-P33	STR 7-26-5 Any Reclassification Application for Multifamily Development	Retained	NS-P14	
10703	NSP-P34	STR 26-26-5	Retained	NS-P15	
10703	NSP-P35	Potential Zone Requirements	Multiple	NS-P19	
11653-103	NSP-P36	Swamp Creek Rezone	Retained	NS-P16	
11653-133	NSP-P37	Parcel 618170-0160 (Greenup Property)	Retained	NS-P17	
12061-4-1E	NSP-P38	Goldstar 4 to 1	Retained	NS-P18	
RESOURCE LANDS					
8848	RLP-P1	Forest Wilderness and Snoqualmie Pass	Repealed		Multiple
SHORELINE					
2508	SLP-2508	126-75R (2508)	Repealed		KCC21A.16
2608	SLP-2608	135-75R (2608)	Multiple	SL-P11	
2677	SLP-2677	101-76R (2677)	Multiple	SL-P1	
2703	SLP-2703	149-75R (2703)	Repealed		Covered, KC Road Standards
2840	SLP-2840	118-76R (2840)	Multiple	SL-P2	
2940	SLP-2940	139-76R (2940)	Repealed		Covered, KCC16.04.052 and KCC21A.16.
3262	SLP-3262	109-77R (3262)	Repealed		Covered, KCC16.04.052
3496	SLP-3496	141-77R (3496)	Repealed		Covered, KC Road Standards
3561	SLP-3561	158-77R (3561)	Retained	SL-P3	
3905	SLP-3905	158-78R (3905)	Repealed		Covered, KCC21A.24.310
3988	SLP-3988	114-78R (3988)	Repealed		Multiple
4008	SLP-4008	180-78R (4008)	Multiple	SL-P5	
4043	SLP-4043	152-78R (4043)	Multiple	SL-P4	
4051	SLP-4051	182-78R (4051)	Repealed		Multiple
4053	SLP-4053	197-78R (4053)	Retained	SL-P6	
4289	SLP-4289	104-79R (4289)	Repealed		Multiple
4418	SLP-4418	125-79R (4418)	Repealed		Multiple
4706	SLP-4706	167-79R (4706)	Repealed		Multiple
5986	SLP-5986	115-82R (5986)	Repealed		Multiple
7008	SLP-7008	120-84R (7008)	Repealed		Multiple
8573	SLP-8573	105-87R (8573)	Repealed		Multiple
8361	SLP-8361	115-87R (8361)	Repealed		Multiple
8452	SLP-8452	102-88R (8452)	Repealed		Multiple
9476	SLP-9476	125-89R (9476)	Multiple	SL-P7	

ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE / NOTES
10194	SLP-10194	L90RZ022 (10194)	Multiple	SL-P8	
10419	SLP-10419	L91RZ005 (10419)	Repealed		Multiple
10813	SLP-10813	L92RZ002 (10813)	Multiple	SL-P9	
11025	SLP-11025	L93RZ003 (11025)	Multiple	SL-P10	
SNOQUALMIE VALLEY					
9118	SQP-P1	Historic Sites	Repealed		Covered, Landmarks Code 20.62
9118	**SQP-P2**	**Erosion Problem Areas**	**Replaced**	**SR-15-5**	**Landslide Hazard Drainage Area Requirements and Level 2 Flow Control (KCRTS) for Sensitive Slope Protection Areas (CR #3)**
9118	SQP-P3	Forest Practice Permits	Repealed		Covered, KCC16.82.140 (B)
9118	**SQP-P4**	**AR-5-P**	**Replaced**	**SO-230**	**Floodplain Density SDO**
9118	SQP-P5	Unincorporated Rural Activity Center: Fall City	Multiple	SV-P2	
		(part E.) As amended by Ordinance 12531 (12/15/96)	Multiple	SV-P3	
9118	SQP-P6	SE North Bend Way	Replaced	SO-170	Highway Oriented Development SDO
9118	SQP-P7	Stillwater	Multiple	SV-P11	
9118	SQP-P8	Preston	Multiple	SV-P12	
		(AR-10)	Multiple	SV-P13	
		(MP-P)	Multiple	SV-P15	
		(AR 2.5-P)	Repealed		Multiple
		(F-P)	Multiple	SV-P17	
9118	SQP-P9	Weyerhaeuser Mill	Multiple	SV-P18	
11653-95A	SQP-P10	Preston Industrial Park	Retained	SV-P19	
		(part 1. Preston Village)	Retained	SV-P20	
		(part 2. Preston Mill)	Retained	SV-P21	
11653-116	SQP-P11	Tax Lots 032407-9026-03, 902801, 902900, 0424-07, 9015-05, 9017-03, 9018-02, 9020-08, 9025-03, 092407-9001-06	Repealed		Multiple
11653-87	SQP-P12	Parcels 13, 27, 33, 35, 36, 37 Located in Section 18, Township 23, Range 9	Retained	SV-P23	
11653-90	SQP-P13	Tax Lot 062607-9032-00, located in Section 6, Township 26, Range 7E	Retained	SV-P24	
4004	SQP-4004	115-77R (4004)	Multiple	SV-P34	
5664	SQP-5664	157-80R (5664)	Multiple	SV-P26	
5744	SQP-5744	112-79R (5744)	Multiple	SV-P25	
6916	SQP-6916	108-84R (6916)	Multiple	SV-P28	
6993	SQP-6993	120-82R (6993)	Multiple	SV-P27	
7207	SQP-7207	102-85R (7207)	Repealed		Condition Met
7694	SQP-7694	130-85R (7694)	Multiple	SV-P30	
7831	SQP-7831	109-85R (7831)	Multiple	SV-P29	
8307	SQP-8307	122-86R (8307)	Multiple	SV-P31	
10668	SQP-10668	L91RZ003 (10668)	Multiple	SV-P32	
11774	SQP-11774	L93RZ008 (11774)	Multiple	SV-P33	
SOOS CREEK					
10197	**SCP-P1**	**Soos Creek Basin Streams**	**Replaced**	**SO-210**	**Urban Stream Protection Area SDO**
		(A.3)	**Replaced**	**SR-15-6**	**See Flow Control Application Map and CR#3: Flow Control**
10197	**SCP-P2**	**Soos Creek Basin Lot Coverage**	**Replaced**	**SO-210**	**Urban Stream Protection Area SDO**
10197	**SCP-P3**	**Clearing and Grading**	**Replaced**	**SC-P3**	**See Reference Section 2-A**

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ORDS#	PRE-CON P#	DESCRIPTION	ACTION	NEW REG#	REPEAL RATIONALE/ NOTES
10197	**SCP-P4**	**Seasonal Clearing Restrictions**	**Replaced**	**KCC-16.82.150D**	**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10197	**SCP-P5**	**Vegetation Coverage**	**Replaced**	**KCC-16.82.150C**	**KCC16.82.150 (C) covers vegetation retention requirements (see Reference Section 2-A).**
10197	**SCP-P7**	**Significant Tree Retention**	**Replaced**	**SO-220**	**Significant Tree SDO**
10197	SCP-P14	Historic Preservation	Repealed		Covered, Landmarks Code 20.62
10197	SCP-P15	Urban Separators	Repealed		KCC21A.12.030 and KCC21A.04.080 amended with this package to address this issue
10197	**SCP-P16**	**Phase 1 Lake Desire**	**Replaced**	**SR-15-7**	**Sensitive Lake WQ Treat. Standard (CR #8); Level 3 Flow Control Standard (KCRTS, CR #3)**
10197	SCP-P17	Phase 2 Clustering	Repealed		Inconsistent with KCCP
10197	SCP-P18	Covington Urban Activity Center	Retained	SC-P1	
10197	SCP-P20	Crest Airpark Covenant	Replaced	SO-150	Aviation Facilities SDO
10197	SCP-P21	Meridian Valley Center	Replaced	SR-15-8	
11653-55	SCP-P22	Seattle International Raceway (SIR)	Retained	SC-P2	
10197	**SCP-P23**	**Green River/Cedar River Valleys**	**Replaced**	**SR-15-9**	**Landslide Hazard Drainage Area Requirements. Also addressed in KCC21A.24.280**
10197	SCP-P24	Lotto/Toppano/Ranninger Rezone	Multiple	SC-P4	
10197	SCP-P25	Sandifer Rezone	Repealed		Incorporated – Renton
10197	SCP-P26	Northwest Lead Products	Repealed		Zoning changed to RA-5 during conversion to KCC 21A.
10197	SCP-P27	West Coast Auto Storage	Repealed		Zoning changed to RA-5 during conversion to KCC21A.
10197	SCP-P28	Kofal Rezone	Retained	SC-P7	
11653-105	SCP-P29	Glacier Ridge	Retained	SC-P8	
10197	SCP-P30	Pasko Plan Amendment	Multiple	SC-P9	
10197	**SCP-P31**	**Covington Master Drainage Plan**	**Replaced**	**SO-160**	**Urban Aquifer Protection Area SDO**
11653-56A	**SCP-P32**	**Covington Master Drainage - TL9111 etc.**	**Repealed**		**All property located within Covington MDP area.**
11653-57A	**SCP-P33**	**Covington Master Drainage - TL 259 etc.**	**Repealed**		**All property located within Covington MDP area.**
12061-4-1D	SCP-P34	Spring Lake 4 to 1	Retained	SC-P10	
11651	SCP-P35	Soos Creek Area Zoning Amendment Study - Covington	Retained	SC-P18	
12531	SCP-P36	Aqua Barn	Retained	SC-P19	
4767	SCP-4767	289-79R (4767)	Multiple	SC-P11	
4978	SCP-4978	224-80R (4978)	Multiple	SC-P12	
6618	SCP-6618	243-83R (6618)	Multiple	SC-P14	
7115	SCP-7115	201-85R (7115)	Multiple	SC-P16	
7583	SCP-7583	204-84R (7583)	Multiple	SC-P15	
10970	SCP-10970	L92RZ009 (10970)	Multiple	SC-P17	
TAHOMA/RAVEN HEIGHTS					
10200	**TRH-P1**	**Clearing and Grading**	**Retained**	**TR-P44**	**See Reference Section 2-A**

AR 032282

ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE/ NOTES
10200	**TRH-P2**	**Seasonal Clearing Restrictions**	**Replaced**	**KCC-16.82.150D**	**KCC16.82.150 (D) covers Seasonal Clearing requirements (see Reference Section 2-A).**
10200	**TRH-P3**	**Vegetation Coverage**	**Replaced**	**KCC-16.82.150C**	**KCC16.82.150 (D) covers vegetation retention requirements (see Reference Section 2-A).**
10200	TRH-P4	Wilderness Village Property Group One	Multiple	TR-P20	
10200	TRH-P5	Wilderness Village Property Group Three	Multiple	TR-P1	Wilderness Village Property Group Three: CB-P
		(SR7200-P)	Multiple	TR-P2	Wilderness Village Property Group Three: R-12-P
		(RM900-P)	Multiple	TR-P3	Wilderness Village Property Group Three: O-P
		(RM2400-P)	Multiple	TR-P4	Wilderness Village Property Group Three: R-18-P
		(SR7200-P)	Multiple	TR-P5	Wilderness Village Property Group Three: R-12-P
10200	TRH-P6	Wilderness Village Property Group Four	Multiple	TR-P6	Wilderness Village Property Group Four: Right-of-Way Dedication
		(RM900-P)	Multiple	TR-P7	Wilderness Village Property Group Four: O-P and R48-P
10200	TRH-P7	Four Corners	Multiple	TR-P8	
10200	TRH-P8	Ravensdale	Multiple	TR-P9	
10200	TRH-P9	Lake Sawyer	Repealed		Multiple
10200	TRH-P10	Urban/Suburban Residential Areas	Repealed		Area now rural by '95 KCCP.
10200	TRH-P11	Historic Sites	Repealed		Covered, Landmarks Code 20.62
10200	TRH-P12	S-R-7200-P	Retained	TR-P11	
10200	TRH-P13	B-C-P, Community Business	Retained	TR-P12	
10200	TRH-P14	RM-900-P, Maximum Density, Multiple Dwelling	Retained	TR-P13	
12061-T6B	TRH-P15	Spoerer/Watkins	Retained	TR-P14	
11653-105	TRH-P16	Matelich Rezone	Retained	TR-P15	
10200	TRH-P18	Wilderness Village Property Group Two	Retained	TR-P16	
12061-72	TRH-P19	R & H Partnership Urban Reserve Study	Retained	TR-P17	
12061-4-1G	TRH-P21	Plum Creek 4 to 1	Retained	TR-P19	
11694	TRH-P22	Maple Valley Center	Multiple	TR-P42	
12533	TRH-P24	Black Diamond	Retained	TR-P43	
3494	TRH-3494	239-77R (3494)	Multiple	TR-P21	
4082	TRH-4082	294-78R (4082)	Repealed		Covered, KCC16.04.052
4764	TRH-4764	284-79R (4764)	Multiple	TR-P22	
5087	TRH-5087	234-80R (5087)	Repealed		Covered, KCC16.04
5689	TRH-5689	229-81R (5689)	Multiple	TR-P23	
5765	TRH-5765	260-81R (5765)	Multiple	TR-P24	
6698	TRH-6698	202-84R (6698)	Multiple	TR-P25	
7382	TRH-7382	226-85R (7382)	Multiple	TR-P26	
7677	TRH-7677	207-86R (7677)	Repealed		Multiple
7705	TRH-7705	214-86R (7705)	Multiple	TR-P30	
7757	TRH-7757	215-86R (7757)	Multiple	TR-P31	
7758	TRH-7758	205-86R (7758)	Multiple	TR-P28	

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ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE/ NOTES
7944	TRH-7944	202-82R (7944)	Repealed		Covered, KCC21A.28.040
8427	TRH-8427	203-88R (8427)	Retained	TR-P33	
8603	TRH-8603	220-88R (8603)	Multiple	TR-P35	
8733	TRH-8733	218-88R (8733)	Multiple	TR-P34	
8865	TRH-8865	124-88R (8865)	Multiple	TR-P32	
9030	TRH-9030	210-89R (9030)	Multiple	TR-P45	
9295	TRH-9295	218-89R (9295)	Multiple	TR-P37	
9622	TRH-9622	214-89R (9622)	Multiple	TR-P36	
9991	TRH-9991	L90RZ002 (9991)	Multiple	TR-P38	
10287	TRH-10287	202-86R (10287)	Multiple	TR-P27	
11349	TRH-11349	L93RZ001 (11349)	Multiple	TR-P40	
11898	TRH-11898	L94RZ001 (11898)	Multiple	TR-P41	
VASHON					
7837	VIP-P1	Islandwide Commercial/ Industrial	Repealed		Covered, KCC21A.28.020 and .030
7837	**VIP-P2**	**High Recharge Area**	**Replaced**	**SO-140**	**Sole Source Aquifer SDO**
7837	VIP-P3	Historic Sites	Repealed		Covered, Landmarks Code 20.62
7837	VIP-P4	BR-N-P, Residential Density Limit	Repealed		Covered, KCC21A.28.030
7837	VIP-P5	Rezones to BR-C-P	Repealed		Multiple
7837	VIP-P6	W29-23-3: Maximum Density in RM 900-P is 12 DU/Acre	Retained	VS-P1	
7837	VIP-P7	W5-22-3: MP-P (99 Ave. SW and SW 192nd St.)	Multiple	VS-P2	
7837	VIP-P8	E18-22-3: RS-15,000 to BN-P - Use Limited to Fire Station	Retained	VS-P3	
7837	VIP-P9	W19-22-3: RS-15000-P - Max. Number of Units is 87	Repealed		Covered, KCC21A.12.030
7837	VIP-P10	E19-22-3: RS-15,000-P to BC-P - Use Limited to Guest Inn/ Restaurant	Retained	VS-P4	
7837	VIP-P11	W13-22-2: G-P to AR-5-P	Retained	VS-P5	
12061-11z	VIP-P12	Parcel Number 292303-9127	Retained	VS-P6	
12395	VIP-P13	Vashon Town Plan - Setback Limitations	Retained	VS-P19	
12395	VIP-P14	Vashon Town Plan - Access and Landscaping Requirements	Retained	VS-P20	
12395	VIP-P15	Vashon Town Plan - Access and Use Restrictions	Retained	VS-P21	
12395	VIP-P16	Vashon Town Plan - Access and Density Limits	Retained	VS-P22	
12395	VIP-P17	Vashon Town Plan - Use and Parking Restrictions	Retained	VS-P23	
12395	VIP-P18	Vashon Town Plan - Use Limits	Retained	VS-P24	
12395	VIP-P19	Vashon Town Plan - Access Restrictions	Retained	VS-P25	
12395	VIP-P20	Vashon Town Plan - Town Gateway	Retained	VS-P26	
12395	VIP-P21	Vashon Town Plan - Town Gateway landscaping Requirement	Retained	VS-P27	
12395	VIP-P22	Vashon Town Plan - Town Core	Retained	VS-P28	
12395	VIP-P23	Vashon Town Plan - Restricted Uses for CB Zoned Properties	Retained	VS-P29	
12395	VIP-P24	Vashon Town Plan - Restricted Uses for I Zoned Properties	Retained	VS-P30	
1483	VIP-1483	209-72P (1483)	Repealed		Time Limited Condition
2884	VIP-2884	134-76R (2884)	Multiple	VS-P7	
3360	VIP-3360	129-77R (3360)	Repealed		Multiple
4137	VIP-4137	107-78R (4137)	Repealed		Condition Met
4290	VIP-4290	101-79R (4290)	Multiple	VS-P9	
4888	VIP-4888	150-79R (4888)	Repealed		Multiple
4890	VIP-4890	115-80R (4890)	Multiple	VS-P10	

ORD. #	PRE-CON P#	DESCRIPTION	ACTION	NEW REG #	REPEAL RATIONALE/ NOTES
4970	VIP-4970	164-79R (4970)	Repealed		Multiple
5242	VIP-5242	158-80R (5242)	Multiple	VS-P12	
5353	VIP-5353	169-77R (5353)	Multiple	VS-P8	
5984	VIP-5984	103-80R (5984)	Multiple	VS-P11	
6832	VIP-6832	151-79R (6832)	Repealed		Multiple
6885	VIP-6885	111-84R (6885)	Multiple	VS-P13	
7396	VIP-7396	116-85R (7396)	Repealed		Multiple
8571	VIP-8571	219-88R (8571)	Multiple	VS-P14	
9823	VIP-9823	105-89R (9823)	Multiple	VS-P15	
70598	VIP-10598	L90RZ027 (10598)	Multiple	VS-P16	
11024	VIP-11024	L91RZ006 (11024)	Multiple	VS-P18	
11389	VIP-11389	L90RZ028 (11389)	Multiple	VS-P17	
WEST HILL					
11166	WHP-P1	Street Design	Repealed		Covered, KC Road Standards 2.08
11166	WHP-P2	Common Tracts	Repealed		KCC21A.14.080 amended with this package to address this issue
11166	WHP-P3	Panorama View Clustered Development	Replaced	SO-130	Residential Infill SDO
11166	WHP-P4	Other Conditions	Retained	WH-P4	
11166	WHP-P5	Commercial, Industrial, and Multifamily Residential Areas: Building Arrangements	Repealed		Covered, KCC21A.14.180
11166	WHP-P6	Special District Overlay Provisions	Repealed		Office/Research Park SDO has been applied.
WHITE CENTER					
11568	WCP-P1	16th Ave SW - Pedestrian Commercial Subarea	Replaced	SO-090	KCC21A.38.090 – Economic Redevelopment SDO
11568	WCP-P2	16th Ave SW - Commercial/Industrial Subarea	Replaced	SO-100	KCC21A.38.100 – Commercial/Industrial SDO
11568	WCP-P3	Industrial	Replaced	SO-090	KCC21A.38.090 – Economic Redevelopment SDO
11568	WCP-P4	Old Puget Sound Junior High School	Retained	WC-P1	

AR 032285

GROUND WATER PROTECTION

Special District Overlay, SO-140

(Effective c. August 18. 1997)

Condition Text

A. The purpose of the ground water protection special district overlay is to limit land uses that have the potential to severely contaminate groundwater supplies and to provide increased areas of permeable surface to allow for infiltration of surface water into groundwater resources.

B. For all commercial and industrial development proposals, at least 40 percent of the site shall remain in natural vegetation or planted with landscaping, which area shall be used to maintain predevelopment infiltration rates for the entire site. For purposes of the special district overlay, the following shall be considered commercial and industrial land uses:

1. amusement/entertainment land uses as defined by K.C.C. 21A.08.040 except golf facilities;
2. general services land uses as defined by K.C.C. 21A.08.050 except health and educational services, daycare 1, churches, synagogues, and temples;
3. government/business services land uses as defined by K.C.C. 21A.08.060 except government services;
4. retail/wholesale land uses as defined by K.C.C. 21A.08.070 except forest product sales and agricultural product sales;
5. manufacturing uses as defined by K.C.C. 21A.08.080; and
6. mineral extraction and processing land uses as defined by K.C.C.. 21A.08.090.

C. Permitted uses within the area of the ground water protection special district overlay shall be those permitted in the underlying zone, excluding the following as defined by Standard Industrial Classification number and type:

1. SIC 4581, airports, flying fields, and airport terminal services;
2. SIC 4953, refuse systems, (including landfills and garbage transfer stations operated by a public agency);
3. SIC 4952, sewerage systems (including wastewater treatment facilities);
4. SIC 7996, amusement parks; SIC 7948, racing, including track operation; or other commercial establishments or enterprises involving large assemblages of people or automobiles except where excluded by Section B above;
5. SIC 0752, animal boarding and kennel services.
6. SIC 1721, building painting services;
7. SIC 3260, pottery and related products manufacturing;
8. SIC 3599, machine shop services;
9. SIC 3732, boat building and repairing;
10. SIC 3993, electric and neon sign manufacturing;
11. SIC 4226, automobile storage services;
12. SIC 7334, blueprinting and photocopying services;

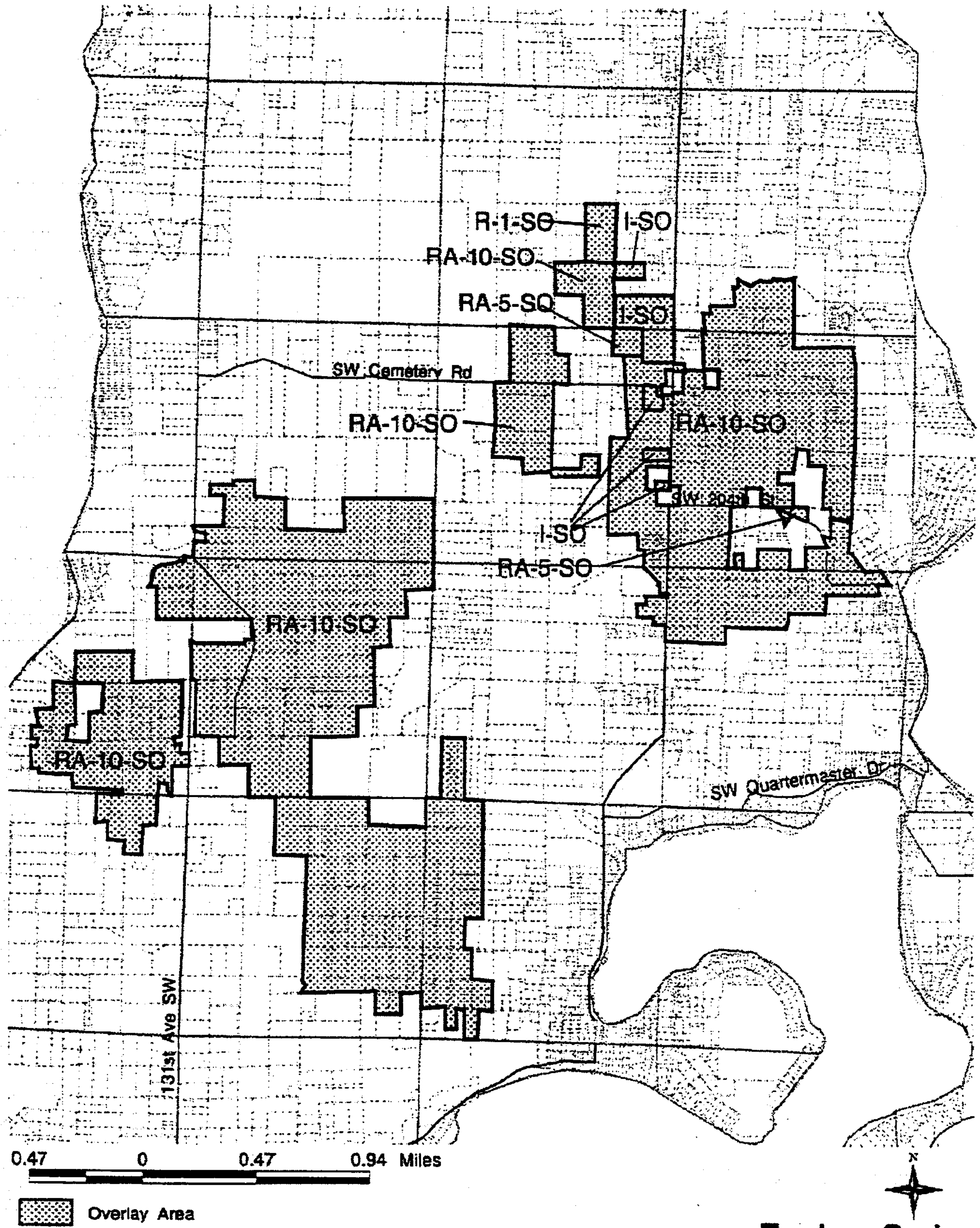
AR 032286

13. SIC 7534, tire retreading and repair services;
14. SIC 7542, carwashes;
15. SIC 8731, commercial, physical and biological research laboratory services;
16. SIC 02, interim agricultural crop production and livestock quarters or grazing on properties 5 acres or larger in size, within I zoned lands;
17. SIC 0752, public agency animal control facility;
18. SIC 2230, 2260, textile dyeing;
19. SIC 2269, 2299, textile and textile goods finishing;
20. SIC 2700, printing and publishing industries;
21. SIC 2834, pharmaceuticals manufacturing;
22. SIC 2844, cosmetics, perfumes and toiletries manufacturing;
23. SIC 2893, printing ink manufacturing;
24. SIC 3000, rubber products fabrication;
25. SIC 3111, leather tanning and finishing;
26. SIC 3400, metal products manufacturing and fabrication;
27. SIC 3471, metal electroplating;
28. SIC 3691, 3692, battery rebuilding and manufacturing;
29. SIC 3711, automobile manufacturing; and
30. SIC 4600, petroleum pipeline operations.

Ordinance
12823

Effective Date
August 18, 1997

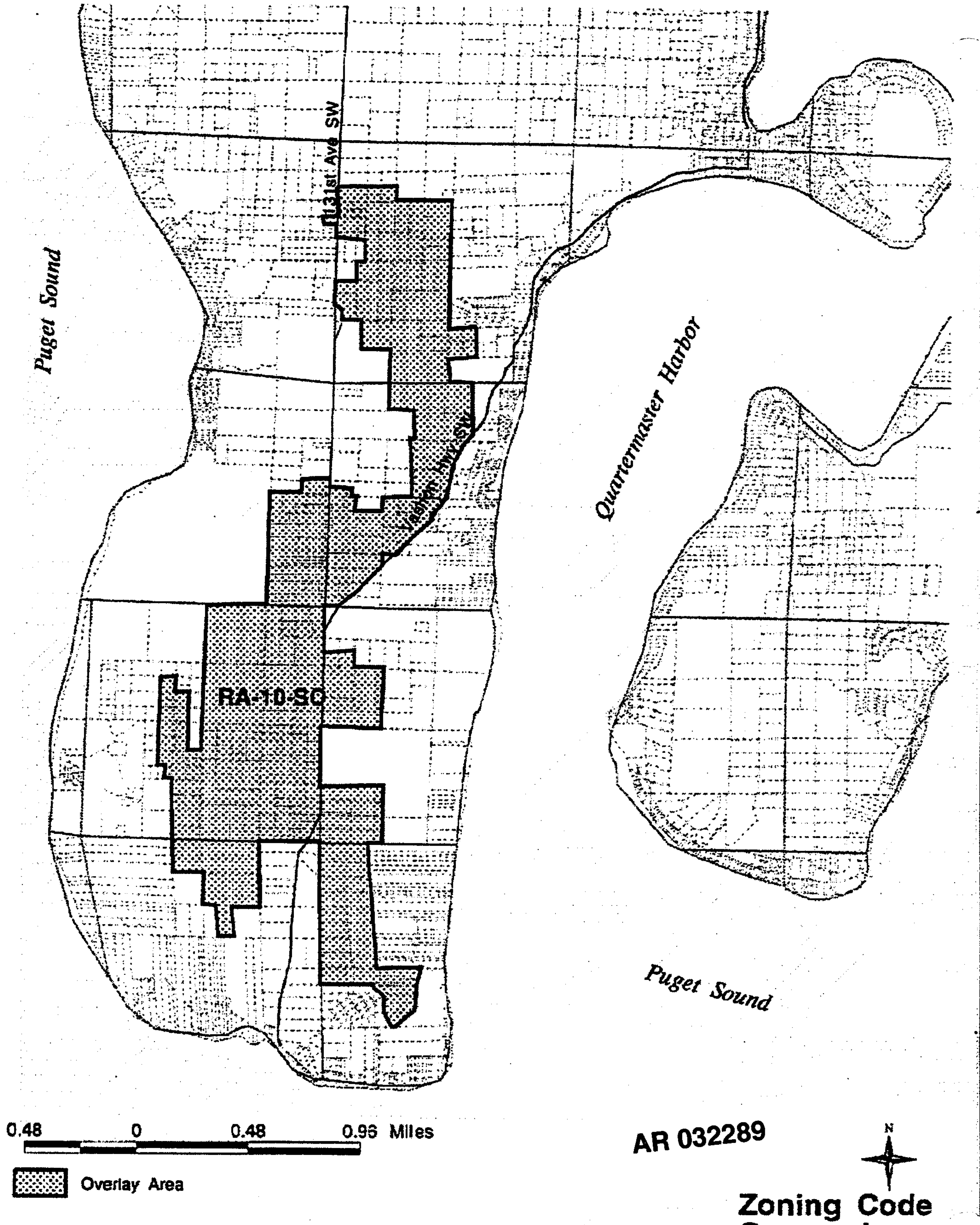
AR 032287



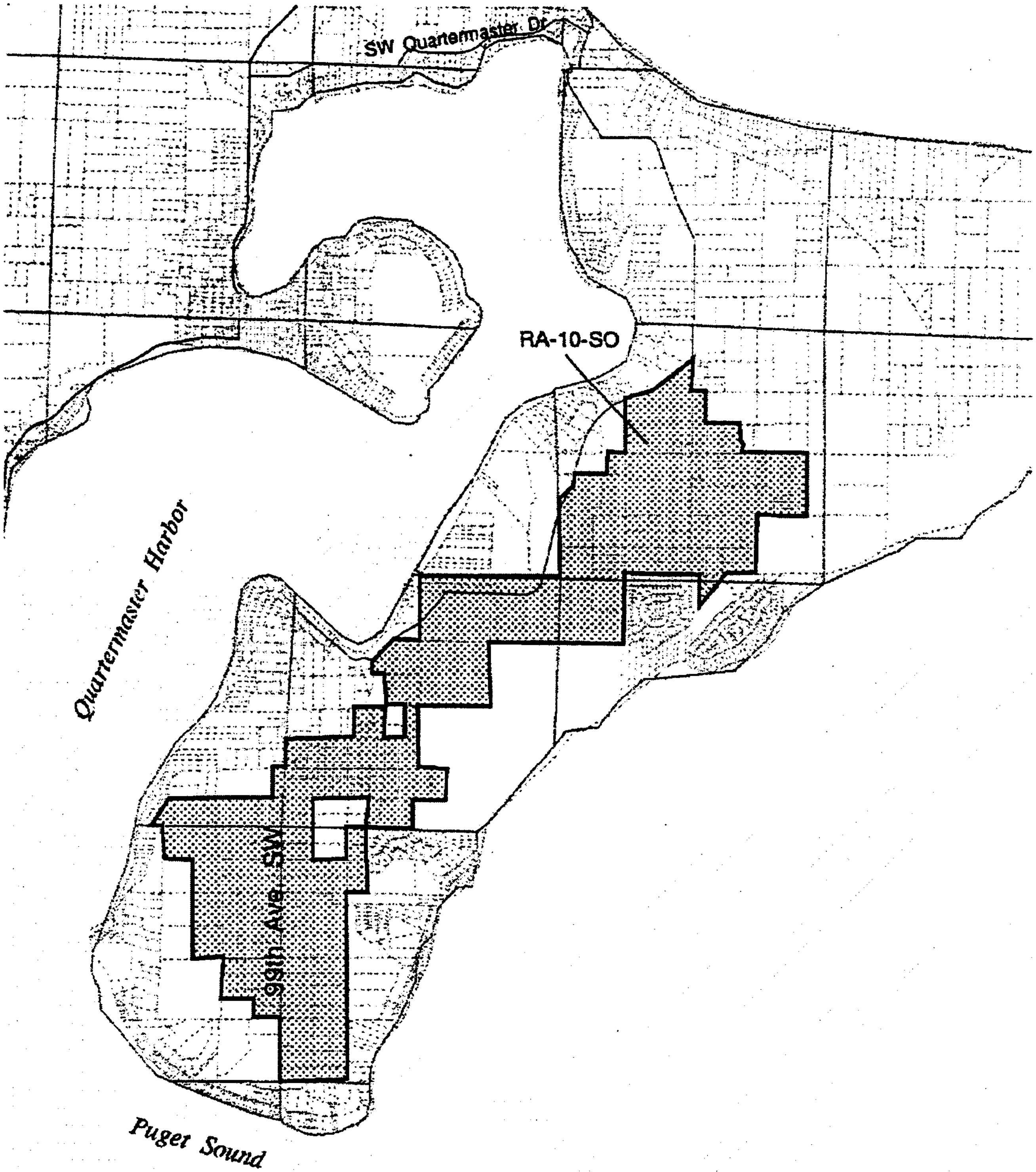
Sole Source Aquifer Special District Overlay 1/4
Vashon Island Community Planning Area

Zoning Code Conversion Phase Two

AR 032288



Sole Source Aquifer Special District Overlay 2/4
Vashon Island Community Planning Area



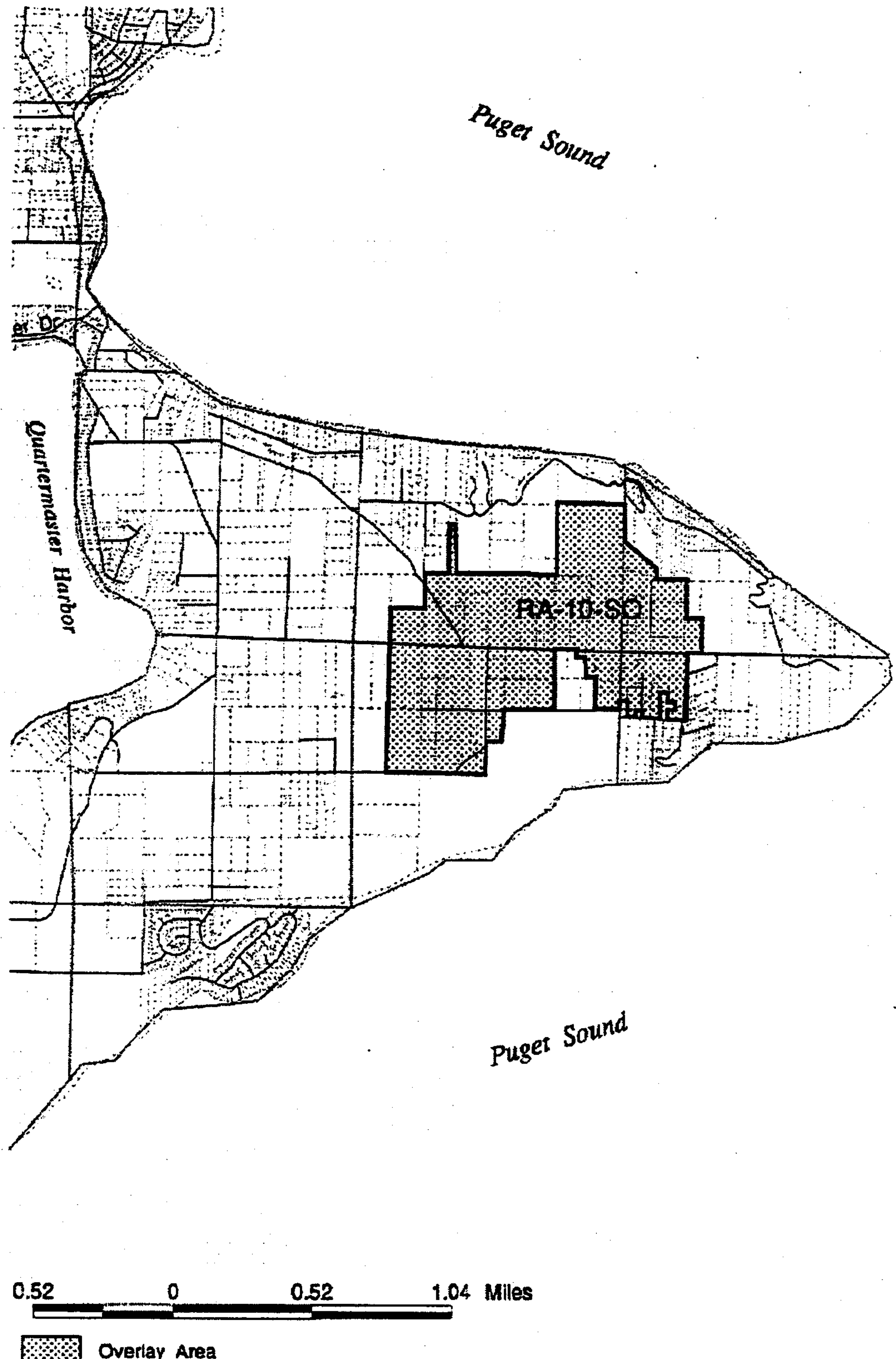
0.47 0 0.47 0.94 Miles

Overlay Area

N

Sole Source Aquifer Special District Overlay 3/4
Vashon Island Community Planning Area

Zoning Code Conversion Phase Two



Sole Source Aquifer Special District Overlay 4/4
Vashon Island Community Planning Area

Zoning Code Conversion Phase Two

AR 032291

URBAN AQUIFER PROTECTION

Special District Overlay, SO-160

(Effective c. August 18. 1997)

Condition Text

A. The purpose of the urban aquifer protection area special district overlay is to provide additional protection for urban areas that are highly susceptible to ground water contamination. An urban aquifer protection area special district overlay shall only be established within areas designated in the comprehensive plan as highly susceptible to ground water contamination, including the surrounding area up to 1/2 mile, and zoned UR, R, NB, CB, O, and I.

B. Permitted uses shall be those permitted in the underlying zone, excluding the following as defined by Standard Industrial Classification (SIC) number and type:

1. SIC 4953, refuse systems (including hazardous waste recycling or treatment and solid waste landfills);

2. SIC 461, pipelines, except natural gas (including petroleum pipelines); and

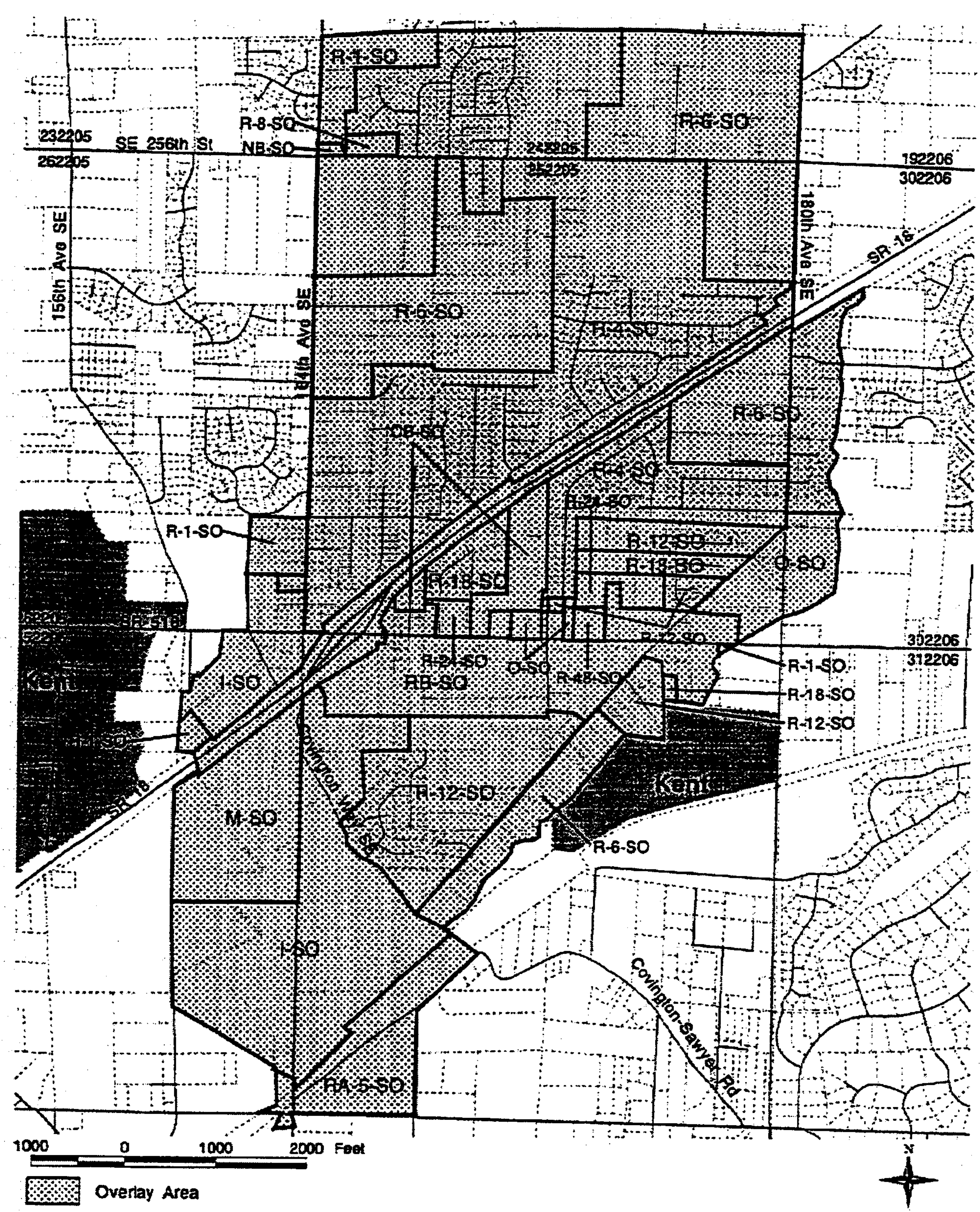
3. businesses maintaining open storage of toxic substances.

C. New septic tank drainfield systems shall be prohibited.

Ordinance
12823

Effective Date
August 18, 1997

AR 032292



Urban Aquifer Protection Area Special District Overlay
Soos Creek Community Planning Area

Zoning Code Conversion Phase Two

AR 032293

WETLAND MANAGEMENT AREAS

Special District Overlay, SO-180

(Effective c. August 18. 1997)

Condition Text

A. The purpose of the wetland management area special overlay district is to provide a means to designate certain unique and outstanding wetlands when necessary to protect their functions and values from the impacts created from geographic and hydrologic isolation and impervious surface.

B. The following development standards shall be applied in addition to all applicable requirements of K.C.C. 21A.24 to development proposals located within a wetland management area district overlay:

1. All subdivisions and short subdivisions in R-1 and RA zones shall have a maximum impervious surface area of 8 percent of the gross acreage of the plat. Distribution of the allowable impervious area among the platted lots shall be recorded on the face of the plat. Impervious surface of existing roads need not be counted towards the allowable impervious area. This condition may be modified by the director for the minimum necessary to accommodate unusual site access conditions;

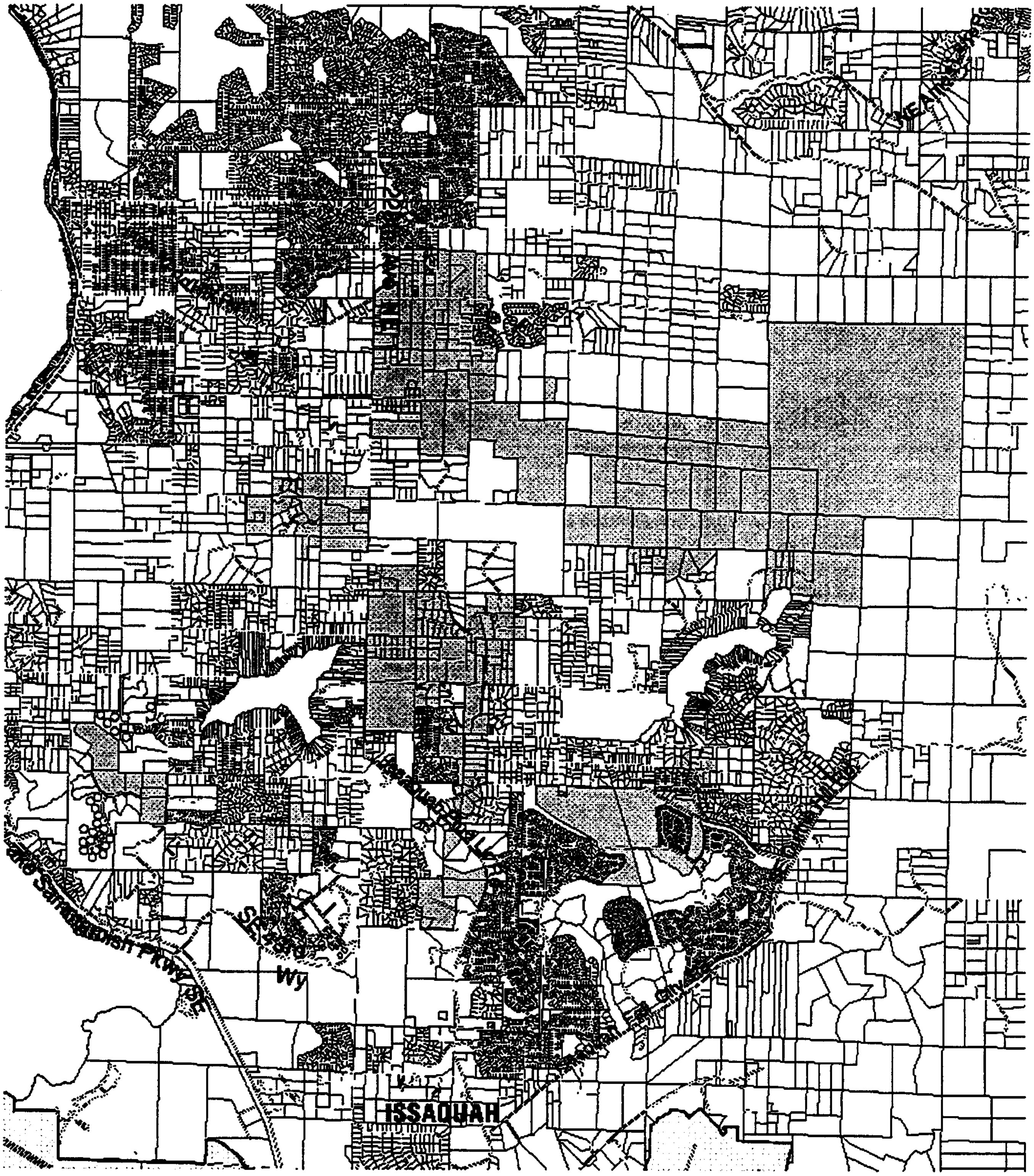
2. All subdivisions and short subdivisions shall be required to cluster away from wetlands or the axis of corridors along stream tributaries and identified swales connecting wetlands in order to minimize land disturbance and maximize distance from these sensitive features. At least 50 percent of the R-1 zoned portions of the site and at least 65% of the RA-zoned portions of the site shall be left in native vegetation, preferably forest, and placed in a permanent open space tract; and

3. Clearing and grading activity from October 1 through March 31 shall meet the provisions of K.C.C. 16.82.150D wherever not already applicable.

Ordinance
12823

Effective Date
August 18, 1997

AR 032294



Executive Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-180. Wetland Management Areas

0.5 0 0.5 1 Miles

N

Special District Overlay

City Area

AR 032295

Zoning Code Conversion Phase Two

Special District Overlay

EROSION HAZARDS NEAR SENSITIVE WATER BODIES.

Special District Overlay, SO-190

(Effective c. August 18. 1997)

Condition Text

A. The purpose of the erosion hazards near sensitive water bodies special overlay district is to provide a means to designate sloped areas posing erosion hazards which drain directly to lakes or streams of high resource value which are particularly sensitive to the impacts of increased erosion and the resulting sediment loads from development.

B. The following development standards shall be applied in addition to all applicable requirements of K.C.C. 21A.24 to development proposals located within erosion hazards near a sensitive water bodies district overlay:

1. A no-disturbance area shall be established on the sloped portion of the special district overlay to prevent damage from erosion. Land clearing or development shall not occur in the no-disturbance area, except for the clearing activities listed in subsection a. Clearing activities listed in subsection a shall only be permitted if they meet the requirements of subsection b.

   a. Clearing activities may be permitted as follows:

      i. for the construction of single family residences on pre-existing separate lots;

      ii. for the construction of utility corridors to service existing development along existing rights-of-way including any vacated portions of otherwise contiguous rights-of-way;

      iii. for the construction of roads providing sole access to buildable property and associated utility facilities within those roadways; or

      iv. for the construction of development within an isolated no-disturbance area of two acres or less in size. The isolated no-disturbance area is either geologically separated from other no-disturbance areas or lies completely within a separate drainage subbasin and is, therefore, hydrologically isolated from the rest of the no-disturbance area.

   b. The clearing activities listed in subsection a may be permitted only if the following requirements are met:

      i. a report which meets the requirements of K.C.C. 21A.24. 120 shall show that the clearing activities will not subject the area to risk of landslide or erosion and that the purpose of the no disturbance area is not compromised in any way;

      ii. the clearing activities shall be mitigated, monitored and bonded consistent with the mitigation requirements applicable to sensitive areas regulated in K.C.C. 21A.24;

      iii. the clearing activities are limited to the minimal area and duration necessary for construction; and

      iv. the clearing activities are consistent with K.C.C. 21A.24;

2. The upslope boundary of the no-disturbance area lies at the first obvious break in slope from the upland plateau over onto the steep valley walls. The downslope boundary of this zone includes those areas designated as erosion or landslide hazard areas pursuant to K.C.C. 21A.24.220 and 21A.24.280. The sensitive areas folio indicates the general location of these hazard areas, but it cannot be used to specify the areas' precise boundaries. Maps of the approximate boundaries of these no-disturbance zones shall be available at the department. Single family or multi-family residential density from the no-disturbance area may be reallocated onto any buildable portion of the site pursuant to K.C.C. 21A.12.080, or transferred to other sites pursuant to K.C.C. 21A.36;

AR 032296

3. New development proposals for sites which drained predeveloped runoff to the no-disturbance zone shall evaluate the suitability of onsite soils for infiltration. All runoff from newly constructed impervious surfaces shall be retained on-site unless this requirement precludes the ability to meet minimum density requirements in K.C.C. 21A.12. When minimum density cannot be met, runoff shall be retained on-site as follows:

   a. Infiltration of all site runoff shall be required in granular soils as defined in the King County Surface Water Design Manual.

   b. Infiltration of downspouts shall be required in granular soils and in soil conditions defined as allowable in the Surface Water Design Manual when feasible to fit the required trench lengths onsite;

   c. When infiltration of downspouts is not feasible, downspout dispersion trenches shall be required when minimum flow paths defined in the Surface Water Design Manual can be met onsite or into adjacent open space; and

   d. When dispersion of downspouts is not feasible, downspouts shall be connected to the drainage system via perforated pipe.

4. For the portions of proposed subdivisions, short subdivisions and binding site plans that cannot infiltrate runoff up to the 100-year peak flow, at least 25 percent shall remain undisturbed and set aside in an open space tract consistent with K.C.C. 21A.24.150-180; and

5. For the portions of all development proposals that cannot infiltrate runoff up to the 100-year peak flow, no more than 35 percent of the gross site area shall be covered by impervious surfaces. For new subdivisions and short subdivisions, maximum lot coverage should be specified for subsequent residential building permits on individual lots.

6. If the application of this section would deny all reasonable use of property, the applicant may apply for a reasonable use exception pursuant to K.C.C. 21A.24.070B.

7. The director may modify the property specific development standards required by B.1 through B.5 of this section, when a development proposal complies with the following:

   a. The proposed development is subject to public/private partnerships such as an approved community block grant or other such water quality program designed to improve water quality in the basin,

   b. The proposed development is designated by King County, in consultation with the Lake Sammamish Management Committee, as a demonstration project designed to implement best management practices and state of the art technology that assures the greatest possible improvement to water quality, and

   c. A site specific study is conducted by the applicant and approved by the director, which demonstrates that the proposed development substantially increases water quality by showing the following:

      (1) water quality on-site is improved;

      (2) the development project will not subject downstream channels to increased risk of landslide or erosion;

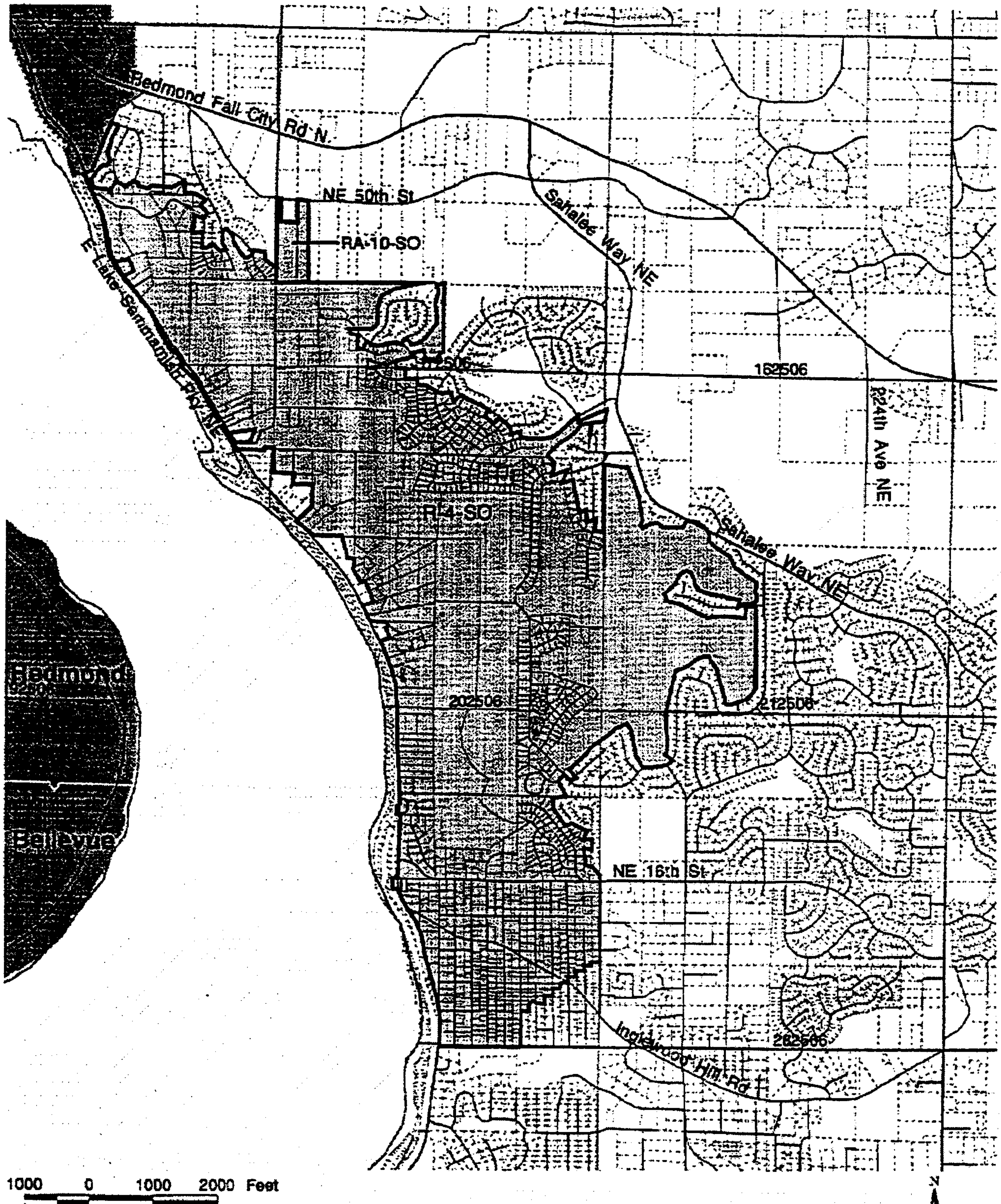
      (3) the development project will not subject the nearest sensitive water body to additional erosion hazards; and

      (4) the project is consistent with element a. and b. above, and provides predictable improvements to the water quality of Lake Sammamish.

Ordinance
12823

Effective Date
August 18, 1997

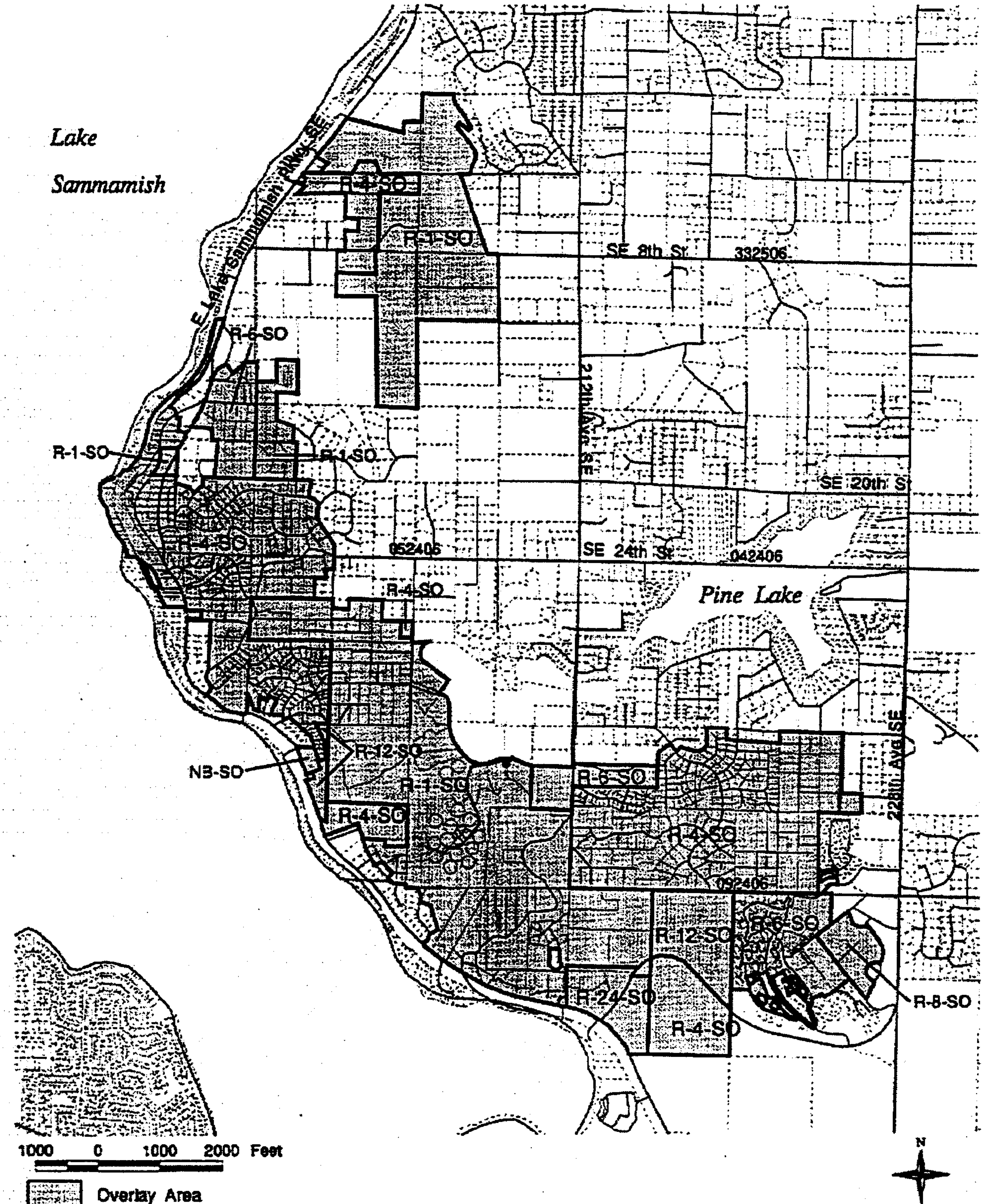
AR 032297



Erosion Hazards Near Sensitive Water Bodies
Special District Overlay 1/2
East Sammamish Community Planning Area

Zoning Code Conversion Phase Two

AR 032298



Erosion Hazards Near Sensitive Water Bodies
Special District Overlay 2/2
East Sammamish Community Planning Area

Zoning Code Conversion Phase Two

AR 032299

HERON HABITAT PROTECTION AREA

Special District Overlay, SO-200

(Effective c. August 18. 1997)

Condition Text

A. The purpose of the heron habitat protection area special district overlay is to provide a means to designate areas that provide essential feeding, nesting and roosting habitat for identified great blue heron rookeries. A district overlay will usually contain several isolated areas of known heron habitat in the general region surrounding the heron rookery.

B. The following development standards shall be applied in addition to all applicable requirements of K.C.C. 21A.24 and Title 25 to development proposals located within a heron habitat protection area district overlay:

1. The following conditions shall apply to the wetland or along the main channel of the stream riparian zone containing the heron rookery (tributary streams are excluded):

   a. The 100-year floodplain shall be left undisturbed. Development proposals on individual lots shall require the 100-year floodplain to retain the native vegetation and be placed in a county-approved conservation easement or notice shall be placed on the title of the lot. The notice shall be approved by King County and filed with the records and elections division. The notice shall inform the public of the presence and location of the floodplain and heron habitat on the property and that limitations on actions in or affecting the area exist. Subdivisions, short subdivisions and binding site plans shall require the 100-year floodplain to retain the native vegetation and be placed in a sensitive areas tract, to be dedicated to the homeowner's association or other legal entity which assumes maintenance and protection of the tract. Determination of the floodplain shall be done for each permit application based on actual field survey using county-approved floodplain elevations;

   b. There shall be a 660 foot radius buffer maintained around the periphery of the great blue heron rookery. If the sensitive areas and buffers are not adequate to provide the radius, then the buffer shall be expanded to meet the requirement. A rookery and its buffer shall be designated as sensitive area tract, easement or noticed on title as required in this subsection; and

   c. All access shall be restricted under nest trees from February 15 to July 31 and noted on signage at the floodplain or buffer edge, whichever is further from the rookery. Access may be further restricted with fencing or dense plantings with native plant material approved by the county. All developments in R-12 or higher density zones shall restrict access and provide an interpretive sign that provides information about the stream or wetland and its wildlife, biological, and hydrological functions. All signs shall be consistent with sensitive area signage requirements and subject to review and approval of the county;

2. Subdivisions, short subdivisions, binding site plans, site development permits or other commercial or multifamily permits adjacent to stream reaches and wetlands designated on the heron habitat protection area district overlay map, shall provide buffers that are 50 feet greater that required pursuant to K.C.C. 21A.24 along those streams and wetlands to provide habitat for herons. This additional 50 foot buffer shall be planted with dense native plant material to discourage human intrusion into feeding or nesting and roosting areas. Plantings shall be reviewed and approved by the department. If conformance with the additional buffer requirement results in an unbuildable lot, then the minimum variation necessary to accommodate the proposed development shall be determined in consultation with county biologists and be reviewed and approved by the department;

3. Along the shoreline of lakes and river corridors included in the heron habitat protection area, all subdivisions, short subdivisions, binding site plans, site development permits or other commercial or multifamily permits shall provide a 50 foot buffer in addition to required shoreline setbacks of K.C.C. Title 25 and 21A.24. Along the shoreline of the major rivers (Sammamish, Green, Cedar, Snoqualmie, Snohomish, Skykomish and White River), the setback requirement may be waived if a special wildlife study shows no great blue heron nesting, roosting, and feeding areas on the site. These studies shall be done by a wildlife biologist and approved by county biologists. This additional 50

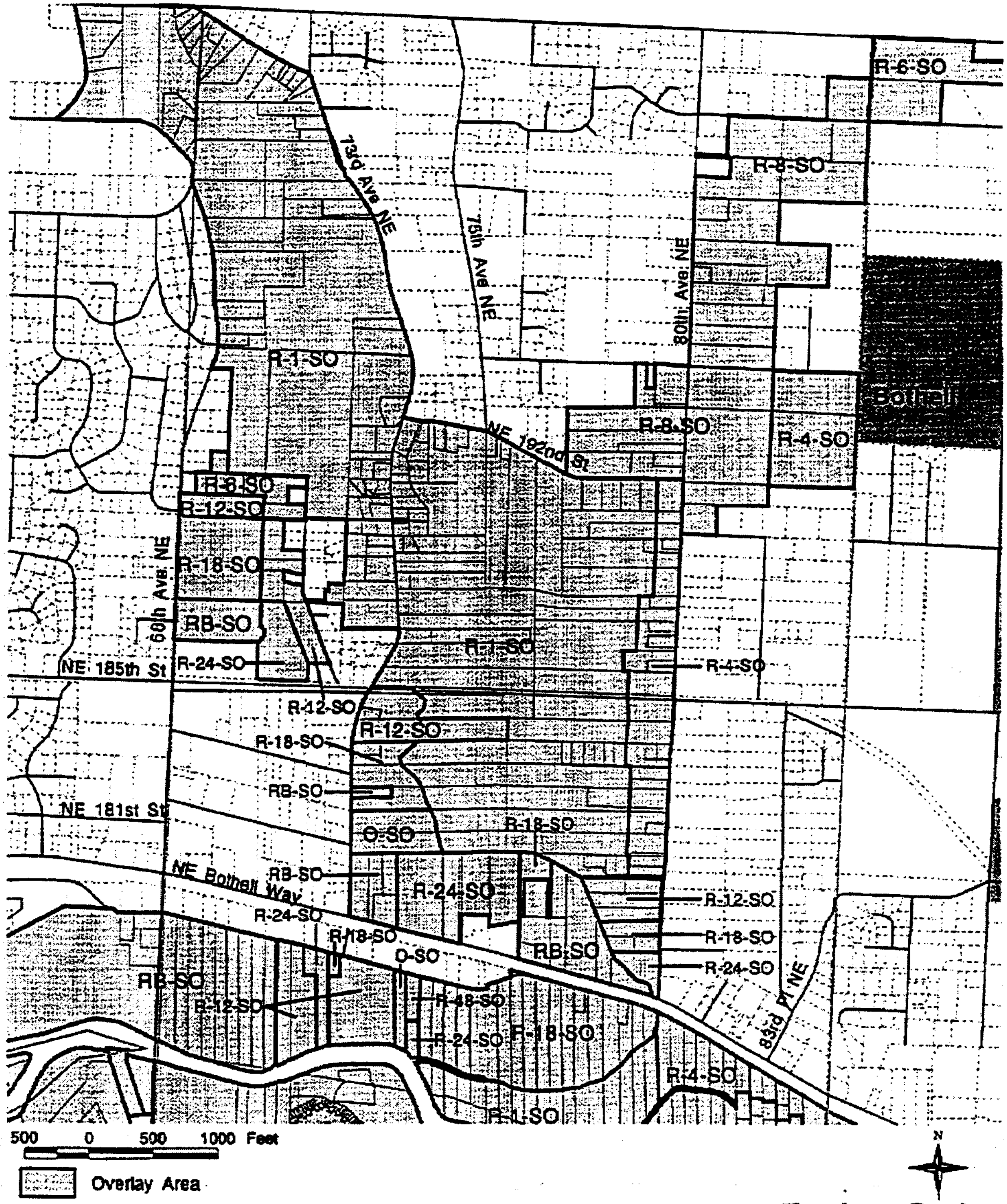
foot buffer shall be planted with dense native plant material to discourage human intrusion into feeding or nesting and roosting areas. Plantings shall be reviewed and approved by the department; and

4. New docks, piers, bulkheads, and boat ramps constructed within the heron habitat protection area shall mitigate for loss of heron feeding habitat by providing enhanced native vegetation approved by the county adjacent to the development or between the development and the shoreline. Bulkheads shall be buffered from the water's edge by enhanced plantings of native vegetation approved by the county.

Ordinance
12823

Effective Date
August 18, 1997

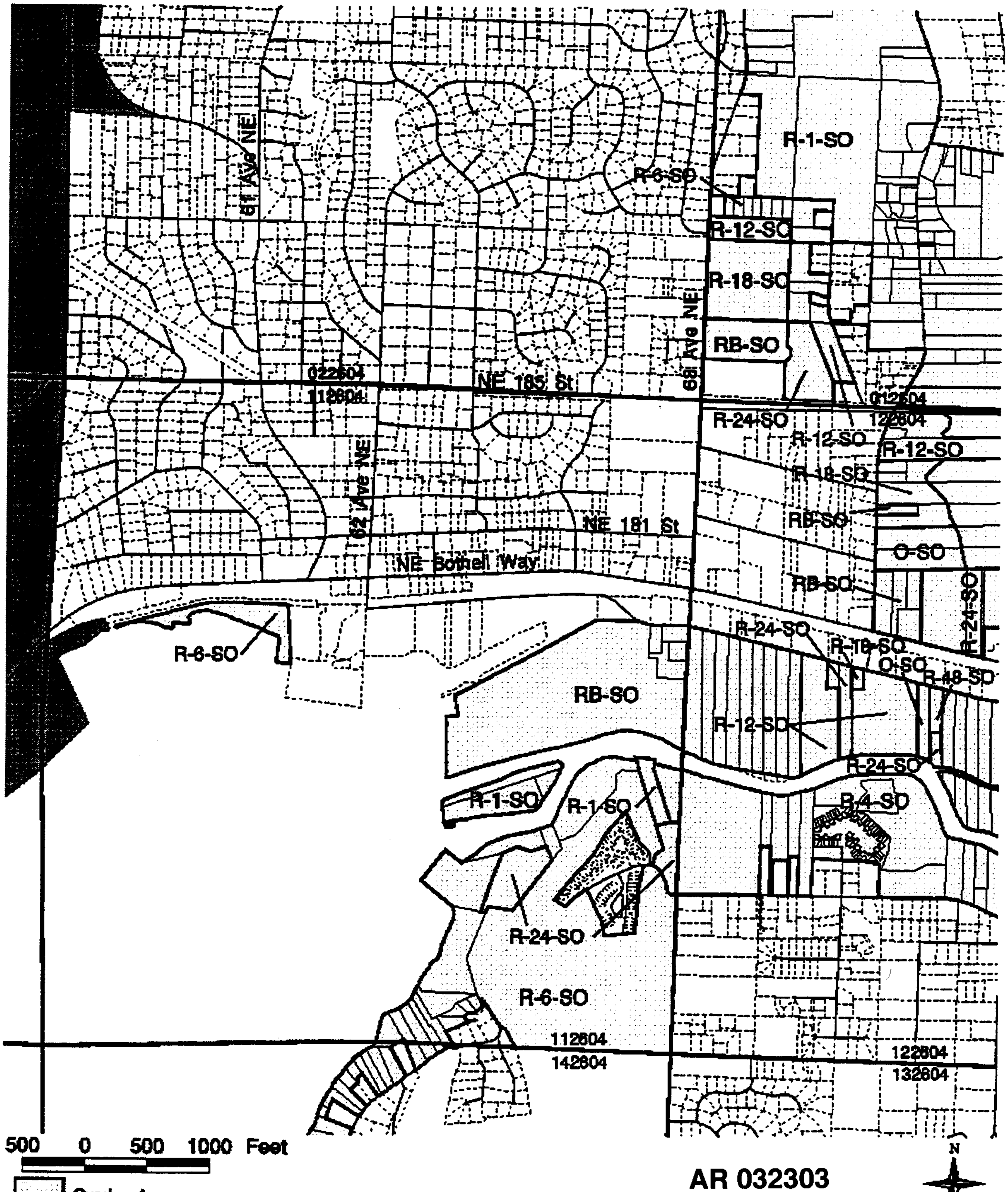
AR 032301



Zoning Code Conversion Phase Two

Heron Habitat Protection Area Special District Overlay 1/6
Northshore Community Planning Area

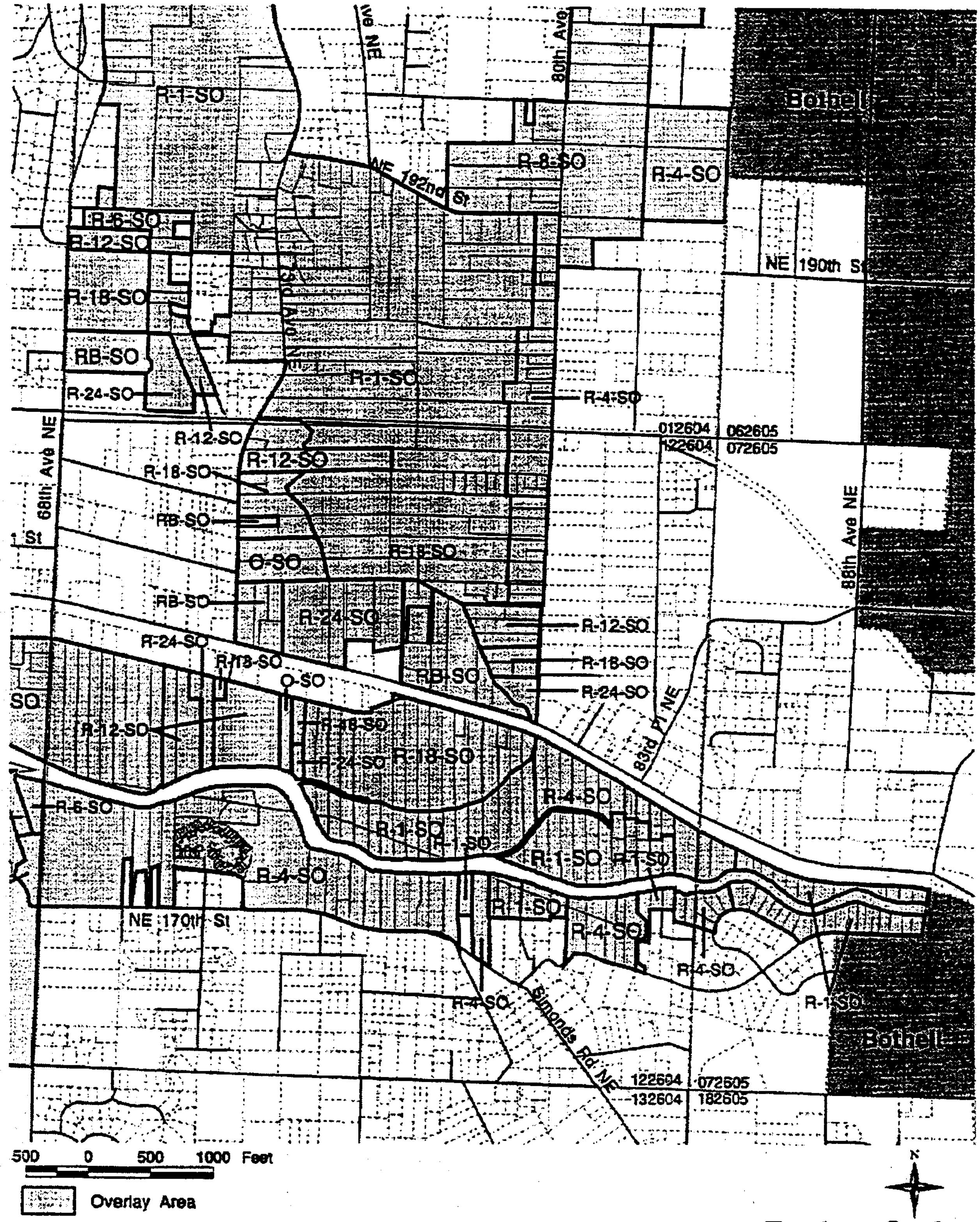
AR 032302



AR 032303

Executive Proposed Amendment to
Proposed Ordinance 96-263, Appendix B:
Heron Habitat Protection Area Special District Overlay 2/6
Northshore Community Planning Area

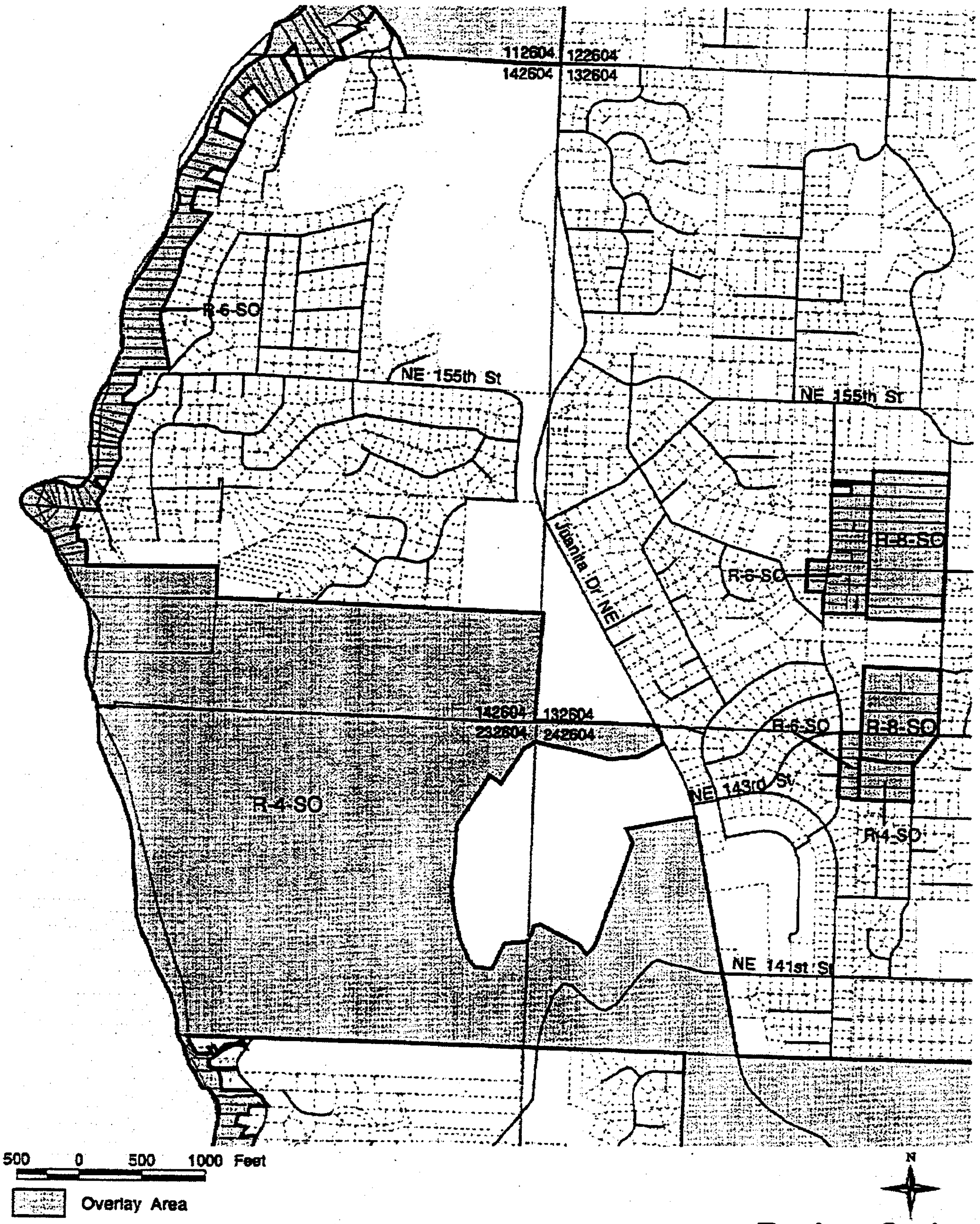
Zoning Code Conversion Phase Two



Heron Habitat Protection Area Special District Overlay 3/6
Northshore Community Planning Area

Zoning Code Conversion Phase Two

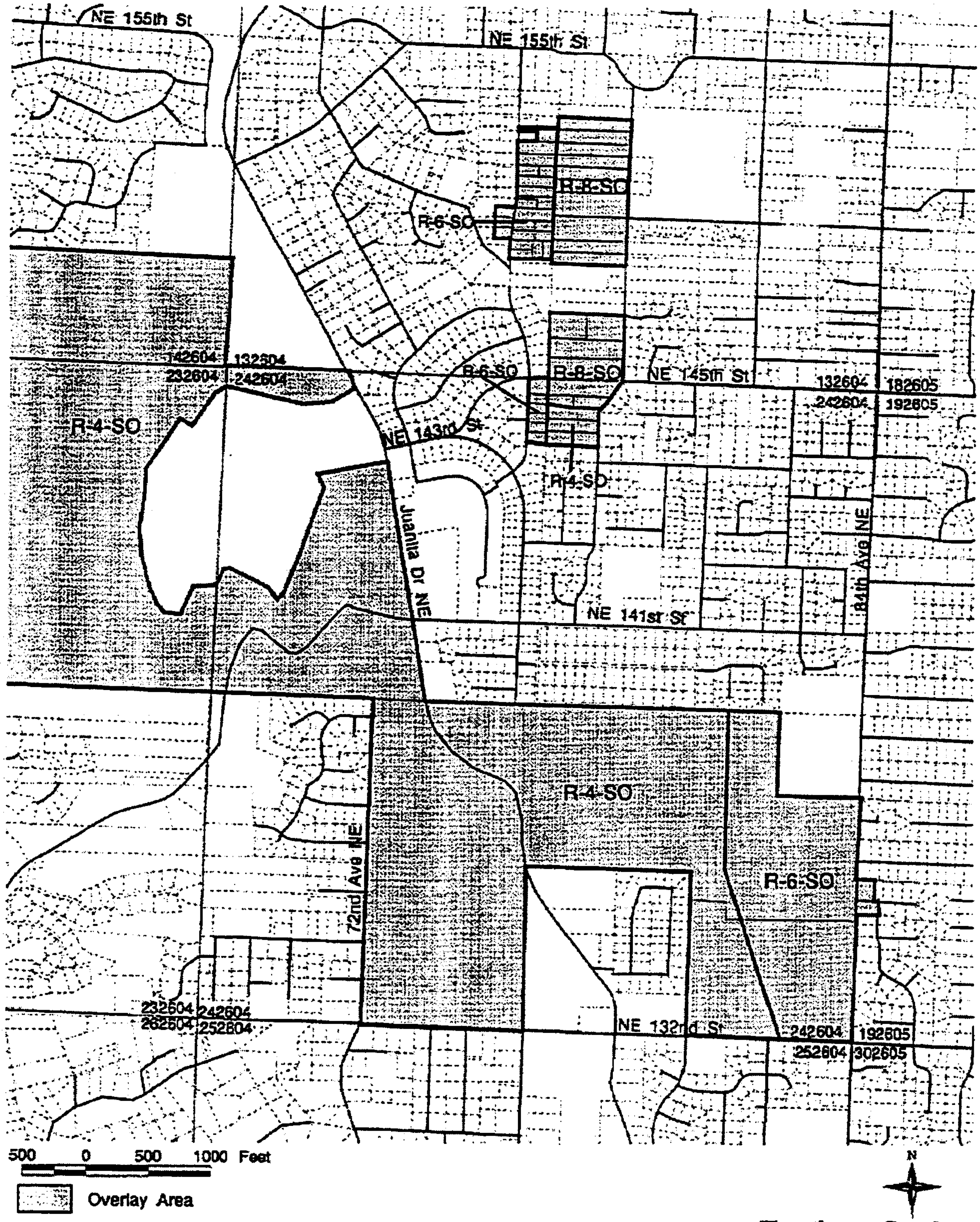
AR 032304



Heron Habitat Protection Area Special District Overlay 4/6
Northshore Community Planning Area

Zoning Code Conversion Phase Two

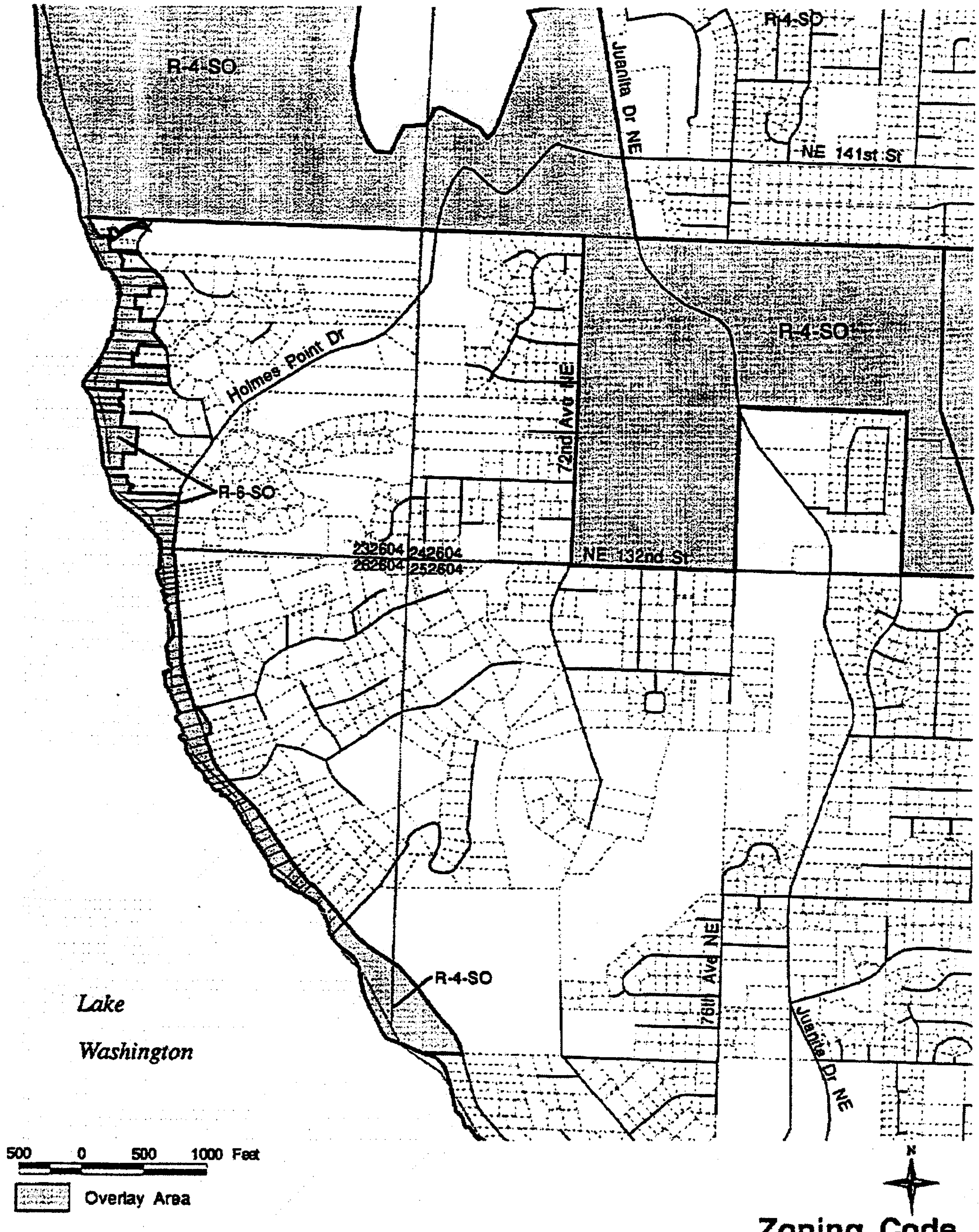
AR 032305



Heron Habitat Protection Area Special District Overlay 5/6
Northshore Community Planning Area

Zoning Code Conversion Phase Two

AR 032306



Heron Habitat Protection Area Special District Overlay 6/6
Northshore Community Planning Area

Zoning Code Conversion Phase Two

AR 032307

URBAN STREAM PROTECTION AREA

Special District Overlay, SO-210

(Effective c. August 18. 1997)

Condition Text

A. The purpose of the urban stream protection area special district overlay is to provide a means to designate areas with substantial fisheries resources that have severe flooding and stream damage problems from high storm water volumes. This district overlay limits land coverage along significant urban stream corridors to reduce stormwater volumes and the costs associated with flooding problems and loss of salmon resources.

B. The following development standards shall be applied to development proposals on R-1 zoned parcels located within an urban stream protection area district overlay:

1. Clearing is limited to and development shall be clustered on 30 percent of the site. Parcels adjacent to streams or wetlands shall place structures as far as feasible from streams and wetlands. For binding site plans, subdivisions and short subdivisions, the remaining 70 percent of the site shall be placed in a contiguous permanent open-space tract retaining the native vegetation. For individual lots, the remaining 70 percent of the parcel shall retain the native vegetation and be placed in a county-approved conservation easement, or notice shall be placed on the title of the lot. The notice shall be approved by King County and filed with the records and elections division. The notice shall inform the public of the presence and location of an urban stream protection area on the property and that limitations on actions in or affecting the corridor exist;

2. Where existing clearing has already exceeded 30 percent of the gross acreage of the site, reforestation according to a county-approved plan shall be provided to restore native forested cover to 70 percent of the site;

3. The maximum impervious surface area shall be 8 percent of the gross acreage of the site. Proposed short subdivisions, subdivisions, and binding site plans shall record the distribution of allowable impervious area among individual parcels on the face of the plat. Impervious surface of roads shall not be counted towards the allowable impervious area. This condition may be modified by the director only as necessary to accommodate unusual site access conditions;

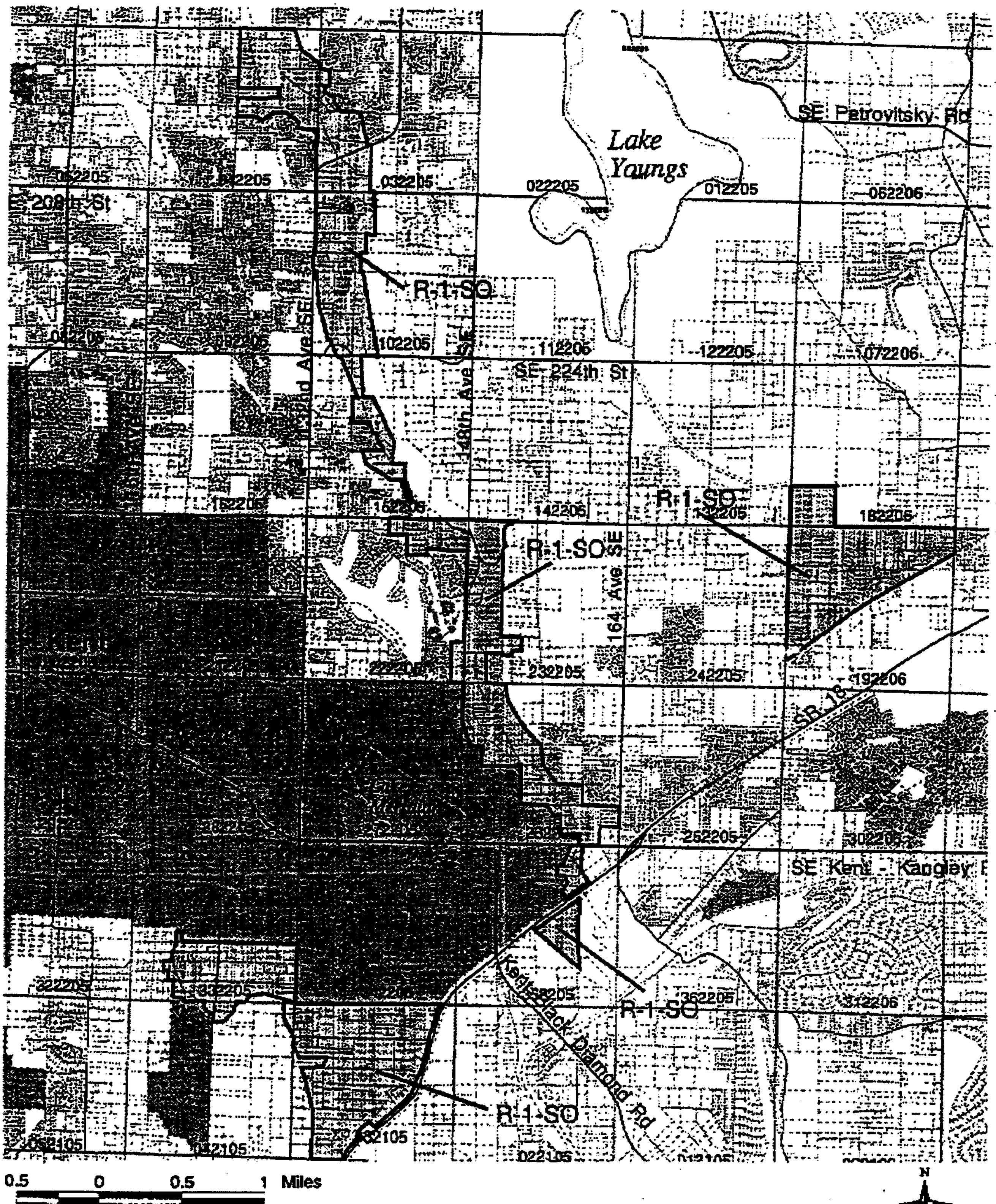
4. Keeping or grazing of livestock shall be prohibited; and

5. No road crossings of streams defined in K.C.C. 21A.06.1240 shall be allowed. Crossing of streams by utilities shall be limited to existing road or utility rights-of-way unless no feasible alternative exists.

Ordinance
12823

Effective Date
August 18, 1997

AR 032308



Overlay Area

Urban Stream Protection Area Special District Overlay
Soos Creek Community Planning Area

Zoning Code Conversion Phase Two

AR 032309

SIGNIFICANT TREES.

Special District Overlay, SO-220
(Effective c. August 18. 1997)

Condition Text

A. The purpose of the significant trees special district overlay is to provide a means to designate areas losing their natural vegetation that characterizes their community and receiving the accompanying impacts from increased stormwater runoff and decreased wildlife habitat. This district overlay limits removal of significant trees in these urbanizing areas to reduce visual impacts of development and maintain a portion of the natural vegetation and soils characteristic of the Pacific Northwest.

B. The following development standards shall be applied to all residential, commercial (including golf courses), industrial or institutional development proposals located within a significant tree district overlay:

1. Significant tree retention rates. Except when replacement trees are used as provided in subsection B.5, significant trees defined pursuant to K.C.C. 21A.06 shall be at a minimum retained as follows:

a. Exclusive of the area required for site access by vehicles, pedestrians, or utility infrastructure, significant trees shall be retained within required perimeter landscape areas at the following rates:

(1) One hundred percent for the interior perimeters.

(2) Seventy-five percent for the street perimeter, provided that this standard may be reduced to 50 percent for retail commercial developments if:

(a). the combined landscaping and tree retention requirement is shown by the applicant to result in:

i. the loss of the line-of-sight necessary for identification of the retail commercial development; and

ii. a vegetative buffer exceeding the screening characteristics of a Type III landscape screen; or

(b) The average width of the street perimeter landscape area is increased by 50 percent, provided that within the additional landscape area, significant trees are retained at the rate consistent with subsection c;

b. If any portion of the lot contains erosion hazards, significant trees located in the interior of separate lots, including sensitive areas or their buffers, shall be retained in single detached dwelling development at the rate of 20 trees per acre or ten percent of such trees, whichever is greater;

c. Significant trees located in the interior of the development proposal, including sensitive areas or their buffers, shall be retained in a residential subdivision at the rate of 20 trees per acre or ten percent of such trees, whichever is greater;

d. Significant trees located in the interior of the development proposal, excluding sensitive areas or their buffers, shall be retained in an apartment or townhouse development at the rate of 20 trees per acre or ten percent of such trees, whichever is greater;

e. Significant trees located in the interior of the development proposal, excluding sensitive areas or their buffers, shall be retained in commercial or industrial development at a rate of ten trees per acre or five percent of such trees, whichever is greater;

AR 032310

f. Significant trees located in the interior of the development proposal, excluding sensitive areas or their buffers and areas designated for sport fields, playfields or other recreational facilities, shall be retained in institutional developments at a rate of ten trees per acre or five percent of such trees, whichever is greater;

g. Utility developments and mineral extraction operations shall be exempt from the significant tree retention requirements of this section; and

h. Project sites with 25 percent or greater of the total gross site area in sensitive areas, sensitive area buffers and other areas to be left undisturbed such as wildlife corridors, shall be exempt from the significant tree retention requirements of this chapter;

2. Retention plan. The applicant shall submit tree retention plans as follows:

a. A significant tree inventory shall be submitted for review prior to or with submittal of development permit applications. The tree inventory may be conducted by any method that reflects general locations, numbers and grouping of significant trees on-site; and

b. A detailed tree retention plan shall be submitted for review prior to or with submittal of grading permit applications or other permit applications incorporating grading plans. This plan shall identify the exact location, size, species, and condition of the significant trees proposed to be retained, transplanted or replaced in order to comply with this chapter;

3. The retention requirements shall be met as follows:

a. Except as provided in subsection b, the applicant shall determine that the final tree retention plan does not include significant trees unable to survive more than ten years after the date of project completion due :

(1) Damage or disease;

(2) Safety hazards due to potential root, trunk or primary limb failure;

(3) Windfall; or

(4) Age in relation to the normal lifespan of the tree species;

b. At the discretion of the county, damaged or diseased or standing dead trees, not classified as a danger tree, may be counted toward the significant tree requirement if demonstrated that such trees will provide important wildlife habitat;

c. A significant tree may be credited as two trees when it meets one or more of the following characteristics:

(1) The tree is 18 inches or greater in diameter;

(2) The tree is located in a grouping of at least five trees with canopies that touch or overlap;

(3) The tree provides energy savings through winter wind protection or summer shading as a result of its location relative to buildings;

(4) The tree belongs to a unique or unusual species;

(5) The tree is located within 25 feet of any sensitive area or required sensitive area buffers; or

(6) The tree is listed on a historical register; and

AR 032311

d. The department shall, pursuant to K.C.C. 2.98, develop and maintain an advisory listing of trees recommended for retention. Such list shall describe their general characteristics and suitability, and provide guidelines for their retention;

4. Protection. To provide the best protection for significant trees designated for retention, the development shall comply with the following:

   a. No tree removal for a project action shall be allowed prior to the county approval of a grading permit consistent with tree retention and landscape plans;

   b. Prior to clearing for a project action, trees to be retained shall be flagged;

   c. Prior to grading for a project action and throughout construction, a temporary chainlink or plastic net fence shall be used to identify the protected area of any significant tree designated for retention. The height of such fencing shall be adjusted according to the topographic and vegetative conditions of the site to provide clear visual delineation of the protected area. The size of protected area around the tree shall be equal to one foot diameter for each inch of tree trunk diameter measured four feet above the ground; and

   d. At no time during and after construction shall the following be permitted within the area described in subsection c:

      (1) Impervious surfaces, fill, excavation, or storage of construction materials; or

      (2) Grade level changes, except in limited circumstances where proposed improvements using permeable materials are determined by an arborist to be non-detrimental to the trees root system; and

   e. Alternative or additional protection methods may proposed and be used if determined by the director to provide equal or greater protection for trees designated for retention;

5. Plan modifications and tree replacement are permitted as follows:

   a. Any significant tree in the interior may be replaced by another significant tree in the interior;

   b. If the required number of significant trees cannot be retained, then non-significant sized trees may be retained or new trees may be planted to meet significant tree requirements as follows, provided that the reason for the purpose of this subsection, the significant tree to be replaced by the new or existing replacement tree is assigned a diameter of 12 inches:

      (1) When using replacement trees measuring three inches in diameter or greater (as measured by caliper), one-half inch diameter of replacement tree shall be provided for every one inch diameter of significant tree to be replaced; and

      (2) When using replacement trees measuring less than three inches in diameter (as measured by caliper), one inch diameter of replacement tree shall be provided for every one inch diameter of significant tree to be replaced; and

   c. An approved tree retention plan shall be modified to reflect any changes made pursuant to subsection a and b: and

6. Maintenance. The following provisions apply to significant trees where applicable:

   a. All significant trees shall be maintained for the life of the project;

   b. All significant trees shall be pruned and trimmed as necessary to maintain a healthy growing condition or to prevent primary limb failure. This requirement shall not be interpreted to allow:

      (1) Topping of primary stems;

      (2) Pruning that results in the loss of 20 percent of vegetative mass, and

AR 032312

(3) Cutting of major roots, except in preparation for transplantation or as deemed necessary and/or acceptable by a certified arborist; and

c. With the exception of dead, diseased or damaged trees specifically retained to provide wildlife habitat; other dead, diseased, damaged or stolen plantings shall be replaced within three months or during the next planting season if the loss does not occur in a planting season.

C. The development standards set forth in paragraph B shall not be applied to institutional development proposals that consist of one or more of the following uses:

1. Government services listed in K.C.C. 21A.08.060,

2. Educational services listed in K.C.C. 21A.08.050,

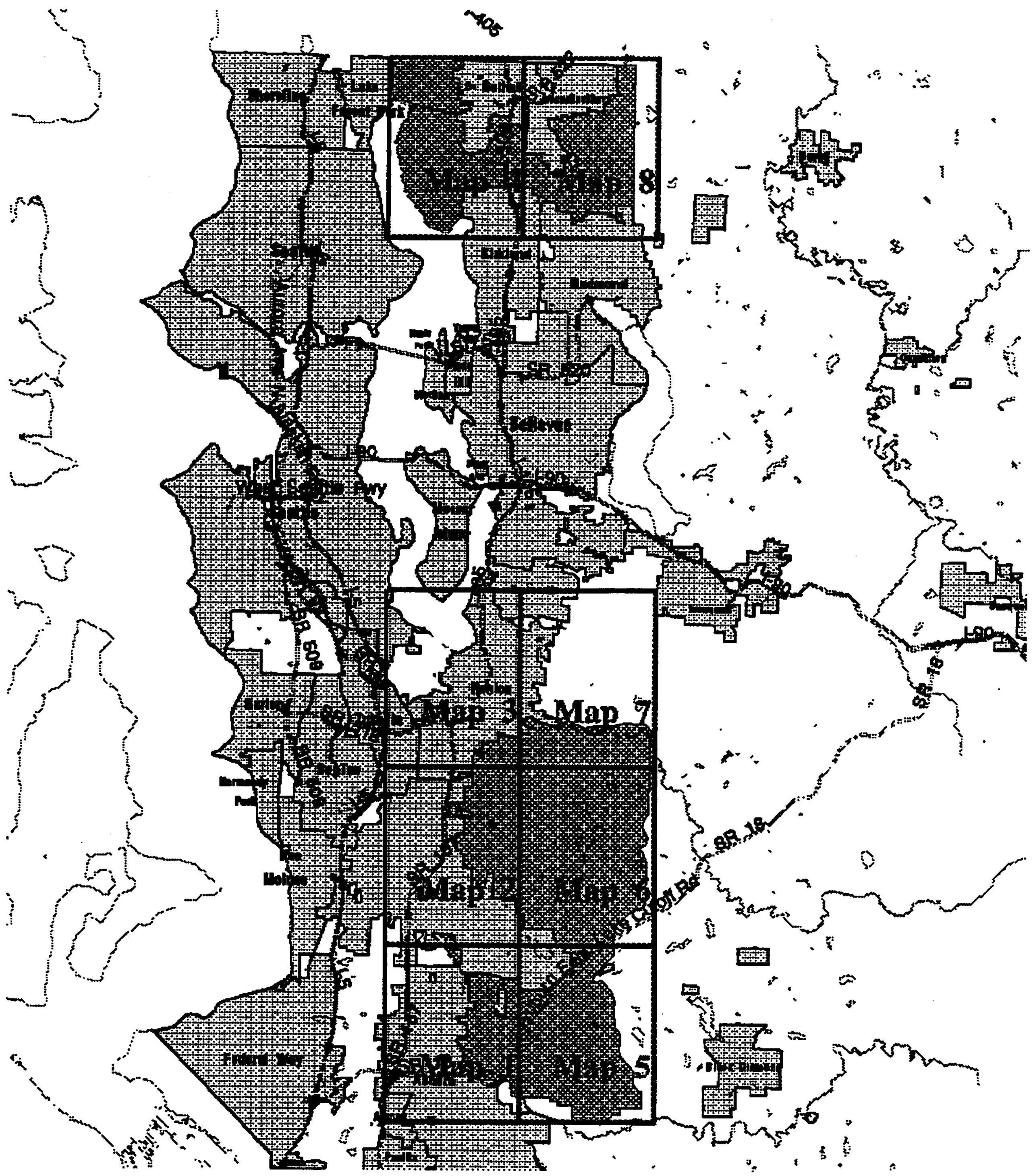
3. Parks as listed in K.C.C. 21A.08.040 when located adjacent to an existing or proposed school, or

4. Libraries listed in K.C.C. 21A.08.040.

Ordinance
12823

Effective Date
August 18, 1997

AR 032313



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention Index Map

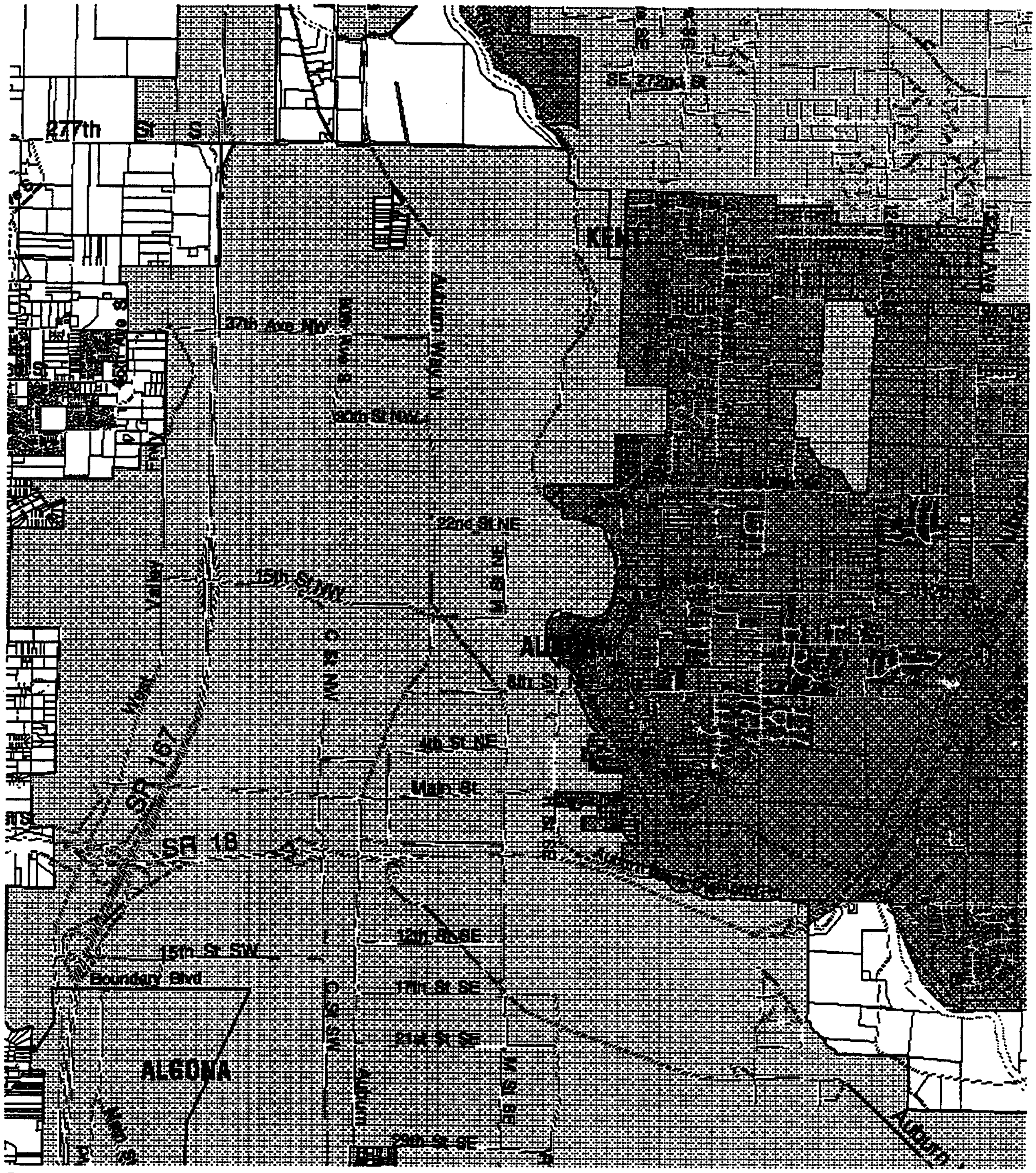
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032314



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 1 of 8

0.5 0 0.5 1 Miles

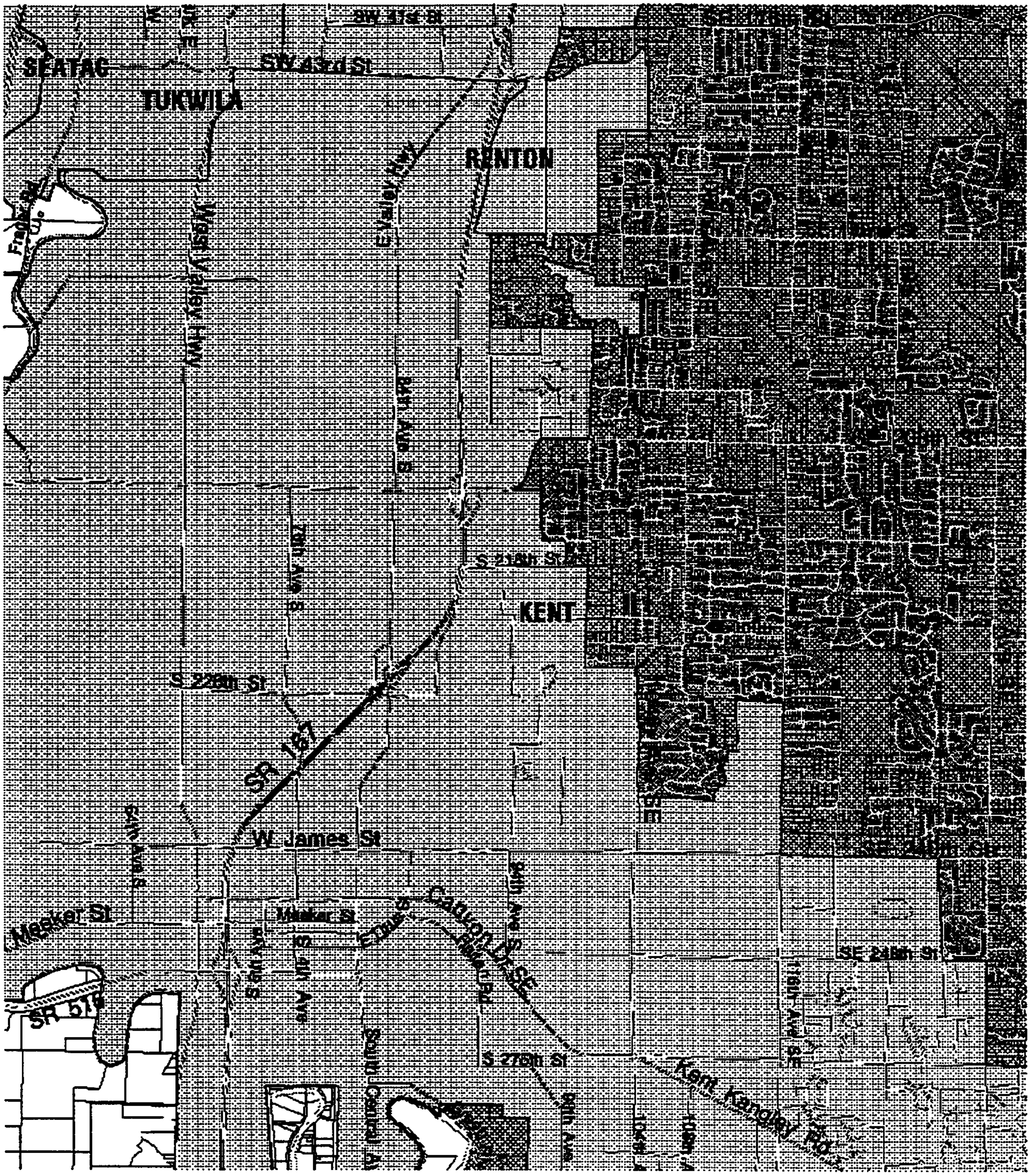
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032315



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 2 of 8

0.5 0 0.5 1 Miles

N

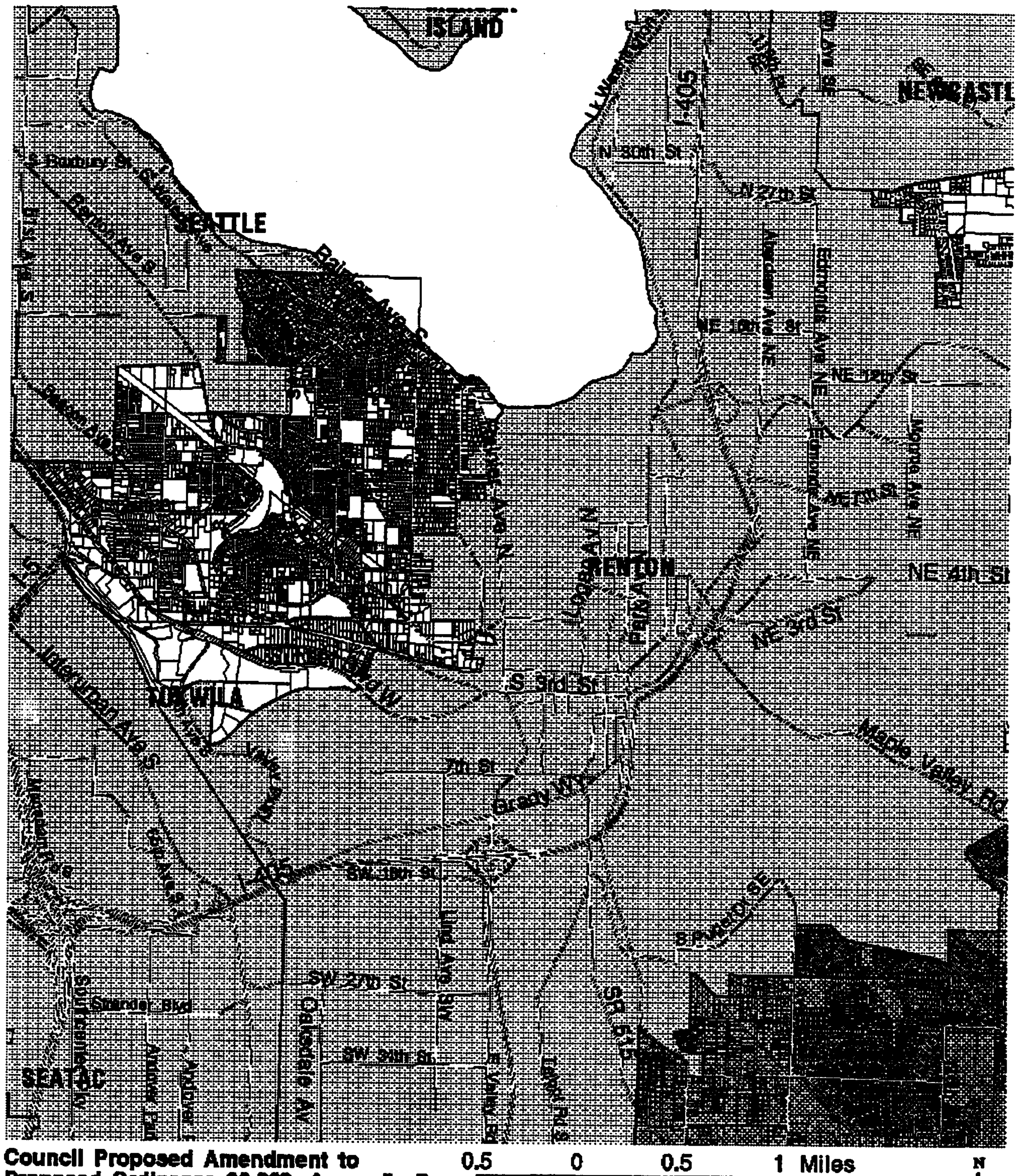
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032316



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 3 of 8

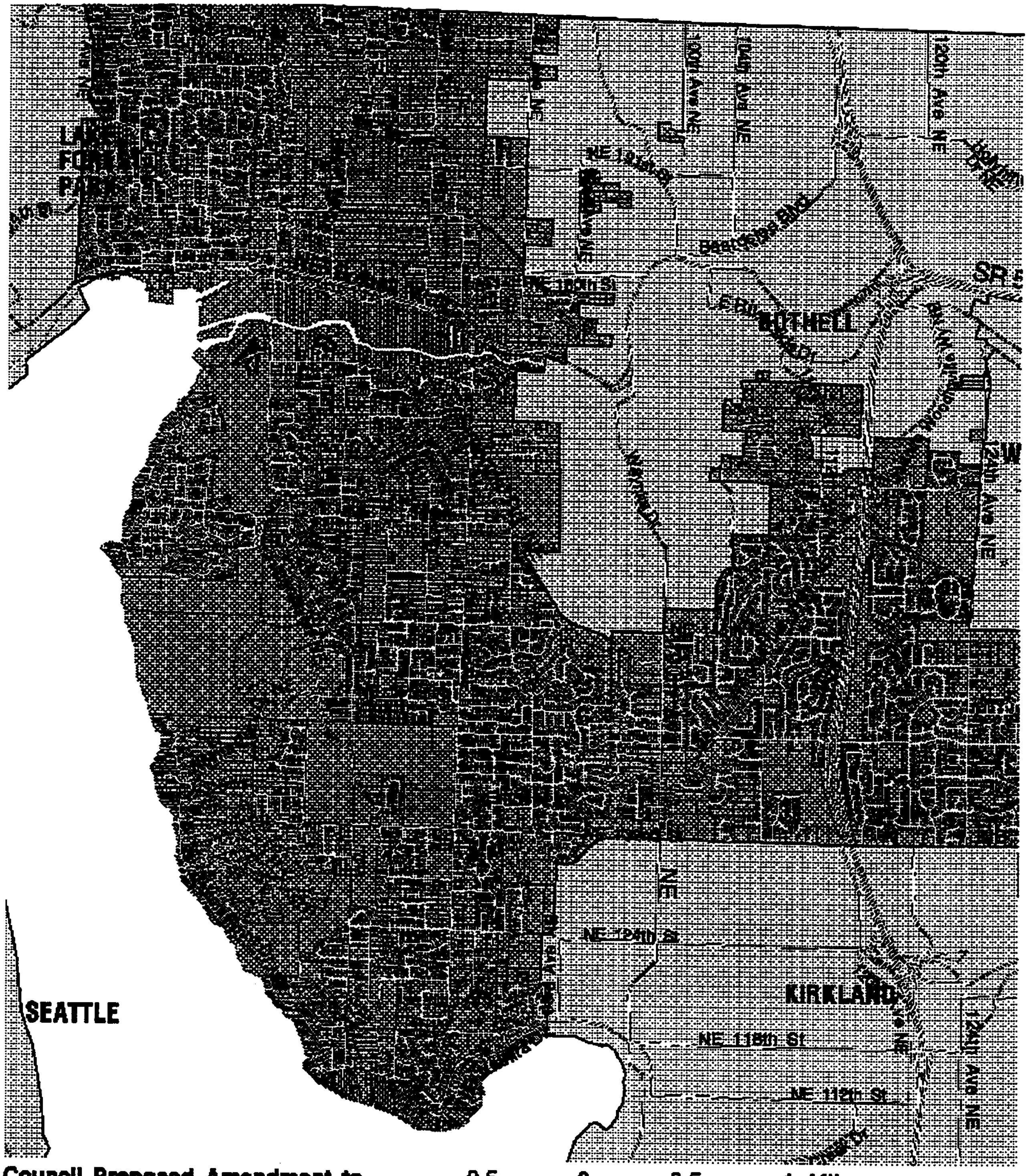
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032317



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 4 of 8

0.5 0 0.5 1 Miles

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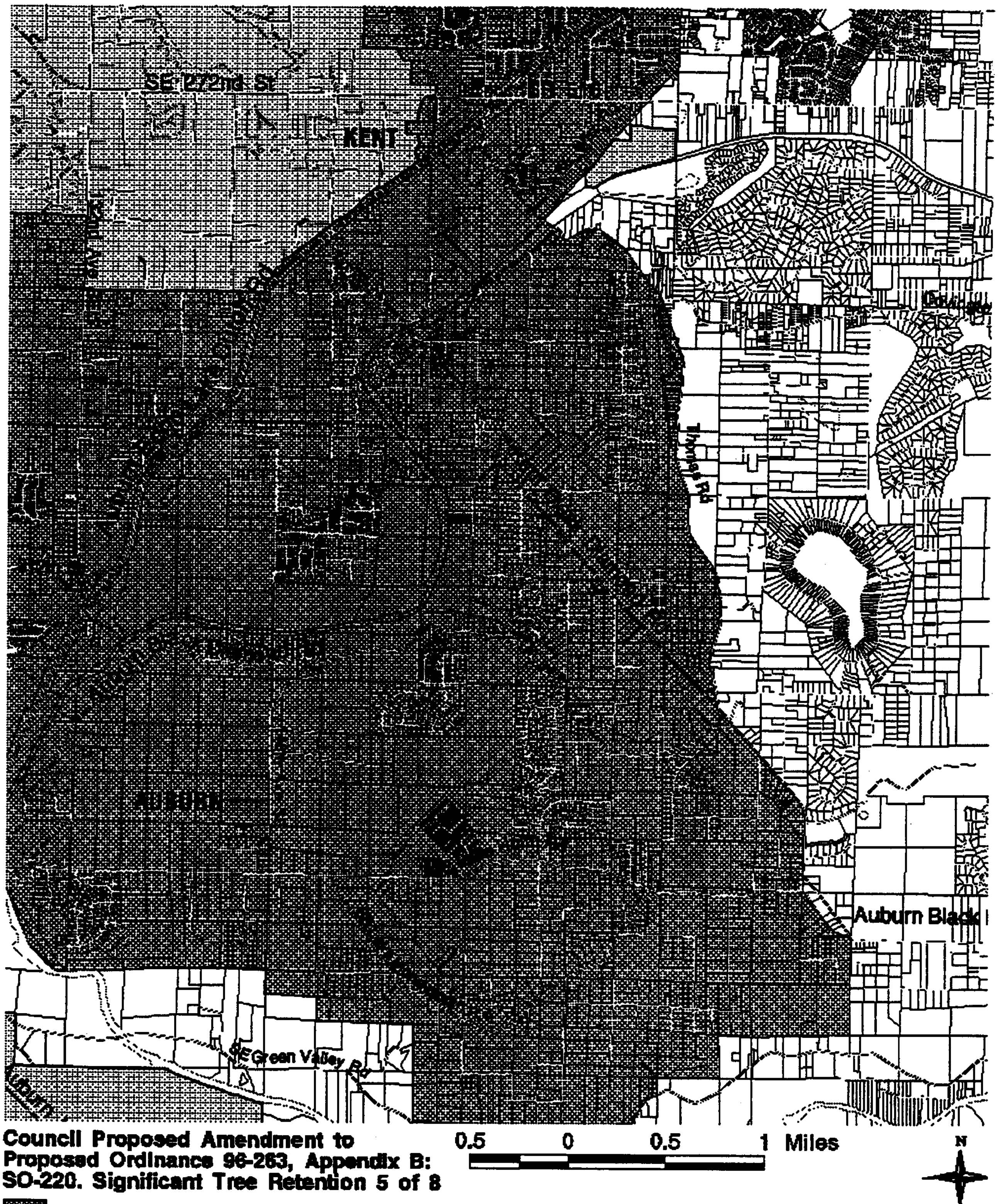
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032318



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 5 of 8

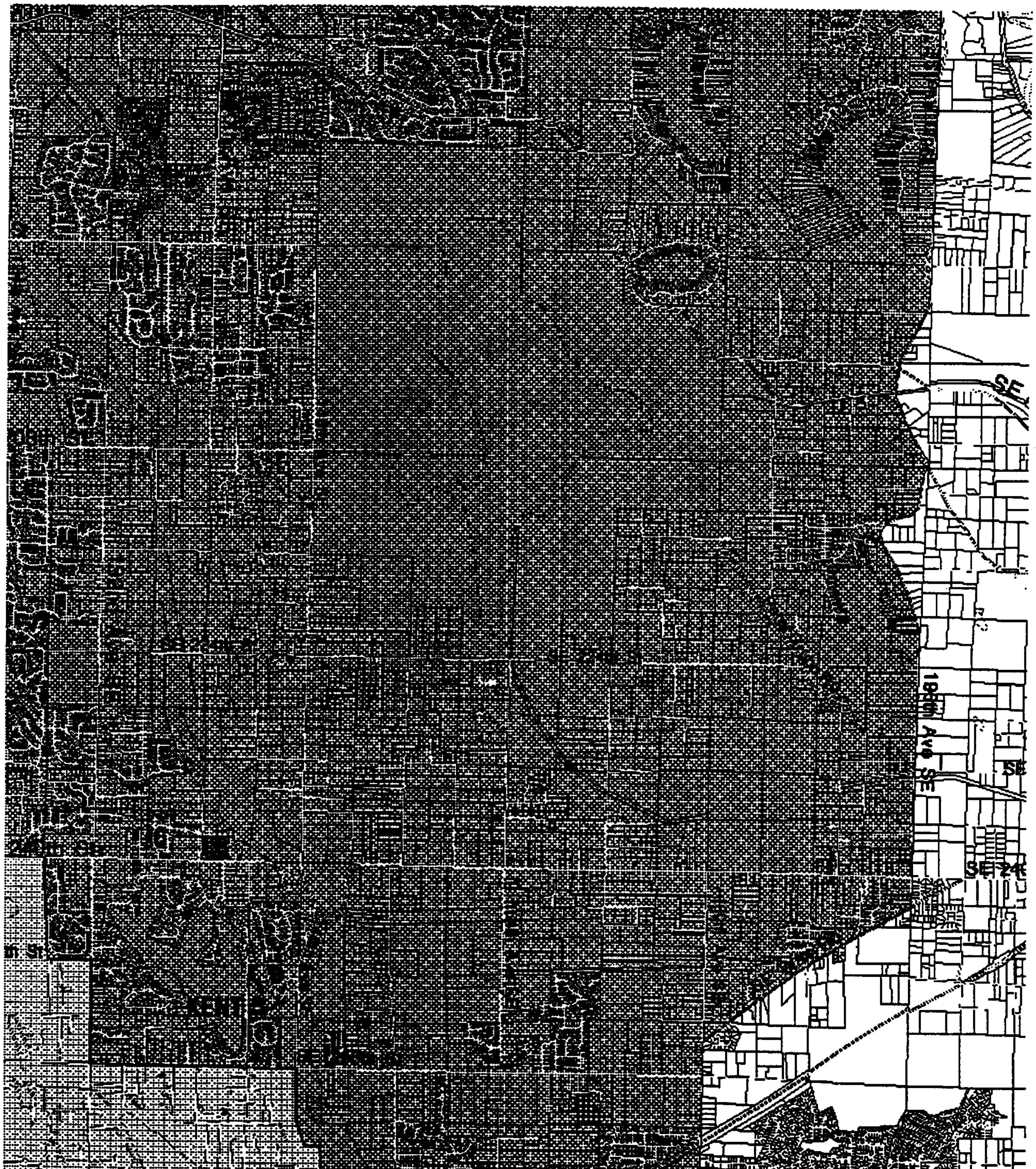
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032319



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 6 of 8

0.5 0 0.5 1 Miles

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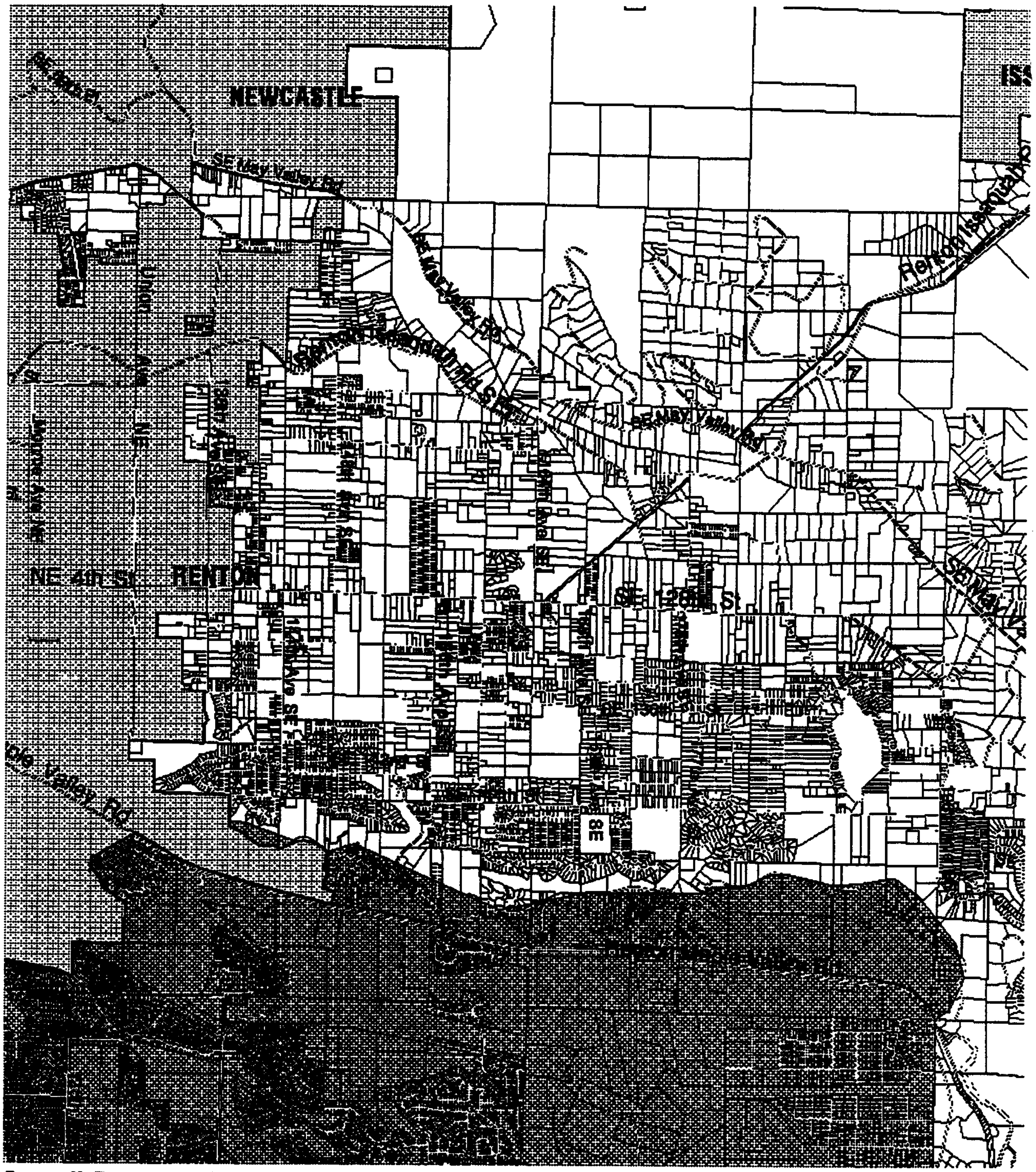
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032320



Council Proposed Amendment to Proposed Ordinance 96-263, Appendix B: SO-220. Significant Tree Retention 7 of 8

0.5 0 0.5 1 Miles

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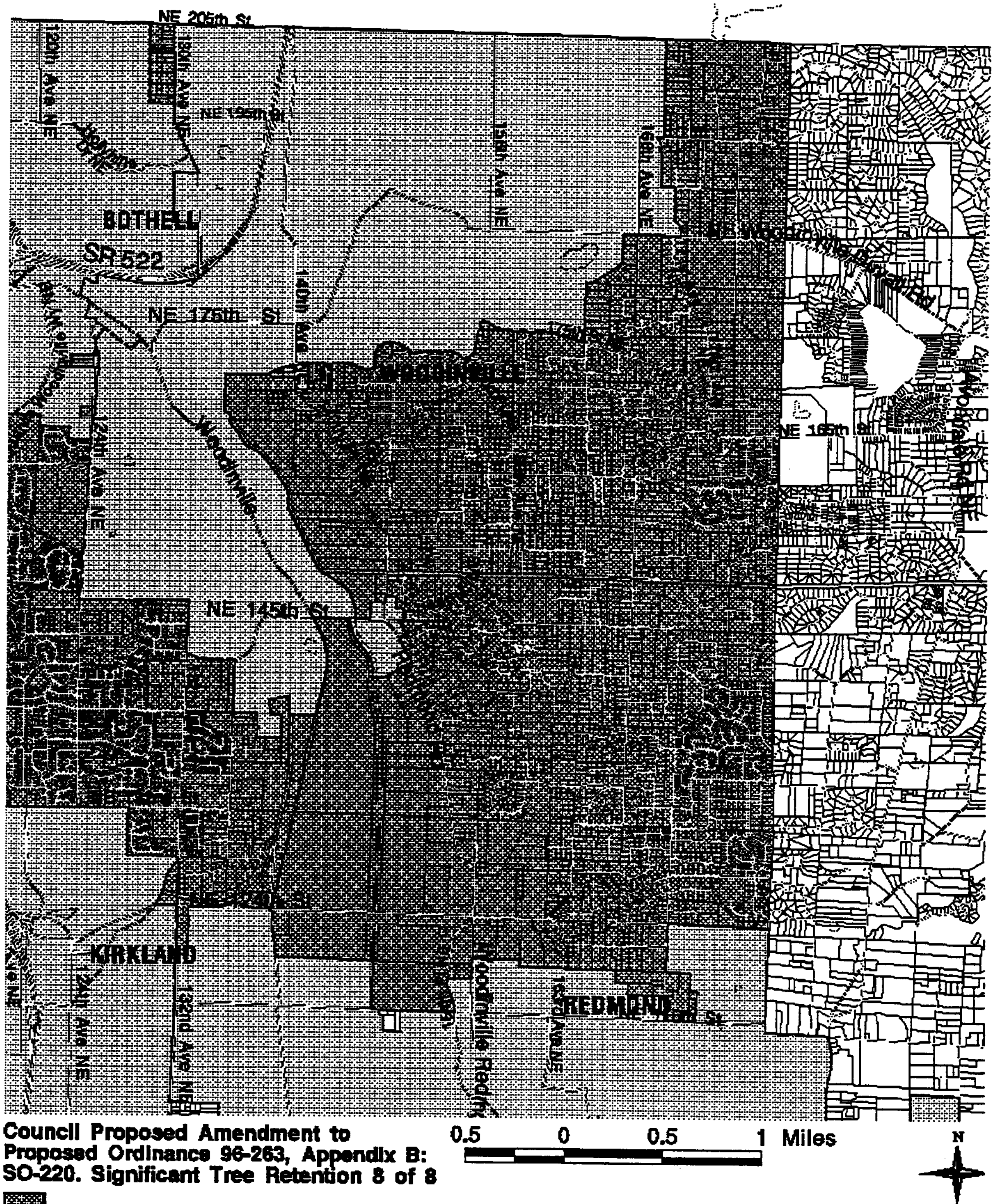
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032321



Zoning Code Conversion Phase Two

Special District Overlay

AR 032322

FLOODPLAIN DENSITY SDO

Special District Overlay, SO-230

(Effective August 18. 1997)

Condition Text

Floodplain Density.

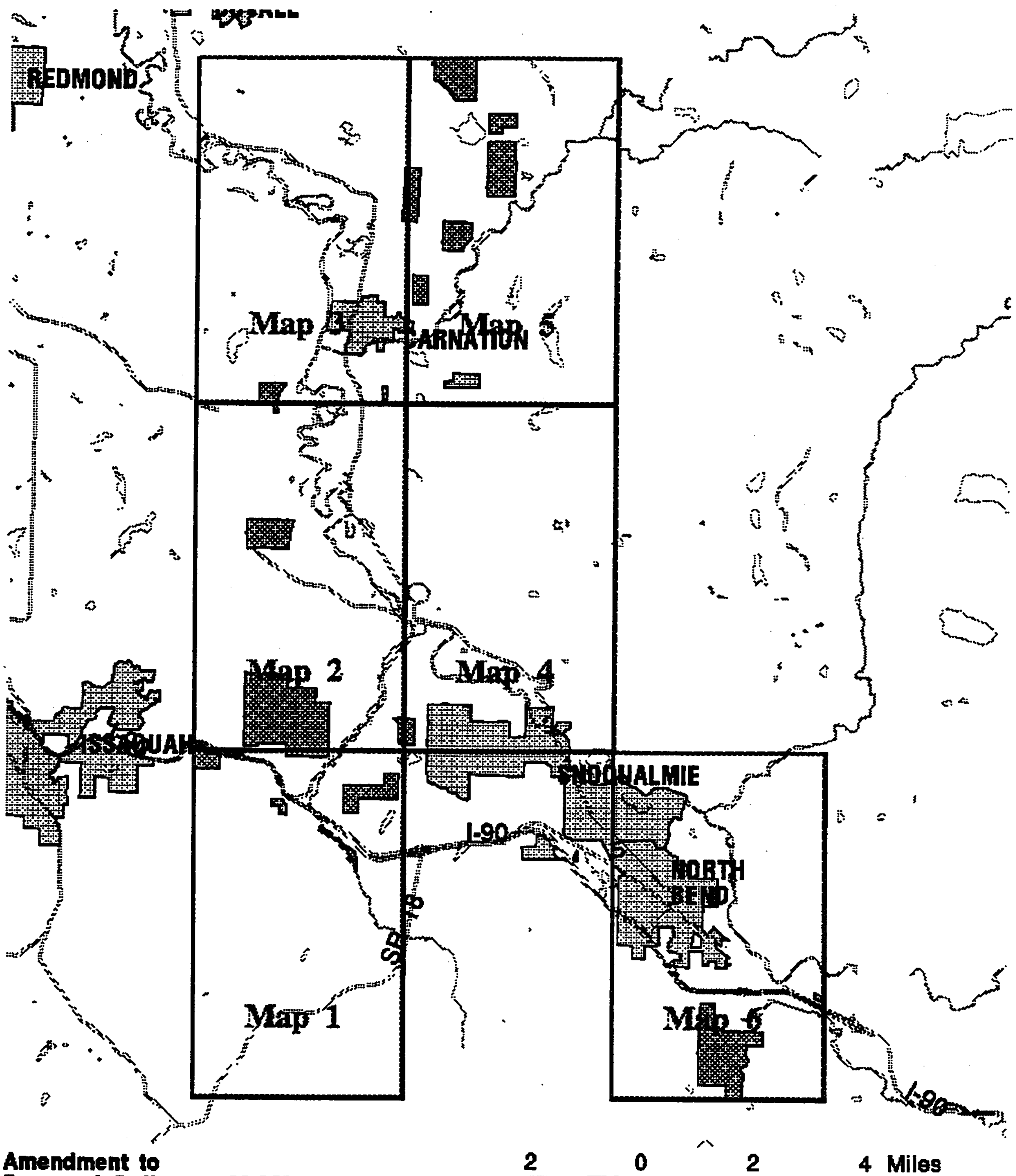
A. The purpose of the floodplain density special district overlay is to provide a means to designate areas that cannot accommodate additional density due to severe flooding problems. This district overlay limits development in sensitive areas to reduce potential future flooding.

B. The following development standards shall be applied to all development proposals on RA-5 zoned parcels located within a floodplain density special district overlay:

1. Density is limited to one home per 10 acres for any property that is located within a sensitive area; and

2. All development shall be clustered outside of the identified sensitive areas, unless the entire parcel is a mapped sensitive area.

Ordinance 12823
Effective Date August 18, 1997



Amendment to
Proposed Ordinance 96-263, Appendix B:
SO-230. Floodplain Density SDO Index Map

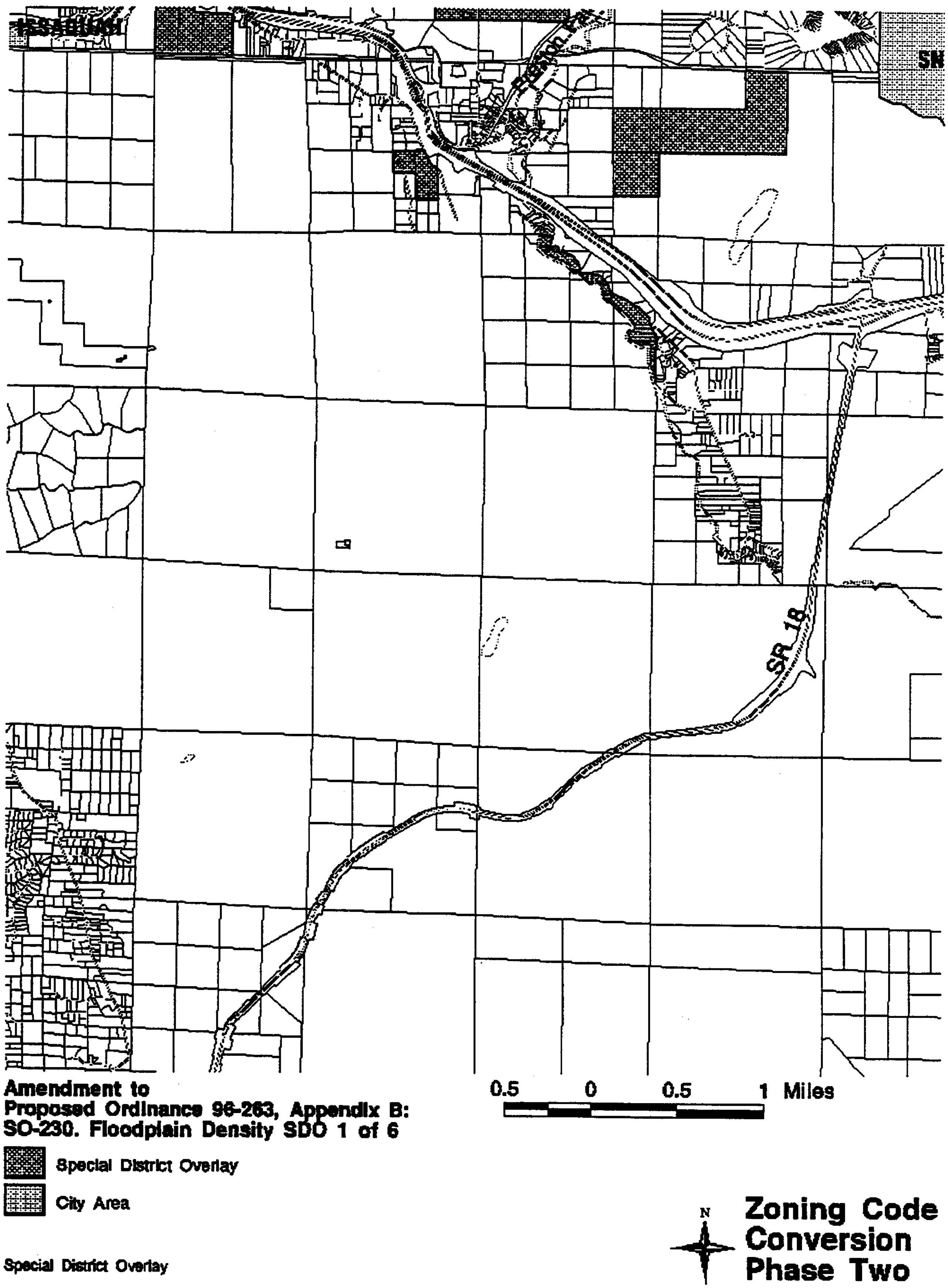
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032324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Amendment to
Proposed Ordinance 96-263, Appendix B:
SO-230. Floodplain Density SDO 1 of 6
Special District Overlay
City Area
Special District Overlay
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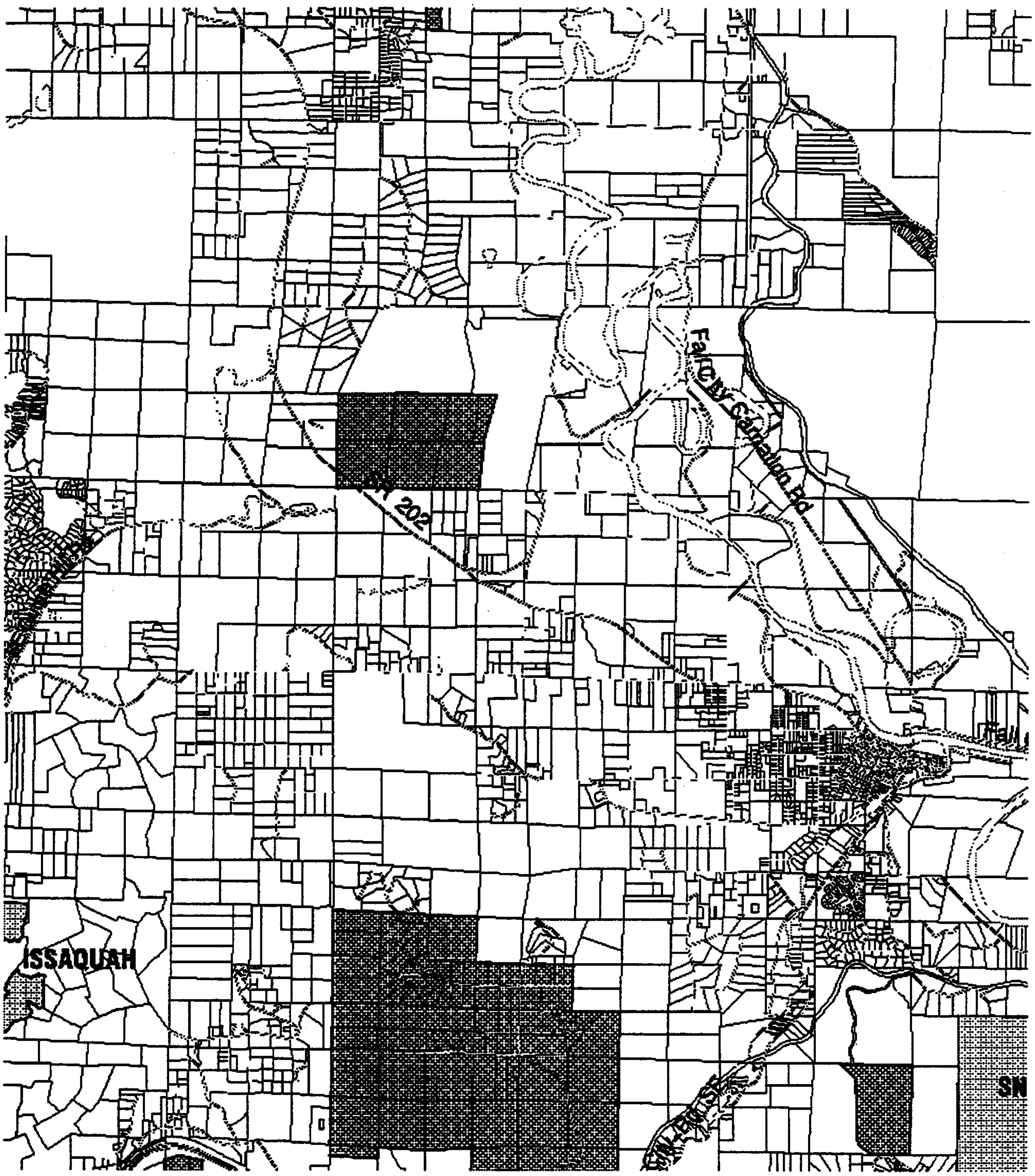
Zoning Code
Conversion
Phase Two

AR 032325



Amendment to
Proposed Ordinance 96-263, Appendix B:
SO-230. Floodplain Density SDO 2 of 6

0.5 0 0.5 1 Miles

Special District Overlay

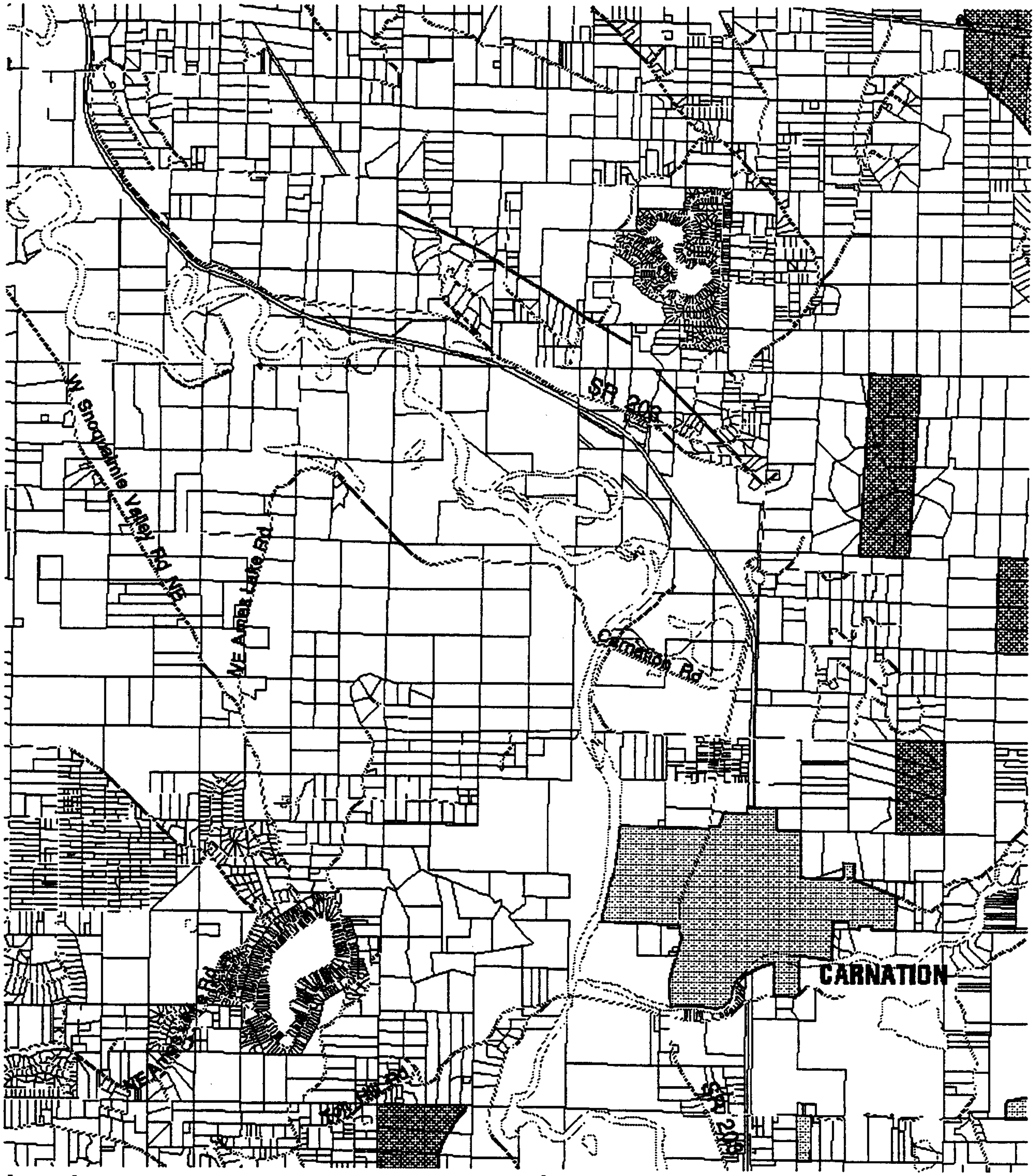
City Area

Special District Overlay

N

Zoning Code Conversion Phase Two

AR 032326



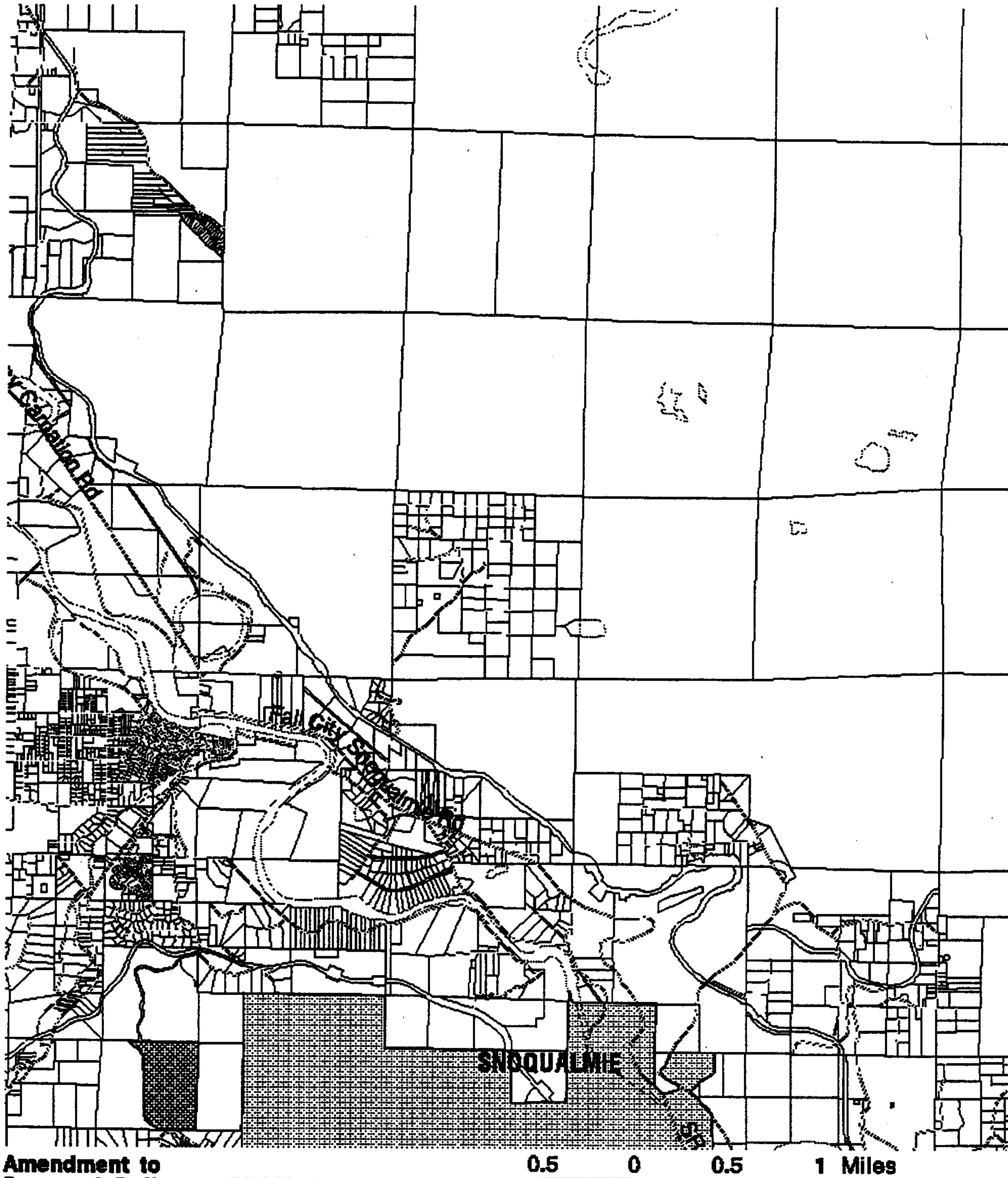
Amendment to
Proposed Ordinance 96-263, Appendix B:
SO-230. Floodplain Density SDO 3 of 6

Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two



Amendment to
Proposed Ordinance 96-263, Appendix B:
SO-230. Floodplain Density SDO 4 of 6

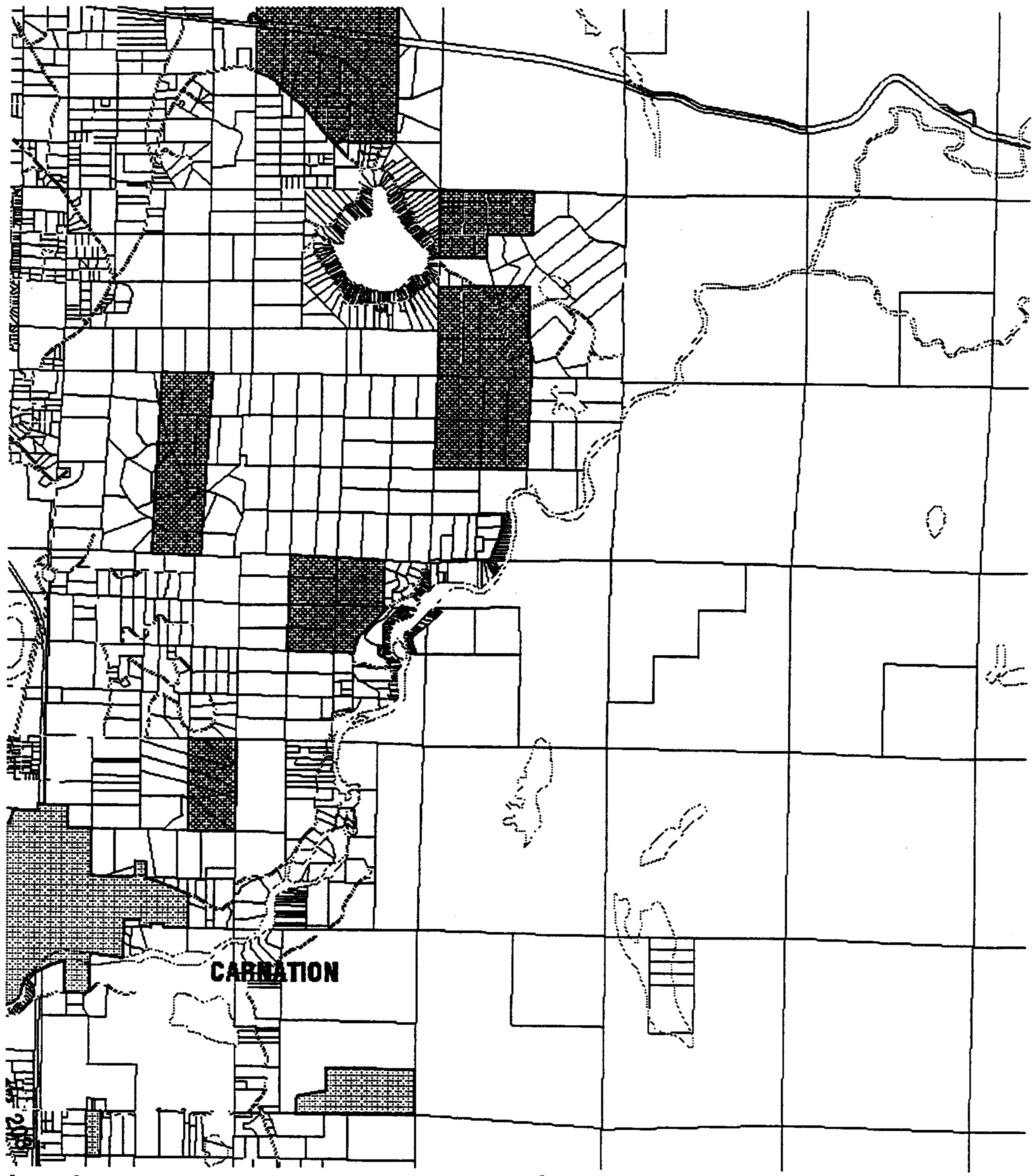
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032328



Amendment to Proposed Ordinance 96-263, Appendix B: SO-230. Floodplain Density SDO 5 of 6

0.5 0 0.5 1 Miles

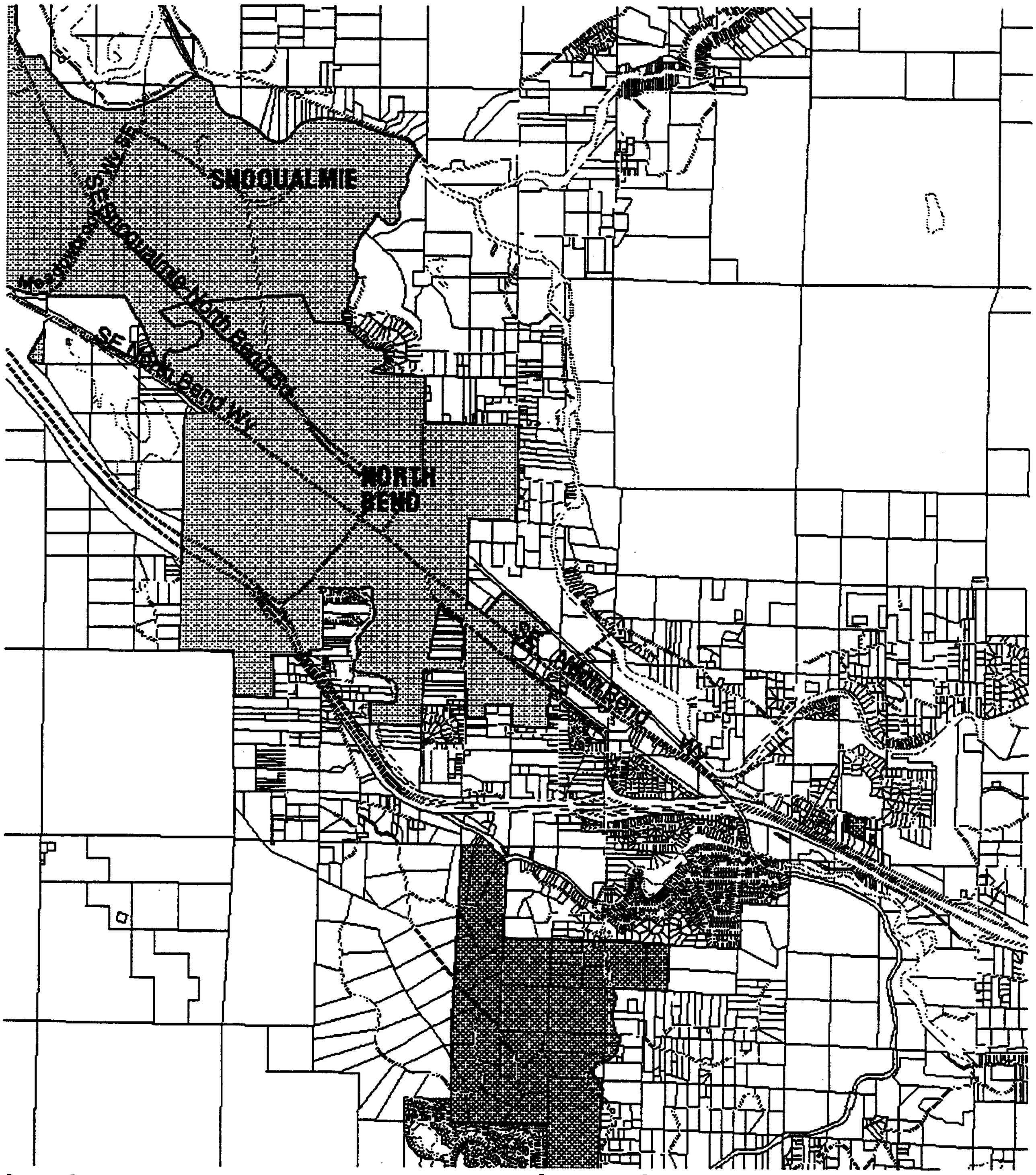
Special District Overlay

City Area

Special District Overlay

Zoning Code Conversion Phase Two

AR 032329



Amendment to
Proposed Ordinance 96-263, Appendix B:
SO-230. Floodplain Density SDO 6 of 6

0.5 0 0.5 1 Miles

Special District Overlay

City Area

Special District Overlay

N

Zoning Code Conversion Phase Two

AR 032330

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 3

CRITICAL DRAINAGE AREAS-REQUIREMENTS

TITLE	EFFECTIVE DATE
None designated at this time.	

AR 032331

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 4

DESIGN MANUAL SUPPORTING DOCUMENTS AND OTHER DRAINAGE RELATED ORDINANCE AND RULES

AR 032332

REFERENCE 4-A

Guidelines for preparing a landscape management plan

Landscape management plans have the potential to significantly reduce the pollutant load washing off managed green spaces. For this reason, landscape management plans that incorporate key pollution prevention elements and which are consistently implemented can be used in lieu of water quality treatment facilities (see Section 1.2.8). Submittal requirements for obtaining an approved landscape management plan are given in Chapter 2.

GENERAL CONSIDERATIONS

Studies of pollutant transport have consistently shown that forested lands consistently produce lower pollutant loads—of solids, phosphorus and metals—than do lands used for residential, industrial or agricultural purposes. "Loading" refers to the total weight of a pollutant leaving a particular area or site. It is measured by determining both the concentration of a pollutant and the amount of flow leaving a site. Since the Puget Sound area was largely forested before settlement, lakes and streams in the area have developed biotic regimes in response to this low pollutant loading—clear, cool waters supporting salmon and other aquatic life. When the input of pollutants increases, lakes and streams often shift to a more biologically productive mode, often with a concomitant loss of clear water and a shift or even a decline in fish species.

When forests are converted to cities, this increase in pollutant load needs to be managed in order to maintain the beneficial uses of lakes and streams. One way to manage pollutants is to treat stormwater before it enters a water body. Biofiltration swales, wetponds and sand filters, as well as other facilities, can be used to provide this treatment. Another approach to manage pollutant loads is to prevent the pollutants from entering stormwater in the first place.

Our best models on how to keep nutrients and pollutants from entering storm water are from the original, unaltered landscape—the forests. Forests have a soft, absorptive **duff** layer, as well as **dense vegetative cover**, especially near the ground surface. Nutrients are provided in the form of **slow-release** organic materials, or leaves, needles and woody material. Rainfall **runoff is greatly reduced** from the levels seen in developed landscapes. These factors help to keep the total load of nutrients and sediments transported to receiving waters low.

ELEMENTS OF A SUCCESSFUL LANDSCAPE MANAGEMENT PLAN

Good planning, tailored to the specific conditions of the site, as well as good follow-through, are both essential in controlling the pollutants generated when forests are replaced with lawns, gardens or other landscape features. This section will focus on planning. Follow-through, or implementation, will be discussed in the next section.

I. PLAN CONTENTS

A landscape management plan for any particular site works best if developed with the specific site characteristics in mind. Soil type, slope, exposure, depth to groundwater as well as the particular suite of plants chosen for the site all should help direct the specific make-up of the plan. However, there are some basic principles that all sites should consider in order to be successful in controlling the export of soil or organic matter, fertilizers and pesticides in stormwater runoff. Landscape management plans should address each of the general principles given in Table 1, tailoring them to fit the specific site situation.

Each of the five basic principles is expanded upon in the following section. The recommendations discussed under each principle are intended as a framework for a variety of site situations, from individual homes to large parks and golf courses. Thus, not every landscape management plan may be able to apply each of the listed recommendations. In addition, landscapes are managed for different purposes, some more formal than others. It may be that some recommendations will not be appropriate for very formal sites and thus not adopted, in favor of other management practices that better fit the uses for which the site is intended. In the end, the extent to which a landscape management plan is successful depends on the ability of the practices chosen to retain soil, fertilizers and pesticides on the site and away from water resources throughout the entire year.

Table 1 Basic principles to reduce pollutant transport from landscaped areas

1	Minimize bare soil areas
2	Reduce water demand
3	Reduce extent of turf area—manage remaining turf for low-impact
4	Choose plants with sustainability in mind
5	Manage fertilizer and pesticide use wisely

Principle 1 Minimize bare soil areas

Bare soil areas are one source of solids that can be mobilized and carried downstream by rainfall. Minimizing bare soil areas makes it less likely that solid particles will be dislodged by rainfall. Some pointers on how to manage landscapes to minimize bare soil are given below.

a) Establish dense plantings of pest-resistant groundcover to shade out weeds. Some easy-care recommendations are rock rose (*Cistus* sp.), snowberry (*Symphoricarpus alba*), salal (*Gaultheria shallon*) and kinnickinick (*Arctostaphylos uva-ursi*).

b) If bare soil areas are required, as in plant beds or ball diamonds, surround the bare area with an area of grass or groundcover to filter out solids that may be picked up by stormwater runoff.

- The denser the grass or groundcover, the better it works to capture solids in runoff.
- Try to make the filtering area as level as possible. Avoid low spots, where runoff can concentrate and create channels.
- In general, filter areas should be about one-fourth as long (along the flow path) as the area contributing low, assuming that slopes are gentle (less than about 10 percent). For flat, level areas without dips, this length can be reduced.

c) Repair promptly bare patches in lawns or groundcovers that could contribute solids to stormwater runoff.

d) Don't place bark or loose mulch on slopes where it can be carried to stormdrains.

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Principle 2 Reduce water demand

Reducing the need for irrigation reduces the potential movement of pollutants, conserves water and saves money.

a) Use drought tolerant or native vegetation.

b) Install underground irrigation systems timed to water at night or drip irrigation systems.

c) Increase the organic content of soils to improve water-retention capability.

d) Allow for longer water retention by terracing sloped areas.

Principle 3 Reduce turf area and manage remaining turf for low-impact

Turf requires care to look good. In addition to mowing, turf areas typically require water, fertilizer and weed and disease control. However, some practices can reduce or minimize the amount of chemical controls needed.

a) Amend soil with organic matter to a depth of 8 -12 inches before the lawn is established. Till the organic matter into the native soil.

b) Decide if all lawn area needs the same level of upkeep: let some areas have a less formal look if possible, and reduce fertilizer and pesticide use in those areas.

c) Rely on irrigation and lawn aeration as the primary tools to maintain healthy turf.

d) Remove thatch each year to increase water penetration to grass roots and reduce runoff.

e) Plant groundcovers rather than grass in shady areas. Turf grasses usually need at least partial sun to remain vigorous.

Principle 4 Choose plants with sustainability in mind

Plants differ in their ability to cope with different soils, rainfall conditions, pest and diseases and microclimates. Choosing resilient plant species, plants with adaptations for particular environments or creating optimal microenvironments are all techniques that can be used to create landscapes that require less intervention. Less watering and less need for pesticide and fertilizer application means less potential for pollutants to leave the site.

a) Choose disease resistant plants.

b) Choose drought-resistant groundcovers, shrubs and trees in areas with poor soil or little shading.

c) Group plants in clusters with tree, shrub and groundcover layers to create a better micro-environment and to supply organic matter back to the soil.

d) Include plants in the landscape that are important for beneficial insects such as parasitic wasps. If beneficial insects have nothing to sustain them, they won't stick around to control pests when you need them.

e) Use dense plantings or close spacing to shade out weeds rather than herbicides.

f) Use plants with fibrous roots on steep slope or erosion-prone areas. Some good choices include:
- New Zealand flax (*Phormium penax*)
- Ornamental grasses, lawn grasses
- Rock rose (*Cistus* sp.)
- Rosa rugosa
- Salmonberry (*Rubus spectabilis*) -- native

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- Snowberry (*Symphoricarpus alba*)-- native

g) Use wetland plants in areas with seeps or a high water table.

h) Attend to installation details. Write enforceable planting specifications that include details such as soil preparation, plant spacing, plant condition and size, planting depth, transplant handling and irrigation. Inspect the job during planting to prevent short cuts such as blowing the soil mixture around root balls rather than digging the roots into amended native soils.

Principle 5 Manage fertilizer and pesticide use wisely

Many landscape plants and turf simply won't do well without fertilization and some amount of pest management. It's therefore important for landscape management plans to address when and how these actions will be taken.

a) Keep plants healthy by building healthy soil using composted organic material. Healthy plants can better resist diseases and insect pests.

b) Tailor fertilizer make-up to lawn needs. Adjust application rate and timing of fertilizer applications to avoid carry-off in storm runoff.

c) Reduce the phosphorus (P) concentration in fertilizers when possible by using a low phosphorous formulation or formulations containing only nitrogen or potassium. Added phosphorus is often not needed for health foliage growth, only for encouraging profuse blooms.

d) Use an integrated pest management approach to control pests. Keep current about non-chemical controls as a first-defense against pests.

e) Encourage a diverse insect community in your landscape: Beneficial insects can help control pests, especially pests of trees and shrubs.

f) Target pesticide application to the specific pest of concern. Avoid pesticide "mixes" targeting generic problems (such as weed and feed) unless you actually need each of the formulations for a current problem.

g) Only apply pesticides during the life-stage when the pest is vulnerable.

h) Use fungicides very sparingly—they disrupt the base of aquatic food webs. If you need to use fungicides, spray formulations with faster break-down times. Consult a golf course management text for information on the attributes of various fungicides (and other pesticides). Balough and Walker, 1992, *Golf course management and construction* by Lewis Publishers is one source of information.

i) Tolerate some weeds.

References

"Weed management for lawns and gardens." Washington Toxics Coalition Fact Sheet, 1989.

"Least toxic lawn management." The BioIntegral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA 94707

Washington State Cooperative Extension publications on lawn care, Bulletin Office, Cooperative Extension, Cooper Publication Building, Washington State University, Pullman, WA 99164-5912

Selected tittles include: "Turf grass diseases" and supplement (EB0713 and EB0713S); "European crane fly"(EB0856); "Fertilizer guide: western Washington" (FG0041); "Disease control in home lawns" (EB0938); "Home lawns" (EB0482).

II PLAN IMPLEMENTATION

A landscape management plan, no matter how good, will not reduce pollutants in runoff if it is not implemented. And implementation often means that the plan needs to be modified over time, since as plants grow and as the cycle of pests change, the original plan may not fit the site. The following must be addressed before a landscape management plan can be approved.

1. Identify who will be responsible for assuring the management plan is carried out.
2. Identify how the applicant will assure that grounds crews or homeowners have the training and/or resources required to implement the plan and keep up to date on advances in landscape care practices and products.
3. Agree to keep records of fertilizer and pesticide application, including rate of application, area treated and disposal or storage of residue.
4. Agree to certify each year that the landscape management plan for the project in question has been carried out, and that needed amendments or updates have been made.
5. Provide the plan to County maintenance or inspection personnel on request
6. Agree to pay an annual fee (based on time expended) to allow the County to administer the certification process, including review of plans, tracking of information, periodic field inspections and sampling.

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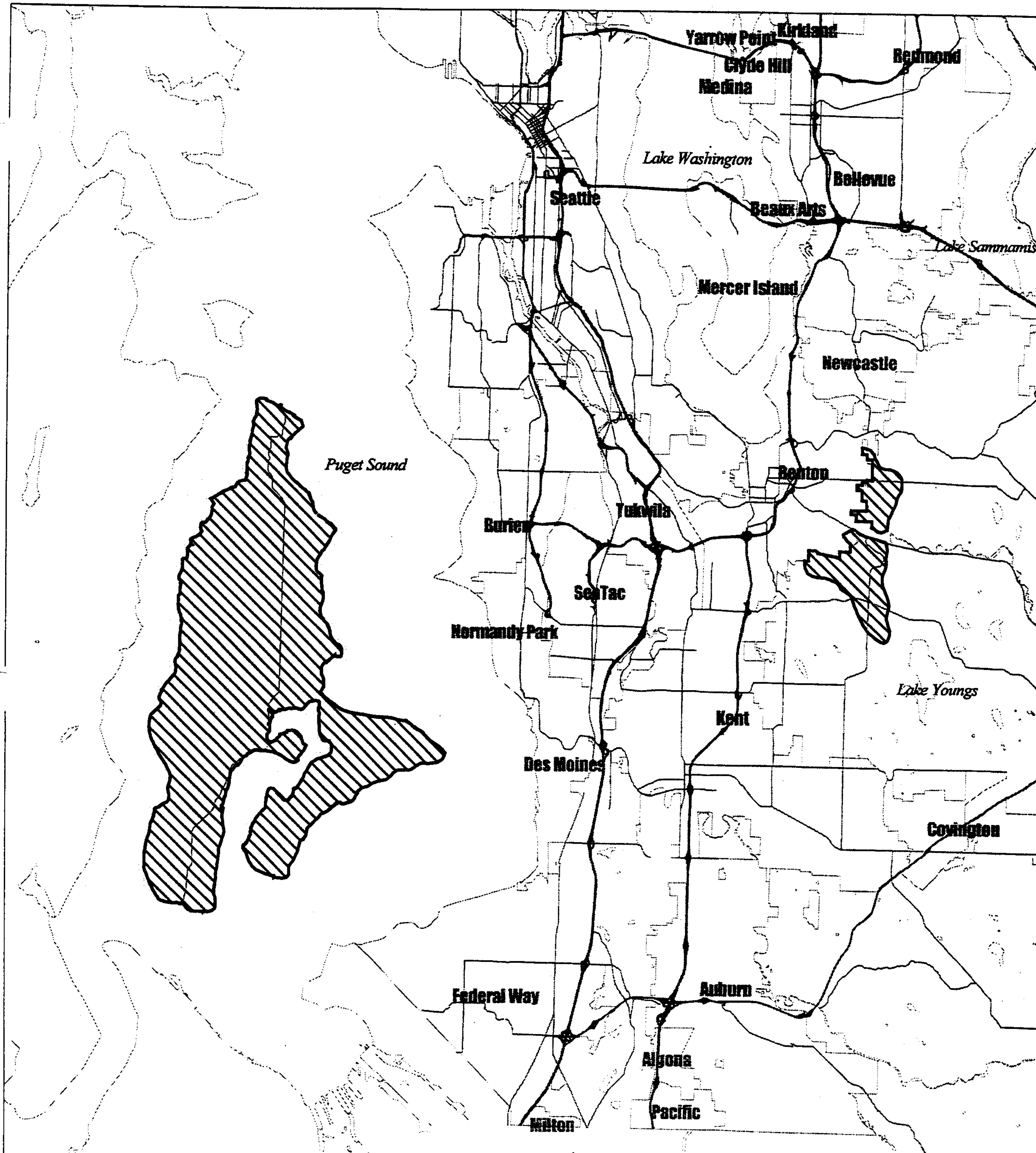

Sole Source Aquifers

Sole Source Aquifer

Cities

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2 0 2 Miles

N W E S

King County
DDES Department of Development and Environmental Services
Geographic Information System

This map is intended for planning purposes only and is not guaranteed to show accurate measurements.

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KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 5

BIBLIOGRAPHY OF SUPPORTING STUDIES AND RESEARCH

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BIBLIOGRAPHY OF SUPPORTING STUDIES & RESEARCH

Several studies, issue papers and reports were prepared by King County Surface Water Management (SWM) Division staff and consultants in support of the 1996 revisions to this manual. This section presents a bibliography of these documents which are available from the SWM Division.

FLOW CONTROL ISSUE PAPERS

Director's Briefing - Summary of Key Issues to the King County Surface Water Design Manual Update. Rick Schaefer, R.W. Beck and Associates; Linda Holden, Jeff Stern, King County Surface Water Management. September, 1993. Briefing paper presenting an overview of proposed changes in flow control, water quality and the review process. Each section establishes the need for a change, evaluates options for implementing the change, recommends an option, and discusses effects of the recommendation.

Comparison of Current and Proposed Detention Standards. Linda Holden, Jeff Stern, King County Surface Water Management. September, 1993. Comparison of current and proposed peak and duration standards, in terms of peak flow increases, flooding frequency, and impacts to resources.

Detention Issue Paper. Malcolm Leytham, Northwest Hydraulic Consultants; Linda Holden, Kelly Whiting, King County Surface Water Management. April, 1994. Provides an overview of proposed detention-related changes, including:

- comparison of alternative design techniques - Discusses advantages and disadvantages of various hydrological models including the "Y&W" method, SCS/SBUH 24-hour event method, SCS 7-day event method, HSPF Version 10, and HSPF Runoff Files.
- components of design - Discusses use of various models for design of conveyance systems, R/D facilities and other miscellaneous hydraulic structures, with emphasis on applicability of KCRTS.
- impact analysis - Presents impacts on detention sizing for several development case studies, comparing SBUH 24-hour method and KCRTS for a variety of detention performance standards.

The "Runoff Files" Implementation of HSPF. Malcolm Leytham, Northwest Hydraulic Consultants; Linda Holden, Kelly Whiting, King County Surface Water Management. April, 1994. Provides details on the Runoff Files method, including principles and background, application of runoff files for facility design, and responses to some common questions and concerns.

Retention/Detention Standards: Benefits and Limits in King County Basins. Rhett Jackson, Derek Booth, King County Surface Water Management. July, 1993. A discussion on the range of R/D standards available, the role of management objective and design methodology on their effectiveness, and fundamental limitations of onsite R/D on a basin-wide scale. Includes a comparison of KCRTS and SBUH standards and effectiveness.

Rationale For a "Threshold of Concern" in Stormwater Release Rates. Derek Booth, King County Surface Water Management. March, 1993. Discusses selection of "50% of the 2-year storm" as the lower threshold for duration control for stream protection detention standards.

A Comparison of 7-Day and 24-Hour Detention Pond Design Standards - The Consequences of Inadequate Detention. Rhett Jackson, King County Surface Water Management. August, 1992. A comparison of the effectiveness of 1990 Design Manual 24-hour SBUH ponds and SBUH 7-day ponds ("Barker method") as specified in the East Lake Sammamish Basin Plan, including effects on stream channels, water quality, stream and wetland habitats, and proposed capital improvement projects.

WATER QUALITY ISSUE PAPERS

Incentives analysis of five case studies. Gaynor Landscape Architechs/Designers, Inc. September, 1992. Five case studies exploring better ways to integrate stormwater facilities into sites--emphasis is on aesthetic enhancements.

The selection and sizing of treatment BMPs in new developments to achieve water quality objectives. 1993. Prepared by Gary Minton, Resource Planning Associates with the assistance of Herrera Environmental Consultants and R.W. Beck. A summary of the literature and some original analysis related to the size and performance of water quality facilities.

Water quality thresholds decision paper. Louise Kulzer, King County Surface Water Management, April 15, 1994. Explores the need to revise the 5,000 square pollution-generating impervious surface foot threshold used to trigger water quality facilities. Roof runoff quality explored. Summaries stormwater from a number of local studies in Table 1.

High use/ Oil control decision paper. Jennifer Gaus, King County Surface Water Management. October, 1994. Examines the intensity of vehicle use and other "high use" land uses which would generate a concentration of oil in stormwater treatable via oil/water separators. Based on assumptions of uniform oil loss per vehicle. Redevelopment water quality controls also discussed. Identifies land use types affected and benefits of better oil control.

Water quality credits decision paper. Sheryl Corrigan, John Heal, Louise Kulzer. King County Surface Water Management. November, 1994. Identifies actions that reduce pollutant loading and presents example cases to show effect of source reduction versus stormwater treatment on annual phosphorus loading.

WATER QUALITY BENCH TESTS & MODELING STUDIES

Oil leachate tests for various adsorbant filter media. Randy Brake, King County Surface Water Management. May, 1994. Presents results of bench tests exploring the release of oil into water from six oil absorbant media once oil saturated. Developed a standardized testing protocol.

Infiltration and pollutant removal characteristics of a proposed sand filter configuration. John Koon, King County Surface Water Management. May 1994. DRAFT, revision write-up expected November 1995. Presents results of infiltration plugging potential and pollutant removal (TSS, turbidity & TP) from sand column tests using mortar sand. Silty alluvial Duwamish valley sediments used to determine plugging potential.

Sand Filter sizing and costing. Linda Holden, King County Surface Water Management. May, 1995. Extensive exploration of the effect of various sand filter design parameters and criteria on facility size using the KCRTS model. Summary of options & recommendation, supported by spreadsheets detailing results of various options.

Infiltration, hydraulic conductivity and pollutant removal characteristics of sand filter materials. John Koon, King County Surface Water Management, March, 1995. Field Notes. Report expected November, 1995. Sand column tests expanded and modified to determine hydraulic conductivity in addition to infiltration rate. Pollutant removal (TSS, turbidity, TP) of various fast and slow draining sands.

Sand filter sand specifications. John Koon, King County Surface Water Management. June 16, 1995 Memo to Louise Kulzer. Documents sand mixes examined and logic for the sand specification recommended, including vendor availability.

OTHER ISSUE PAPERS AND STUDIES

King County Surface Water Design Manual Update - Cost Analysis. Bruce Johnson, King County Surface Water Management. December, 1995. Assessment of costs associated with proposed flow control and water quality changes.

Infiltration Issue Paper. Steve Foley, King County Surface Water Management. April, 1994. Summarizes and discusses recent changes to portions of the manual dealing with infiltration, including revisions intended to increase the use of infiltration, provide increased water quality protection, and improve the functioning of infiltration facilities.

Temporary Erosion and Sedimentation Control Decision Paper. Thor Tyson, King County Surface Water Management. November, 1993. Discussion and recommendations on recently implemented TESC issues, including maintenance standards,

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TESC contact persons, wet season requirements and extensions, performance standards, stream and wetland protection and BMP revisions.

Summary of Proposed Changes to the Variance Process. Amy Carlson, Don Althauser, King County Surface Water Management. February, 1994. Discussion of changes proposed to the variance process with the goals of increasing flexibility and predictability and reducing review time and costs.

Shared Surface Water Facilities. Matrix Management Group. May, 1994. Outlines a proposal to provide developers with the option of constructing shared surface water detention and treatment facilities as an alternative to currently required on-site facilities, including a discussion on financing options.

Application of Surface Water Control to Roadways. Rick Schaefer, R.W. Beck and Associates. December, 1992. Identifies provisions of the current Design Manual that fail to address design challenges inherent in linear (roadway) projects, and recommends alternative methods of surface water quantity and quality control.

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SURFACE WATER DESIGN MANUAL

REFERENCE 6

HYDROLOGIC/HYDRAULIC DESIGN METHODS

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REFERENCE 6-A

FALLING HEAD PERCOLATION TEST PROCEDURE

Source: EPA, Onsite Wastewater Treatment and Disposal Systems, 1980.

Number and Location of Tests

A minimum of three tests shall be performed within the area proposed for an absorption system. They shall be spaced uniformly throughout the area. If soil conditions are highly variable, more tests may be required.

Preparation of Test Hole

The diameter of each test hole is 6 inches, dug or bored to the proposed depths of the absorption systems or to the most limiting soil horizon. To expose a natural soil surface, the sides of the hole are scratched with a sharp pointed instrument and the loose material is removed from the bottom of the test hole. Two inches of ½- to ¾-inch rock are placed in the hole to protect the bottom from scouring when the water is added.

Soaking Period

The hole is carefully filled with at least 12 inches of clear water. The depth of water should be maintained for at least 4 hours and preferably overnight if clay soils are present. A funnel with an attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons or float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

In sandy soils with little or no clay, soaking is not necessary. If, after filling the hole twice with 12 inches of water, the water seeps completely away in less than ten minutes, the test can proceed immediately.

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Measurement of the Percolation Rate

Except for sandy soils, percolation rate measurements are made 15 hours but no more than 30 hours after the soaking period began. Any soil that sloughed in to the hole during the soaking period is removed and the water level is adjusted to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6 inches above the gravel.

Immediately after adjustment, the water level is measured from a fixed reference point to the nearest 1/16th inch at 30-minute intervals. The test is continued until two successive water level drops do not vary by more than 1/16 inch within a 90-minute period.

After each measurement, the water level is readjusted to the 6-inch level. The last water level drop is used to calculate the percolation rate.

In sandy soils or soils in which the first 6-inch of water added after the soaking period seeps away in less than 30 minutes, water level measurements are made at 10-minute intervals for a 1-hour period. The last water level drop is used to calculate the percolation rate.

Calculation of the Percolation Rate

The percolation rate is calculated for each test hole by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in terms of minutes/inch. To determine the percolation rate for the area, the rates obtained from each hole are averaged. (If tests in the area vary by more than 20 minutes/inch, variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.)

Example: If the last measured drop in water level after 30 minutes is 5/8-inch, then:

Percolation rate = (30 minutes)/(5/8 inch) = 48 minutes/inch.

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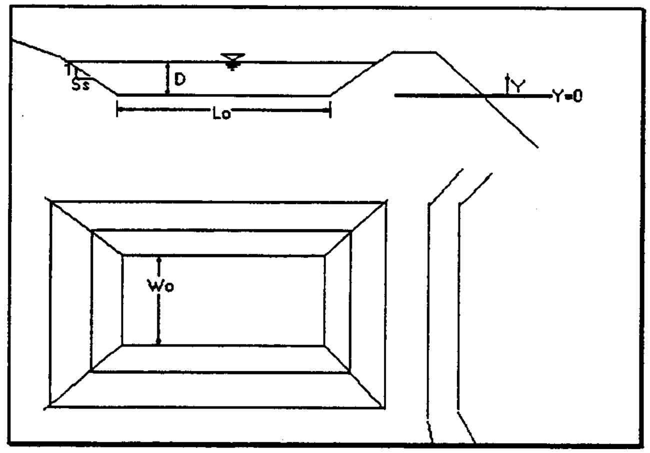
Reference Section 6-B

Pond Geometry Calculations



<Known>

Volume	(V)
Pond Depth	(D)
Side Slope	(S_S)
Length-to-Width Ratio	(R)

<Find>

Bottom Area of Rectangular Pond

<Solution>

Y = depth of section measured from bottom, from zero to D
W_0= width at pond bottom

The pond width (W) at any depth, Y

$$W_Y = W_0 + 2S_S Y \qquad \text{Eq. 1}$$

The pond length (L) at any depth, Y

$$L_Y = RW_0 + 2S_S Y \qquad \text{Eq. 2}$$

The pond area at any depth, Y

$$A_Y = L_Y W_Y = (RW_0 + 2S_S Y)(W_0 + 2S_S Y) \qquad \text{Eq. 3}$$

or,

$$A_Y = RW_0^2 + (R+1)2W_0 S_S Y + 4S_S^2 Y^2 \qquad \text{Eq. 4}$$

The equation for the pond-full volume (V) is obtained by integrating between Y=0 and Y=D

$$V = \int_0^D \left(RW_0^2 + (R+1)2W_0 S_S Y + 4S_S^2 Y^2\right) dY \qquad \text{Eq. 5}$$

or,

$$V = \left[RW_0^2 Y + (R+1)W_0 S_S Y^2 + \frac{4}{3} S_S^2 Y^3 \right]\Bigg|_0^D \qquad \text{Eq. 6}$$

or,

$$V = RDW_0^2 + S_S D^2 (R+1)W_0 + \frac{4}{3} S_S^2 D^3 \qquad \text{Eq. 7}$$

Where

V =	Volume of rectangular pond	R =	Length-to-width ratio
D =	Depth	Ss =	Side Slope
W_0 =	Bottom width		

Rearrange equation to solve for W_0 using quadratic equation, $0 = ax^2 + bx + c$

$$0 = RDW_0^2 + S_S D^2 (R+1)W_0 + \frac{4}{3} S_S^2 D^3 - V \qquad \text{Eq. 8}$$

Use Quadratic Equation to solve for positive solution of W_0, $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$$W_0 = \frac{-S_S D^2 (R+1) \pm \sqrt{\left[S_S D^2 (R+1)\right]^2 - 4RD\left(\frac{4}{3} S_S^2 D^3 - V\right)}}{2RD} \qquad \text{Eq. 9}$$

Use Equation 2 for Length of pond at Y=0,
$L_0 = RW_0$

Use Equation 3 for Area of pond at Y=0,
$A_O = L_0 W_0 = RW_0^2$

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REFERENCE 7
ENGINEERING PLAN SUPPORT

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TEXT/DIMENSIONS/SYMBOLS

PLAN/DETAIL VIEW:

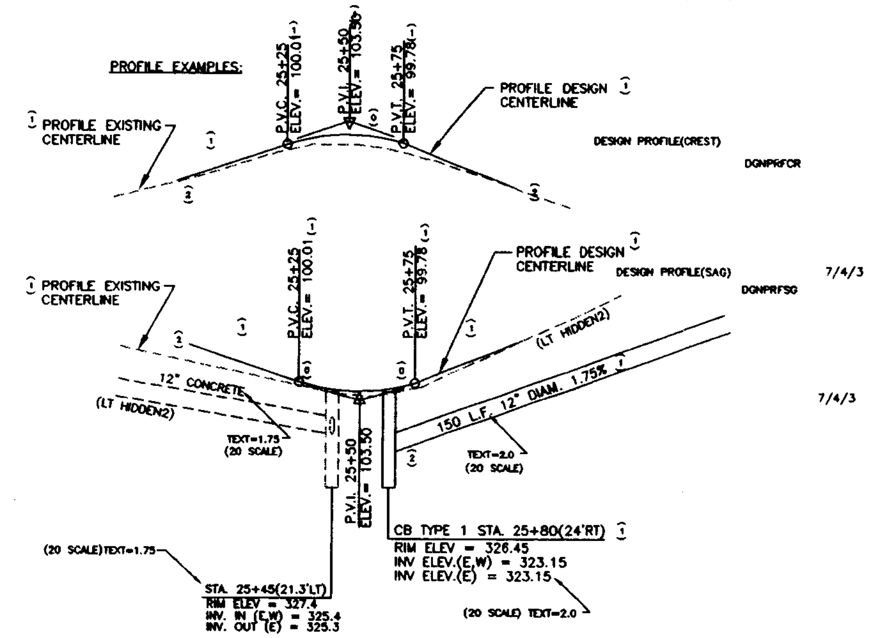
TEXT	DESCRIPTION (ABBR)	BLOCK	COLOR
STA. XXX BEGIN PROJECT	BEGINNING OF PROJECT TEXT(STYLE BOLD)=4.5	BEGPRO	/7
STA. XXX END PROJECT	END OF PROJECT TEXT(STYLE BOLD=4.5	ENDPRO	/7
P.C. STA. 55+65.37(21'RT) BEGIN SIDEWALK / STA. XX+XX.XX(XX'RT) RELOCATE POWER POLE (BY OTHERS)	PROPOSED PROJECT CALL OUTS TEXT SIZE = 2' AT 20 SCALE NOTE ARROW SIZE: 3.6' AT 20 SCALE 1ST LINE IS DEFINED LOCATION (NOTE IF P.C., P.T., INT., ETC.)	CALLOUT / CALLOUT2	2/3/7 / 2/3/7
50'	TYPICAL DIMENSION LINE W/ARROWS DO NOT USE DIM LINES UNLESS THERE ARE MULTIPLE DIMENSIONS IN AN AREA. NOTE ARROW SIZE: 3.6' AT 20 SCALE	NO BLOCK	3/7/2
N.E. 175 ST.	ROAD-STREET NAMES IN BOLD TEXT(STYLE BOLD)=5 (PRIMARY CONSTRUCTION ROAD)	MAINST	/7
AVONDALE AVE. N.	SECONDARY ROADS ALONG PROJECT TEXT(BOLD)=4	2NDARYST	/7
CALL 2 DAYS BEFORE YOU DIG 1-800-424-5555 (UNDERGROUND UTILITY LOCATIONS ARE APPROX.)	GENERAL NOTE ON ALL SHEETS (N.T.S.)	B4UDIG	/7
9-1992-015-00	R/W CODE	RWCODE(ATTRIB.)	10/10
	TAX LOT / PARCEL NUMBER	STLN	/7
C/L	CENTERLINE	C/L	/7
GRAVEL D/W	DESCRIPTION OF EXISTING ITEMS TEXT SIZE = 1.75 AT 20 SCALE	NO BLOCK	/8
N 87°13'44" E	BEARINGS EXISTING TEXT SIZE = 2.0 AT 20 SCALE	BEARNG	7
N 87°13'44" E	BEARINGS PROPOSED TEXT SIZE = 2.25 AT 20 SCALE	BEARNGP	7
HOUSING DIVISION/PLAT	TEXT(STYLE SHADOW)=3.5	HOUSE-DIV	2
SEC 25, T26 N, R5 E, WM	SECTION, TOWNSHIP, RANGE STYLE(ROMAND) SIZE 5	STR	4
SE 4 NW 4	QUARTER SECTION STYLE(ROMAND) ALPHAS SIZE 3 STYLE(ROMAND) NUMBERS SIZE 2	QSEC	7/3
CITY OF PACIFIC	TEXT(STYLE TECHNIC)=6	CITYNAME	2
DETAIL TITLE / STA. XX+XX.XX TO STA. XX+XX.XX N.T.S.	TITLE(BOLD)=5 TEXT= STA.00+00(ROMANS)=2.5	DETITLE	/7
SURVEY C/L CURVE DATA Δ = 88°22'01" R = 30.00 L = 46.27 PI = STA. XXX	CURVE DATA ALONG CENTERLINE CURVES. border /4 text /7	CURVDATA	4/7
P.T. CURB STA. 58+73.25(24'RT) BEGIN SIDEWALK / CURB RETURN DATA Δ = 88°22'01" R = 30.00 L = 46.27	CURB RETURN DATA border /4 text /7 (2.0 AT 20 SCALE)	CURBDATA	4/7

FACE OF CURB = COLOR 2
BACK OF CURB = COLOR 7
R=30

PROFILE VIEW:

TEXT	DESCRIPTION	BLOCK	COLOR
EXIST. DWY. ASPH. ON LT. +50 / EXIST. DWY. ASPH. ON RT. +50	DRIVEWAY CALL (PLUS SIGN ON STATION) TEXT=2 / STATION LOCATION	DWCALL_L/DWCALL_R	3/7
+00 ROADWAY SECTION X CLEARING AND GRUBBING - LUMP SUM +00 (TEXT=2)		STRCALLB	3/7
+00 85 L.F. CONCRETE CURB & GUTTER +85 (TEXT=2)		STRCALLL	3/7
+00 85 L.F. GUARD RAIL +85 (TEXT=2)		STRCALLR	3/7
MATCHLINE STA. 25+00 (TEXT=3) PLAN SHEET MATCHLINE STA. 25+00 (TEXT=3)	SHEET MATCHLINES(TEXT=3)	MATCHL/MATCHR (BLOCKS)	/4
325 320 315 310 PROFILE ELEV. TEXT=2.5; BEGIN PROJECT STA. 85+00 (TEXT=3) PROFILE AREA END PROJECT STA. 92+00 (TEXT=3); 85 92 PROFILE STATIONING TEXT=2.5		BEGPROPR/ENDPROPR	/4

PROFILE EXAMPLES:



TEXT	DESCRIPTION	BLOCK	COLOR
PROPOSED = C.B. TYPE X STA. XX+XX(XX'RT) RIM ELEV. XXX.XX INV. ELEV.(N,S) = XXX.XX INV. ELEV.(E) = XXX.XX	STORM DRAINAGE STRUCTURE NOTE IN PROFILE (EXISTING/PROPOSED) DEPENDING ON LINE WT. TEXT(2.0) AT 20 SCALE LINES (PROPOSED)	SDNOTE_P	7/7
EXISTING = STA. XX+XX(XX'RT) RIM ELEV. XXX.XX INV. ELEV.(N,S) = XXX.XX INV. ELEV.(E) = XXX.XX	STORM DRAINAGE STRUCTURE NOTE IN PROFILE 0000TEXT(1.75) AT 20 SCALE 0000LINES (EXISTING)	SDNOTE_E	10/10

CATCH BASIN PROFILE BLOCKS:

DESC:	CB (EX) TYPE 1	CB (PROP) TYPE 1	CB (EX) TYPE 1-L	CB (PROP) TYPE 1-L	CB (EX) TYPE 2(48)	CB (PROP) TYPE 2(48)	CB (EX) TYPE 2(54)	CB (PROP) TYPE 2(54)	CB (EX) TYPE 2(60)	CB (PROP) TYPE 2(60)	CB (EX) TYPE 2(72)	CB (PROP) TYPE 2(72)	CB (EX) TYPE 2(96)	CB (PROP) TYPE 2(96)	INLET (EX)	INLET (PROP)
BLOCK NAMES:	CB1XPR	CB1PPR	CB1LXPR	CB1LPPR	CB2X48	CB2P48	CB2X54	CB2P54	CB2X60	CB2P60	CB2X72	CB2P72	CB2X96	CB2P96	INLETX	INLETP

THIS IS NOT INTENDED TO REPLACE APWA OR KC RDSTNDS.

LINETYPES

SURFACE FEATURES:

EXISTING FEATURE LINETYPES	DESCRIPTION	COLOR	LTYPE
	BUILDING FOOTPRINT (EXIST.)	/8	DASHED2
	STREAMBED/WATER CHANNEL	/8	DITCH
	WATER COURSE FLOWLINE (ARROWS EVERY 25')	/8	DITCH (W/BLOCK)
	FENCE (BLOCK EVERY 10')	/8	CONT. (W/BLOCK)
	GUARDRAIL (EXISTING) (BLOCK EVERY 10')	/8	CONT. (W/BLOCK)
	LAKE/POND/SHORELINE	/8	LAKE
INTERIOR EXTERIOR	WETLAND PERIMETER (DELINEATED BY BIOLOGIST) BLOCK EVERY 10'	/8	CONT. (W/BLOCK)
INTERIOR EXTERIOR	STREAM PERIMETER (DELINEATED BY BIOLOGIST) BLOCK EVERY 10'	/8	CONT. (W/BLOCK)
	RR 100 SCALE OR SMALLER(EX.) (BLOCK EVERY 10')	/8	SPECIAL
	RR 200 SCALE OR LARGER(EX.) (BLOCK EVERY 10')	/8	CONT. (W/BLOCK)
	RETAINING WALL (EXISTING)	/8	SPECIAL
EDGE OF PAVEMENT	CURB/PAVEMENT/SIDEWALK (EX) (TEXT SIZE 1.75)	/8	HIDDEN2
EDGE OF GRAVEL SHOULDER	SHOULDER (EX) (TEXT SIZE 1.75)	/8	HIDDEN
PFL/ PAINTED C/L	PAINTED FOG LINE/CENTERLINE (TEXT SIZE 1.75)	/10	SH-DASH
	CONTOUR (DEPRESSION) (BLOCK EVERY 2')	/8	CONT. (W/BLOCK)
	CONTOUR (INTERVAL) (EXIST.)	/8	CONT.
560	CONTOUR (INDEX) (EXIST.) (TEXT SIZE 1.75) ***	/9	CONT. (W/BLOCK)
TOE/TOP	GRADE BREAK	/10	CONT.

*** INSERT ELEVATION AT 120' INTERVALS [TEXT (EXIST. 1.75')(PROP. 2') HIGH]

DESIGN FEATURE LINETYPES	DESCRIPTION	COLOR	LTYPE
	BUILDING LINE (PROPOSED)	/4	CONT
	FLAT BOTTOM SWALE	/7	DITCH
	CREEK/DITCH CENTERLINE (PROP.)	/4	DITCH (W/BLOCK)
	FENCE (BLOCK EVERY 10')	/7	CONT. (W/BLOCK)
DRAW TO SCALE	GUARDRAIL (BLOCK EVERY 10')	/4	CONT. (W/BLOCK)
	LAKE/POND	/7	LAKE
FACE / BACK	CURB (PROPOSED)	2/7	CONT.
	RETAINING WALL (PROPOSED)	/4	SPECIAL
EDGE OF PAVEMENT	EDGE PAVEMENT	/4	CONT.
EDGE A.C. SHOULDER	EDGE A.C. SHOULDER	/4	CONT.
EDGE OF GRAVEL SHOULDER	EDGE OF GRAVEL SHOULDER	/4	CONT.
EDGE OF CONC./A.C. SIDEWALK	SIDEWALK (PROP)	/4	CONT.
	CONTOUR (INTERVAL)(PROPOSED)	/7	CONT.
560	CONTOUR (INDEX) (PROPOSED) (TEXT SIZE 2.0) ***	/4	CONT.
GRADING LIMITS	CUT/FILL LINE (LIMITS OF GRADING)	/7	CONT.
C X' F	OPTIONAL CUT-FILL LINE(SEE FEATURES) X = DISTANCE IN FEET BEYOND R/W	/3	CONT.

SURVEY:

FEATURE LINETYPES	DESCRIPTION	COLOR	LTYPE
SURVEY C/L	SURVEY CENTERLINE (TEXT SIZE 2) (WHEN CONGRUENT WITH R/W C/L)	/6	CONTINUOUS
SURVEY C/L	SURVEY CENTERLINE (TEXT SIZE 2) (WHEN VARIES FROM R/W C/L)	/2	CENTER
R/W C/L	RIGHT OF WAY C/L (TEXT SIZE 2)	/5	CONT.
CONSTRUCTION C/L	CONSTRUCTION C/L (TEXT SIZE 2)	/6	CENTER
DRAINAGE/UTILITY EASEMENT	EASEMENT (PERMANENT) (TEXT SIZE 2)	/4	DASHED2
TEMPORARY CONST. EASEMENT	EASEMENT (TEMPORARY) (TEXT SIZE 2)	/4	DASHED2
	PROPERTY LINE (EXISTING)	/2	PROPERT
	PROPERTY LINE (PROPOSED)	/7	CONT.
	RESERVATION/PARK/FOREST (EX)	/4	PARK
R/W	RIGHT-OF-WAY (CURRENT) (TEXT SIZE 2)	/5	CONT.
PROPOSED R/W	RIGHT-OF-WAY (PROPOSED) (TEXT SIZE 2)	/5	CONT.
PREVIOUS R/W	R/W(REVISIONS SHOWN DURING DESIGN REVIEW ONLY)	/5	DASHED2
	RIGHT-OF-WAY (LIMITED ACCESS) COINCIDENTAL (BLOCK EVERY 2')	7/5	CONT. (W/BLOCK)
	CITY-LIMITS (BLOCK EVERY 5')	/4	CONT. (W/BLOCK)
T.26 N. / T.25 N.	RANGE/TOWNSHIP LINE (TEXT SIZE 2)	/6	CONT.
SECTION LINE N 88°57'32" E	SECTION LINE (TEXT SIZE 2)	/5	SECT
1/4 SECTION LINE S 89°06'58" W	QUARTER SECTION LINE (TEXT SIZE 2)	/5	QTRSECT
1/16 SECTION LINE N 89°54'38" E	SIXTEENTH SECTION LINE (TEXT SIZE 2)	/4	16THSECT
	STATE/COUNTY/CORPORATE LIMIT (LINE WIDTH 1.1')	/5	STATE
	MEANDER LINE	/3	MEANDER

UTILITIES (EXISTING):

EXISTING FEATURE LINETYPES	DESCRIPTION	COLOR	LTYPE
TV	CABLE TELEVISION (BURIED)	/8	CONT.
FM	FORCE MAIN	/8	CONT.
G	GAS	/8	CONT.
O	OIL	/8	CONT.
P	POWER (BURIED)	/8	CONT.
SS	SANITARY SEWER	/8	CONT.
T	TELEPHONE (BURIED)	/8	CONT.
	UTILITY SERVICE LINE (GENERAL)	/8	SERV
6"W	WATER	/8	CONT.
6"G	GAS	/8	CONT.
12"	STORM DRAIN/CULVERT (LABEL IF NOT SHOWN ON PROFILE)	/8	SERV

EXISTING UTILITIES-INSERT TEXT AT 80' INTERVALS (TEXT 1.75' HIGH)
PROPOSED UTILITIES-INSERT TEXT AT 80' INTERVALS (TEXT 2' HIGH)

NOTES:

1. PRINT APWADOC2.DOC FOR MORE INFORMATION ON SYMBOL/LINETYPE INSERTION AND USE OF APWA MENUS.
2. INSERT MON OR MON-IN-CASE SYMBOLS INTO CENTER OF MONUMENTED SECTION CORNERS.
3. USE WATER VALVE AND FITTING SYMBOLS FOR SEWER FORCEMAIN VALVES AND FITTINGS.
4. LINETYPES ARE LOADED FROM THE APWALIN2.LIN LINETYPE FILE.
5. DITCH LINETYPE FLOW DIRECTION ARROW MUST BE INSERTED AT ENDS OF DASHED LINES AS SHOWN ABOVE (BLOCK NAME IS "FL").
6. COMPOSITE LINETYPES ARE DRAWN USING LISP ROUTINES IN APWA MENUS. ALTERNATE METHOD IS TO INSERT BLOCKS OR TEXT ALONG CONTINUOUS LINES USING A MEASURE COMMAND AND MANUALLY BREAK THE LINE AROUND THE TEXT.
7. LINEWEIGHTS ARE BASED ON STANDARD TECHNICAL PENS
8. EXISTING SYMBOLS ARE SHOWN AS SCREENED. IF SCREENING ISN'T AVAILABLE, SUCH AS PEN PLOTTERS, USE A 00 PEN AND SHORT DASHES.
9. WHEN DEVELOPING AUTOCAD FILES USE THE DVIEW COMMAND (NOT UCS) TO ROTATE DISPLAY FITTING BORDER SHEETS AROUND PLAN. THIS WILL INSURE THE ABILITY TO SHARE COMMON COORDINATES AMONG THE DEPARTMENTS. RESET CROSSHAIRS WITH THE SNAP R COMMAND.
10. 0 IS A SYMBOL FOR LINE WEIGHT.
11. ANY PROPOSED ITEM OTHER THAN DRAINAGE MUST BE DEFINED AND LOCATED. LOCATION - IS A STATION ALONG THE BASELINE AND A OFFSET LEFT & RIGHT. STA 50+43(15'RT) DEFINITION - IS WHAT THE ITEM IS.(CURB, SIDEWALK, SHOULDER, GUARDRAIL, ETC.) AN ITEM IS ALSO A GEOMETRIC POINT.(P.C., INT. A.P., ETC.)
12. USING LEFT AND RIGHT ON PLAN AND PROFILE (12'RT) OR (LT)
13. ALL EXISITNG TEXT IS 1.75

SCALE:

THIS SHEET IS BASED ON TEXT AND SYMBOL SIZE OF A 20 SCALE DRAWING (SYMBOL X 20). FACTOR THE SIZES FOR THE REQUIRED DRAWING SCALE. (i.e.: 50 SCALE = SYMBOL X 50)

FACTORS:

MOST SYMBOLS ARE SET AT A 1:1 SCALE.
SOME KING CO. SYMBOLS THAT ARE TEXT BLOCKS ARE SET AT 20 SCALE. FOR 50 SCALE = (BLOCK) OR (TEXT) x 2.5

TEXT STYLES(ACAD):

ROMANS	SHADOW
ROMAND TECHNIC	BOLD

AR 032349

FIELD BOOK		BR	7/18/96
SURVEYED		BR	3/26/96
SURVEY BASE MAP			
DESIGN ENTERED			
DESIGNED			
CHECKED			
DATE	REVISION	BY	DATE

CONSULTANT ENGINEER'S STAMP

CONSULTANT ENGINEER'S STAMP

FED. AID No. ______
PROJECT No. ______
SURVEY No. ______
MAINTENANCE DIVISION No. ______

COUNTY ENGINEER'S STAMP (JESSE KRAIL) FOR COUNTY ROAD ENGINEER

ROADS OR TRAFFIC MANAGER'S STAMP (MIKE GILLESPIE OR NORTON POSEY)

KING COUNTY DEPT. OF TRANSPORTATION
PAUL TOLIVER, DIRECTOR

STANDARD TEXT AND LINETYPES

REVISED 7/18/96

SHEET 1 OF 2 SHEETS

XXX-X(X)

DRAINAGE

DESCRIPTION	(ABBR)	BLOCK	COLOR
SAN. SEWER CLEAN OUT	(CO)	SSCO/SSCOP	E8/P7
SAN. SEWER MANHOLE	(SSMH)	SSMH/SSMHP	E8/P7
STORM DRAIN CATCH BASIN	(CB)	SDCB/SDCBP	E8/P7
STORM DRAIN INLET(NO CATCH)	(CI)		E8/P7
STORM DRAIN CULVERT	(CULV)		E8/P7
STORM DRAIN MANHOLE	(SDMH)	SDMH/SDMHP	E8/P7
25 L.F. 12" — STORM PIPE(PROPOSED) DOUBLE LINE TO SIZE OF PIPE DIAMETER (TEXT / 2 / PIPE)			

WATER

DESCRIPTION	(ABBR)	BLOCK	COLOR
CAP/PLUG		WCAP	E8/P3
COUPLING	(CPL)	WCOUP/WCOUPP	E8/P3
GUARD POST	(GP)	WGP/WGPP	E8/P3
REDUCER	(RED)	WRED/WREDP	E8/P3
THRUST BLOCK	(TB)	WTB/WTBP	E8/P3
WATER METER	(WM)	WMET/WMETP	E8/P3
FIRE HYDRANTS:			
2-NOZZLE	(FH)	WFH2/WFH2P	E8/P3
3-NOZZLE	(FH)	WFH3/WFH3P	E8/P3
JOINTS:			
FLANGE/BLIND FL	(FL)	WFL	E8/P3
MECHANICAL	(BL FL) (MJ)	WMJ	E8/P3
PUSH-ON/HUB		WHUB	E8/P3
THREAD	(THD)	WTH	E8/P3
VALVES:			
AIR RELIEF	(AIR)	WARV/WARVP	E8/P3
BLOW-OFF	(BO)	WBOV/WBOVP	E8/P3
BUTTERFLY	(BF)	WBFV/WBFVP	E8/P3
CHECK	(CK)	WCKV/WCKVP	E8/P3
GATE/GENERAL	(WV)	WGV/WGVP	E8/P3
PLUG VALVE	(PV)	WPV/WPVP	E8/P3

GAS/POWER/TELEPHONE

DESCRIPTION	(ABBR)	BLOCK	COLOR
GAS METER	(GM)	GMET/GMETP	E8/P3
GAS VALVE	(GV)	GV/GVP	E8/P3
PAD MOUNTED TRANSFORMER	(P TRAN)	PTRAN/PTRANP	E8/P7
POWER VAULT	(POW V)	PV/PVP	E8/P7
TRANSMISSION TOWER (SCALEABLE)	(TRANS TWR)	PTWR	E8/P3
UTILITY POLE	(PP, TP)	UP/UPP	E8/P3
POWER POLE	(PP)	KPP	E8/P7
UTILITY POLE ANCHOR		UPA/UPAP	E8/P3
TELEPHONE RISER	(TEL R)	TELR/TELRP	E8/P3
TELEPHONE VAULT	(TEL V)	TV/TVP	E8/P7

SURVEY

DESCRIPTION	(ABBR)	BLOCK	COLOR
ANGLE POINT	(AP)	SAP/SAPP	E8/P3
BENCH MARK	(BM)	SBM/SBMP	E8/P3
BLOCK CORNER	(BC)	SBC/SBCP	E8/P3
IRON PIPE	(IP)	SIP/SIPP	E8/P3
MONUMENT (IN CASE)	(MC)	SMC/SMCP	E8/P3
MONUMENT (SURFACE)	(MON)	SMON/SMONP	E8/P3
OWNERSHIP TIE	(OT)	SOT	E7
SECTION CENTER		SSCT	E7
SECTION CORNER		SSC/SSCP	E8/P3
QUARTER CORNER		SQC/SQCP	E8/P3
SIXTEENTH CORNER		SSXC/SSXCP	E8/P3
CLOSING CORNER		SCC/SCCP	E8/P3
MEANDER CORNER	(MC)	SMC/SMCP	E8/P3
WITNESS CORNER	(WC)	SWC/SWCP	E8/P3
SOIL BORING	(SB)	SSB/SSBP	E8/P3
SPOT ELEVATION	(SE)	SSE/SSEP	E8/P3
TAX LOT / PARCEL NUMBER		STLN	P7
INTERSTATE		I-5SYM	P7

CHANNELIZATION

DESCRIPTION	(ABBR)	BLOCK	COLOR
BIKE PATH		CB/CBP	E8/P2
HANDICAP		CHS/CHSP	E8/P2
H.O.V. LANE		CHOV/CHOVP	E8/P2
ONLY		CO/COP	E8/P2
RR CROSSING		CRR/CRRP	E8/P2
SCHOOL		CSC/CSCP	E8/P2
STOP		CS/CSP	E8/P2
LANE CONTROL ARROWS:			
STRAIGHT		CSA/CSAP	E8/P2
LT.RT.STR		CLRS/CLRSP	E8/P2
LEFT-RIGHT		CLR/CLRP	E8/P2
LEFT TURN		CLT/CLTP	E8/P2
RIGHT TURN		CRT/CRTP	E8/P2
LEFT-STRAIGHT		CLS/CLSP	E8/P2
RIGHT-STRAIGHT		CRS/CRSP	E8/P2
RAISED MARKERS-STRIPING:			
MARKERS TYPE I		CLM1/CLM1P	E8/P2
MARKERS TYPE II		CLM2/CLM2P	E8/P2
CROSSWALK 1' LINE			E8/P2
SOLID STRIPE 0.5' LINE			E8/P2
SKIP STRIPE 0.5' LINE			

SURFACE FEATURES

DESCRIPTION	(ABBR)	BLOCK	COLOR
BUS STOP		SFBS/SFBSP	E8/P7
MAIL BOX		SFMB/SFMBP	E8/P7
RIP RAP		SFRR/SFRRP	E8/P7
ROCK FACING		SFR/SFRP	E8/P7
SHRUB		SFS/SFSP	E8/P7
GENERAL SIGN		SFSN/SFSNP	E8/P7
REGULATORY SIGN		RSN/RSNP	E8/P7
TREE (Conifer)		SFC/SFCP	E8/P7
TREE (Deciduous)		SFD/SFDP	E8/P7
YARD LIGHT		SFL/SFLP	E8/P7
EXISTING BRIGDE/TUNNEL (SCALEABLE)			E8/P4
PROPOSED BRIDGE/TUNNEL (SCALEABLE)			E8/P4

SIGNALIZATION

DESCRIPTION	(ABBR)	BLOCK	COLOR
AERIAL DISCONNECT		TAD/TADP	E8/P3
AERIAL TERMINAL COMPARTMENT		TATC/TATCP	E8/P3
DETECTORS:			
DIPOLE DETECTOR		TDD/TDDP	E8/P7
QUADRAPOLE DETECTOR		TQD/TQDP	E8/P7
PEDESTRIAN DETECTOR		TPD/TPDP	E8/P7
EMERGENCY VEHICLE INDICATOR LIGHTS:			
INDICATOR LIGHTS		TIL/TILP	E8/P7
OPTICOM SENSOR		TOS/TOSP	E8/P7
OPTICOM SENSOR W/ INDICATOR LIGHTS		TOSL/TOSLP	E8/P7
FLASHING WARNING SYSTEM		TFWS/TFWSP	E8/P7
JUNCTION BOX (TYPE I, II, III)		TJB1/TJB1P TJB2/TJB2P TJB3/TJB3P	E8/P7
PEDESTRIAN PUSHBUTTON POST W/ PUSHBUTTON		TPB/TPBP	E8/P7
PEDESTRIAN SIGNAL HEAD		TPSH/TPSHP	E8/P7
POLE NOTE		TPN	E8/P7
R/R CROSSING GATE		TRG/TRGP	E8/P7
R/R CROSSING SIGNAL		TRC/TRCP	E8/P7
SIGNAL CONTROLLER		TSC/TSCP	E8/P7
SIGNAL LOAD CENTER		TSLC/TSLCP	E8/P7
STREET LIGHT ASSEMBLY		TSLA/TSLAP	E8/P7
LUMINAIRE		LUM/LUMP	E8/P7
TRAFFIC SIGNS:			
BRIDGE		TSB/TSBP	E8/P7
CANTILEVERED		TSCL/TSCLP	E8/P7
SINGLE POST		TSS/TSSP	E8/P7
DOUBLE POST		TSD/TSDP	E8/P7
TRAFFIC SIGNAL POLE		TPOL/TPOLP	E8/P7
TRAFFIC SIGNAL POLE W/ LUMINAIRE		TSPL/TSPLP	E8/P7
TRAFFIC SIGNAL SUPPORT POLE		TSPOL/TSPOLP	E8/P7

ROAD PLAN

DESCRIPTION	(ABBR)	BLOCK	COLOR
NORTH ARROW (N.T.S.)		SNA	/P7
SCALE BAR (N.T.S.) (SCALE IN FEET)		SCALE10 SCALE20 SCALE50 SCALE100	/P7
BREAKLINES FOR ROADS, PIPE, STC.		BKLN	/P7
CURB RAMP SYMBOL (CHECK STNDS FOR DISTANCES) (WHEN USING THIS SYMBOL)		C-RAMP	/P7
DRIVEWAY CURB CUT SYMBOLS (VARIES)		DW-RAMP	/P7
CUT SLOPE CATCH POINTS (OPTIONAL) (SCALEABLE) EMBANKMENT		C-SLOPE	/P3
FILL SLOPE CATCH POINTS (OPTIONAL) (SCALEABLE) EMBANKMENT (SHOULDER)		F-SLOPE	/P3

ROAD PROFILE

DESCRIPTION	(ABBR)	BLOCK	COLOR
CIRCLE TO BE SHOWN AT GEOMETRICAL POSITIONS I.E. P.C.,P.T., INT. PVI,PI,PVC (BOTH IN PLAN AND PROFILE) 1' DIAM.		PC	/7
POINT OF VERTICAL INTERSECTION	PVI	PVI	/7
DATUM (N.T.S.) (MERIDIAN ZONE / DATA)		SDAT	/7
EQUATION FOR PROFILE CAN ALSO BE USED FOR BREAKING STEEP PROFILES TO FIT ON A PROFILE PAGE TEXT(ROMAND)=3.5		EQTN	/P7
ARROWS:			
PROFILE ARROWS (FOR USE FOR CALLS ALONG THE PROFILE.) SIZE = 6'x 2' USE WITH LINE AT PEN 2			/P2
ARROWS DEPICTING LEFT(UP) OR RIGHT(DOWN) USE HALF ARROW IF RT./LT. ITEM IS NOT LABELED. SIZE = 3'x 1'		AR-PR-L AR-PR-R	/P2
FLOWLINE(EXIST) (2%, 1.5', 8', 3', 1', TEXT=1.75, ARROW)	EFL	EFL	E8/
FLOWLINE(PROP.) NO "+ OR − SIGN NEEDED (2%, TEXT=2)	PFL	PFL	/P7
STORM DRAINAGE REFERENCE NOTE FOR STRUCTURE NOTE SHEET WITH TEXT ATTRIBUTES		DRAIN-NO	/P7

REFERENCE SYMBOLS

DESCRIPTION	(ABBR)	BLOCK	COLOR
CONSTRUCTION REFERENCE NOTE WITH TEXT ATTRIBUTES		BUBBLE-HX	/P7

REFERENCE SYMBOLS OR BULLETS CAN BE USED INSTEAD OF CALLING OUT STATIONS AND ITEMS.

IF A REFERENCE SYMBOL IS USED THE ASSOCIATED DATA MUST BE WRITTEN SOMEWHERE WITHIN THE PLAN SET. THIS WILL BE ALL THE DESCRIPTIVE DATA AS WELL AS LOCATIONS USING THE REFERENCE NUMBER AS A KEY.

AR 032350

KEY

STANDARD PEN WIDTHS:

COMMON USAGE:	ACAD COLOR	PEN SIZE (MM (IN))	PEN CLASS	PIXELS CALCOMP *	ACAD NUMBER	PEN STOP
(HATCHING, SMALL FULL TONE TEXT)	RED	0.25(0.010)	3x0	3	1	1
(DIMENSIONS LINES, ARROWS,LEADERS)	YELLOW	0.30(0.013)	2x0	4	2	2
(LEADERS,TEXT,SYMBOLS)	GREEN	0.35(0.017)	0	5	3	3
(PROPOSED TEXT, LINES,SYMBOLS)	WHITE	0.45(0.020)	1	6	7	4
(PROPOSED TEXT, LINES, TITLES)	CYAN	0.60(0.026)	2	8	4	5
(R/W, PROPOSED LINES, TITLES)	BLUE	0.70(0.035)	3	10	5	6
	MAGENTA	0.80(0.043)	4	12	6	5
(EXISTING SYMBOLS, LINES)	8	0.35	0(HALF TONED)	5	8	7
(EXISTING TEXT, LINES)	9	0.45	1(HALF TONED)	6	9	8
	10	0.20(0.008)	4x0	2	10	

* PEN WIDTH=PIXEL(s) x (0.0025) + 0.0012(INCHES)
* PEN WIDTH=PIXEL(s) x (0.069) + 0.033(MM)

FIELD BOOK:				
SURVEYED:				
SURVEY BASE MAP:				
DESIGN ENTERED:				
DESIGNED:			BR	7/18/96
CHECKED:			BR	3/28/96
	DATE	REVISION	BY	DATE

CONSULTANT ENGINEER'S STAMP

CONSULTANT ENGINEER'S STAMP

FED. AID No. ______

PROJECT No. ______

SURVEY No. ______

MAINTENANCE DIVISION No. ______

COUNTY ENGINEER'S STAMP

COUNTY ROAD ENGINEER

ROADS OR TRAFFIC MANAGER'S STAMP

KING COUNTY DEPT. OF TRANSPORTATION
PAUL TOLIVER, DIRECTOR

STANDARD TEXT AND LINETYPES

REVISED 7/18/96

SHEET 2 OF 2 SHEETS

XXX-X(X)

/KCFS/STANDARD/SYMBOLS/APWA-KC3.DWG

KING COUNTY
STANDARD PLAN NOTES

Standard plan notes must be included on all plans. At the applicant's discretion, notes which in no way apply to the project may be omitted; however, the remaining notes must not be renumbered. For example, if General Note #3 were omitted, the remaining notes should be numbered 1, 2, 4, 5, 6, etc.

GENERAL NOTES

1. All construction shall be in accordance with the King County Code (KCC), King County Road Standards (KCRS), and the King County Council's conditions of preliminary subdivision approval. It shall be the sole responsibility of the applicant and the professional civil engineer to correct any error, omission, or variation from the above requirements found in these plans. All corrections shall be at no additional cost or liability to King County.

2. The design elements within these plans have been reviewed according to the King County Department of Development and Environmental Services (DDES) Engineering Review checklist. Some elements may have been overlooked or missed by the DDES plan reviewer. Any variance from adopted standards is not allowed unless specifically approved by King County prior to construction.

3. Approval of this road, grading, and drainage plan does not constitute an approval of any other construction (e.g., domestic water conveyance, sewer conveyance, gas, electrical, etc.).

4. Before any construction or development activity, a preconstruction meeting must be held between the DDES Land Use Inspection Section, the Applicant, and the Applicant's Construction Representative.

5. A copy of these approved plans must be on the job site whenever construction is in progress.

6. Construction noise shall be limited in accordance with King County Code (Section 12.88); normally, this is
7 a.m. to 10 p.m. on weekdays and 9 a.m. to 10 p.m. on weekends.

7. It shall be the Applicant's/Contractor's responsibility to obtain all construction easements necessary before initiating offsite work within the road right-of-way.

8. Franchised utilities or other installations that are not shown on these approved plans shall not be constructed unless an approved set of plans that meets all requirements of KCRS Chapter 8 is submitted to the DDES Land Use Inspection Section three days prior to construction.

9. Datum shall be NAVD 1988 unless otherwise approved by DDES.

10. Groundwater system construction shall be within a right-of-way or appropriate drainage easement, but not underneath the roadway section. All groundwater systems must be constructed in accordance with Section B1 3.02 of the APWA Standard Specifications.

11. All utility trenches shall be backfilled and compacted to 95 percent density.

12. All roadway subgrade shall be backfilled and compacted to 95 percent density (WSDOT 2-06.3).

13. Open cutting of existing roadways is not allowed unless specifically approved by DDES and noted on these approved plans. Any open cut shall be restored in accordance with KCRS 8.03(B)3.

14. The Contractor shall be responsible for providing adequate safeguards, safety devices, protective equipment, flaggers, and any other needed actions to protect the life, health, and safety of the public, and to protect property in connection with the performance of work covered by the contractor. Any work within the traveled right-of-way that may interrupt normal traffic flow shall require at least one flagger for each lane of traffic affected. Section 1-07.23, "Traffic Control," of the WSDOT Standard Specifications shall apply in its entirety.

DRAINAGE NOTES

1. Proof of liability insurance shall be submitted to DDES prior to the preconstruction meeting (KCC 9.04.100.D).

2. All pipe and appurtenances shall be laid on a properly prepared foundation in accordance with WSDOT 7-02.3(1). This shall include leveling and compacting the trench bottom, the top of the foundation material, and any required pipe bedding to a uniform grade so that the entire pipe is supported by a uniformly dense unyielding base.

3. Steel pipe shall be galvanized and have asphalt treatment #1 or better inside and outside (KCRS 7.03).

4. All drainage structures, such as catch basins and manholes, not located within a traveled roadway or sidewalk shall have solid locking lids. All drainage structures associated with a permanent retention/detention facility shall have solid locking lids (KCRS 7.05).

5. All catch basin grates shall conform to KCRS drawing numbers 2-013, 2-018, 2-019, or 2-020, and shall include the stamping "OUTFALL TO STREAM, DUMP NO POLLUTANTS" and "Property of King County" (KCRS 7.05).

6. All driveway culverts located within King County right-of-way shall be of sufficient length to provide a minimum 3:1 slope from the edge of the driveway to the bottom of the ditch. Culverts shall have beveled end sections to match the side slope (KCRS 7.03(L), Drawing No. 2-001).

7. Rock for erosion protection of roadway ditches, where required, must be of sound quarry rock, placed to a depth of 1 foot, and must meet the following specifications: 4"-8"/40-70% passing; 2"- 4" rock/30-40% passing; and 2" minus rock/10-20% passing. Installation shall be in accordance with KCRS 7.02(B), Drawing No. 2-024.

8. Drainage outlets (stub-outs) shall be provided for each individual lot, except for those lots approved for infiltration by King County. Stub-outs shall conform to the following:

   a) Each outlet shall be suitably located at the lowest elevation on the lot, so as to service all future roof downspouts and footing drains, driveways, yard drains, and any other surface or subsurface drains necessary to render the lots suitable for their intended use. Each outlet shall have free-flowing, positive drainage to an approved stormwater conveyance system or to an approved outfall location.

   b) Outlets on each lot shall be located with a five-foot-high, 2" x 4" stake marked "storm" or "drain". The stub-out shall extend above surface level, be visible, and be secured to the stake.

   c) Pipe material shall conform to underdrain specifications described in KCRS 7.04. If non-metallic, the pipe shall contain wire or other acceptable detection.

   d) Drainage easements are required for drainage systems designed to convey flows through individual lots.

   e) The Applicant/Contractor is responsible for coordinating the locations of all stub-out conveyance lines with respect to utilities (e.g., power, gas, telephone, television).

   f) All individual stub-outs shall be privately owned and maintained by the lot homeowner.

EROSION AND SEDIMENT CONTROL NOTES

1. Approval of this erosion and sediment control (ESC) plan does not constitute an approval of permanent road or drainage design (e.g., size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).

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2. The implementation of these ESC plans and the construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the applicant/ESC supervisor until all construction is approved.

3. The boundaries of the clearing limits shown on this plan shall be clearly flagged by a continuous length of survey tape (or fencing, if required) prior to construction. During the construction period, no disturbance beyond the clearing limits shall be permitted. The clearing limits shall be maintained by the applicant/ESC supervisor for the duration of construction.

4. The ESC facilities shown on this plan must be constructed prior to or in conjunction with all clearing and grading so as to ensure that the transport of sediment to surface waters, drainage systems, and adjacent properties is minimized.

5. The ESC facilities shown on this plan are the minimum requirements for anticipated site conditions. During the construction period, these ESC facilities shall be upgraded as needed for unexpected storm events and modified to account for changing site conditions (e.g., additional sump pumps, relocation of ditches and silt fences, etc.).

6. The ESC facilities shall be inspected daily by the applicant/ESC supervisor and maintained to ensure continued proper functioning. Written records shall be kept of weekly reviews of the ESC facilities during the wet season (Oct. 1 to April 30) and of monthly reviews during the dry season (May 1 to Sept. 30).

7. Any areas of exposed soils, including roadway embankments, that will not be disturbed for two days during the wet season or seven days during the dry season shall be immediately stabilized with the approved ESC methods (e.g., seeding, mulching, plastic covering, etc.).

8. Any area needing ESC measures not requiring immediate attention shall be addressed within fifteen (15) days.

9. The ESC facilities on inactive sites shall be inspected and maintained a minimum of once a month or within forty-eight (48) hours following a storm event.

10. At no time shall more than one (1) foot of sediment be allowed to accumulate within a catch basin. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operation shall not flush sediment-laden water into the downstream system.

11. Stabilized construction entrances and roads shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures, such as wash pads, may be required to ensure that all paved areas are kept clean for the duration of the project.

12. Any permanent flow control facility used as a temporary settling basin shall be modified with the necessary erosion control measures and shall provide adequate storage capacity. If the facility is to function ultimately as an infiltration system, the temporary facility must be graded so that the bottom and sides are at least three feet above the final grade of the permanent facility.

13. Where straw mulch for temporary erosion control is required, it shall be applied at a minimum thickness of 2 to 3 inches.

14. Prior to the beginning of the wet season (Oct. 1), all disturbed areas shall be reviewed to identify which ones can be seeded in preparation for the winter rains. Disturbed areas shall be seeded within one week of the beginning of the wet season. A sketch map of those areas to be seeded and those areas to remain uncovered shall be submitted to the DDES inspector. The DDES inspector can require seeding of additional areas in order to protect surface waters, adjacent properties, or drainage facilities.

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STRUCTURAL NOTES

1. These plans are approved for standard road and drainage improvements only. Plans for structures such as bridges, vaults, and retaining walls require a separate review and approval by DDES prior to construction (KCC 16.04. 16.70, 14.20).

2. Rockeries are considered to be a method of bank stabilization and erosion control. Rockeries shall not be constructed to serve as retaining walls. All rockeries in County road right-of-way shall be constructed in accordance with KCRS drawing numbers 5-004, 5-005, 5-006, and 5-007. Rockeries outside of road right-of-way shall be constructed in accordance with the Uniform Building Code.

RECOMMENDED CONSTRUCTION SEQUENCE

1. Pre-construction meeting.
2. Flag or fence clearing limits.
3. Post sign with name and phone number of ESC supervisor.
4. Install catch basin protection if required.
5. Grade and install construction entrance(s).
6. Install perimeter protection (silt fence, brush barrier, etc.).
7. Construct sediment ponds and traps.
8. Grade and stabilize construction roads.
9. Construct surface water controls (interceptor dikes, pipe slope drains, etc.) simultaneously with clearing and grading for project development.
10. Maintain erosion control measures in accordance with King County standards and manufacturer's recommendations.
11. Relocate surface water controls and erosion control measures or install new measures so that as site conditions change the erosion and sediment control is always in accordance with the King County Erosion and Sediment Control Standards.
12. Cover all areas that will be unworked for more than seven days during the dry season or two days during the wet season with straw, wood fiber mulch, compost, plastic sheeting or equivalent.
13. Stabilize all areas that reach final grade within seven days.
14. Seed or sod any areas to remain unworked for more than 30 days.
15. Upon completion of the project, all disturbed areas must be stabilized and bmps removed if appropriate.

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KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8

PLAN REVIEW FORMS AND WORKSHEETS

AR 032355

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-A

TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

AR 032356

King County Department of Development and Environmental Services

TECHNICAL INFORMATION REPORT (TIR) WORKSHEET

Part 1 PROJECT OWNER AND PROJECT ENGINEER

Project Owner ______________________

Address ______________________

Phone ______________________

Project Engineer ______________________

Company ______________________

Address/Phone ______________________

Part 2 PROJECT LOCATION AND DESCRIPTION

Project Name ______________________

Location

Township ______________

Range ______________

............Section ______________

Part 3 TYPE OF PERMIT APPLICATION

Subdivison

Short Subdivision

Grading

Commercial

Other ______________________

Part 4 OTHER REVIEWS AND PERMITS

DFW HPA

COE 404

DOE Dam Safety

FEMA Floodplain

COE Wetlands

Shoreline Management

Rockery

Structural Vaults

Other

Part 5 SITE COMMUNITY AND DRAINAGE BASIN

Community ______________________

Drainage Basin ______________________

Part 6 SITE CHARACTERISTICS

River ______________________

Stream ______________________

Critical Stream Reach

Depressions/Swales

Lake ______________________

Steep Slopes ______________________

Floodplain ______________________

Wetlands ______________________

Seeps/Springs

High Groundwater Table

Groundwater Recharge

Other ______________________

Part 7 SOILS

Soil Type	Slopes	Erosion Potential	Erosive Velcoties

Additional Sheets Attached

Part 8 DEVELOPMENT LIMITATIONS

REFERENCE	LIMITATION/SITE CONSTRAINT
Ch. 4 – Downstream Analysis	

Additional Sheets Attached

Part 9 ESC REQUIREMENTS

MINIMUM ESC REQUIREMENTS DURING CONSTRUCTION	MINIMUM ESC REQUIREMENTS AFTER CONSTRUCTION
Sedimentation Facilities	Stabilize Exposed Surface
Stabilized Construction Entrance	Remove and Restore Temporary ESC Facilities
Perimeter Runoff Control	Clean and Remove All Silt and Debris
Clearing and Graing Restrictions	Ensure Operation of Permanent Facilities
Cover Practices	Flag Limits of SAO and open space preservation areas
Construction Sequence	Other
Other	

Part 10 SURFACE WATER SYSTEM

Grass Lined Channel	Tank	Infiltration	Method of Analysis
Pipe System	Vault	Depression	______________
Open Channel	Energy Dissapator	Flow Dispersal	Compensation/Mitigation of Eliminated Site Storage
Dry Pond	Wetland	Waiver	______________
Wet Pond	Stream	Regional Detention	

Brief Description of System Operation ______________________________

____

Facility Related Site Limitations

Reference	Facility	Limitation

Part 11 STRUCTURAL ANALYSIS

Cast in Place Vault

Retaining Wall

Rockery > 4' High

Structural on Steep Slope

Other

Part 12 EASEMENTS/TRACTS

Drainage Easement

Access Easement

Native Growth Protection Easement

Tract

Other

Part 13 SIGNATURE OF PROFESSIONAL ENGINEER

I or a civil engineer under my supervision my supervision have visited the site. Actual site conditions as observed were incorporated into this worksheet and the attachments. To the best of my knowledge the information provided here is accurate.

____

Signed/Date

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-B

OFFSITE ANALYSIS DRAINAGE SYSTEM TABLE

OFF-SITE ANALYSIS DRAINAGE SYSTEM TABLE
Surface Water Design Manual, Core Requirement #2

Basin: **Subbasin Name:** **Subbasin Number:**

Symbol	Drainage Component Type, Name, and Size	Drainage Component Description	Slope	Distance from site discharge	Existing Problems	Potential Problems	Observations of field inspector resource reviewer, or resident
see map	Type: sheet flow, swale, stream, channel, pipe, pond; Size: diameter, surface area	drainage basin, vegetation, cover, depth, type of sensative area, volume	%	1/4 ml = 1,320 ft	constrictions, under capacity, ponding, overtopping, flooding, habitat or organism destruction, scouring, bank sloughing, sedimentation, incision, other erosion		tributary area, likelihood of problem, overflow pathways, potential impacts.

AR 032361

OFF-SITE ANALYSIS DRAINAGE SYSTEM TABLE
Surface Water Design Manual, Core Requirement #2

Basin: Crystal Drainage Basin **Subbasin Name:** Clear Creek **Subbasin Number:** AA

Symbol	Drainage Component Type, Name, and Size	Drainage Component Description	Slope	Distance from site discharge	Existing Problems	Potential Problems	Observations of field inspector resource reviewer, or resident
see map	Type: sheet flow, swale, stream, channel, pipe, pond; Size: diameter, surface area	drainage basin, vegetation, cover, depth, type of sensative area, volume	%	1/4 mi = 1,320 ft	constrictions, under capacity, ponding, overtopping, flooding, habitat or organism destruction, scouring, bank sloughing, sedimentation, incision, other erosion		tributary area, likelihood of problem, overflow pathways, potential impacts.
A	Site Discharge Location	Crystal Drainage Basin		0'			
A - B	Natural Swale	Natural, dense vegetation	2%	0 - 240'	None	None	Swale has capacity; no erosion exists.
B - C	12" CMP	Under private drive	3%	240' - 260'	None	Under capacity	No erosion exists
C - D	Draw	Natural, dense vegetation	8%	260' - 500'	Erosion	Further erosion	Tributary area about 650 - 1900 acres
D - E	18" CMP	Under 57th Street	6%	500' - 660'	None	Under capacity	Overtopping is unlikely. If culvert were plugged, drainage would flow toward roadside ditch.
E - F	Seasonal stream	Natural, dense vegetation with gravel and sand at the flow line	5%	660' - 860'	None	None	No erosion exists.
G - H	36" RCP	Under 15th Street	5%	860' - 1010'	None	Under capacity	No erosion exists.
H - I	36" RCP	Under I-22	3%	1010' - 1160'	None	Under capacity	No erosion exists.
I - J	36" RCP	Adjacent to Smith Street	1.5%	1160' - 1310'	Flooding and Sedimentation	Under capacity	No erosion exists.
J - K	Clear Creek	Type 2 Stream	1.5%	1310' - 1610'	Erosion	Further erosion	No erosion exists.
K - L	Wetland CL21	Type 2 Wetland		1610' - 1660'			Tributary area 15 sq. mi.
L - M	Crystal Lake			1660'			

AR 032362

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-C

FLOW CONTROL AND WATER QUALITY FACILITY SUMMARY SHEET AND SKETCH

STORMWATER FACILITY SUMMARY SHEET

Development________________________________Date_______________

Location____

ENGINEER	DEVELOPER
Name	Name
Firm	Firm
Address	Address
Phone	Phone

Developed Site: Acres________ Number of lots__________

Number of detention facilities on site:
______ ponds
______ vaults
______ tanks

Number of infiltration facilities on site:
______ ponds
______ vaults
______ tanks

Flow control provided in regional facility (give location)________________________________

No flow control required____________ Exemption number ______________________________

Downstream Drainage Basins

		Immediate	Major Basin
	Basin A		
	Basin B		
	Basin C		
	Basin D		

Number & type of water quality facilities on site:

______ biofiltration swale (regular/wet/ or continuous inflow?)
______ combined detention/WQ pond (WQ portion basic or large?)
______ combined detention/wetvault
______ compost filter
______ filter strip
______ flow dispersion
______ farm management plan
______ landscape management plan

______ sand filter (basic or large?)
______ sand filter, linear (basic or large?)
______ sand filter vault (basic or large?)

______ stormwater wetland
______ wetpond (basic or large?)
______ wetvault

______ oil/water separator (baffle or coalescing plate?)
______ catch basin inserts: Manufacturer________________________________

______ pre-settling pond
______ pre-settling structure: Manufacturer______________________________
______ flow-splitter catchbasin

DESIGN INFORMATION	INDIVIDUAL BASIN			
	A	B	C	D
Water Quality design flow				
Water Quality treated volume or wetpond Vr				

DESIGN INFORMATION, cont'd	TOTAL	INDIVIDUAL BASIN			
Drainage basin(s)		A	B	C	D
Onsite area					
Offsite area					
Type of Storage Facility					
Live Storage Volume					
Predeveloped Runoff Rate	2-year				
	10-year				
	100-year				
Developed runoff rate	2-year				
	10-year				
	100-year				
Type of restrictor					
Size of orifice/restriction	No. 1				
	No. 2				
	No. 3				
	No. 4				

FLOW CONTROL & WATER QUALITY FACILITY SUMMARY SHEET SKETCH

All detention, infiltration and water quality facilities must include a sketch per the following criteria:

1. Heading for the drawings should be located at the top of the sketch (top right-hand corner). The heading should contain:
   - North arrow (point up or to left)
   - Plat name or short plat number
   - Date drawn (or updated)
   - D9#_____
   - Address (nearest)
   - Thomas Brothers page, grid number
2. Label CBs and MHs with the plan and profile designation. Label the control structure in writing or abbreviate with C.S. Indicate which structures provide spill control.
3. Pipes-- indicate:
   Pipe size
   Pipe length
   Flow direction
   Use s single heavyweight line
4. Tanks-- use a double, heavyweight line and indicate size (diameter)
5. Access roads
   - Outline the limits of the road
   - Fill the outline with dots if the road is gravel. Label in writing if another surface.
6. Other Standard Symbols:
   - Bollards: ● ●●● ■■■■
   - Rip rap oooooo
     oooooo

Fences --x---x---x---x---x---x---
   - Ditches ~D~~➤D~~➤D~~➤D
7. Label trash racks in writing.
8. Label all streets with the actual street sign designation. If you don't know the actual street name, consult the plat map.
9. Include easements and lot lines or tract limits when possible.
10. Arrange all the labeling or writing to read from left to right or from bottom to top with reference to a properly oriented heading.
11. Indicate driveways or features that may impact access, maintenance or replacement.

AR 032365

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-D

BOND QUANTITIES WORKSHEET

AR 032366

Site Improvement Bond Quantity Worksheet

King County Department of Development & Environmental Services
900 Oakesdale Avenue Southwest
Renton, Washington 98055-1219

Project Name: ______________________ **Date:** ______________

Location: ______________________ **SIERRA Project No.:** ______________

SIERRA Activity No.: ______________

Clearing greater than or equal to 5000 board feet of timber?

__________ yes __________ no

If yes,
Forest Practice Permit Number: ______________
(RCW 76.09)

Note: All prices include labor, equipment, materials, overhead and profit. Prices are from RS Means data adjusted for the Seattle area or from local sources if not included in the RS Means database.

AR 032367

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

	Reference #	Unit Price	Unit	Quantity	# of Applications	Cost
EROSION/SEDIMENT CONTROL						
Backfill & compaction-embankment		$ 4.89	CY			
Check dams, 4" minus rock	SWDM 5.4.6.3	$ 58.70	Each			
Crushed surfacing 1 1/4" minus	WSDOT 9-03.9(3)	$ 74.30	CY			
Ditching		$ 7.03	CY			
Excavation-bulk		$ 1.30	CY			
Fence, silt	SWDM 5.4.3.1	$ 1.20	LF			
Fence, Temporary (NGPE)		$ 1.20	LF			
Hydroseeding	SWDM 5.4.2.4	$ 0.51	SY			
Jute Mesh	SWDM 5.4.2.2	$ 1.26	SY			
Mulch, by hand, straw, 3" deep	SWDM 5.4.2.1	$ 1.75	SY			
Mulch, by machine, straw, 2" deep	SWDM 5.4.2.1	$ 0.46	SY			
Piping, temporary, CPP, 6"		$ 9.30	LF			
Piping, temporary, CPP, 8"		$ 14.00	LF			
Piping, temporary, CPP, 12"		$ 18.00	LF			
Plastic covering, 6mm thick, sandbagged	SWDM 5.4.2.3	$ 2.00	SY			
Rip Rap, machine placed; slopes	WSDOT 9-13.1(2)	$ 33.98	CY			
Rock Construction Entrance, 50'x15'x1'	SWDM 5.4.4.1	$ 1,273.34	Each			
Rock Construction Entrance, 100'x15'x1'	SWDM 5.4.4.1	$ 2,546.68	Each			
Sediment pond riser assembly	SWDM 5.4.5.2	$ 1,695.11	Each			
Sediment trap, 5' high berm	SWDM 5.4.5.1	$ 15.57	LF			
Sed. trap, 5' high, riprapped spillway berm section	SWDM 5.4.5.1	$ 59.60	LF			
Seeding, by hand	SWDM 5.4.2.4	$ 0.44	SY			
Sodding, 1" deep, level ground	SWDM 5.4.2.5	$ 5.24	SY			
Sodding, 1" deep, sloped ground	SWDM 5.4.2.5	$ 6.48	SY			
TESC Supervisor		$ 65.00	HR			
Water truck, dust control	SWDM 5.4.7	$ 85.00	HR			
WRITE-IN-ITEMS						
			Each			

ESC SUBTOTAL: $ -
COLUMN: A

AR 032368

S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

			Existing Right-of-Way		Future Public Road Improvements & Drainage Facilities		Private Improvements		Bond Reduction*	
	Unit Price	Unit	Quant.	Cost	Quant.	Cost	Quant.	Cost	Quant. Complete	Cost
GENERAL ITEMS										
Backfill & Compaction- embankment	$ 4.89	CY								
Backfill & Compaction- trench	$ 7.42	CY								
Clear/Remove Brush, by hand	$ 0.31	SY								
Clearing/Grubbing/Tree Removal	$ 7,718.40	Acre								
Excavation - bulk	$ 1.30	CY								
Excavation - Trench	$ 3.53	CY								
Fencing, cedar, 6' high	$ 16.13	LF								
Fencing, chain link, vinyl coated, 6' high	$ 11.69	LF								
Fencing, chain link, gate, vinyl coated, 20'	$ 1,105.92	Each								
Fencing, split rail, 3' high	$ 10.54	LF								
Fill & compact - common barrow	$ 19.63	CY								
Fill & compact - gravel base	$ 22.16	CY								
Fill & compact - screened topsoil	$ 32.91	CY								
Gabion, 12" deep, stone filled mesh	$ 47.23	SY								
Gabion, 18" deep, stone filled mesh	$ 65.09	SY								
Gabion, 36" deep, stone filled mesh	$ 115.20	SY								
Grading, fine, by hand	$ 1.76	SY								
Grading, fine, with grader	$ 0.83	SY								
Monuments, 3' long	$ 117.50	Each								
Sensitive Areas Sign	$ 2.50	Each								
Sodding, 1" deep, sloped ground	$ 6.49	SY								
Surveying, line & grade	$ 685.44	Day								
Surveying, lot location/lines	$ 1,353.60	Acre								
Traffic control crew (2 flaggers)	$ 74.07	HR								
Trail, 4" chipped wood	$ 6.60	SY								
Trail, 4" crushed cinder	$ 7.24	SY								
Trail, 4" top course	$ 7.12	SY								
Wall, retaining, concrete	$ 38.40	SF								
Wall, rockery	$ 8.25	SF								
SUBTOTAL										

AR 032369

*KCC 27A authorizes only one bond reduction.
S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

	Unit Price	Unit	Existing Right-of-way		Future Public Road Improvements & Drainage Facilities		Private Improvements		Bond Reduction*	
			Quant.	Cost	Quant.	Cost	Quant.	Cost	Quant. Complete	Cost
ROAD IMPROVEMENT										
AC Grinding, 4' wide machine < 1000sy	$ 20.00	SY								
AC Grinding, 4' wide machine 1000-2000sy	$ 5.00	SY								
AC Grinding, 4' wide machine > 2000sy	$ 1.20	SY								
AC Removal/Disposal/Repair	$ 35.77	SY								
Barricade, type I	$ 26.11	LF								
Barricade, type III (Permanent)	$ 39.17	LF								
Curb & Gutter, rolled	$ 11.54	LF								
Curb & Gutter, vertical	$ 8.43	LF								
Curb and Gutter, demolition and disposal	$ 11.81	LF								
Curb, extruded asphalt	$ 2.12	LF								
Curb, extruded concrete	$ 2.23	LF								
Sawcut, asphalt, 3" depth	$ 1.61	LF								
Sawcut, concrete, per 1" depth	$ 1.47	LF								
Sealant, asphalt	$ 0.86	LF								
Shoulder, AC, (see AC road unit price)	$ -	SY								
Shoulder, gravel, 4" thick	$ 6.55	SY								
Sidewalk, 4" thick	$ 26.54	SY								
Sidewalk, 4" thick, demolition and disposal	$ 24.11	SY								
Sidewalk, 5" thick	$ 30.38	SY								
Sidewalk, 5" thick, demolition and disposal	$ 30.13	SY								
Sign, handicap	$ 74.16	Each								
Striping, per stall	$ 5.06	Each								
Striping, thermoplastic, (for crosswalk)	$ 2.07	SF								
Striping, 4" reflectorized line	$ 0.22	LF								

SUBTOTAL

AR 032370

*KCC 27A authorizes only one bond reduction.
S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

			Existing Right-of-way		Future Public Road Improvements & Drainage Facilities		Private Improvements		Bond Reduction*	
	Unit Price	Unit	Quant.	Cost	Quant.	Cost	Quant.	Cost	Quant Complete	Cost
ROAD SURFACING (4" Rock = 2.5 base & 1.5" top course) For '93 KCRS (6.5" Rock= 5" base & 1.5" top course)										
For KCRS '93, (additional 2.5" base) add:	$ 3.13	SY								
AC Overlay, 1.5" AC	$ 6.43	SY								
AC Overlay, 2" AC	$ 7.61	SY								
AC Road, 2", 4" rock, First 2500 SY	$ 14.99	SY								
AC Road, 2", 4" rock, Qty. over 2500SY	$ 11.62	SY								
AC Road, 3", 4" rock, First 2500 SY	$ 17.12	SY								
AC Road, 3", 4" rock, Qty. over 2500 SY	$ 13.75	SY								
AC Road, 5", First 2500 SY	$ 12.67	SY								
AC Road, 5", Qty. Over 2500 SY	$ 12.12	SY								
AC Road, 6", First 2500 SY	$ 14.57	SY								
AC Road, 6", Qty. Over 2500 SY	$ 14.02	SY								
Asphalt Treated Base, 4" thick	$ 8.01	SY								
Gravel Road, 4" rock, First 2500 SY	$ 9.92	SY								
Gravel Road, 4" rock, Qty. over 2500 SY	$ 6.55	SY								
PCC Road, 5", no base, over 2500 SY	$ 18.70	SY								
PCC Road, 6", no base, over 2500 SY	$ 19.02	SY								
Thickened Edge	$ 5.99	LF								

SUBTOTAL

AR 032371

*KCC 27A authorizes only one bond reduction.
S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

			Existing Right-of-way		Future Public Road Improvements & Drainage Facilities		Private Improvements		Bond Reduction*	
	Unit Price	Unit	Quant.	Cost	Quant.	Cost	Quant.	Cost	Quant Complete	Cost
DRAINAGE (CPP = Corrugated Plastic Pipe, N12 or Equivalent) For Culvert prices, Average of 4' cover was assumed. Assume perforated PVC is same price as solid pipe.										
Access Road, R/D	$ 14.56	SY								
Bollards - fixed	$ 209.34	Each								
Bollards - removable	$ 393.34	Each								
* (CBs include frame and lid)										
CB Type I	$ 1,093.60	Each								
CB Type IL	$ 1,246.60	Each								
CB Type II, 48" diameter	$ 1,768.32	Each								
for additional depth over 4'	$ 379.58	FT								
CB Type II, 54" diameter	$ 1,906.56	Each								
for additional depth over 4'	$ 423.07	FT								
CB Type II, 60" diameter	$ 2,044.80	Each								
for additional depth over 4'	$ 466.56	FT								
CB Type II, 72" diameter	$ 2,793.60	Each								
for additional depth over 4'	$ 601.92	FT								
Through-curb Inlet Framework (Add)	$ 318.34	Each								
Cleanout, PVC, 4"	$ 113.52	Each								
Cleanout, PVC, 6"	$ 152.09	Each								
Cleanout, PVC, 8"	$ 194.95	Each								
Culvert, PVC, 4"	$ 7.51	LF								
Culvert, PVC, 6"	$ 10.96	LF								
Culvert, PVC, 8"	$ 11.59	LF								
Culvert, PVC, 12"	$ 18.93	LF								
Culvert, CMP, 8"	$ 15.00	LF								
Culvert, CMP, 12"	$ 23.00	LF								
Culvert, CMP, 15"	$ 28.46	LF								
Culvert, CMP, 18"	$ 32.82	LF								
Culvert, CMP, 24"	$ 46.37	LF								
Culvert, CMP, 30"	$ 62.13	LF								
Culvert, CMP, 36"	$ 97.49	LF								
Culvert, CMP, 48"	$ 122.46	LF								
Culvert, CMP, 60"	$ 204.74	LF								
Culvert, CMP, 72"	$ 263.11	LF								

AR 032372

SUBTOTAL

*KCC 27A authorizes only one bond reduction.

S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97

Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

DRAINAGE CONTINUED			Existing Right-of-way		Future Public Road Improvements & Drainage Facilities		Private Improvements		Bond Reduction*	
	Unit Price	Unit	Quant.	Cost	Quant.	Cost	Quant.	Cost	Quant. Complete	Cost
Culvert, Concrete, 8"	$ 18.28	LF								
Culvert, Concrete, 12"	$ 26.13	LF								
Culvert, Concrete, 15"	$ 32.47	LF								
Culvert, Concrete, 18"	$ 38.70	LF								
Culvert, Concrete, 24"	$ 53.10	LF								
Culvert, Concrete, 30"	$ 90.59	LF								
Culvert, Concrete, 36"	$ 119.68	LF								
Culvert, Concrete, 42"	$ 137.76	LF								
Culvert, Concrete, 48"	$ 152.99	LF								
Culvert, CPP, 6"	$ 9.30	LF								
Culvert, CPP, 8"	$ 14.00	LF								
Culvert, CPP, 12"	$ 18.00	LF								
Culvert, CPP, 15"	$ 20.00	LF								
Culvert, CPP, 18"	$ 24.00	LF								
Culvert, CPP, 24"	$ 32.00	LF								
Culvert, CPP, 30"	$ 42.00	LF								
Culvert, CPP, 36"	$ 48.00	LF								
Ditching	$ 7.03	CY								
Flow Dispersal Trench (1,436 base+)	$ 22.60	LF								
French Drain (3' depth)	$ 19.65	LF								
Geotextile, laid in trench, polypropylene	$ 2.09	SY								
Infiltration pond testing	$ 65.00	HR								
Mid-tank Access Riser, 48" dia, 6' deep	$ 1,396.00	Each								
Pond Overflow Spillway	$ 12.18	SY								
Restrictor/Oil Separator, 12"	$ 908.86	Each								
Restrictor/Oil Separator, 15"	$ 952.66	Each								
Restrictor/Oil Separator, 18"	$ 996.66	Each								
Riprap, placed	$ 33.98	CY								
Tank End Reducer (36" diameter)	$ 870.00	Each								
Trash Rack, 12"	$ 184.32	Each								
Trash Rack, 15"	$ 206.32	Each								
Trash Rack, 18"	$ 233.82	Each								
Trash Rack, 21"	$ 266.82	Each								

AR 032373

SUBTOTAL

*KCC 27A authorizes only one bond reduction.
S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

			Existing Right-of-way		Future Public Road Improvements & Drainage Facilities		Private Improvements		Bond Reduction*	
	Unit Price	Unit	Quant.	Price	Quant.	Cost	Quant.	Cost	Quant. Complete	Cost
PARKING LOT SURFACING										
2" AC, 2" top course rock & 4" borrow	$ 13.77	SY								
2" AC, 1.5" top course & 2.5" base course	$ 14.99	SY								
4" select borrow	$ 3.96	SY								
1.5" top course rock & 2.5" base course	$ 9.92	SY								
WRITE-IN-ITEMS										
		EA.								
		EA.								

SUBTOTAL				
SUBTOTAL (SUM ALL PAGES):				
30% CONTINGENCY & MOBILIZATION:				
GRANDTOTAL:				
COLUMN:	B	C	D	E

AR 032374

*KCC 27A authorizes only one bond reduction.
S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

Site Improvement Bond Quantity Worksheet

Original bond computations prepared by:

Name: ______________________ **Date:** ____________

PE Registration Number: ______________________ **Tel. #:** ____________

Firm Name: ______________________

Address: ______________________

	Column	PERFORMANCE BOND* AMOUNT	PUBLIC ROAD IMPROVEMENTS & DRAINAGE FACILITIES MAINTENANCE/DEFECT BOND* AMOUNT
Stabilization/Erosion Sediment Control (ESC)	(A)	$ -	
Existing Right-of-Way Improvements	(B)	$ -	
Future Public Road Improvements & Drainage Facilities	(C)	$ -	(B+C) X 0.25 = $ -
Private Improvements	(D)	$ -	
(A+B+C+D) =TOTAL (T) PERFORMANCE BOND AMOUNT		$ - Minimum bond amount is $1000.	
SITE RESTORATION BOND (First $7,500 of bond shall be cash.)	(A)	$ -	
RIGHT-OF-WAY BOND	(B)	$ -	
TOTAL RIGHT-OF-WAY & SITE RESTORATION BOND** (First $7,500 of bond shall be cash.)	(A+B)	$ -	
PERFORMANCE BOND TOTAL AFTER BOND REDUCTION***	(T-E)		

NAME OF PERSON PREPARING BOND REDUCTION: ______________________ Date: ____________

*NOTE: The word "bond" is used to
represent any financial guarantee acceptable to King County.
**NOTE: KCC 27A authorizes bonds to be combined when both are required.

***NOTE: Per KCC 27A, total bond amounts remaining after reduction shall not be less than 30% of the original amount.

S:PUBLIC\LUSD\LUIS\REF8D SITE BOND QUANTITY WORKSHEET

Unit prices updated 12/97
Revision date: 8/22/98

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-E

MAINTENANCE AND DEFECT AGREEMENT

MAINTENANCE AND DEFECT AGREEMENT (Two Years) For public roads and drainage facilities	Applicant's Name and Address
Agreement Number	Project Number and Name
Guarantee Amount	Site Location/Section

This AGREEMENT is made and entered into this ______ day of __________, 19____, between the King County Department of Transportation, Road Services Division, hereinafter called the COUNTY, and the above named APPLICANT, hereinafter called APPLICANT.

Basis for AGREEMENT:

WHEREAS the undersigned APPLICANT has constructed public roads and/or drainage facilities in connection with the above-referenced project; and

WHEREAS the APPLICANT has agreed to secure the successful maintenance and operation of said improvements for the referenced projects pursuant to King County Ordinance 12020 and King County Code Title 14 and 19;

NOW THEREFORE, the APPLICANT hereby agrees and binds itself and it's legal representatives, successors, and assigns as follows:

ns of the AGREEMENT:

1. The improvements constructed by the APPLICANT or his representative shall successfully operate and shall remain free of defects in design, workmanship, materials, and design for a period of two years from the date of satisfactory completion of the improvements or final plat approval, whichever is later. As used in this AGREEMENT, the term "defects" includes but is not limited to, damage resulting from construction activities and/or use during the two year period.
2. The APPLICANT is responsible for maintenance of the public road and drainage facilities, including the roadway surface for the two year period from the date of satisfactory construction approval or final plat approval, whichever is later.
3. In the event of any failure of the improvements to satisfactorily operate or in the event of a defect in design, workmanship or materials, the APPLICANT shall promptly and adequately repair and/or correct the failure or defect.
4. The COUNTY will perform maintenance inspections during the two year period.
5. During the two year period upon notification by the COUNTY, the APPLICANT shall correct and/or make repairs to the right-of-way improvements within the time period specified by the COUNTY when defects in the design, workmanship, or materials occur.
6. In the event the COUNTY determines that repairs must be performed immediately to prevent risk to person(s) and property, the COUNTY may make necessary repairs and the costs of those repairs shall be paid by the APPLICANT upon demand.
7. The APPLICANT shall pay all required fees in accordance with King County Code.
8. At the end of the two year period, the APPLICANT shall clean the drainage system prior to the COUNTY's final inspection.

Agreement Number	Project Number and Name

9. If, at the conclusion of the two year period, King County, at its sole discretion, determines that the improvements are not adequately maintained, the APPLICANT shall perform prompt maintenance to the COUNTY's satisfaction. In the event this maintenance is not performed within the time period specified by the COUNTY, the COUNTY will invoke the enforcement and Notice and Order processes found in K.C.C. 23.12.

10. Any failure by the APPLICANT to comply with the terms of this AGREEMENT in a timely manner shall constitute default. Any action or inaction by King County following any default in any term or condition of this AGREEMENT shall not be deemed to waive any rights of King County pursuant to this AGREEMENT.

11. The APPLICANT shall indemnify and hold the COUNTY and it's agents, employees and/or officers harmless from and shall process and defend at it's own expense all claims, damages, suits at law or equity, actions, penalties, losses, or costs of whatsoever kind or nature, brought against the COUNTY arising out of, in connection with, or incident to the execution of this AGREEMENT and/or the APPLICANT's performance or failure to perform any aspect of the AGREEMENT. Provided, however, that if such claims are caused by or result from concurrent negligence of the APPLICANT and the COUNTY, it's agents, employees and/or officers, this provision shall be valid and enforceable only to the extent of the negligence of the APPLICANT, and provided further, that nothing herein shall require the APPLICANT to hold harmless or defend the COUNTY from any claim arising from the sole negligence of the COUNTY's agents, employees and/or officers.

12. In the event that any party deems it necessary to institute legal action or proceedings to enforce any right or obligation under this AGREEMENT, the parties hereto agree that any such action or proceeding shall be brought in a court of competent jurisdiction situated in King County, Washington.

Release Requirements: This AGREEMENT shall remain in full force and effect and shall not be released until all terms of this AGREEMENT have been completed to the satisfaction of the King County Road Engineer or his/her designee.

IN WITNESS THEREOF, the parties hereto have executed this AGREEMENT as of the day and year first above written.

APPLICANT

By Title Date

Received for King County By Date

2 year Maintenance and Defect Agreement.doc July 20, 1998

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-F

DECLARATION OF COVENANT

After Recording return to:

____
____
____

DECLARATION OF COVENANT

IN CONSIDERATION of the approved King County ________________ ____________ permit for application No. ____________________ relating to the real property described as follows: ________________
____
____
____.

The undersigned as Grantor(s), declares that the above described property is hereby subject to an easement for a natural or constructed conveyance system and hereby dedicates, covenants and agrees as follows:

1. King County shall have the right to ingress and egress over those portions not contained in Exhibit "A" to access such easement area for inspection of and to reasonably monitor the performance, operational flows, or defects in accordance with and [as presented in King County Code Section 9.04.120].

2. If King County determines that maintenance or repair work is required to be done to the system, the Manager of the Water and Land Resources Division of the King County Department of Natural Resources shall give notice of the specific maintenance and/or repair work required pursuant to K.C.C 9.04.030. The Manager shall also set a reasonable time in which such work is to be completed by the Grantor(s), its heirs or assigns. If the above required maintenance or repair is not completed with the time set by the Manager, the County may perform the required maintenance or repair. Written notice will be sent to the Grantor(s) stating the County's intention to perform such maintenance. Maintenance work will not

commence until at least seven (7) days after such notice is mailed. If, within the sole discretion of the Water and Land Resources Division Manager, there exists an imminent or present danger, said seven (7) day notice period will be waived and maintenance and/or repair work will begin immediately.

3. If at any time King County reasonably determines that any existing retnetion/detention system creates any of the conditions listed in K.C.C. 9.04.030 and herein incorporated by reference, the Water and Land Resources Division Manager may take measures specified therein.

4. The Grantor(s) shall assume all responsibility for the cost of any maintenance and for repairs to the system. Such responsibility shall include reimbursement to the County within thirty (30) days of the receipt of the invoice for any such work performed. Overdue payments will require payment of interest at the current legal rate as liquidated damages. If legal action ensues, the prevailing party is entitled to costs or fees

5. The Grantor(s) is (are) hereby required to obtain written approval from the Water and Land Resources Division Manager of the King County Department of Natural Resources prior to filling, piping, cutting, or removing vegetation (except in routine landscape maintenance) in open vegetated drainage facilities (such as swales, channels, ditches, ponds, etc.), or performing any alterations or modifications to the drainage facilities contained within said drainage easement. Any notice or consent required to be given or otherwise provided for by the provisions of this Agreement shall be effective upon personal delivery, or three (3) days after mailing by Certified Mail, return receipt requested.

6. This agreement constitutes the entire agreement between the parties, and supercedes all prior discussions, negotiations, and all agreements whatsoever whether oral or written.

This covenant is intended to protect the value of desirability of the real property described above, and shall insure to the benefit of all the citizens of King County, and shall be binding on all heirs, successors and assigns.

____

OWNER

____

OWNER

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this day personally appeared before me:

______________________________, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of ______________, 199__.

____
NOTARY PUBLIC in and for the State of Washington, residing at ____________.
My Commission Expires: ____________.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-G

DRAINAGE RELEASE COVENANT

AR 032383

After Recording return to:

____
____
____

DRAINAGE RELEASE COVENANT

This agreement made this ____ day of ______________, 19___, ____, hereinafter called the GRANTOR(s), and KING COUNTY, a political subdivision of the State Of Washington, hereinafter called the GRANTEE, and whereas the GRANTOR represents and warrants that it is the owner in fee of that certain parcel of land, described as follows:

____

____

____

____

____,

and whereas the GRANTEE is implementing an approved drainage plan for the project known as ________________________________, permit no. ________________________, on lands located at the above description, which said plan shall divert surface and storm waters from their natural course and cause them to flow (onto)/(away from) the lands of GRANTOR; NOW THEREFORE in consideration of either GRANTEE approval of diversion of said plan and/or other valuable consideration, receipt of which is hereby acknowledged, the GRANTOR hereby willfully acknowledges, agrees and consents to the diversion of surface and storm waters (onto)/(away from) its lands and to hold and release GRANTEE harmless for any damage that may be caused by such diversion of flow. This release shall be a covenant running with the land and shall be binding upon the GRANTOR, its heirs, successors and assigns forever.

IN WITNESS THEREOF, the parties hereto have hereunto set their hands:

____

GRANTOR

____

GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this day personally appeared before me:

____________________________________, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of _______________, 199__.

____
NOTARY PUBLIC in and for the State of
Washington, residing at ______________.
My Commission Expires: ______________.

AR 032385

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-H
DRAINAGE EASEMENTS

AR 032386

After Recording return to:

____
____
____

DRAINAGE EASEMENT

For a valuable consideration, receipt of which is hereby acknowledged, the GRANTOR(s), ______________________________

____

____,

the owner(s) in fee of that certain parcel of land, described as follows:

____

____

____

____,

hereby grant and convey a(an) [exclusive/non-exclusive] easement (attached and incorporated as Exhibit "A") to King County, a political subdivision of the State of Washington, (GRANTEE) for the purpose of conveying, storing, managing and facilitating storm and surface water per an engineering plan approved by King County for the project known as: ______________________________

____,

together with the right for King County to reasonably [ingress and egress to] enter said drainage easement for the purpose of inspecting, operating, maintaining, repairing and improving the drainage facilities contained herein. Note that except for facilities which have been formally accepted for maintenance by King

County, maintenance of drainage facilities on private property is the responsibility of the property owner.

The GRANTOR(s) of said parcel is (are) required to obtain prior written approval from the Water and Land Resources Division of the King County Department of Natural Resources prior to filling, piping, cutting or removing vegetation (except for routine landscape maintenance such as lawn mowing) in open vegetated drainage facilities (such as swales, channels, ditches, ponds, etc.), or performing any alterations or modifications to the drainage facilities, contained within said drainage easement.

This easement is intended to facilitate reasonable access to the drainage facilities. It is binding upon the GRANTOR(s), its heirs, successors and assigns.

____

GRANTOR

____

GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this day personally appeared before me:

____, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of _______________, 199__.

____

NOTARY PUBLIC in and for the State of
Washington, residing at ______________.
My Commission Expires: ______________.

AR 032388

PRIVATE DRAINAGE EASEMENT

For a valuable consideration, receipt of which is hereby acknowledged, the GRANTOR(s), ____

____

____,

the owner(s) in fee of that certain parcel of land, described as follows:

____

____

____

____

____,

hereby grants and conveys a drainage easement (as shown on the attached Exhibit "A") for the purpose of conveying or storing storm and surface water per an engineering plan, a political subdivision of the State of Washington, for the project known as: ____

____,

together with the right for King County to enter said drainage easement for the purpose of observing that the owner(s) are properly operating and maintaining the drainage facilities contained within.

The owner(s) of said parcel are responsible for operating, maintaining and repairing the drainage facilities contained within said drainage easement, and are hereby required to obtain written approval from the Water and Land Resources Division of the King County Department of Natural Resources prior to filling, piping, or cutting or removing vegetation (except for routine landscape maintenance such as lawn mowing), in open vegetated drainage facilities (such as swales, channels, ditches, ponds, etc.), or performing any alterations or modifications to the drainage facilities, contained within said drainage easement.

The covenants herein contained shall run with the land and are binding upon the GRANTOR(s), its heirs, and all subsequent owner(s) thereof, forever.

IN WITNESS THEREOF, the said GRANTOR(s) hereto have hereunto set their hands:

____

GRANTOR

____

GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss

On this day personally appeared before me:

______________________________, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this _____ day of ____________, 19__.

____

NOTARY PUBLIC in and for the State of Washington, residing at

____

____

____

____

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-J

ADJUSTMENT APPLICATION FORM AND PROCESS GUIDELINES

AR 032391

EXAMPLE FORESTED OPEN-SPACE COVENANT

IN CONSIDERATION OF the approved King County residential building permit for application No. _________ relating to real property legally described as follows:

____

____

____

____

____

The undersigned as Grantor(s), declares that the above described property is hereby established as a native growth retention area for the purpose of dispersing and treating stormwater flows and is subject to restrictions applying to vegetation removal in all designated areas shown in Attachment A, and hereby covenants and agrees as follows:

1) Any alterations to sensitive areas and their buffers shall be pursuant to King County Code 21.A.24.

2) The remaining property outside of the sensitive areas and their buffers, residences, roadways, drainage facilities, drainfield areas, lawns and pastures shall be maintained in a forested condition. The following activities are allowed:

   a) On slopes which have been disturbed by human activity or infested by noxious weeds, replacement with appropriate native species or other appropriate vegetation.

   b) Construction of private trails, provided that they are guided by construction and maintenance standards in the US Forest Service "Trails Management Handbook" (FSH 2309.18, June 1987, as amended) and "Standard Specifications for Construction of Trails" (EM-7720-102, June 1984, as amended); but in no case shall trails be constructed of concrete, asphalt or other impervious surface which would contribute to surface water runoff unless such construction is necessary for soil stabilization or soil erosion prevention.

c) Limited trimming and pruning of vegetation for the creation and maintenance of views per 21.A.24310.D.4.

d) Replacement of individual trees with native trees on a limited basis. Forested hydrologic conditions and soil stability shall be maintained.

This easement/restriction is binding upon the GRANTOR(s), its heirs, successors and assigns unless or until a new drainage or site plan is reviewed and approved by the Department of Development and Environmental Services or its successor.

____

GRANTOR

____

GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this date, personally appeared before me:

____, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this ____________________ day of ____________________, 199___.

____

NOTARY PUBLIC in and for the State of
Washington, residing at ________________
My Commission Expires: ________________

AR 032393

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-J

ADJUSTMENT APPLICATION FORM AND PROCESS GUIDELINES

AR 032394

King County
Department of Development
and Environmental Services
900 Oakesdale Avenue Southwest
Renton, WA 98055-1219

DDES

SURFACE WATER DESIGN MANUAL REQUIREMENTS / STANDARDS ADJUSTMENT REQUEST

Project Name:	DDES File No. DDES Enginer/Planner Name:
Project Address:	Design Engineer:
Applicant:	Signature: Date:
Signature: Date:	Engineering Firm Name:
Address: City, State, Zip:	Address: City, State, Zip:

INSTRUCTIONS TO APPLICANT/DESIGN ENGINEER:
Please be sure to include all plans, sketches, photos, and maps which may assist in complete review and consideration of this adjustment request. Failure to provide all pertinent information may result in delayed processing or denial of your request. Please submit this request and all applicable fee to the Intake Counter at DDES, 900 Oakesdale Avenue Southwest, Renton, WA 98055-1219. For additional information, phone 296-6600.

REFER TO SECTION 1.4 IN CHAPTER 1 OF THE SURFACE WATER DESIGN MANUAL FOR ADJUSTMENTS

DESCRIPTION OF ADJUSTMENT REQUEST: ○ Standard ○ Complex ○ Experimental ○ Blanket ○ Pre-application

APPLICABLE SECTION(S) OF STANDARDS:

JUSTIFICATION (see attachments, pages _____ to _____):

AUTHORIZATION SIGNATURES:

DDES Director/Designee Determination:

☐ Approval ☐ Conditional Approval (see below) ☐ Denial

☐ DNR-WLR Approval Signed: ______________________________ Date: ___________ (Experimental & Blanket adjustments only)

CONDITIONS OF APPROVAL:

☐ See attached memo dated: ___________________

DDES, Land Use Services Division, Engineering Review Supervisor:	DDES, Bldg. Serv. Div., Site Engineering & Planning Supervisor:
Signed: Date:	Signed: Date:

ORIGINAL: DDES File-White [ ] COPIES TO: DNR-WLR Division-Pink[ ] DDES Inspection-Canary [ ] Applicant-Goldenrod [ ] Design-Engineer-Green [ ]

inB03 (rev. 8/5/97)

REFERENCE 8-J

ADJUSTMENT PROCESS GUIDELINES

1.0 PREAPPLICATION ADJUSTMENT PROCESS

This process is used when the applicant needs an adjustment decision to determine if a project is feasible or the results are needed to determine if a project is viable before funding a full application. Preapplication adjustment requests will be accepted when 1) an issue is raised or a potential constraint is identified at a preapplication conference with DDES, and 2) sufficient engineering information to evaluate the request is provided. A higher preapplication adjustment fee will apply to these requests, and any unused adjustment fee will be credited towards the permit application fee.

Steps in the processing of a preapplication adjustment shall include:

- A DDES preapplication conference is scheduled at which the applicant provides justification that a decision on the adjustment will effect viability of the project. An example could include a need to divert flows due to a downstream problem.
- King County may request additional information and site visits due to the limited data and lack of prior project review.
- A preapplication deposit is required and fee for review will be an hourly rate billing applied against the deposit. Any unused fees could be returned to the applicant. Any fees in excess of the deposit must be paid prior to the issuance of a decision.
- For approved preapplication adjustment, the applicant can apply that approval to the applied for permit proposal provided conditions of the approval are met, the proposal has not substantially changed and the applicable regulations have not changed. This will be determined by DDES.

The criteria for granting a preapplication adjustment are the same as for a Standard or Complex adjustment. However, preapplication adjustments will be tied by condition to the project proposal resented at the preapplication meeting. The appeal process is also the same as for a Standard adjustment or a Complex adjustment. This approval will expire 1 year after the approval date, unless a complete permit application is submitted and accepted.

AR 032396

2.0 EXPERMIENTAL DESIGN ADJUSTMENT PROCESS

This process is used for proposing new designs or methods different from those in the manual, that are not site specific, and where data sufficient to establish functional equivalence does not exist. Experimental design proposals will be submitted to DDES for processing review and recommendations and forwarded to DNR for review. These adjustments will incur a special review fee as adopted in the King County DDES fee ordinance. Experimental adjustments should be submitted prior to development permit application since they may take longer than a typical adjustment to review.

Upon approval of the adjustment by the DNR Division Manager, the application can use the design or method in a development proposal without applying for a site-specific adjustment. This type of adjustment is provided to encourage innovation on the part of the development community. It also can expedite the review and development of alternative designs for incorporation in future Manual updates.

Steps in the application for an Experimental Design Adjustment will include:

- The application for adjustment is preferably submitted prior to engineering plan review due to the extended review period that may occur. However, it may occur at any permit stage prior to final plan approval. If the review time is to exceed the time outlined in Section 1.4, staff will provide an estimate of the additional time necessary to complete the review within 10 working days of submittal of the adjustment.

- Review will follow the Standard or Complex adjustment procedure. DDES may forward to DNR without a recommendation.

- DDES will process and bill the applicant.

- Justification supporting comparable performance of the proposed system to a standard design is required. Where uncertainty or lack of supportive literature or performance testing exists, monitoring may be applicable with joint participation and funding between King County and the applicant.

Only a limited number of experimental adjustments for a particular facility or method will be granted. If the design proves successful, DNR and DDES may establish a blanket adjustment for the design until such time as it can be incorporated in the Design Manual by formal update. The appeal process is also the same as for a Standard adjustment or a Complex adjustment.

AR 032397

3.0 FEE REDUCTION

This process is used for adjustments that are determined to meet either of the conditions A or B identified below. The DDES Director or designee shall be responsible for making the determination for a fee reduction.

A. Minor adjustment requests that are defined as issues requiring no engineering review to determine appropriateness. These include:

- New or revised standard specifications for engineering and construction which are cited in the Manual (e.g., APWA standard specifications for public works construction, WSDOT standard specifications),
- Minor design alternatives that meet the stated intent in the Manual,
- Identified errors in the Manual.

B. Blanket Adjustments (See Reference Section 10-A Blanket Adjustments, for approved Blanket Adjustments).

AR 032398

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 8-K

DEDICATION AND INDEMNIFICATION CLAUSE – FINAL RECORDING

AR 032399

Dedication and Indemnification Clause - Subdivision

KNOW ALL PEOPLE BY THESE PRESENTS that we, the undersigned owners of interest in the land hereby subdivided, hereby declare this plat to be the graphic representation of the subdivision made hereby, and do hereby dedicate to the use of the public forever all streets and avenues not shown as private hereon and dedicate the use thereof for all public purposes not inconsistent with the use thereof for public highway purposes, and also the right to make all necessary slopes for cuts and fills upon the lots shown thereon in the original reasonable grading of said streets and avenues, and further dedicate to the use of the public all the easements and tracts shown on this plat for all public purposes as indicated thereon, including but not limited to parks, open space, utilities and drainage unless such easements or tracts are specifically identified on this plat as being dedicated or conveyed to a person or entity other than the public, in which case we do hereby dedicate such streets, easements, or tracts to the person or entity identified and for the purpose stated.

Further, the undersigned owners of the land hereby subdivided, waive for themselves, their heirs and assigns and any person or entity deriving title from the undersigned, any and all claims for damages against King County, its successors and assigns which may be occasioned by the establishment, construction, or maintenance of roads and/or drainage systems within this subdivision other than claims resulting from inadequate maintenance by King County.

Further, the undersigned owners of the land hereby subdivided, agree for themselves, their heirs and assigns to indemnify and hold King County, its successors and assigns, harmless from any damage, including any costs of defense, claimed by persons within or without this subdivision to have been caused by alterations of the ground surface, vegetation, drainage, or surface or sub-surface water flows within this subdivision or by establishment, construction or maintenance of the roads within this subdivision. Provided, this waiver and indemnification shall not be construed as releasing King County, its successors or assigns, from liability for damages, including the cost of defense, resulting in whole or in part from the negligence of King County, its successors, or assigns.

This subdivision, dedication, waiver of claims and agreement to hold harmless is made with the free consent and in accordance with the desires of said owners.

IN WITNESS WHEREOF we set our hands and seals.

______________________ Name	______________________ Name
______________________ Name	______________________ Name
______________________ Name	______________________ Name

State of Washington
County of ______________________

I certify that I know or have satisfactory evidence that

____

Signed the instrument and acknowledged it to be (his/her) free and voluntary act for the uses and purposes mentioned in the instrument.

Dedication and Indemnification Clause – Short Subdivision

KNOW ALL PEOPLE BY THESE PRESENTS that we, the undersigned owners of interest in the land hereby short subdivided, hereby declare this short plat to be the graphic representation of the short subdivision made hereby, and do hereby dedicate to the use of the public forever all streets and avenues not shown as private hereon and dedicate the use thereof for all public purposes not inconsistent with the use thereof for public highway purposes, and also the right to make all necessary slopes for cuts and fills upon the lots shown thereon in the original reasonable grading of said streets and avenues, and further dedicate to the use of the public all the easements and tracts shown on this plat for all public purposes as indicated thereon, including but not limited to parks, open space, utilities and drainage unless such easements or tracts are specifically identified on this plat as being dedicated or conveyed to a person or entity other than the public, in which case we do hereby dedicate such streets, easements, or tracts to the person or entity identified and for the purpose stated.

Further, the undersigned owners of the land hereby short subdivided, waive for themselves, their heirs and assigns and any person or entity deriving title from the undersigned, any and all claims for damages against King County, its successors and assigns which may be occasioned by the establishment, construction, or maintenance of roads and/or drainage systems within this short subdivision other than claims resulting from inadequate maintenance by King County.

Further, the undersigned owners of the land hereby short subdivided, agree for themselves, their heirs and assigns to indemnify and hold King County, its successors and assigns, harmless from any damage, including any costs of defense, claimed by persons within or without this short subdivision to have been caused by alterations of the ground surface, vegetation, drainage, or surface or sub-surface water flows within this short subdivision or by establishment, construction or maintenance of the roads within this short subdivision. Provided, this waiver and indemnification shall not be construed as releasing King County, its successors or assigns, from liability for damages, including the cost of defense, resulting in whole or in part from the negligence of King County, its successors, or assigns.

This subdivision, dedication, waiver of claims and agreement to hold harmless is made with the free consent and in accordance with the desires of said owners.

IN WITNESS WHEREOF we set our hands and seals.

______________________	______________________
Name	Name
______________________	______________________
Name	Name
______________________	______________________
Name	Name

State of Washington
County of ______________________

I certify that I know or have satisfactory evidence that

____

Signed the instrument and acknowledged it to be (his/her) free and voluntary act for the uses and purposes mentioned in the instrument.

AR 032401

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

REFERENCE 9

INTERIM CHANGES TO REQUIREMENTS

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REFERENCE 9-A

BLANKET ADJUSTMENTS

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REFERENCE 9-B

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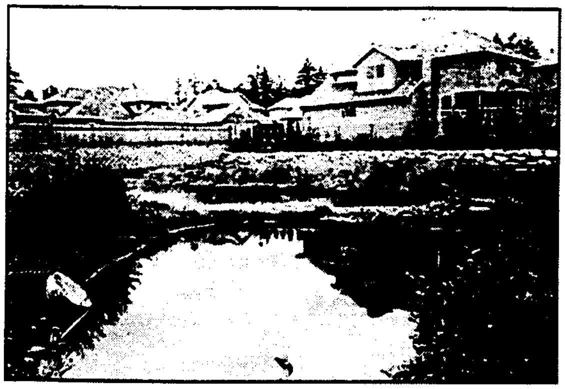

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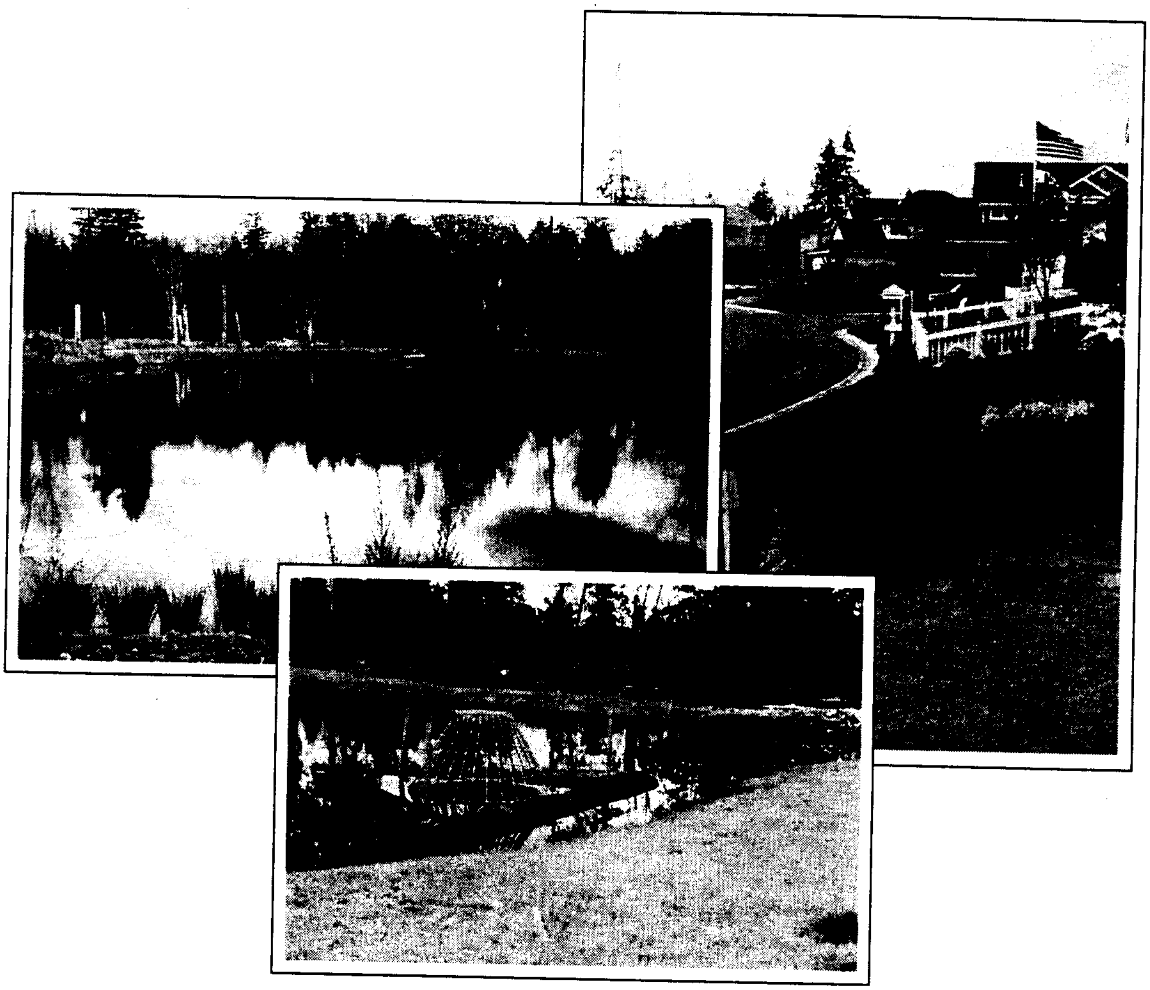
Appendix D
Erosion and Sediment Control Standards



King County, Washington
Surface Water Design Manual

King County
Department of Natural Resources

APPENDIX D

EROSION AND SEDIMENT CONTROL STANDARDS

KING COUNTY, WASHINGTON

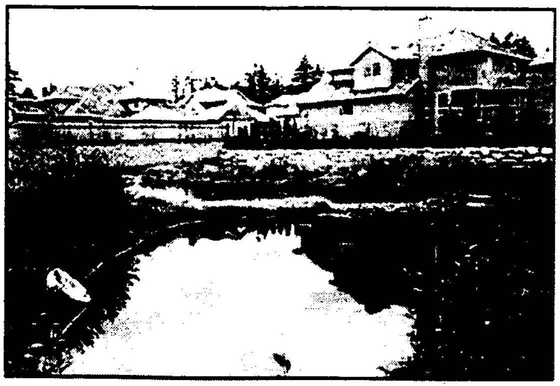
SURFACE WATER DESIGN MANUAL

King County
Department of Natural Resources
Department of Development and Environmental Services

September 1998

APPENDIX D

EROSION AND SEDIMENT CONTROL STANDARDS



KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

EROSION AND SEDIMENT CONTROL STANDARDS

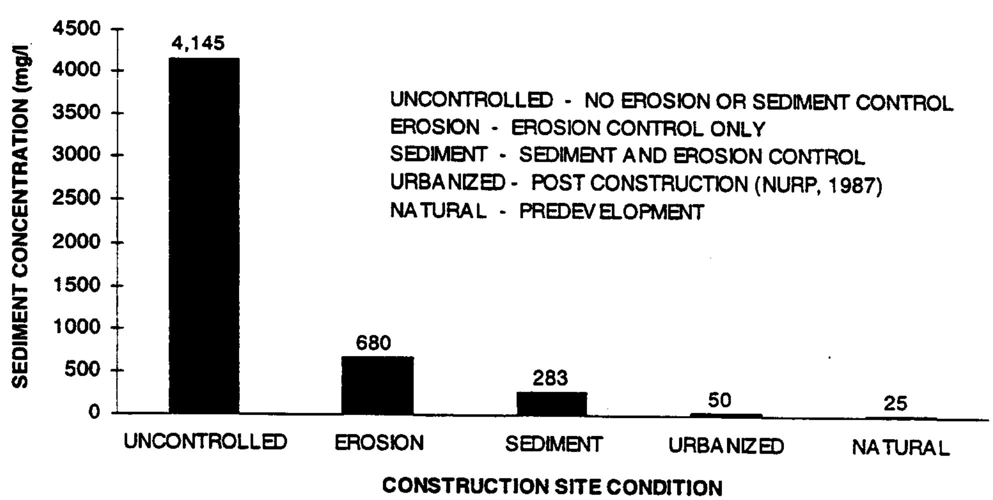
D.1 PURPOSE AND OVERVIEW

The purpose of erosion and sediment control (ESC) is to prevent the transport of sediment to streams, wetlands, lakes, drainage systems, and adjacent properties. In most circumstances, however, it is impossible to completely prevent the transport of sediment to these features, either because of the difficulty in removing silt and clay-sized particles from runoff or because of large storms that overwhelm the ESC facilities. Due to the inherent difficulties in entirely preventing the transport of sediment, it is the responsibility of those involved in the design and construction of any project to utilize a variety of strategies to minimize erosion and the transport of sediment to the greatest extent possible. These strategies shall include overall project planning that reduces the risk of erosion through appropriate design and scheduling (see Section D.2) and traditional structural and cover measures, such as those described in Section D.4.

Erosion and sediment control is necessary because erosion rates associated with uncontrolled construction sites are much higher than normal rates—often a thousand or more times that of undeveloped land. The erosion rates increase during construction due to the removal of soil cover, alteration of soil characteristics, and changes in site topography. These vastly accelerated erosion rates, together with the higher rates typical of urbanized areas, result in excessive deposition of sediment in water resources and drainage facilities. This excessive erosion and consequent sediment deposition can result in devastating impacts to surface waters such as smothering of salmonid spawning beds, algal blooms in lakes, and flooding due to obstruction of drainage ways.

Applying erosion and sediment controls to construction sites can greatly reduce the delivery of sediment to surface waters. Figure D.1.A demonstrates how controls can significantly reduce the concentration of sediment leaving the site. Even with good controls, the concentration of sediment leaving the site will still be significantly higher than either undeveloped or developed conditions and this may result in significant adverse impacts; however, the likelihood of such impacts are dramatically less than if no controls are used.

FIGURE D.1.A MEDIAN STORM SEDIMENT CONCENTRATIONS (METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS, 1990)



D.2 EROSION AND SEDIMENT CONTROL PRINCIPLES

This section provides basic information on the principles of erosion and sediment control that shall be applied to all projects in King County. This section is intended to highlight certain principles that are particularly critical to achieving effective control and that are the basis for the *Surface Water Design Manual's* Core Requirement #5: Erosion and Sediment Control Requirements (see Section D.10.1, p. D-63). Projects that are consistent with these principles will generally meet the intent of the Core Requirement and this appendix, even if the details of the project are not entirely consistent with County standards. If a more complete treatment of ESC is needed, there are a number of useful references available (for example, Goldman et al., 1986). Additionally, information on permanent erosion control in natural channels is available in the *Guidelines for Bank Stabilization Projects* (King County, 1993).

- **Design the project to fit the natural topography, soils, and drainage patterns.** Through such practices as limiting disturbance of steeper slopes, avoiding disturbance of natural drainage ways, or using soils with a high infiltration rate to treat polluted runoff, the characteristics of the site can be used to minimize erosion and sediment transport.

- **Emphasize erosion control rather than sediment control.** Erosion control minimizes the entrainment of sediment by runoff, while sediment control removes entrained sediment from runoff. Erosion control is more efficient and cost-effective because it is impossible to entirely remove sediment from runoff once it is entrained. Examples of erosion control include covering disturbed soils and controlling surface runoff using measures such as dikes and lined ditches. One illustration of the relative effectiveness of erosion control is straw mulch, which can reduce sediment concentrations in runoff over 90%.

  Since it is nearly impossible to entirely prevent erosion, it will also be necessary to incorporate sediment control facilities such as sedimentation ponds and silt fences. Sediment controls vary in their effectiveness, but typically reduce sediment concentrations 50 to 75%. However, sediment controls have little effect on the very fine sediment that causes turbidity, whereas cover measures, such as straw mulch, can be highly effective in reducing turbidity.

- **Minimize the extent and duration of area exposed.** Restricting clearing to only those areas necessary for construction is probably the single most effective form of erosion control. Additionally, exposing areas only as long as necessary reduces the risk of erosion substantially. This can be accomplished by planning the project so that areas are disturbed only when construction is imminent, and by mulching or seeding disturbed areas as soon as grading is completed.

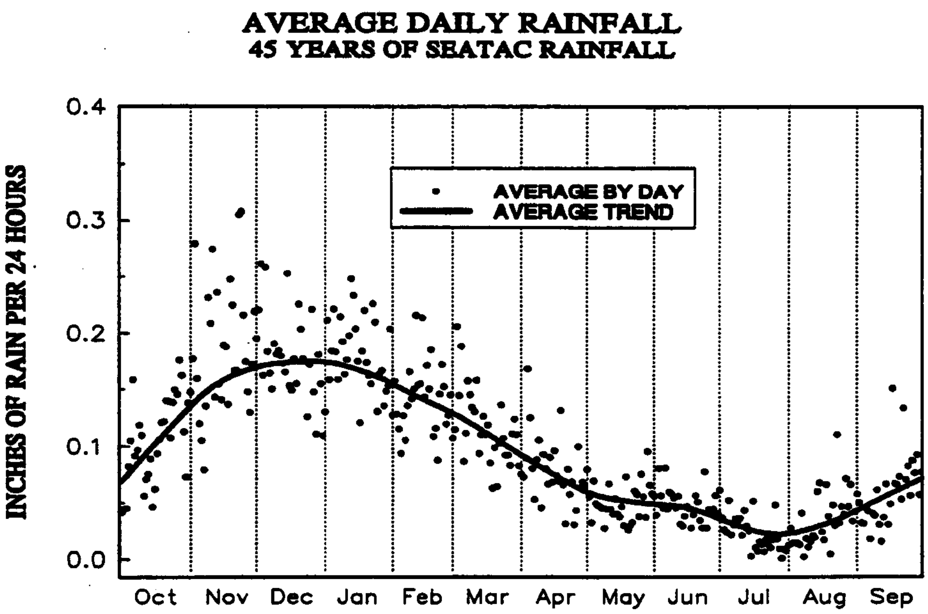
- **Keep runoff velocities low.** While erosion of exposed soil begins with a single raindrop, the largest volumes of eroded materials are typically associated with concentrated runoff forming rills and gullies. One of the best ways to minimize erosion, therefore, is to reduce the possibility of concentrated runoff by intercepting runoff and conveying it in a non-erosive manner to a sediment pond or trap. This can include the use of dikes, swales, and benches to intercept runoff on slopes and ditches or drains to convey the intercepted runoff.

- **Retain sediment on site.** Sediment retention is less effective than erosion control measures, such as cover, but it is nevertheless a vital part of most projects because it is impossible to completely prevent erosion and the entrainment of sediment by runoff. Sediment can be retained by allowing it to settle out in ponds and traps or by filtering runoff from small areas through vegetation or a silt fence. Note that settling and filtration typically only remove sand-sized and coarse silt particles. Fine silts and clays cannot be removed in these ways, unless the runoff is released to vegetated areas or if chemical flocculents, such as alum, are used.

- **Thoroughly monitor the site and maintain all ESC measures.** Maintenance and vigilance are the most vital components of effective ESC management. All measures require regular maintenance. The overall site also needs to be constantly examined to ensure that all areas are protected, that the measures are working together to provide maximum protection, and that all areas are mulched and/or vegetated as soon as possible.

- **Schedule major earthwork during the dry season.** The climate in the Puget Sound region is unique in that there are generally well-defined wet and dry seasons (see Figure D.2.A) and the wet season is characterized by a large number of low-intensity, but frequent and long-lasting, storms. As a result, construction in the dry season is a very effective form of erosion control. If construction does occur in the wet season, the need for regular maintenance is even more imperative.

FIGURE D.2.A YEARLY RAINFALL PATTERN



AR 032420

D.3 GENERAL ESC REQUIREMENTS

To satisfy the King County requirements for ESC, the following steps are required of all construction projects:

1. In accordance with Sections 2.3.1 and 2.3.3 of the *Surface Water Design Manual* (*SWDM*), prepare and submit a technical information report (TIR) and an ESC plan for King County review. Incorporate any King County review comments as necessary to comply with Core Requirement #5 of the *SWDM* (see Section D.10.1, p. D-63) and the Erosion and Sediment Control Standards in this appendix.
2. Construct initial ESC measures on site according to the approved ESC plan.
3. Inspect and maintain all ESC measures throughout construction in accordance with the inspection and maintenance standards of Section D.5.4 (p. D-43).
4. Make any changes or additions necessary during construction to ensure that ESC measures perform in accordance with Core Requirement #5 and Sections D.4 and D.5.
5. Prior to final construction approval, meet all the conditions in Section D.5.5 (p. D-44) for final stabilization.

Proposed projects that add less than 10,000 square feet of impervious surface can satisfy the King County requirements by meeting all the conditions for Small Site ESC in Section D.7 (p. D-50).

D.4 ESC MEASURES

This section details the ESC measures that are required to minimize erosion and sediment transport off a construction site. These ESC measures represent Best Management Practices (BMPs) for the control of erosion and entrained sediment. The measures and practices are grouped into seven sections corresponding to each of the ESC measures in Core Requirement #5 (see Section D.10.1, p. D-63). The introductory paragraphs at the beginning of most sections present the purpose of the measures, installation requirements relative to construction activity, guidelines for the conditions of use for each measure, and other information relevant to all BMPs in the section. Compliance with each of the seven sections of the ESC measures and the implementation requirements in Section D.5 ensures compliance with the ESC requirements. *Note: Additional measures shall be required by the County if the existing standards are insufficient to protect adjacent properties, drainage facilities, or water resources.*

The standards for each individual ESC measure are divided into four sections:

1. Purpose
2. Conditions of Use
3. Design and Installation Specifications
4. Maintenance Requirements.

A code and symbol for each measure have also been included for ease of use on ESC plans. Note that the "Conditions of Use" always refers to site conditions. As site conditions change, ESC measures must be changed to remain in compliance with the requirements of this appendix.

AR 032421

D.4.1 CLEARING LIMITS

ESC Requirement 1: Prior to any site clearing or grading, those areas that are to remain undisturbed during project construction shall be delineated. At a minimum, clearing limits shall be installed at the edges of all sensitive area buffers and any other areas required to be left uncleared such as portions of the site subject to clearing limits under KCC 16.82.150, areas around significant trees identified to be retained, and other areas identified to be left undisturbed to protect sensitive features.

Purpose: The purpose of clearing limits is to prevent disturbance of those areas of the project site that are not designated for clearing or grading. This is important because limiting site disturbance is the single most effective method for reducing erosion. Clearing limits may also be used to control construction traffic, thus reducing the disturbance of soil and limiting the amount of sediment tracked off site.

When to Install: Clearing limits shall be installed prior to the clearing and/or grading of the site.

Measures to Use: Marking clearing limits by delineating the site with a continuous length of brightly colored survey tape is sometimes sufficient. The tape can be supported by vegetation or stakes, and it shall be 3 to 6 feet high and highly visible. Sensitive areas and their buffers require more substantial protection and shall be delineated with plastic or metal safety fences (also referred to as Sensitive Area Setback Area or SASA fences) or stake and wire fences. Fencing may be required at the County's discretion to control construction traffic or at any location where greater protection is warranted. Permanent fencing may also be used if desired by the applicant. Silt fence, in combination with survey flagging, is also an acceptable method of marking sensitive areas and their buffers.

D.4.1.1 PLASTIC OR METAL FENCE

Code: FE Symbol:

Purpose

Fencing is intended to (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and (4) protect areas where marking with survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits, plastic or metal fence may be used:

1. At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared
2. As necessary to control vehicle access to and on the site (see Sections D.4.4.1 and D.4.4.2).

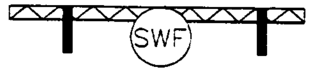
Design and Installation Specifications

1. The fence shall be designed and installed according to the manufacturer's specifications.
2. The fence shall be at least 3 feet high and must be highly visible.
3. The fence shall not be wired or stapled to trees.

Maintenance Requirements

1. If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.
2. Disturbance of a sensitive area, sensitive area buffer, native growth retention area, or any other area required to be left undisturbed shall be reported to the County for resolution.

D.4.1.2 STAKE AND WIRE FENCE

Code: SWF Symbol: 

Purpose

Fencing is intended to (1) restrict clearing to approved limits; (2) prevent disturbance of sensitive areas, their buffers, and other areas required to be left undisturbed; (3) limit construction traffic to designated construction entrances or roads; and (4) protect any areas where marking with survey tape may not provide adequate protection.

Conditions of Use

To establish clearing limits, stake or wire fence may be used:

1. At the boundary of sensitive areas, their buffers, and other areas required to be left uncleared
2. As necessary, to control vehicle access to and on the site (see Sections D.4.4.1 and D.4.4.2).

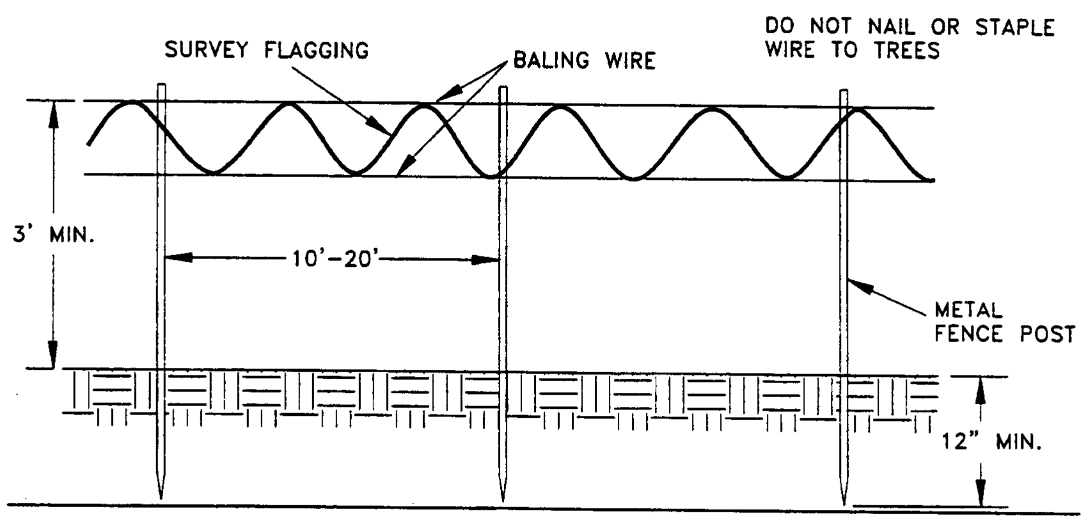
Design and Installation Specifications

See Figure D.4.A for details.

Maintenance Requirements

1. If the fence has been damaged or visibility reduced, it shall be repaired or replaced immediately and visibility restored.
2. Disturbance of a sensitive area, sensitive area buffer, native growth retention area, or other area required to be left undisturbed shall be reported to the County for resolution.
3. More substantial fencing shall be required by the County if the fence does not prevent encroachment into those areas that are not to be disturbed.

FIGURE D.4.A STAKE AND WIRE FENCE



D.4.2 COVER MEASURES

ESC Requirement 2: Temporary and permanent cover measures shall be provided to protect disturbed areas. Temporary cover shall be installed if an area is to remain unworked for more than seven days during the dry season (May 1 to September 30) or for more than two days during the wet season (October 1 to April 30). These time limits may be relaxed if an area poses a low risk of erosion due to soil type, slope gradient, anticipated weather conditions, or other factors. Conversely, the County may reduce these time limits if site conditions warrant greater protection (e.g., adjacent to significant aquatic resources or highly erosive soils) or if significant precipitation (see Section D.5.2) is expected. Any area to remain unworked for more than 30 days shall be seeded or sodded, unless the County determines that winter weather makes vegetation establishment infeasible. During the wet season, slopes and stockpiles 3H:1V or steeper and with more than ten feet of vertical relief shall be covered if they are to remain unworked for more than 12 hours. Also during the wet season, the material necessary to cover all disturbed areas must be stockpiled on site. The intent of these cover requirements is to have as much area as possible covered during any period of precipitation.

Purpose: The purpose of covering exposed soils is to prevent erosion, thus reducing reliance on less effective methods that remove sediment after it is entrained in runoff. Cover is the only practical method of reducing turbidity in runoff. Structural measures, such as silt fences and sediment ponds, are only capable of removing coarse particles and in most circumstances have little to no effect on turbidity.

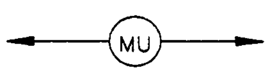
When to Install: Any exposed soils that will remain unworked for more than the time limit set in ESC Requirement 2 shall be covered by the end of the working day. If the exposed area is to remain unworked for more than 30 days, the area shall be seeded with the temporary seed mix or an equivalent mix that will provide rapid protection (see Section 0). If the disturbed area is to remain unworked for a year or more or if the area has reached final grade, permanent seed mix or an equivalent mix shall be applied.

Measures to Use: Cover methods include the use of mulch, erosion control nets and blankets, plastic covering, seeding, and sodding. Mulch and plastic sheeting are primarily intended to protect disturbed areas for a short period of time, typically days to a few months. Seeding and sodding are measures for areas that are to remain unworked for months. Erosion nets and blankets are to be used in conjunction with seeding steep slopes. The choice of measures is left to the designer; however, there are restrictions on the use of these methods, which are listed in the "Conditions of Use" and the "Design and Installation Specifications" sections for each measure.

The methods listed are by no means exhaustive. Variations on the standards presented here are encouraged if other cost-effective products or methods provide substantially equivalent or superior performance. Also, the details of installation can, and should, vary with the site conditions. A useful reference on the application of cover measures in the Puget Sound area is Horner, Guedrey, and Kortenhof (1990).

D.4.2.1 MULCHING

Code: MU   Symbol:



Purpose

The purpose of mulching soils is to provide immediate temporary protection from erosion. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoil in place, and moderating soil temperatures. There is an enormous variety of mulches that can be used. Only the most common types are discussed in this section.

Conditions of Use

As a temporary cover measure, mulch should be used:

1. On disturbed areas that require cover measures for less than 30 days

2. As a cover for seed during the wet season and during the hot summer months
3. During the wet season on slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Design and Installation Specifications

For mulch materials, application rates, and specifications, see Table D.4.A. *Note: Thicknesses may be increased for disturbed areas in or near sensitive areas or other areas highly susceptible to erosion.*

TABLE D.4.A MULCH STANDARDS AND GUIDELINES

Mulch Material	Quality Standards	Application Rates	Remarks
Straw	Air-dried; free from undesirable seed and coarse material	2"-3" thick; 2-3 bales per 1000 sf or 2-3 tons per acre	Cost-effective protection when applied with adequate thickness. Hand-application generally requires greater thickness than blown straw. Straw should be crimped to avoid wind blow. The thickness of straw may be reduced by half when used in conjunction with seeding.
Wood Fiber Cellulose	No growth inhibiting factors	Approx. 25-30 lbs per 1000 sf or 1000-1500 lbs per acre	Shall be applied with hydromulcher. Shall not be used without seed and tackifier unless the application rate is at least doubled. Some wood fiber with very long fibers can be effective at lower application rates and without seed or tackifier.
Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit.	2" thick min.; approx. 100 tons per acre (approx. 800 lbs per yard)	More effective control can be obtained by increasing thickness to 3". Excellent mulch for protecting final grades until landscaping because it can be directly seeded or tilled into soil as an amendment. Sources for compost are available from the King County Commission for Marketing Recyclable Materials at (206) 296-4439.
Chipped Site Vegetation	Average size shall be several inches.	2" minimum thickness	This is a cost-effective way to dispose of debris from clearing and grubbing, and it eliminates the problems associated with burning. Generally, it should not be used on slopes above approx. 10% because of its tendency to be transported by runoff. It is not recommended within 200 feet of surface waters. If seeding is expected shortly after mulch, the decomposition of the chipped vegetation may tie up nutrients important to grass establishment.

Maintenance Standards

1. The thickness of the cover must be maintained.
2. Any areas that experience erosion shall be remulched and/or protected with a net or blanket. If the erosion problem is drainage related, then the problem shall be fixed and the eroded area remulched.

D.4.2.2 NETS AND BLANKETS

Code: NE Symbol: —(NET)—

Purpose

Erosion control nets and blankets are intended to prevent erosion and hold seed and mulch in place on steep slopes and in channels so that vegetation can become well established. In addition, some nets and blankets can be used to permanently reinforce turf to protect drainage ways during high flows. Nets are strands of material woven into an open, but high-tensile strength net (for example, jute matting). Blankets are strands of material that are not tightly woven, but instead form a layer of interlocking fibers, typically held together by a biodegradable or photodegradable netting (for example, excelsior or straw blankets). They generally have lower tensile strength than nets, but cover the ground more completely. Coir (coconut fiber) fabric comes as both nets and blankets.

Conditions of Use

Erosion control nets and blankets should be used:

1. For permanent stabilization of slopes 2H:1V or greater and with more than 10 feet of vertical relief.
2. In conjunction with seed for final stabilization of a slope, not for temporary cover. However, they can be used for temporary applications as long as the product is not damaged by repeated handling. In fact, this method of slope protection is superior to plastic sheeting, which generates high-velocity runoff (see Section D.4.2.3).
3. For drainage ditches and swales (highly recommended). The application of appropriate netting or blanket to drainage ditches and swales can protect bare soil from channelized runoff while vegetation is established. Nets and blankets also can capture a great deal of sediment due to their open, porous structure. Synthetic nets and blankets can be used to permanently stabilize channels and may provide a cost-effective, environmentally preferable alternative to riprap.

Design and Installation Specifications

1. See Figure D.4.B and Figure D.4.C for **typical orientation and installation** of nettings and blankets. *Note: Installation is critical to the effectiveness of these products. If good ground contact is not achieved, runoff can concentrate under the product, resulting in significant erosion.*
2. With the variety of products available, it is impossible to cover all the details of appropriate use and installation. Therefore, it is critical that the design engineer thoroughly consults the **manufacturer's information** and that a site visit takes place in order to insure that the product specified is appropriate.
3. Jute matting must be used in conjunction with mulch (Section D.4.2.1). Excelsior, woven straw blankets and coir (coconut fiber) blankets may be installed without mulch. There are many other types of **erosion control nets and blankets** on the market (though not authorized here) that may be appropriate in certain circumstances. Other types of products will have to be evaluated individually. In general, most nets (e.g., jute matting) require mulch in order to prevent erosion because they have a fairly open structure. Blankets typically do not require mulch because they usually provide complete protection of the surface.
4. Purely synthetic blankets are allowed but shall only be used for long-term stabilization of waterways. The organic blankets authorized above are better for slope protection and short-term waterway protection because they retain moisture and provide organic matter to the soil, substantially improving the speed and success of revegetation.

AR 032426

Maintenance Standards

1. Good contact with the ground must be maintained, and there must not be erosion beneath the net or blanket.

2. Any areas of the net or blanket that are damaged or not in close contact with the ground shall be repaired and stapled.
3. If erosion occurs due to poorly controlled drainage, the problem shall be fixed and the eroded area protected.

FIGURE D.4.B WATERWAY INSTALLATION

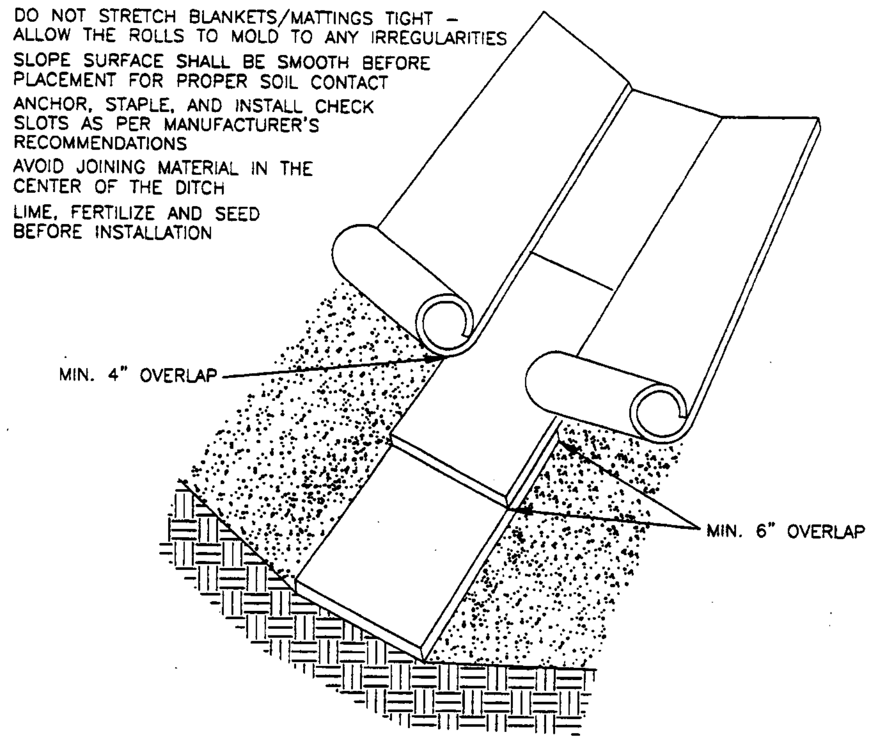
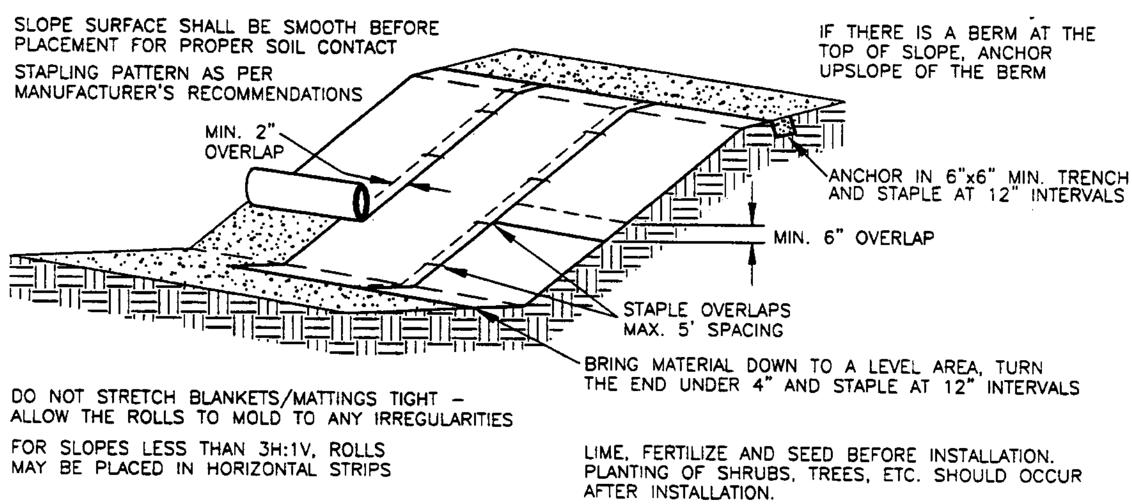
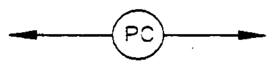


FIGURE D.4.C SLOPE INSTALLATION



D.4.2.3 PLASTIC COVERING

Code: PC Symbol: 

Purpose

Plastic covering provides immediate, short-term erosion protection to slopes and disturbed areas.

Conditions of Use

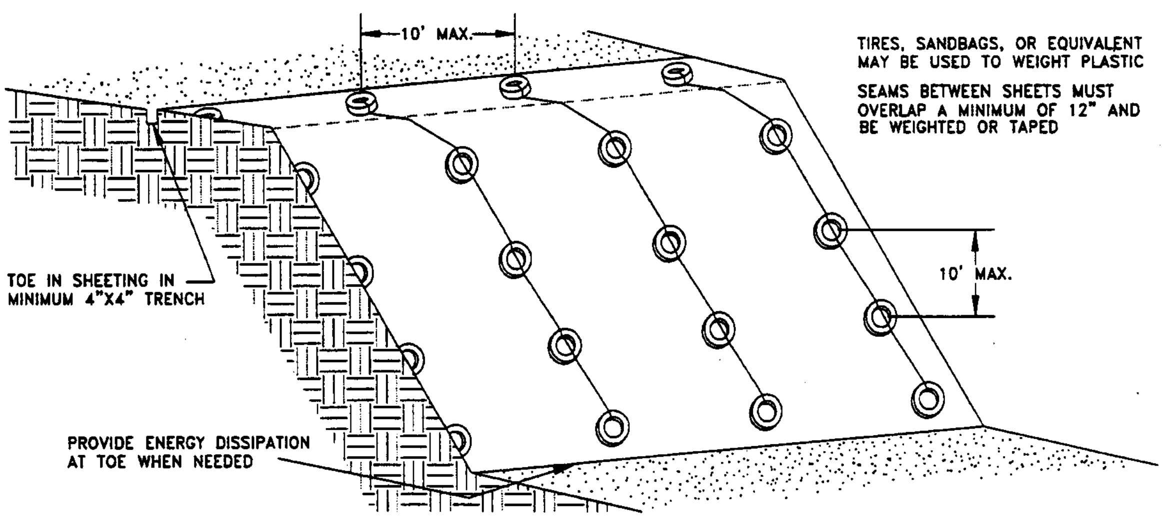
1. Plastic covering may be used on disturbed areas that require cover measures for less than 30 days.
2. Plastic is particularly useful for protecting cut and fill slopes and stockpiles. *Note: The relatively rapid breakdown of most polyethylene sheeting makes it unsuitable for long-term applications.*
3. Clear plastic sheeting can be used over newly-seeded areas to create a greenhouse effect and encourage grass growth. Clear plastic should not be used for this purpose during the summer months because the resulting high temperatures can kill the grass.
4. Due to rapid runoff caused by plastic sheeting, this method shall not be used upslope of areas that might be adversely impacted by concentrated runoff. Such areas include steep and/or unstable slopes.

Note: There have been many problems with plastic, usually attributable to poor installation and maintenance. However, the material itself can cause problems, even when correctly installed and maintained, because it generates high-velocity runoff and breaks down quickly due to ultraviolet radiation. In addition, if the plastic is not completely removed, it can clog drainage system inlets and outlets. It is highly recommended that alternatives to plastic sheeting be used whenever possible and that its use be limited.

Design and Installation Specifications

1. See Figure D.4.D for details.
2. Plastic sheeting shall have a minimum thickness of 0.06 millimeters.
3. If erosion at the toe of a slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe of the slope in order to reduce the velocity of runoff.

FIGURE D.4.D PLASTIC COVERING

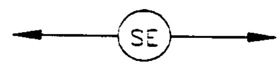


Maintenance Standards for Plastic Covering

1. Torn sheets must be replaced and open seams repaired.
2. If the plastic begins to deteriorate due to ultraviolet radiation, it must be completely removed and replaced.
3. When the plastic is no longer needed, it shall be completely removed.

D.4.2.4 TEMPORARY AND PERMANENT SEEDING

Code: SE Symbol:



Purpose

Seeding is intended to reduce erosion by stabilizing exposed soils. A well-established vegetative cover is one of the most effective methods of reducing erosion.

Conditions of Use

1. Seeding shall be used throughout the project on **disturbed areas** that have reached final grade or that will remain unworked for more than 30 days.
2. **Vegetation-lined channels** shall be seeded.
3. **Retention/detention ponds** shall be seeded as required.
4. At the County's discretion, seeding without mulch during the **dry season** is allowed even though it will take more than seven days to develop an effective cover. Mulch is, however, recommended at all times because it protects seeds from heat, moisture loss, and transport due to runoff.
5. At the beginning of the **wet season**, all disturbed areas shall be reviewed to identify which ones can be seeded in preparation for the winter rains (see Section D.5.2). Disturbed areas shall be seeded within one week of the beginning of the wet season. A sketch map of those areas to be seeded and those areas to remain uncovered shall be submitted to the DDES inspector. The DDES inspector may require seeding of additional areas in order to protect surface waters, adjacent properties, or drainage facilities.
6. At final site stabilization, all disturbed areas not otherwise vegetated or stabilized shall be seeded and mulched (see Section D.5.5).

Design and Installation Specifications

1. The best **time to seed** is April 1 through June 30, and September 1 through October 15. Areas may be seeded between July 1 and August 31, but irrigation may be required in order to grow adequate cover. Areas may also be seeded during the winter months, but it may take several months to develop a dense groundcover due to cold temperatures. The application and maintenance of mulch is critical for winter seeding.
2. To prevent seed from being washed away, confirm that **all required surface water control measures** have been installed.
3. The **seedbed** should be firm but not compacted because soils that are well-compacted will not vegetate as quickly or thoroughly. Slopes steeper than 3H:1V shall be surface roughened. Roughening can be accomplished in a variety of ways, but the typical method is track-walking, or driving a crawling tractor up and down the slope, leaving cleat imprints parallel to the slope contours.
4. In general, 10-20-20 N-P-K (nitrogen-phosphorus-potassium) **fertilizer** can be used at a rate of 90 pounds per acre. Slow-release fertilizers are preferred because they are more efficient and have fewer environmental impacts. It is recommended that areas being seeded for final landscaping conduct soil

tests to determine the exact type and quantity of fertilizer needed. This will prevent the over-application of fertilizer. Disturbed areas within 200 feet of water bodies and wetlands must use slow-release low-phosphorus fertilizer (typical proportions 3-1-2 N-P-K).

5. The following requirements apply to **mulching**:
   A. Mulch is always required for seeding slopes greater than 3H:1V (see Section D.4.2.1).
   B. If seeding during the wet season, mulch is required.
   C. The use of mulch may be required during the dry season at the County's discretion if grass growth is expected to be slow, the soils are highly erodible due to soil type or gradient, there is a water body close to the disturbed area, or significant precipitation (see Section D.5.2) is anticipated before the grass will provide effective cover.
   D. Mulch can be applied on top of the seed or simultaneously by hydroseeding.
6. **Hydroseeding** is allowed as long as tackifier is included. Hydroseeding with wood fiber mulch is adequate during the dry season. During the wet season, the application rate shall be doubled because the mulch and tackifier used in hydroseeding break down fairly rapidly. It may be necessary in some applications to include straw with the wood fiber, but this can be detrimental to germination.
7. Areas to be permanently landscaped shall use **soil amendments**. Good quality topsoil shall be tilled into the top six inches to reduce the need for fertilizer and improve the overall soil quality. Most native soils will require the addition of four inches of well-rotted compost to be tilled into the soil to provide a good quality topsoil. Compost used should meet Ecology publication 98-38 specifications for Grade A quality compost.
8. The **seed mixes** listed below include recommended mixes for both temporary and permanent seeding. These mixes, with the exception of the wetland mix, shall be applied at a rate of 120 pounds per acre. This rate can be reduced if soil amendments or slow-release fertilizers are used. Local suppliers should be consulted for their recommendations because the appropriate mix depends on a variety of factors, including exposure, soil type, slope, and expected foot traffic. Alternative seed mixes approved by the County may be used.

Table D.4.B presents the standard mix for those areas where just a temporary vegetative cover is required.

TABLE D.4.B TEMPORARY EROSION CONTROL SEED MIX

	% Weight	% Purity	% Germination
Chewings or red fescue *Festuca rubra var. commutata* or *Festuca rubra*	40	98	90
Annual or perennial rye *Lolium multiflorum* or *Lolium perenne*	40	98	90
Redtop or colonial bentgrass *Agrostis alba* or *Agrostis tenuis*	10	92	85
White dutch clover *Trifolium repens*	10	98	90

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Table D.4.C provides just one recommended possibility for landscaping seed.

TABLE D.4.C LANDSCAPING SEED MIX			
	% Weight	**% Purity**	**% Germination**
Perennial rye blend *Lolium perenne*	70	98	90
Chewings and red fescue blend *Festuca rubra var. commutata* or *Festuca rubra*	30	98	90

This turf seed mix in Table D.4.D is for dry situations where there is no need for much water. The advantage is that this mix requires very little maintenance.

TABLE D.4.D LOW-GROWING TURF SEED MIX			
	% Weight	**% Purity**	**% Germination**
Dwarf tall fescue (several varieties) *Festuca arundinacea var.*	45	98	90
Dwarf perennial rye (Barclay) *Lolium perenne var. barclay*	30	98	90
Red fescue *Festuca rubra*	20	98	90
Colonial bentgrass *Agrostis tenuis*	5	98	90

Table D.4.E presents a mix recommended for bioswales and other intermittently wet areas. Sod shall generally not be used for bioswales because the seed mix is inappropriate for this application. Sod can be used for lining ditches to prevent erosion, but it will provide little water quality benefit during the wet season.

TABLE D.4.E BIOSWALE SEED MIX*			
	% Weight	**% Purity**	**% Germination**
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	75-80	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	92	85
Redtop bentgrass *Agrostis alba* or *Agrostis gigantea*	5-10	90	80
* Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix			

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The seed mix shown in Table D.4.F is a recommended low-growing, relatively non-invasive seed mix appropriate for very wet areas which are not regulated wetlands (if planting in wetland areas, see Section 6.3.1 of the *Surface Water Design Manual*). Other mixes may be appropriate, depending on the soil type and hydrology of the area. Apply this mixture at a rate of 60 pounds per acre.

TABLE D.4.F WET AREA SEED MIX*

	% Weight	% Purity	% Germination
Tall or meadow fescue *Festuca arundinacea* or *Festuca elatior*	60-70	98	90
Seaside/Creeping bentgrass *Agrostis palustris*	10-15	98	85
Meadow foxtail *Alepocurus pratensis*	10-15	90	80
Alsike clover *Trifolium hybridum*	1-6	98	90
Redtop bentgrass *Agrostis alba*	1-6	92	85

* Modified Briargreen, Inc. Hydroseeding Guide Wetlands Seed Mix

The meadow seed mix in Table D.4.G is recommended for areas that will be maintained infrequently or not at all and where colonization by native plants is desirable. Likely applications include rural road and utility right-of-way. Seeding should take place in September or very early October in order to obtain adequate establishment prior to the winter months. The appropriateness of clover in the mix may need to be considered as this can be a fairly invasive species. If the soil is amended, the addition of clover may not be necessary.

TABLE D.4.G MEADOW SEED MIX

	% Weight	% Purity	% Germination
Redtop or Oregon bentgrass *Agrostis alba* or *Agrostis oregonensis*	40	92	85
Red fescue *Festuca rubra*	40	98	90
White dutch clover *Trifolium repens*	20	98	90

Maintenance Standards for Temporary and Permanent Seeding

1. Any seeded areas that fail to establish at least 80 percent cover within one month shall be reseeded. If reseeding is ineffective, an alternate method, such as sodding or nets/blankets, shall be used. If winter weather prevents adequate grass growth, this time limit may be relaxed at the discretion of the County when sensitive areas would otherwise be protected.

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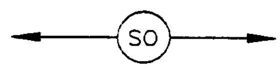
2. After adequate cover is achieved, any areas that experience erosion shall be reseeded and protected by mulch. If the erosion problem is drainage related, the problem shall be fixed and the eroded area reseeded and protected by mulch.
3. Seeded areas shall be supplied with adequate moisture, but not watered to the extent that it causes runoff.

D.4.2.5 SODDING

Code: SO Symbol:



Purpose

The purpose of sodding is to establish permanent turf for immediate erosion protection and to stabilize drainage ways where concentrated overland flow will occur.

Conditions of Use

Sodding may be used in the following areas:

1. Disturbed areas that require short-term or long-term cover
2. Disturbed areas that require immediate vegetative cover
3. All waterways that require vegetative lining (except biofiltration swales—the seed mix used in most sod is not appropriate for biofiltration swales). Waterways may also be seeded rather than sodded, and protected with a net or blanket (see Section D.4.2.2).

Design and Installation Specifications

Sod shall be free of weeds, of uniform thickness (approximately 1-inch thick), and shall have a dense root mat for mechanical strength.

The following steps are recommended for sod installation:

1. Shape and smooth the surface to final grade in accordance with the approved grading plan.
2. Amend two inches (minimum) of well-rotted compost into the top six inches of the soil if the organic content of the soil is less than ten percent. Compost used should meet Ecology publication 98-38 specifications for Grade A quality compost.
3. Fertilize according to the supplier's recommendations. Disturbed areas within 200 feet of water bodies and wetlands must use non-phosphorus fertilizer.
4. Work lime and fertilizer 1 to 2 inches into the soil, and smooth the surface.
5. Lay strips of sod beginning at the lowest area to be sodded and perpendicular to the direction of water flow. Wedge strips securely into place. Square the ends of each strip to provide for a close, tight fit. Stagger joints at least 12 inches. Staple on slopes steeper than 3H:1V.
6. Roll the sodded area and irrigate.
7. When sodding is carried out in alternating strips or other patterns, seed the areas between the sod immediately after sodding.

Maintenance Standards

If the grass is unhealthy, the cause shall be determined and appropriate action taken to reestablish a healthy groundcover. If it is impossible to establish a healthy groundcover due to frequent saturation, instability, or some other cause, the sod shall be removed, the area seeded with an appropriate mix, and protected with a net or blanket.

D.4.3 PERIMETER PROTECTION

ESC Requirement 3: Perimeter protection to filter sediment from sheetwash shall be located downslope of all disturbed areas and shall be installed prior to upslope grading. Perimeter protection includes the use of vegetated strips as well as more conventional, constructed measures, such as silt fences. During the wet season, 50 linear feet of silt fence (and the necessary stakes) per acre of disturbed area must be stockpiled on site.

Purpose: The purpose of perimeter protection is to reduce the amount of sediment transported beyond the disturbed areas of the construction site. Perimeter protection is primarily a backup means of sediment control. Most, if not all, sediment-laden water is to be treated in a sediment trap or pond. The only circumstances in which perimeter control is to be used as a primary means of sediment removal is when the catchment is very small (see below).

When to Install: Perimeter protection is to be installed prior to any upslope clearing and grading.

Measures to Use: There are three perimeter protection measures in this section that can be used to satisfy ESC Requirement 3: silt fence, brush barriers, and vegetated strips. These measures can be used interchangeably. If surface water is collected by an interceptor dike or swale and routed to a sediment pond or trap, there is no need for the perimeter protection measures specified in this section.

Criteria for Use as Primary Treatment: At the boundary of a site, perimeter protection may be used as the sole form of treatment when the flowpath meets the criteria listed below. If these criteria are not met, perimeter protection shall only be used as a backup to a sediment trap or pond.

Average Slope	Slope Percent	Flowpath Length
1.5H:1V or less	67% or less	100 feet
2H:1V or less	50% or less	115 feet
4H:1V or less	25% or less	150 feet
6H:1V or less	16.7% or less	200 feet
10H:1V or less	10% or less	250 feet

D.4.3.1 SILT FENCE

Code: SF Symbol: —X—X—X—X—X

Purpose

Use of a silt fence reduces the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

1. Silt fence may be used downslope of all disturbed areas.
2. Silt fence is not intended to treat concentrated flows, nor is it intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment trap or pond. The only circumstance in which overland flow can be treated solely by a silt fence, rather than by a sediment trap or pond, is when the area draining to the fence is small (see "Criteria for Use as Primary Treatment" on page D-18).

Design and Installation Specifications

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1. See Figure D.4.E for details.

2. The geotextile used must meet the standards listed below. A copy of the manufacturer's fabric specifications must be available on site.

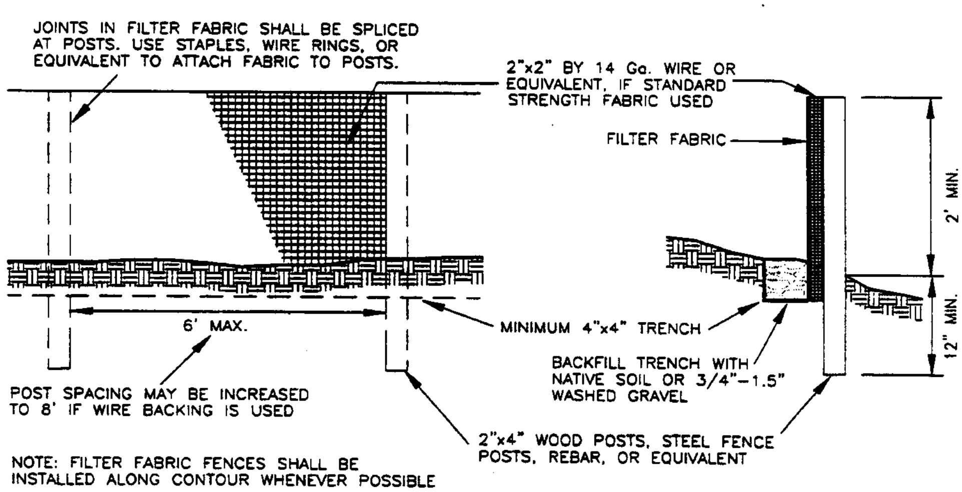
AOS (ASTM D4751)	30-100 sieve size (0.60-0.15 mm) for slit film 50-100 sieve size (0.30-0.15 mm) for other fabrics
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum
Grab Tensile Strength (ASTM D4632)	180 lbs. min. for extra strength fabric 100 lbs. min. for standard strength fabric
Grab Tensile Elongation(ASTM D4632)	30% max.
Ultraviolet resistance (ASTM D4355)	70% min.

3. Standard strength fabric requires wire backing to increase the strength of the fence. Wire backing or closer post spacing may be required for extra strength fabric if field performance warrants a stronger fence.
4. Where the fence is installed, the slope shall be no steeper than 2H:1V.

Maintenance Standards

1. Any damage shall be repaired immediately.
2. If concentrated flows are evident uphill of the fence, they must be intercepted and conveyed to a sediment trap or pond.
3. It is important to check the uphill side of the fence for signs of the fence clogging and acting as a barrier to flow and then causing channelization of flows parallel to the fence. If this occurs, replace the fence or remove the trapped sediment.
4. Sediment must be removed when the sediment is 6 inches high.
5. If the filter fabric (geotextile) has deteriorated due to ultraviolet breakdown, it shall be replaced.

FIGURE D.4.E SILT FENCE



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D.4.3.2 BRUSH BARRIER

Code: BB Symbol:

Purpose

The purpose of brush barriers is to reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

1. Brush barriers may be used downslope of all disturbed areas.
2. Brush barriers are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment trap or pond. The only circumstance in which overland flow can be treated solely by a barrier, rather than by a sediment trap or pond, is when the area draining to the barrier is small (see "Criteria for Use as Primary Treatment" on page D-18).

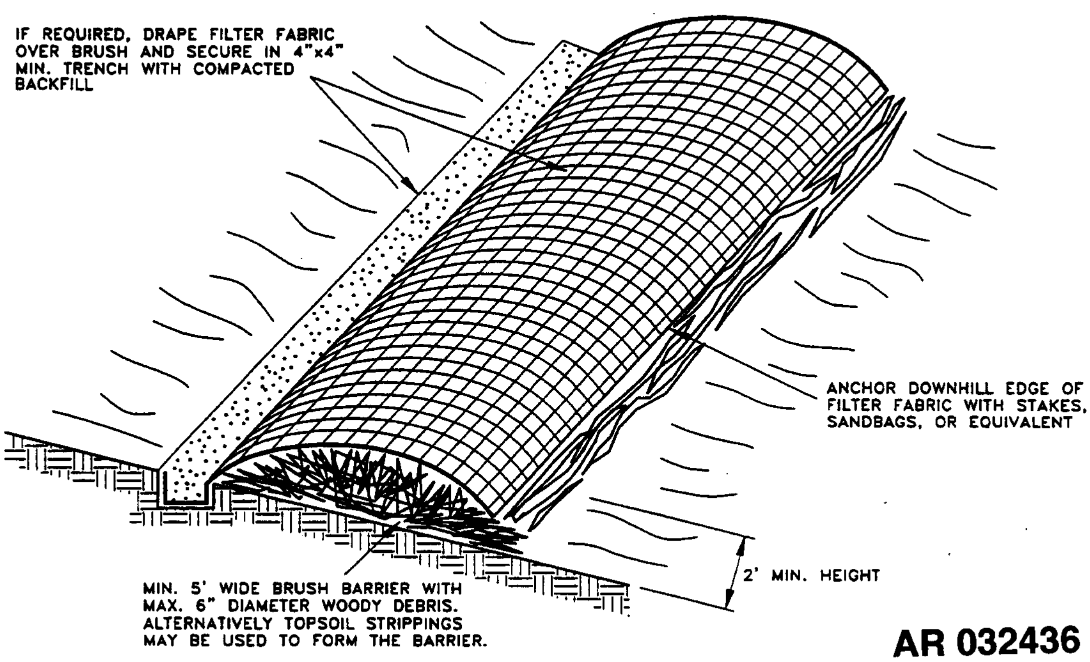
Design and Installation Specifications

1. See Figure D.4.F for details.
2. King County may require filter fabric (geotextile) anchored over the brush berm to enhance the filtration ability of the barrier.

Maintenance Standards

1. There shall be no signs of erosion or concentrated runoff under or around the barrier. If concentrated flows are bypassing the barrier, it must be expanded or augmented by toed-in filter fabric.
2. The dimensions of the barrier must be maintained.

FIGURE D.4.F BRUSH BARRIER



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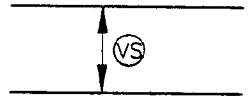
D.4.3.3 VEGETATED STRIP

Code: VS Symbol: 

Purpose

Vegetated strips reduce the transport of coarse sediment from a construction site by providing a temporary physical barrier to sediment and reducing the runoff velocities of overland flow.

Conditions of Use

1. Vegetated strips may be used downslope of all disturbed areas.
2. Vegetated strips are not intended to treat concentrated flows, nor are they intended to treat substantial amounts of overland flow. Any concentrated flows must be conveyed through the drainage system to a sediment trap or pond. The only circumstance in which overland flow can be treated solely by a strip, rather than by a sediment trap or pond, is when the area draining to the strip is small (see "Criteria for Use as Primary Treatment" on page D-18).

Design and Installation Specifications

1. The vegetated strip shall consist of a 25-foot wide continuous strip of dense vegetation with a permeable topsoil. Grass-covered, landscaped areas are generally not adequate because the volume of sediment overwhelms the grass. Ideally, vegetated strips shall consist of undisturbed native growth with a well-developed soil that allows for infiltration of runoff.
2. The slope within the strip shall not exceed 4H:1V.
3. The uphill boundary of the vegetated strip shall be delineated with clearing limits as specified in Section D.4.1 (p. D-6).

Maintenance Standards

1. Any areas damaged by erosion or construction activity shall be seeded immediately and protected by mulch.
2. If more than 5 feet of the original vegetated strip width has had vegetation removed or is being eroded, sod must be installed.
3. If there are indications that concentrated flows are traveling across the buffer, surface water controls must be installed to reduce the flows entering the buffer, or additional perimeter protection must be installed.

D.4.4 TRAFFIC AREA STABILIZATION

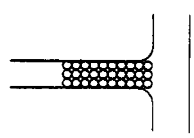
ESC Requirement 4: Unsurfaced entrances, roads, and parking areas used by construction traffic shall be stabilized to minimize erosion and tracking of sediment off site. Stabilized construction entrances shall be installed as the first step in clearing and grading. At the County's discretion, road and parking area stabilization is not required during the dry season (unless dust is a concern) or if the site is underlain by coarse-grained soils. Roads and parking areas shall be stabilized immediately after initial grading.

Purpose: The purpose of traffic area stabilization is to reduce the amount of sediment transported off site by construction vehicles and to reduce the erosion of areas disturbed by vehicle traffic. Sediment transported off site onto paved streets is a significant problem because it is difficult to effectively remove, and any sediment not removed ends up in the drainage system. Additionally, sediment on public right-of-way can pose a serious traffic hazard. Construction road and parking area stabilization is important because the combination of wet soil and heavy equipment traffic typically forms a slurry of easily erodible mud. Finally, stabilization also is an excellent form of dust control in the summer months.

When to Install: The construction entrance is to be installed as the first step in clearing and grading. Construction road stabilization shall occur immediately after initial grading of the construction roads and parking areas.

Measures to Use: There are two types of traffic area stabilization: (1) a stabilized construction entrance and (2) construction road/parking area stabilization. Both measures must be used as specified under "Conditions of Use" for each measure.

D.4.4.1 STABILIZED CONSTRUCTION ENTRANCE

Code: CE Symbol: 

Purpose

Construction entrances are stabilized to reduce the amount of sediment transported onto paved roads by motor vehicles or runoff by constructing a stabilized pad of quarry spalls at entrances to construction sites.

Conditions of Use

Construction entrances shall be stabilized wherever traffic will be leaving a construction site and traveling on paved roads or other paved areas within 1,000 feet of the site.

Design and Installation Specifications

1. See Figure D.4.G for details.
2. A separation geotextile shall be placed under the spalls to prevent fine sediment from pumping up into the rock pad. The geotextile shall meet the following standards:

Grab Tensile Strength (ASTM D4751)	200 psi min.
Grab Tensile Elongation (ASTM D4632)	30% max.
Mullen Burst Strength (ASTM D3786-80a)	400 psi min.
AOS (ASTM D4751)	20-45 (U.S. standard sieve size)

3. Hog fuel may be substituted for or combined with quarry spalls in areas that will not be used for permanent roads. The effectiveness of hog fuel is highly variable, but it has been used successfully on many sites. It generally requires more maintenance than quarry spalls. The inspector may at any time

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require the use of quarry spalls if the hog fuel is not preventing sediment from being tracked onto pavement or if the hog fuel is being carried onto pavement. Hog fuel is prohibited in permanent roadbeds because organics in the subgrade soils cause difficulties with compaction.

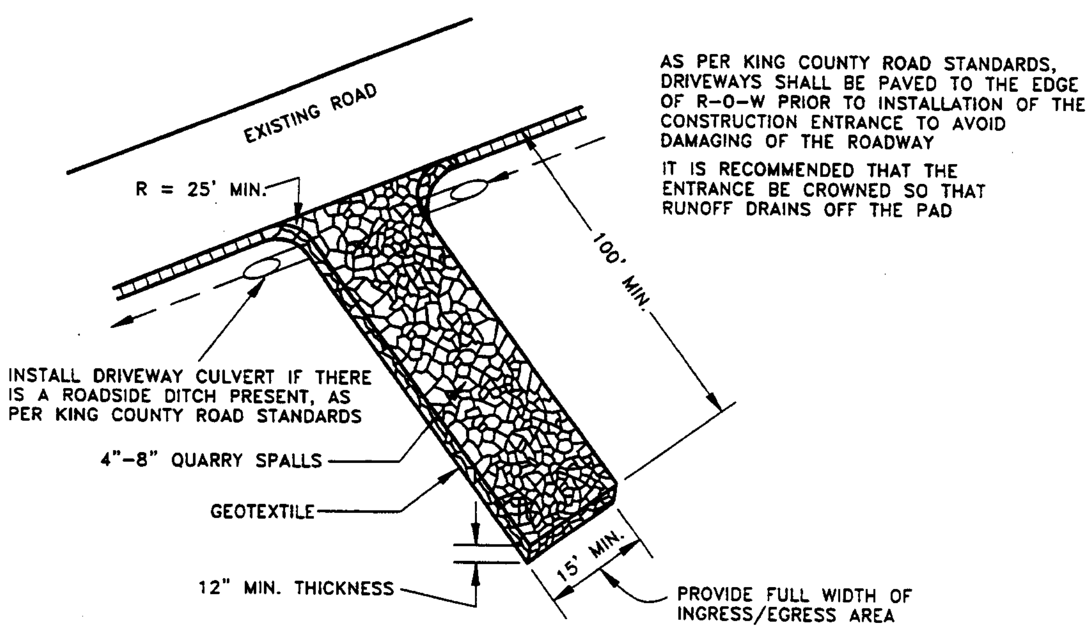
4. Fencing (see Section D.4.1) shall be installed as necessary to restrict traffic to the construction entrance.

5. Whenever possible, the entrance shall be constructed on a firm, compacted subgrade. This can substantially increase the effectiveness of the pad and reduce the need for maintenance.

Maintenance Standards

1. Quarry spalls (or hog fuel) shall be added if the pad is no longer in accordance with the specifications.
2. If the entrance is not preventing sediment from being tracked onto pavement, then alternative measures to keep the streets free of sediment shall be used. This may include street sweeping, an increase in the dimensions of the entrance, or the installation of a wheel wash. If washing is used, it shall be done on an area covered with crushed rock, and wash water shall drain to a sediment trap or pond.
3. Any sediment that is tracked onto pavement shall be removed immediately by sweeping. The sediment collected by sweeping shall be removed or stabilized on site. The pavement shall not be cleaned by washing down the street, except when sweeping is ineffective and there is a threat to public safety. If it is necessary to wash the streets, the construction of a small sump shall be considered. The sediment would then be washed into the sump.
4. Any quarry spalls that are loosened from the pad and end up on the roadway shall be removed immediately.
5. If vehicles are entering or exiting the site at points other than the construction entrance(s), fencing (see Section D.4.1) shall be installed to control traffic.

FIGURE D.4.G STABILIZED CONSTRUCTION ENTRANCE



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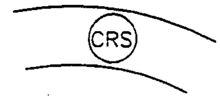
D.4.4.2 CONSTRUCTION ROAD/PARKING AREA STABILIZATION

Code: CRS Symbol: 

Purpose

Stabilizing subdivision roads, parking areas, and other onsite vehicle transportation routes immediately after grading reduces erosion caused by construction traffic or runoff.

Conditions of Use

1. Roads or parking areas shall be stabilized wherever they are constructed, whether permanent or temporary, for use by construction traffic.
2. Fencing (see Section D.4.1) shall be installed, if necessary, to limit the access of vehicles to only those roads and parking areas that are stabilized.

Design and Installation Specifications

1. A 6-inch depth of 2- to 4-inch **crushed rock, gravel base, or crushed surfacing base course** shall be applied immediately after grading or utility installation. A 4-inch course of asphalt treated base (ATB) may also be used, or the road/parking area may be paved. It may also be possible to use cement or calcium chloride for soil stabilization. If the area will not be used for permanent roads, parking areas, or structures, a 6-inch depth of hog fuel may also be used, but this is likely to require more maintenance. Whenever possible, construction roads and parking areas shall be placed on a firm, compacted subgrade. *Note: If the area will be used for permanent road or parking installation later in the project, the subgrade will be subject to inspection.*
2. **Temporary road gradients** shall not exceed 15 percent. Roadways shall be carefully graded to drain transversely. Drainage ditches shall be provided on each side of the roadway in the case of a crowned section, or on one side in the case of a super-elevated section. Drainage ditches shall be designed in accordance with the standards given in Section D.4.6.3 (p. D-37) and directed to a sediment pond or trap.
3. Rather than relying on ditches, it may also be possible to **grade the road** so that runoff sheet-flows into a heavily vegetated area with a well-developed topsoil. Landscaped areas are not adequate. If this area has at least 50 feet of vegetation, then it is generally preferable to use the vegetation to treat runoff, rather than a sediment pond or trap. The 50 feet shall not include vegetated wetlands. If runoff is allowed to sheetflow through adjacent vegetated areas, it is vital to design the roadways and parking areas so that no concentrated runoff is created.
4. In order to control construction traffic, the County can require that **signs** be erected on site informing construction personnel that vehicles, other than those performing clearing and grading, are restricted to stabilized areas.

Maintenance Standards

Crushed rock, gravel base, hog fuel, etc. shall be added as required to maintain a stable driving surface and to stabilize any areas that have eroded.

AR 032440

D.4.5 SEDIMENT RETENTION

ESC Requirement 5: Surface water collected from disturbed areas of the site shall be routed through a sediment pond or trap prior to release from the site. An exception is for areas at the perimeter of the site with drainage areas small enough to be treated solely with perimeter protection (see Section D.4.3, p. D-18). Also, if the soils and topography are such that no offsite discharge of surface water is anticipated up to and including the developed 2-year runoff event, sediment ponds and traps are not required. A 10-year peak flow shall be used for sediment pond/trap sizing if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection (see below). At the County's discretion, sites may be worked during the dry season without sediment ponds and traps if there is some other form of protection of surface waters, such as a 100-foot forested buffer between the disturbed areas and adjacent surface waters. Protection of catch basins is required for inlets that are likely to be impacted by sediment generated by the project and that do not drain to an onsite sediment pond or trap. Sediment retention facilities shall be installed prior to grading of any contributing area.

Purpose: The purpose of sediment retention facilities is to remove sediment from runoff generated from disturbed areas.

When to Install: The facilities shall be constructed as the first step in the clearing and grading of the site. The surface water conveyances can then be connected to the facilities as site development proceeds.

Measures to Use: There are three sediment retention measures in this section. The first two, sediment traps and ponds, serve the same function but for different size catchments. All runoff from disturbed areas must be routed through a trap or pond except for very small areas as specified in Section D.4.3. The third measure is for catch basin protection. It is only to be used in limited circumstances and is not a primary sediment treatment facility. It is only intended as a backup in the event of failure of other onsite systems.

Use of Permanent Drainage Facilities: All projects that are constructing permanent facilities for runoff quantity control are strongly encouraged to use the rough-graded or final-graded permanent facilities for ponds and traps. This includes combined facilities and infiltration facilities. When permanent facilities are used as temporary sedimentation facilities, the surface area requirements of sediment traps (for drainages less than 3 acres) or sediment ponds (more than 3 acres) must be met. If the surface area requirements are larger than the surface area of the permanent facility, then the pond shall be enlarged to comply with the surface area requirement. The permanent pond shall also be divided into two cells as required for sediment ponds. Either a permanent control structure or the temporary control structure described in Section D.4.5.2 can be used. If a permanent control structure is used, it may be advisable to partially restrict the lower orifice with gravel to increase residence time while still allowing dewatering of the pond.

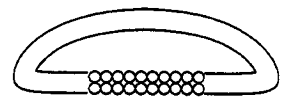
If infiltration facilities are to be used, the sides and bottom of the facility must only be rough excavated to a minimum of three feet above final grade. Excavation should be done with a backhoe working at "arms length" to minimize disturbance and compaction of the infiltration surface. Additionally, any required pretreatment facilities shall be fully constructed prior to any release of sediment-laden water to the facility. Pretreatment and shallow excavation are intended to prevent the clogging of soil with fines. Final grading of the infiltration facility shall occur only when all contributing drainage areas are fully stabilized (see Section D.5.5, p. D-44).

Selection of the Design Storm: In most circumstances, the use of the developed 2-year runoff event is sufficient for calculating surface area for ponds and traps and for determining exemptions to ESC Requirements 5 and 6 (Sections D.4.5 and 0, respectively). In some circumstances, however, the 10-year peak flow should be used. Examples of such circumstances include the following:

- Sites that are within ¼ mile of salmonid streams, Class 1 wetlands, and designated sensitive lakes such as Lake Sammamish
- Sites where significant clearing and grading is likely to occur during the wet season
- Sites with downstream erosion or sedimentation problems.

Natural Vegetation: Whenever possible, sediment-laden water shall be discharged into onsite, relatively level, vegetated areas. This is the only way to effectively remove fine partiçles from runoff. This can be particularly useful after initial treatment in a sediment retention facility. The areas of release must be evaluated on a site-by-site basis in order to determine appropriate locations for and methods of releasing runoff. Vegetated wetlands shall not be used for this purpose. Frequently, it may be possible to pump water from the collection point at the downhill end of the site to an upslope vegetated area. Pumping shall only augment the treatment system, not replace it because of the possibility of pump failure or runoff volume in excess of pump capacity.

D.4.5.1 SEDIMENT TRAP

Code: ST Symbol: 

Purpose

Sediment traps remove sediment from runoff originating from disturbed areas of the site. Sediment traps are typically designed to only remove sediment as small as medium silt (0.02 mm). As a consequence, they usually only result in a small reduction in turbidity.

Conditions of Use

A sediment trap shall be used where the contributing drainage area is 3 acres or less.

Design and Installation Specifications

1. See Figure D.4.H for details.
2. If permanent runoff control facilities are part of the project, they should be used for sediment retention (see "Use of Permanent Drainage Facilities" on page D-25).
3. To determine the trap geometry, first calculate the design surface area (SA) of the trap, measured at the invert of the weir. Use the following equation:

$$SA = FS(Q_2/V_S)$$

where Q_2 = Design inflow based on the peak discharge from the developed 2-year runoff event from the contributing drainage area as computed in the hydrologic analysis. The 10-year peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used (Section 3.2.1 of the *Surface Water Design Manual*).

V_S = The settling velocity of the soil particle of interest. The 0.02 mm (medium silt) particle with an assumed density of 2.65 g/cm^3 has been selected as the particle of interest and has a settling velocity (V_S) of 0.00096 ft/sec.

FS = A safety factor of 2 to account for non-ideal settling.

Therefore, the equation for computing surface area becomes:

$$SA = 2 \times Q_2/0.00096 \quad \text{or} \quad 2080 \text{ square feet per cfs of inflow}$$

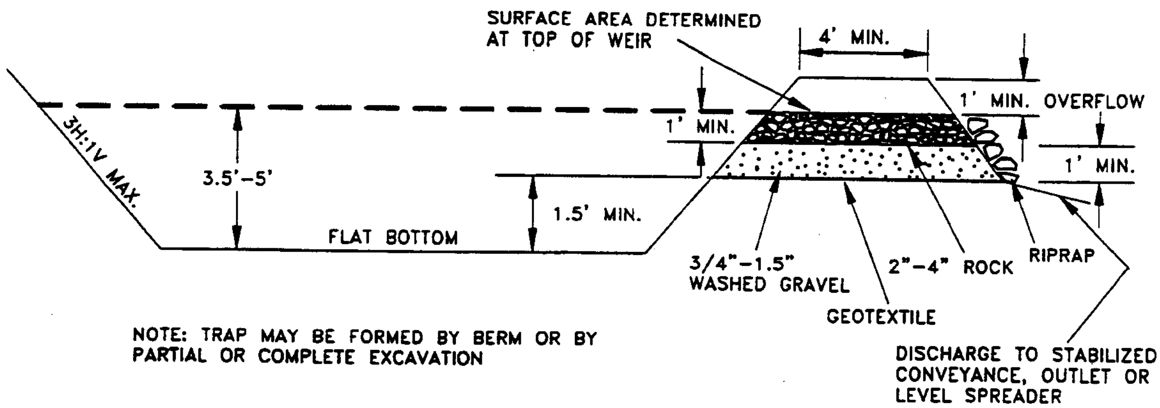
Note: Even if permanent facilities are used, they must still have a surface area that is at least as large as that derived from the above formula. If they do not, the pond must be enlarged.

4. To aid in determining sediment depth, all traps shall have a staff gage with a prominent mark one foot above the bottom of the trap.

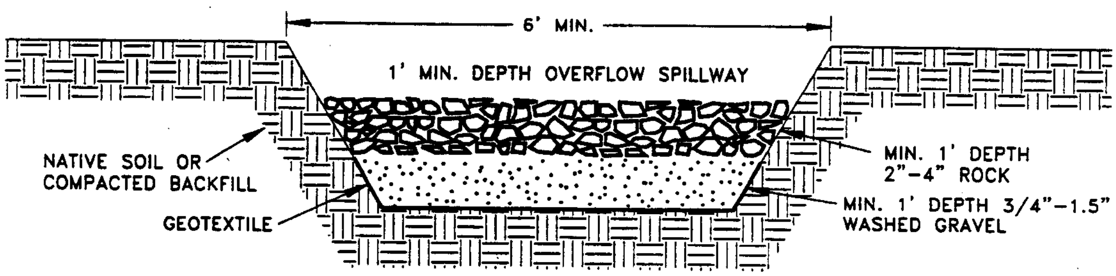
Maintenance Standards

1. Sediment shall be removed from the trap when it reaches 1 foot in depth.
2. Any damage to the trap embankments or slopes shall be repaired.

FIGURE D.4.H SEDIMENT TRAP



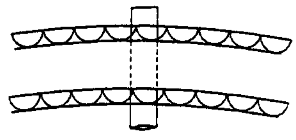
CROSS-SECTION



TRAP OUTLET

D.4.5.2 SEDIMENT POND

Code: SP Symbol:



Purpose

Sediment ponds remove sediment from runoff originating from disturbed areas of the site. Sediment ponds are typically designed to only remove sediment as small as medium silt (0.02 mm). As a consequence, they usually reduce turbidity only slightly.

Conditions of Use

A sediment pond shall be used where the contributing drainage area is 3 acres or more.

Design and Installation Specifications

1. See Figure D.4.I, Figure D.4.J, and Figure D.4.K for details.
2. If permanent runoff control facilities are part of the project, they should be used for sediment retention (see "Use of Permanent Drainage Facilities" on page D-25).

Determining Pond Geometry

1. Obtain the discharge from the hydrologic calculations of the peak flow for the 2-year runoff event (Q_2). The 10-year peak flow shall be used if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection. If no hydrologic analysis is required, the Rational Method may be used (Section 3.2.1 of the *Surface Water Design Manual*).
2. Determine the required surface area at the top of the riser pipe with the equation:

   $SA = 2 \times Q_2/0.00096$ or 2080 square feet per cfs of inflow

   See Section D.4.5.1 (p. D-26) for more information on the derivation of the surface area calculation.
3. The basic geometry of the pond can now be determined using the following design criteria:
   - Required surface area *SA* (from Step 2 above) at top of riser
   - Minimum 3.5-foot depth from top of riser to bottom of pond
   - Maximum 3:1 interior side slopes and maximum 2:1 exterior slopes. The interior slopes can be increased to a maximum of 2:1 if fencing is provided at or above the maximum water surface
   - One foot of freeboard between the top of the riser and the crest of the emergency spillway
   - Flat bottom
   - Minimum one foot deep spillway
   - Length-to-width ratio between 3:1 and 6:1.

Sizing of Discharge Mechanisms

Principal Spillway: Determine the required diameter for the principal spillway (riser pipe). The diameter shall be the minimum necessary to pass the pre-developed 10-year peak flow (Q_{10}). Use Figure 5.3.4.H (*SWDM* Chapter 5) to determine this diameter (h = one foot). *Note: A permanent control structure may be used instead of a temporary riser.*

Emergency Overflow Spillway: Determine the required size and design of the emergency overflow spillway for the developed 100-year peak flow using the procedure in Section 5.3.1 ("Emergency Overflow Spillway" subsection) of the *Surface Water Design Manual.*

Dewatering Orifice: Determine the size of the dewatering orifice(s) (minimum 1-inch diameter) using a modified version of the discharge equation for a vertical orifice and a basic equation for the area of a circular orifice.

1. Determine the required area of the orifice with the following equation:

$$A_o = \frac{A_s(2h)^{0.5}}{0.6\mathrm{x}3600Tg^{0.5}}$$

where A_O = orifice area (square feet)
A_S = pond surface area (square feet)
h = head of water above orifice (height of riser in feet)
T = dewatering time (24 hours)
g = acceleration of gravity (32.2 feet/second^2)

2. Convert the required surface area to the required diameter D of the orifice:

$$D = 24\mathrm{x}\sqrt{\frac{A_o}{\pi}} = 13.54\mathrm{x}\sqrt{A_o}$$

3. The vertical, perforated tubing connected to the dewatering orifice must be at least 2 inches larger in diameter than the orifice to improve flow characteristics. The size and number of perforations in the tubing should be large enough so that the tubing does not restrict flow. The flow rate should be controlled by the orifice.

Additional Design Specifications

- The **pond shall be divided** into two roughly equal volume cells by a permeable divider that will reduce turbulence while allowing movement of water between cells. The divider shall be at least one-half the height of the riser and a minimum of one foot below the top of the riser. Wire-backed, 2- to 3-foot high, extra strength filter fabric (see Section D.4.3.1) supported by treated 4"x4"s can be used as a divider. Alternatively, staked straw bales wrapped with filter fabric (geotextile) may be used.

  If the pond is more than 6 feet deep, a different mechanism must be proposed. A riprap embankment is one acceptable method of separation for deeper ponds. Other designs that satisfy the intent of this provision are allowed as long as the divider is permeable, structurally sound, and designed to prevent erosion under or around the barrier.

- To aid in determining sediment depth, **one-foot intervals** shall be prominently marked on the riser.
- If an **embankment** of more than 6 feet is proposed, the pond must comply with the criteria under "Embankments" in Section 5.3.1 of the *Surface Water Design Manual.*

Maintenance Standards

1. Sediment shall be removed from the pond when it reaches 1 foot in depth.
2. Any damage to the pond embankments or slopes shall be repaired.

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FIGURE D.4.I SEDIMENT POND PLAN VIEW

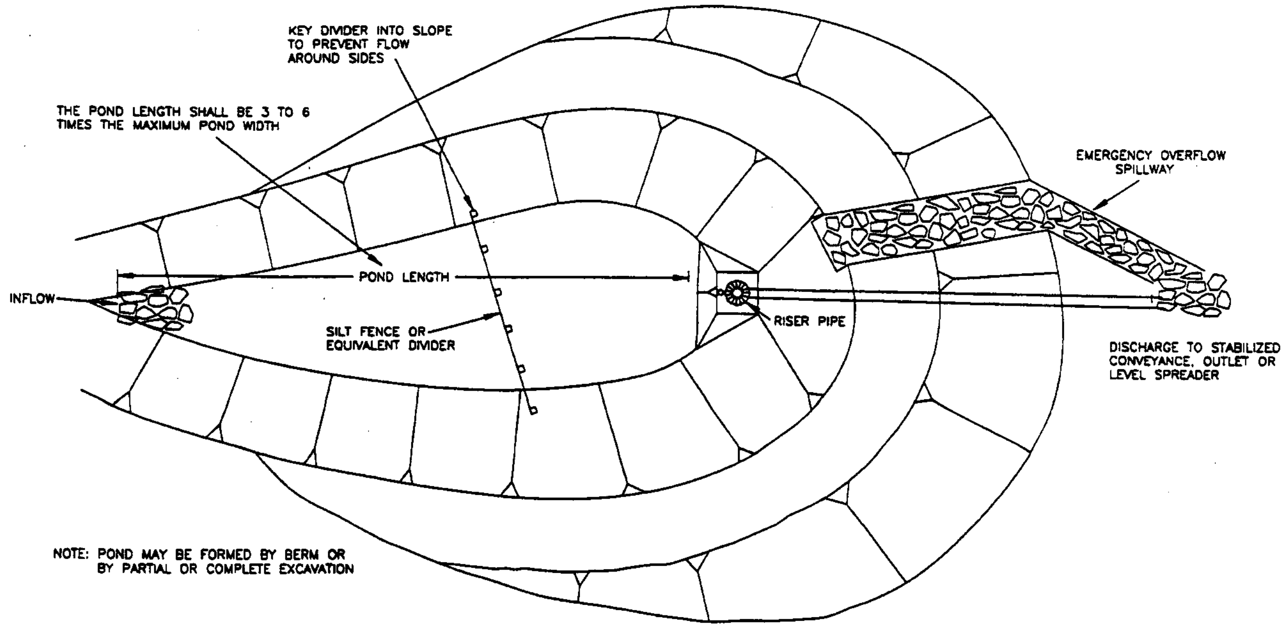

FIGURE D.4.J SEDIMENT POND CROSS SECTION

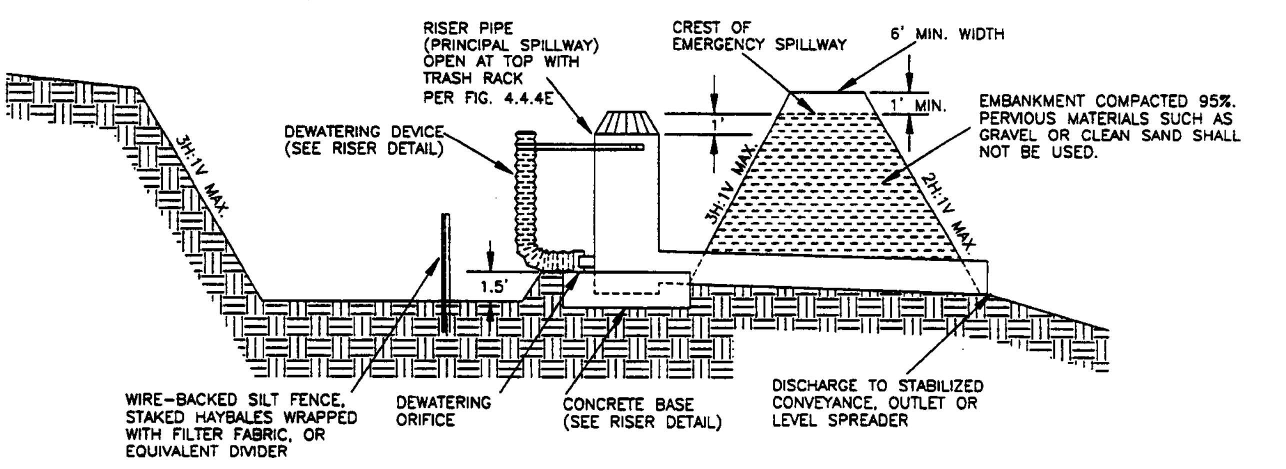

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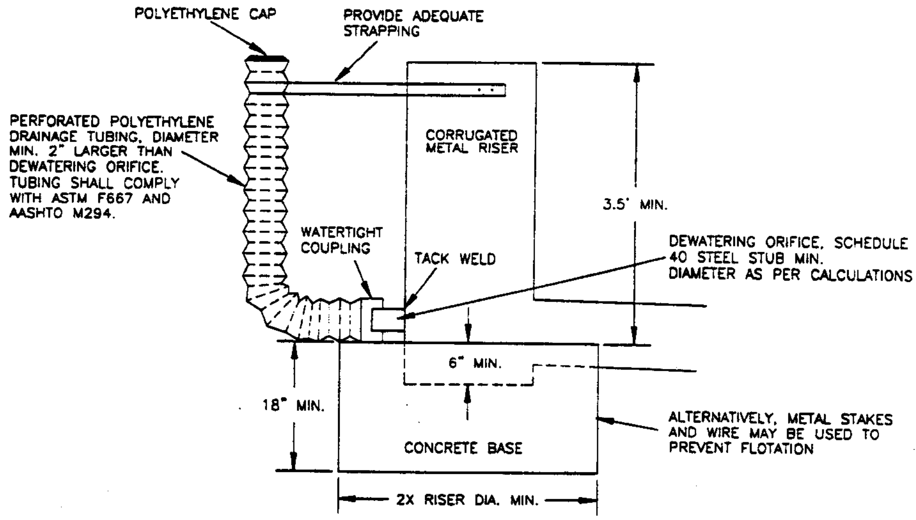
FIGURE D.4.K SEDIMENT POND RISER DETAIL



D.4.5.3 STORM DRAIN INLET PROTECTION

Code: FFP or CBI Symbol:  or 

Purpose

Storm drain inlets are protected to prevent coarse sediment from entering storm drainage systems.

Conditions of Use

1. Protection shall be provided for all storm drain inlets downslope and within 500 feet of a disturbed or construction area, unless the runoff that enters the catch basin will be conveyed to a sediment pond or trap.
2. Inlet protection may be used anywhere at the applicant's discretion to protect the drainage system. This will, however, require more maintenance, and it is highly likely that the drainage system will still require some cleaning.

Design and Installation Specifications

1. There are **two options for protecting storm drain inlets**: filter fabric protection and catch basin inserts. *Filter fabric protection* (see Figure D.4.L) is filter fabric (geotextile) placed *over* the grate. *Catch basin inserts* (see Figure D.4.M) are manufactured devices that nest inside a catch basin. Both options are much simpler to maintain than many other methods of storm drain inlet protection and are not a hazard to traffic. Both options provide adequate protection, but filter fabric is likely to result in ponding of water above the catch basin, while the insert will not. Thus, filter fabric is only allowed where ponding will not be a traffic concern and where slope erosion will not result if the curb is overtopped by ponded water.

   Trapping sediment in the catch basins is unlikely to improve the water quality of runoff if it is treated in a pond or trap because the coarse particles that are trapped at the catch basin settle out very quickly in the pond or trap. **Catch basin protection normally only improves water quality where there is no treatment facility downstream.** In these circumstances, catch basin protection is an important last line of defense. It is not, however, a substitute for preventing erosion.

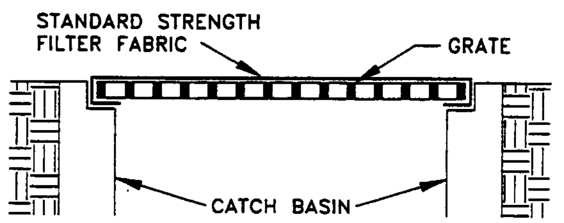
In addition, the use of catch basin protection has been severely scaled back and revised from previous versions of the *Surface Water Design Manual* due to field observations. The traditional method of protection has been placement of filter fabric under the grate of the catch basin. This method is very difficult to maintain, leads to ponding, and can cause substantial erosion because curbs can be overtopped, and concentrated runoff then erodes slopes. The placement of filter fabric *under* grates is therefore prohibited and the use of filter fabric over grates is strictly limited and discouraged.

2. It is sometimes possible to construct a small sump around the catch basin before final surfacing of the road. This is allowed because it can be a very effective method of sediment control.

Maintenance Standards

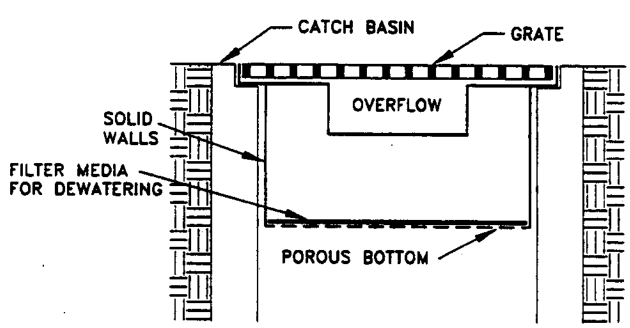
1. Any accumulated sediment on or around the filter fabric protection shall be removed immediately. Sediment shall not be removed with water, and all sediment must be disposed of as fill on site or hauled off site.
2. Any sediment in the catch basin insert shall be removed when the sediment has filled one-third of the available storage. The filter media for the insert shall be cleaned or replaced at least monthly.
3. Regular maintenance is critical for both forms of catch basin protection. Unlike many forms of protection that fail gradually, catch basin protection will fail suddenly and completely if not maintained properly.

FIGURE D.4.L FILTER FABRIC PROTECTION



NOTE: ONLY TO BE USED WHERE PONDING OF WATER ABOVE THE CATCH BASIN WILL NOT CAUSE TRAFFIC PROBLEMS AND WHERE OVERFLOW WILL NOT RESULT IN EROSION OF SLOPES.

FIGURE D.4.M CATCH BASIN INSERT



NOTE: THIS DETAIL IS ONLY SCHEMATIC. ANY INSERT IS ALLOWED THAT HAS A MIN. 0.5 C.F. OF STORAGE, THE MEANS TO DEWATER THE STORED SEDIMENT, AN OVERFLOW, AND CAN BE EASILY MAINTAINED.

AR 032448

D.4.6 SURFACE WATER CONTROL

ESC Requirement 6: All surface water from disturbed areas shall be intercepted, conveyed to a sediment pond or trap, and discharged downslope of any disturbed areas. An exception is for areas at the perimeter of the site with drainage areas small enough to be treated solely with perimeter protection (see Section D.4.3). Also, if the soils and topography are such that no offsite discharge of surface water is anticipated up to and including the developed 2-year runoff event, surface water controls are not required. A 10-year peak flow shall be used for sizing surface water controls if the project size, expected timing and duration of construction, or downstream conditions warrant a higher level of protection (see the introduction to Section D.4.5). At the County's discretion, sites may be worked during the dry season without surface water controls, if there is some other form of protection of surface waters, such as a 100-foot forested buffer between the disturbed areas and adjacent surface waters. Significant sources of upslope surface water that drain onto disturbed areas shall be intercepted and conveyed to a stabilized discharge point downslope of the disturbed areas. Surface water controls shall be installed concurrently with rough grading.

Purpose: The purpose of surface water control is to collect and convey surface water so that erosion is minimized, and runoff from disturbed areas is treated by a sediment pond or trap. Surface water control essentially consists of three elements:

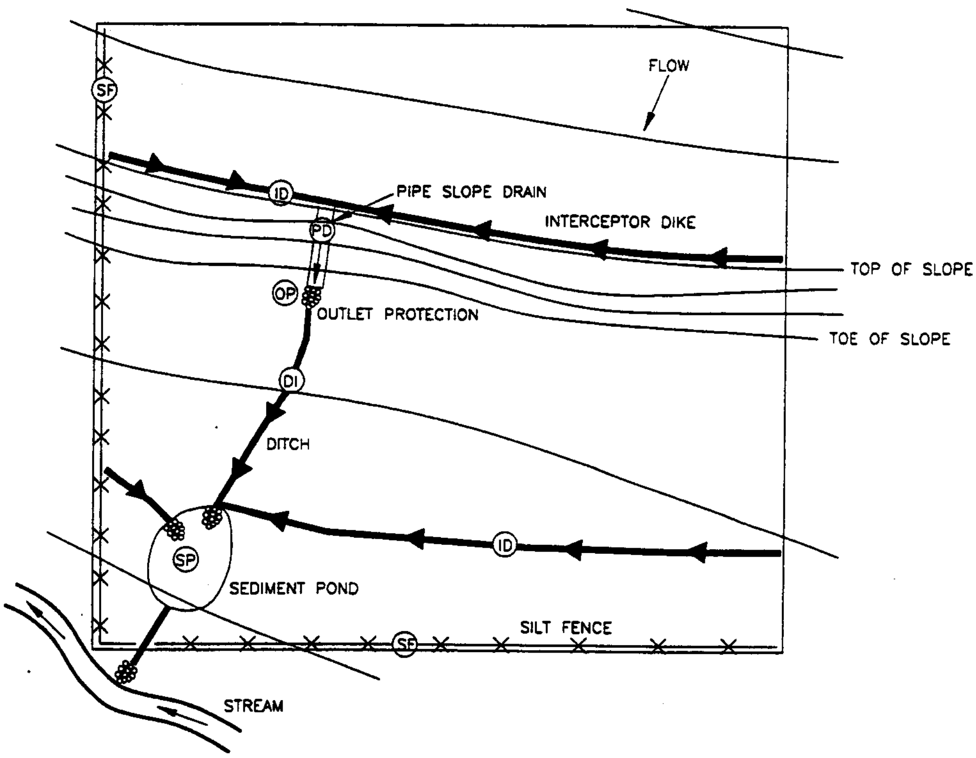
1. Interception of runoff on and above slopes
2. Conveyance of the runoff to a sediment pond or trap (if the runoff was collected from a disturbed area)
3. Release of the runoff downslope of any disturbed areas.

When to Install: Surface water controls shall be constructed during the initial grading of an area and must be in place before there is any opportunity for storm runoff to cause erosion.

Measures to Install: Interceptor dikes/swales intercept runoff, ditches and pipe slope drains convey the runoff, and riprap or level spreaders help release the runoff in a non-erosive manner. Each measure is to be used under different circumstances so there is very little overlap. However, the two options for releasing water in a non-erosive manner, outlet protection and level spreaders, can be somewhat interchangeable. See Figure D.4.N for a schematic drawing demonstrating the use of these measures.

AR 032449

FIGURE D.4.N SKETCH PLAN OF SURFACE WATER CONTROLS



D.4.6.1 INTERCEPTOR DIKE AND SWALE

Code: ID or IS Symbol: 

or 

Purpose

Interceptor dikes and swales intercept storm runoff from drainage areas on or above disturbed slopes and convey it to a sediment pond or trap. They can also be used to intercept runoff from undisturbed areas and convey the runoff to a point below any exposed soils. Interception of surface water reduces the possibility of slope erosion. Interceptor dikes and swales differ from ditches (see Section D.4.6.3) in that they are intended to convey smaller flows along low-gradient drainage ways to larger conveyance systems such as ditches or pipe slope drains.

Conditions of Use

Interceptor dikes and swales are required in the following situations:

1. At the top of all slopes in excess of 3H:1V and with more than 20 feet of vertical relief.
2. At intervals on any slope that exceeds the dimensions specified in this section for the horizontal spacing of dikes and swales.

Design and Installation Specifications

1. See Figure D.4.O for details of an interceptor dike and Figure D.4.P for an interceptor swale.

AR 032450

2. Interceptor dikes and swales shall be **spaced horizontally** as follows:

Average Slope	Slope Percent	Flowpath Length
20H:1V or less	3-5%	300 feet
(10 to 20)H:1V	5-10%	200 feet
(4 to 10)H:1V	10-25%	100 feet
(2 to 4)H:1V	25-50%	50 feet

3. For slopes steeper than 2H:1V with more than 10 feet of vertical relief, **benches** may be constructed or closer spaced interceptor dikes or swales can be used. Whichever measure is chosen, the spacing and capacity of the measures must be designed by the engineer and the design must include provisions for effectively intercepting the high velocity runoff associated with steep slopes.
4. If the dike or swale intercepts runoff from **disturbed areas**, it shall discharge to a stable conveyance system that routes the runoff to a sediment pond or trap (see Section D.4.5). If the dike or swale intercepts runoff that originates from **undisturbed areas**, it shall discharge to a stable conveyance system that routes the runoff downslope of any disturbed areas and releases the water at a stabilized outlet.
5. **Construction traffic** over temporary dikes and swales shall be minimized.

Maintenance Standards

1. Damage resulting from runoff or construction activity shall be repaired immediately.
2. If the facilities do not regularly retain storm runoff, the capacity and/or frequency of the dikes/swales shall be increased.

FIGURE D.4.O INTERCEPTOR DIKE

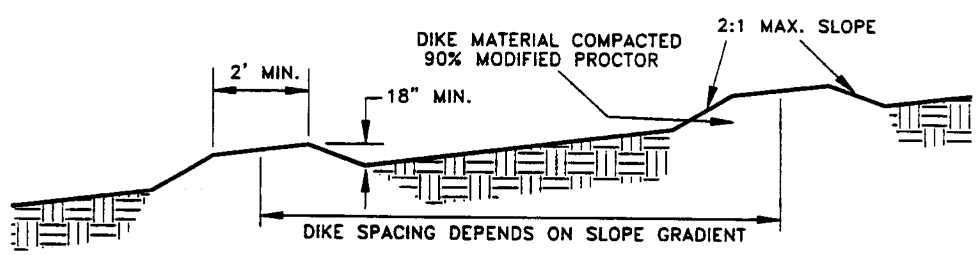
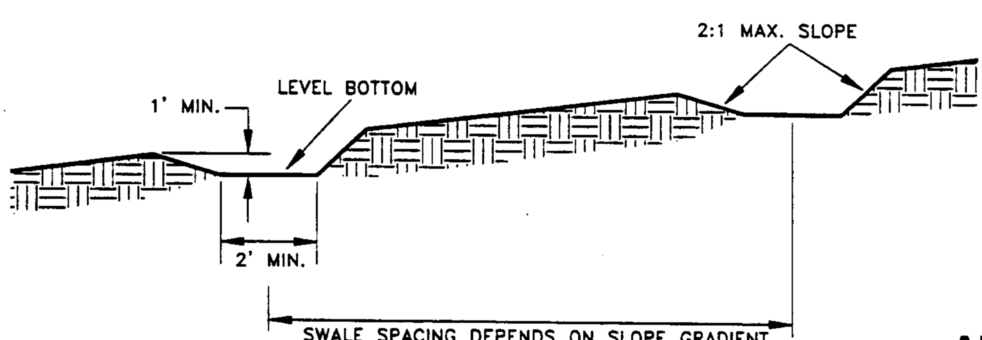


FIGURE D.4.P INTERCEPTOR SWALE



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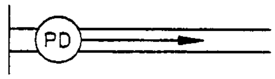
D.4.6.2 PIPE SLOPE DRAINS

Code: PD Symbol:



Purpose

Pipe slope drains are designed to carry concentrated runoff down steep slopes without causing erosion, or saturation of slide-prone soils.

Conditions of Use

1. Pipe slope drains may be used on any slope with a gradient of 2H:1V or greater and with at least 10 feet of vertical relief.
2. Rock-lined ditches or other permanent, non-erosive conveyances may also be used to convey runoff down steep slopes that are not steep slope hazard areas.

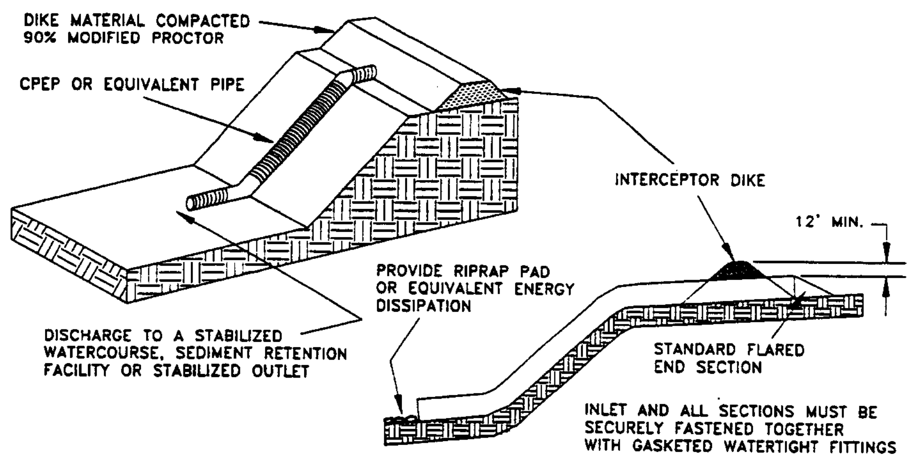
Design and Installation Specifications

1. See Figure D.4.Q for details.
2. The **capacity** for temporary drains shall be sufficient to handle the peak flow from a developed 10-year runoff event. Up to 30,000 square feet may be drained by each 6-inch minimum diameter pipe without computation of the peak flow. Up to 2 acres may be drained by each 12-inch minimum diameter pipe. Otherwise, the peak flow will need to be computed using the Rational Method described in Section 3.2.1 of the *Surface Water Design Manual* (*SWDM*).
3. The **maximum drainage area** allowed for any sized pipe is 10 acres. For larger areas, more than one pipe shall be used or a rock-lined channel shall be installed (see *SWDM* Section 4.4.1, "Open Channels").
4. The **soil** around and under the pipe and entrance section shall be thoroughly compacted.
5. The **flared inlet section** shall be securely connected to the slope drain and be fused or welded, or have flange-bolted mechanical joints to ensure a watertight seal.
6. Slope drains shall be continuously fused, welded, or flange-bolted mechanical joint pipe systems with proper anchoring to the soil.
7. Where slope drains cross steep **slope hazard areas** or their associated buffers, the installation shall be on the ground surface, accomplished with minimum alteration. In most circumstances, this requires that slope drains be constructed of corrugated metal, CPE, or equivalent pipe and installed by hand (see *SWDM* Section 4.2.1). Any area disturbed during installation or maintenance must be immediately stabilized.
8. If the pipe slope drain will convey **sediment-laden runoff**, the runoff must be directed to a sediment retention facility (see Section D.4.5). If the runoff is not from a disturbed area or is conveyed from a sediment trap or pond, it must be conveyed to a stabilized discharge point (see Section D.4.6.4).

Maintenance Standards

1. The inlet shall not be undercut or bypassed by water. If there are problems, the head wall shall be appropriately reinforced.
2. No erosion shall occur at the outlet point. If erosion occurs, additional protection shall be added.

FIGURE D.4.Q PIPE SLOPE DRAIN



D.4.6.3 DITCHES

Code: DI Symbol:

Purpose

Ditches convey intercepted runoff from disturbed areas to and from sediment ponds or traps. They also convey runoff intercepted from undisturbed areas around the site to a non-erosive discharge point.

Conditions of Use

Ditches may be used anywhere that concentrated runoff is to be conveyed on or around the construction site. Temporary pipe systems can also be used to convey runoff.

Design and Installation Specifications

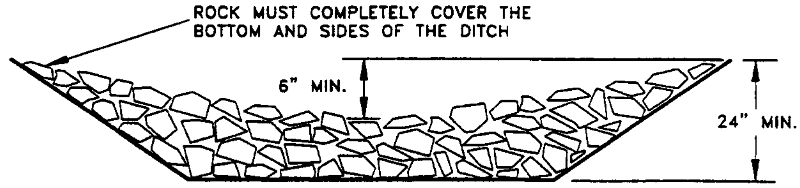
1. Channels and ditches shall be sized to accommodate the peak flow from the developed 10-year runoff event with 0.5 feet of freeboard . If no hydrologic analysis is required for the site, the Rational Method may be used [see Section 3.2.1 of the *Surface Water Design Manual (SWDM)*].
2. See *SWDM* Section 4.4.1 for open-channel design requirements.
3. The only exception to the requirements of *SWDM* Section 4.4.1 is the use of check dams, rather than grass lining, for channels in which the design flow velocity does not exceed 5 fps. See Figure D.4.R for details on check dam installation.

Maintenance Standards

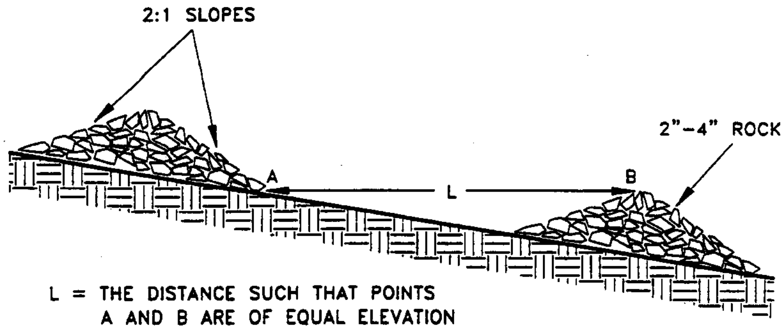
1. Any sediment deposition of more than 0.5 feet shall be removed so that the channel is restored to its design capacity.
2. If the channel capacity is insufficient for the design flow, it must be determined whether the problem is local (e.g., a constriction or bend) or the channel is under-designed. If the problem is local, the channel capacity must be increased through construction of a berm(s) or by excavation. If the problem is under-design, the design engineer shall be notified and the channel redesigned to a more conservative standard to be approved by King County.
3. The channel shall be examined for signs of scouring and erosion of the bed and banks. If scouring or erosion has occurred, affected areas shall be protected by riprap or an erosion control blanket or net.

AR 032453

FIGURE D.4.R CHECK DAMS

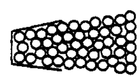


CROSS SECTION



CHECK DAM SPACING

D.4.6.4 OUTLET PROTECTION

Code: OP Symbol: 

Purpose

Outlet protection prevents scour at conveyance outlets.

Conditions of Use

Outlet protection is required at the outlets of all ponds, pipes, ditches, or other approved conveyances, and where runoff is conveyed to a natural or manmade drainage feature such as a stream, wetland, lake, or ditch.

Design and Installation Specifications

For the standard pipe slope drains in Section D.4.6.2 and other smaller conveyance systems, the standard rock pad (6 feet by 8 feet) made of 1-foot thick quarry spall is adequate. For all other outlets, the outlet protection shall meet the requirements of the "Outfalls" section of Core Requirement #4 and Section 4.2.2 of the *Surface Water Design Manual.*

Maintenance Standards for Outlet Protection

If there is scour at the outlet, the eroded area shall be protected with more conservative measures proposed by the design engineer and approved by King County.

D.4.6.5 LEVEL SPREADER

Code: LS Symbol: 

Purpose

Level spreaders convert concentrated runoff to sheet flow and release it onto areas stabilized by existing vegetation.

Conditions of Use

Level spreaders may be used where runoff from undisturbed areas or sediment retention facilities is discharged. This practice applies only where the spreader can be constructed on undisturbed soil and the area below the level lip is vegetated and low gradient (see below).

Note: Level spreaders are conceptually an ideal way to release stormwater since the vegetation and soil allow for the removal of fines from runoff that cannot be removed by settling or filtration. Unfortunately, the performance record of spreaders in the field is dismal. They are frequently under-designed and, despite the best installations, are rarely perfectly level, which results in the release of stormwater at a particular point. This concentrated runoff can result in catastrophic erosion downslope. Given such design failures, ***the use of spreaders is not encouraged.*** *However, where slopes are gentle and the water volume is relatively low, spreaders may still be the best method. When proposing their use, the designer shall carefully evaluate the site for possible concerns.*

Design and Installation Specifications

1. See Figure D.4.S for detail. Other designs may be used subject to County approval.
2. If runoff velocity as it enters the level spreader is more than 4 fps for the developed 10-year peak flow, a **riprap apron** must be provided to dissipate energy before the runoff enters the spreader (Section D.4.6.4).
3. The **total spreader length** shall be at least the square root of the catchment area. The maximum length for an individual spreader is 50 feet, limiting the catchment area that a single spreader may serve to 2500 square feet. Although this is very small, four 50-foot level spreaders next to one another could serve nearly an acre (40,000 square feet). Multiple spreaders shall not be placed uphill or downhill from one another in a configuration that would allow water released from one spreader to enter a downslope spreader.
4. The area below the spreader for a horizontal distance of 100 feet shall not exceed 20 percent and shall be completely vegetated with no areas of instability or erosion. The topography for a horizontal distance of 50 feet below the spreader shall be uniform so that runoff is not funneled into a swale or channel immediately after its release.
5. The level spreader shall be **seeded and mulched** in accordance with Section D.4.2 (p. D-8).

Maintenance Standards

1. Any damage to the spreader shall be immediately repaired.
2. The downslope area shall be checked for signs of erosion and to verify that the spreader is not functioning as a point discharge. Any eroded areas shall be immediately stabilized, and the cause determined and eliminated if possible. If the erosion is recurrent and the design, even when properly installed and maintained, is not adequate to prevent erosion, a new method of releasing runoff shall be installed in accordance with the standards of this appendix. Any new design must be approved by King County.

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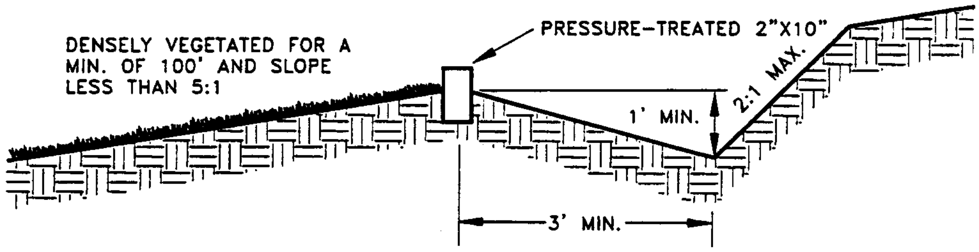
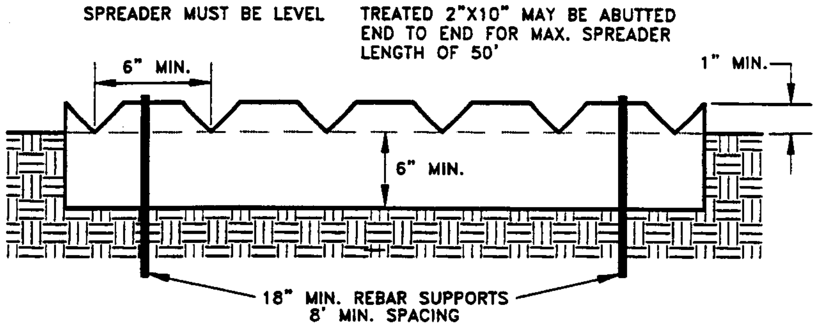
FIGURE D.4.S LEVEL SPREADER



CROSS SECTION



DETAIL OF SPREADER

D.4.7 DUST CONTROL

ESC Requirement 7: Preventative measures to minimize the wind transport of soil shall be taken when a traffic hazard may be created or when sediment transported by wind is likely to be deposited in water resources or adjacent properties.

Purpose: To prevent wind transport of dust from exposed soil surfaces onto roadways, drainage ways, and surface waters.

When to Install: Dust control shall be implemented when exposed soils are dry to the point that wind transport is possible and roadways, drainage ways, or surface waters are likely to be impacted.

Measures to Install: Water is the most common dust control (or palliative) used in the area. When using water for dust control, the exposed soils shall be sprayed until wet, but runoff shall not be generated by spraying. Calcium chloride may also be used for dust control. Exposed areas shall be resprayed as needed. Oil shall not be used for dust control.

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D.5 ESC IMPLEMENTATION REQUIREMENTS

This section describes the ESC implementation requirements that are required at each construction site. The measures and practices correspond to the implementation requirements in Core Requirement #5. Three of the sections [the ESC report (Section D.5.1, below), ESC maintenance requirements (Section D.5.4, p. D-43), and final site stabilization (Section D.5.5, p. D-44)] are required of every project. The rest of the sections are special requirements that may apply to the project depending on site conditions and project type. The introductory paragraphs at the beginning of most sections present the purpose of the measures and when they should be applied to the site. Compliance with the implementation requirements (as appropriate for the site) ensures compliance with the ESC Requirements. Note, however, that additional measures shall be required by the County if the existing standards are insufficient to protect adjacent properties, drainage facilities, or water resources.

D.5.1 ESC REPORT

For all proposed projects, an ESC report, including the ESC plan and supporting information for providing ESC measures and meeting implementation requirements as specified in Section D.6 (p. D-47) shall be submitted to DDES for review. A copy of this report shall be kept at the project site throughout all phases of construction. All of the materials required for the report are standard parts of engineering plan submittals for projects requiring drainage review. The simplest approach to preparing this report is to compile the pieces during preparation for submittal and include the report as a separate part of the submittal package. The ESC report shall include the following:

1. A detailed **construction sequence**, as proposed by the design engineer or erosion control specialist, identifying required ESC measures and implementation requirements;
2. A **technical information report** (TIR) and ESC plan for King County review in accordance with Sections 2.3.1 and 2.3.3 of the *Surface Water Design Manual*. Incorporate any King County review comments as necessary to comply with Core Requirement #5 of the *SWDM* (see Section D.10.1, p. D-63) and the Erosion and Sediment Control Standards in this appendix;
3. Any **calculations** or information necessary to size ESC measures and demonstrate compliance with Core Requirement #5;
4. An **inspection and maintenance program** in accordance with Section D.5.4 (p. D-43) that includes the designation of an ESC supervisor as point of contact; and
5. **Anticipated changes or additions** necessary during construction to ensure that ESC measures perform in accordance with Core Requirement #5 and Sections D.4 (p. D-5) and D.5 (p. D-41).

While the ESC plan focuses on the initial measures to be applied to the site, any changes or additions necessary during construction to ensure that ESC measures perform in accordance with Core Requirement #5 and Sections D.4 and D.5 must be identified in the ESC report. The County may require large, complex projects to phase construction and submit multiple ESC plans for different stages of construction. Development of new ESC plans is not required for changes that are necessary during construction.

D.5.2 WET SEASON REQUIREMENTS

Any site with exposed soils during the wet season (October 1 to April 30) shall be subject to the special provisions below. In addition to the ESC cover measures (see Section D.4.2, p. D-8), these provisions include covering any newly seeded areas with mulch and identifying and seeding as much disturbed area as possible prior to September 23 in order to provide grass cover for the wet season.

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Wet Season Special Provisions

All of the following provisions for wet season construction are detailed in the referenced sections. These requirements are listed here for the convenience of the designer and the reviewer.

1. The allowed time that a disturbed area can remain unworked without cover measures is reduced to two days, rather than seven (Section D.4.2).
2. Stockpiles and steep cut and fill slopes are to be protected if unworked for more than 12 hours (Section D.4.2).
3. Cover materials sufficient to cover all disturbed areas shall be stockpiled on site (Section D.4.2).
4. All areas that are to be unworked during the wet season shall be seeded within one week of the beginning of the wet season (Section 0).
5. Mulch is required to protect all seeded areas (Section 0).
6. Fifty linear feet of silt fence (and the necessary stakes) per acre of disturbance must be stockpiled on site (Section D.4.3.1).
7. Construction road and parking lot stabilization are required for all sites unless the site is underlain by coarse-grained soil (Section D.4.4.2).
8. Sediment retention is required unless no offsite discharge is anticipated for the specified design flow (Section D.4.5).
9. Surface water controls are required unless no offsite discharge is anticipated for the specified design flow (Section 0).
10. Phasing and more conservative BMPs must be evaluated for construction activity near surface waters (Section D.5.3).
11. Any runoff generated by dewatering shall be treated through construction of a sediment trap (Section D.4.5.1) when there is sufficient space or by releasing the water to a well-vegetated, gently sloping area. Since pumps are used for dewatering, it may be possible to pump the sediment-laden water well away from the surface water so that vegetation can be more effectively utilized for treatment. A straw bale filter shall be placed around the discharge from the dewatering pump. If there is not space for a sediment trap or 25 feet of suitable vegetation, other filtration methods shall be required consistent with KCC 9.12.
12. The frequency of maintenance review increases from monthly to weekly (Section D.5.4).

D.5.3 SENSITIVE AREAS RESTRICTIONS

Any construction that will result in disturbed areas on or within a stream or associated buffer, a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake shall be subject to the special provisions below. These provisions include, whenever possible, phasing the project so that construction in these areas is limited to the dry season. The County may require more conservative BMPs, including more stringent cover requirements, in order to protect surface water quality. Any project proposing work within 50 feet of a steep slope hazard area shall evaluate the need for diverting runoff that might flow over the top of the slope.

Sensitive Areas Special Provisions

Any project that disturbs areas on or within a stream or associated buffer, a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake has the potential to seriously damage water resources, even if the project is relatively small. While it is difficult to require specific measures for such projects because the ESC plan must be very site specific, the following recommendations shall be incorporated into the plan where appropriate:

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1. Whenever possible, phase all or part of the project so that it occurs during the dry season. If this is impossible, November through February shall be avoided since this is the most likely period for large, high-intensity storms.
2. All projects shall be completed and stabilized as quickly as possible. Limiting the size and duration of a project is probably the most effective form of erosion control.
3. Where appropriate, sandbags or an equivalent barrier shall be constructed between the project area and the surface water in order to isolate the construction area from high water that might result due to precipitation.
4. Additional perimeter protection shall be considered to reduce the likelihood of sediment entering the surface waters. Such protection might include multiple silt fences, silt fences with a higher AOS, construction of a berm, or a thick layer of organic mulch upslope of a silt fence.
5. If work is to occur within the ordinary high water mark of a stream, most projects must isolate the work area from the stream by diverting the stream or constructing a coffer dam. Certain small projects that propose only a small amount of grading may not require isolation since diversions typically result in disturbance and the release of some sediment to the stream. For such small projects, the potential impacts from construction with and without a diversion must be weighed.
6. If a stream must be crossed, a temporary bridge shall be considered rather than allowing equipment to utilize the streambed for a crossing.
7. Any runoff generated by dewatering shall be treated through construction of a sediment trap (see Section D.4.5.1) when there is sufficient space, or by releasing the water to a well-vegetated, gently sloping area. Since pumps are used for dewatering, it may be possible to pump the sediment-laden water well away from the surface water so that vegetation can be more effectively utilized for treatment. A straw bale filter shall be placed around the discharge from the dewatering pump. If there is not space for a sediment trap or 25 feet of suitable vegetation, other filtration methods shall be required consistent with KCC 9.12.

For projects in or near a salmonid stream, it may be appropriate to monitor the composition of any spawning gravels within a quarter-mile of the site with a McNeil sampler before, during, and after construction. The purpose of such monitoring would be to determine if the fine content of the gravels increases as a result of construction impacts. Monitoring results could be used to guide erosion control efforts during construction and as a threshold for replacing spawning gravels if the fine content rises significantly.

D.5.4 MAINTENANCE REQUIREMENTS

All ESC measures shall be maintained and reviewed on a regular basis as prescribed in the maintenance requirements for each BMP and in this section. The applicant shall designate an **ESC supervisor** who shall be responsible for maintenance and review of ESC and for compliance with all permit conditions relating to ESC. The ESC supervisor must be available for rapid response to ESC problems.

The ESC supervisor shall review the site at least once a month during the dry season, weekly during the wet season, and within 24 hours of significant storms. The County can require that a written record of these reviews be kept on site with copies submitted to DDES within 48 hours. The County can also require that the applicant designate an ESC supervisor with demonstrated experience in ESC to perform these reviews and to be responsible for ESC.

ESC Supervisor

For minor projects, the applicant may serve as the ESC supervisor. The name, address, and phone number of the ESC supervisor shall be supplied to the County prior to the start of construction. A sign shall be posted at all primary entrances to the site identifying the ESC supervisor and his/her phone number. The requirement for an ESC supervisor does not relieve the applicant of ultimate responsibility for the project and compliance with King County Code.

For **highly sensitive sites**, the County can require that the applicant designate an ESC supervisor with demonstrated expertise in erosion and sediment control. The qualifications of such a person shall include at least several years of construction supervision or inspection and a background in geology, soil science, or agronomy. Typically, if a geotechnical consultant is already working on the project, the consultant can also be the designated ESC supervisor. The design engineer may also be qualified for this position. This requirement shall only be used for sensitive sites that pose an unusually high risk of impact to surface waters. At a minimum, the project site shall meet all of the following conditions in order to require the applicant to designate an ESC supervisor with demonstrated expertise in ESC:

- Alderwood soils or other soils of Hydrologic Group C or D
- Five acres of disturbance
- Large areas with slopes in excess of 10 percent

Proximity to Class 1 or 2 streams or wetlands or phosphorus-sensitive lakes, such as Lake Sammamish, shall also be a factor in determining if a site warrants an ESC specialist. However, proximity alone shall not be a determining factor because even projects that are a considerable distance from surface waters can result in significant impacts if there is a natural or constructed drainage system with direct connections to surface waters.

If DDES determines that the onsite ESC measures are inadequately installed, located, or maintained, DDES can require the appointment of an ESC supervisor with expertise in erosion and sediment control.

Documentation

If DDES requires that a written record be maintained, a standard ESC Maintenance Report, included in Section D.10.2 (p. D-66), may be used. A copy of all the required maintenance reports shall be kept on site throughout the duration of construction. Detailed maintenance requirements for each ESC measure are provided in Sections D.4.1 through D.4.7.

Review Timing

During the wet season, weekly reviews shall be carried out every 6 to 8 calendar days. During the dry season, monthly reviews shall be carried out within 3 days of the calendar day for the last inspection (e.g., if an inspection occurred on June 6, then the next inspection must occur between July 3 and July 9). Reviews shall also take place within 24 hours of significant storms. In general, a significant storm is one with more than 0.5 inches of rain in 24 hours or less. Other indications that a storm is "significant" are if the sediment ponds or traps are filled with water, or if gullies form as a result of the runoff.

Note: The site is to be in compliance with the regulations of this appendix at all times. The requirement for periodic reviews does not remove the applicant's responsibility for having the site constantly in compliance with Core Requirement #5 and the requirements of this appendix. The reviews are a mechanism to ensure that all measures are thoroughly checked on a regular basis and that there is documentation of compliance. The requirement for these reviews does not mean that ESC is to be ignored in between.

D.5.5 FINAL STABILIZATION

Prior to obtaining final construction approval, the site shall be stabilized, the structural ESC measures, such as silt fences and sediment traps, removed, and drainage facilities cleaned. The removal of ESC measures is not required for those projects, such as plats, that will be followed by additional construction under a different permit. In these circumstances, the need for removing or retaining the measures must be evaluated on a site-specific basis.

To obtain final construction approval, the following conditions must be met:

1. All disturbed areas of the site shall be **vegetated or otherwise permanently stabilized**. At a minimum, disturbed areas shall be seeded and mulched (see Section 0) with a high likelihood that sufficient cover will develop shortly after final approval. Mulch without seeding is not adequate to

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allow final approval of the permit, except for small areas of mulch used for landscaping. The only exceptions to these requirements are lots within a plat that are to be developed under an approved residential permit immediately following plat approval. In these cases, mulch and/or temporary seeding are adequate for cover.

2. **Structural measures** such as, but not limited to, silt fences, pipe slope drains, construction entrances, storm drain inlet protection, and sediment traps and ponds **shall be removed** from the site. Measures that will quickly decompose, such as brush barriers and organic mulches, may be left in place. In the case of silt fences, it may be best to remove fences in conjunction with the seeding, since it may be necessary to bring machinery back in to remove them. This will result in disturbed soils that will again require protection. The DDES inspector must approve an applicant's proposal to remove fencing prior to the establishment of vegetation. In some cases, such as residential building following plat development, it may be appropriate to leave some or all ESC measures for use during subsequent development. This shall be determined on a site-specific basis.
3. All **permanent surface water facilities**, including catch basins, manholes, pipes, ditches, channels, R/D facilities, and water quality facilities, **shall be cleaned**. Any offsite catch basin that required protection during construction (see Section D.4.5.3) shall also be cleaned.
4. If only the infrastructure of the site has been developed (e.g., subdivisions and short plats) with building construction to occur under a different permit, then the sensitive area buffers, Sensitive Area Tracts, or Sensitive Area Setback Area shall be clearly marked as described in Section D.4.1 (p. D-5) in order to alert future buyers and builders.

D.5.6 ROADS AND UTILITIES

Road and utility projects often pose difficult erosion control challenges because they frequently cross surface waters and because narrow right-of-way constrains areas available to store and treat sediment-laden water. In most cases, the standards of this appendix can be applied to such linear projects without modification. For instance, the ability to use perimeter control rather than a sediment retention facility for small drainage areas (see Section D.4.3) will apply to many of these projects.

However, there may be some projects that cannot reasonably meet the standards of Core Requirement #5 and this appendix. In these cases, other measures may be proposed that will provide reasonable protection. An adjustment is not required for such projects, unless the County determines that measures proposed by the applicant fail to meet the intent of Core Requirement #5 and this appendix, and that significant adverse impacts to surface water may result. Examples of other measures that may be taken in lieu of the standards of this appendix are:

1. Phasing the project so that the site is worked progressively from end to end, rather than clearing and grubbing the entire length of the project. This results in smaller exposed areas for shorter durations, thus reducing the erosion risk.
2. Mulching and vegetating cut and fill slopes as soon as they are graded. Frequently, this is done at the end of construction when paving or utility installation is complete. Vegetating these areas at the start of the project stabilizes those areas most susceptible to erosion.
3. Protecting all catch basin inlets with catch basin inserts when these do not drain to ponds or traps. This will not provide the same level of protection as a sediment pond or trap, but can remove most of the sand-sized material entrained in the runoff.
4. Phasing the project so that all clearing and grading in sensitive area buffers occurs in the dry season. This substantially reduces the chance of erosion and allows for rapid revegetation in the late summer and early fall.
5. Using flocculents to reduce the turbidity of water released from sediment ponds.
6. Hiring a private consultant with expertise in ESC to review and monitor the site.

If alternatives are used, it may be appropriate to develop a monitoring program that would monitor compliance with the performance standard of Core Requirement #5 and/or impacts to nearby water resources. Of particular concern are impacts to salmonid spawning gravels. McNeil sampling is a possible method of sampling to determine impacts to spawning gravels (see Section D.5.3).

D.5.7 NPDES REQUIREMENTS

As part of the implementation of the National Pollutant Discharge Elimination System (NPDES), projects that will disturb more than five acres of total area must apply for coverage under the Washington State Department of Ecology's Baseline General Permit for Stormwater. The five-acre threshold applies even if the five acres are to be disturbed in phases, as long as the construction is "part of a larger common plan of development or sale." In general, the erosion control plan required by the *Surface Water Design Manual* is equivalent to that required by the State through the *Stormwater Management Manual for the Puget Sound Basin* (DOE, 1982). The DOE stormwater permit application requires the filing of a Notice of Intent (NOI) at least 30 days prior to the start of construction. The only major requirement of the stormwater permit that is not included in the *SWDM* is a public notice requirement. Note that this public notice for Ecology's stormwater permit can be published concurrently with other public notices required for permits or SEPA. Contact the Department of Ecology at (360) 407-7156 for complete information on permit thresholds, applications, and requirements.

D.5.8 FOREST PRACTICE PERMIT REQUIREMENTS

Projects that will clear more that two acres of forest or 5,000 board feet of timber must apply for a Class IV Special Forest Practice permit from the Washington State Department of Natural Resources (WSDNR). All such clearing is also subject to the State Environmental Policy Act (RCW 43.21C) and will require SEPA review. King County assumes lead agency status for Class IV permits and the application can be consolidated with the associated King County development permit or approval. The permit must be initiated with WSDNR, but will then be transferred over to King County to conduct the SEPA review and grant the permit. Contact the WSDNR for complete information on permit thresholds, applications, and requirements.

D.5.9 ALTERNATIVE AND EXPERIMENTAL MEASURES

In general, the *Surface Water Design Manual* only contains those BMPs that are standards of the local industry. There are a variety of other BMPs available that can also be used, even though they are not included in this appendix. Such alternatives may be approved without an adjustment if the alternative will produce a compensating or comparable result with the measures in this appendix. Variations on or modifications of the BMPs in this appendix can also be granted based on the same criteria. Technical support will be provided by WLRD when requested by DDES.

An adjustment is only required for those products or techniques that are so new and untested as to be experimental. If the County determines that a proposed alternative is experimental, then an experimental adjustment must be obtained (see Section 1.4.4 of the *SWDM*). The intent of this requirement is not to discourage new techniques, but to insure that new techniques are monitored and documented for adequacy and possible inclusion in subsequent versions of the *SWDM*. An example of a product that would have required an experimental adjustment prior to this version of the manual is the catch basin insert (see Section D.4.5.3) because it was not equivalent to any existing measure.

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D.6 EROSION AND SEDIMENT CONTROL PLANS

This section details the specifications and contents for erosion and sediment control (ESC) plans. An ESC plan and any supporting information must be submitted as part of a complete engineering plan to facilitate proper drainage review. An ESC plan and its supporting information is also an important part of the ESC Report required to be submitted to DDES and a copy kept on the project site (see Section D.5.1, p. D-41).

ESC Plan Specifications

The **site improvement plan** shall be used as the base of the ESC plan. Certain detailed information (e.g., pipe catch basin size, stub-out locations, etc.) that is not relevant may be omitted to make the ESC plan easier to comprehend. At a minimum, the ESC plan shall include all of the information required for the **base map of a site improvement plan** (see Table 2.3.1A of the *Surface Water Design Manual*), as well as existing and proposed roads, driveways, parking areas, buildings and drainage facilities, utility corridors not associated with roadways, all sensitive areas and buffers, and proposed final topography. A smaller scale may be used to provide better comprehension and understanding.

The ESC plan shall generally be designed for proposed topography, not existing topography, since rough grading is usually the first step in site disturbance. The ESC plan focuses on the initial measures to be applied to the site. The County may require large, complex projects to phase construction and submit multiple ESC plans for different stages of construction.

The following list provides the basic information requirements for the ESC plan. Note that the ESC plan may be simplified by the use of the symbols and codes provided for each ESC measure in Section D.4 (p. D-5). In general, the ESC plan shall be submitted as a separate plan sheet(s). However, there may be some relatively simple projects where providing a separate grading and ESC plan is unnecessary.

General

1. Identify areas with a high susceptibility to erosion.
2. Provide all details necessary to clearly illustrate the intent of the ESC design.
3. Provide information consistent with that in Section 8 of the technical information report (TIR) required in the engineering plan submittal (see Section 2.3.1 of the *SWDM*).
4. Include ESC measures for all on- and offsite utility construction included in the permit.
5. Include standard ESC Notes and specify the construction sequence. ESC Notes and a sample construction sequence are provided in the Reference Section.
6. Identify the designated ESC supervisor (if required) and provide phone numbers for 24-hour contact.

Clearing Limits

1. Delineate clearing limits (areas to remain uncleared).
2. Provide details sufficient for installation of markings for maintenance of clearing limits.

Cover Measures

1. Specify the type and location of temporary cover measures to be used on site.
2. If more than one type of cover is to be used on site, indicate the areas where the different measures shall be used, including steep cut and fill slopes.
3. If the type of cover measures to be used will vary depending on the time of year, soil type, gradient, or some other factor, specify the conditions that control the use of the different measures.
4. Specify the nature and location of permanent cover measures. If a landscaping plan is prepared, this may not be necessary.

5. Specify the approximate amount of cover measures necessary to cover all disturbed areas.
6. If erosion netting or blankets are specified, provide typical details sufficient for installation and maintenance.
7. Specify the seed mixes, fertilizers, and soil amendments to be used, as well as the application rate for each item.

Perimeter Protection

1. Specify the location and type of perimeter protection to be used.
2. Provide typical details sufficient for installation and maintenance of perimeter protection.
3. If a silt fence is to be used, specify the type of fabric.

Traffic Area Stabilization

1. Locate the construction entrance(s).
2. Provide typical details sufficient for installation and maintenance of the construction entrance.
3. Locate the construction roads and parking areas.
4. Specify the measure(s) that will be used to create stabilized construction roads and parking areas. Provide sufficient detail to install and maintain.

Sediment Retention

1. Show the locations of all sedimentation ponds and traps.
2. Dimension pond berm widths and all inside and outside pond slopes.
3. Indicate the trap/pond storage required and the depth, length, and width dimensions.
4. Provide typical section views throughout the pond and outlet structure.
5. Provide typical details of the control structure and dewatering mechanism.
6. Detail stabilization techniques for the outlet/inlet.
7. Provide details sufficient to install a cell divider.
8. Specify mulch and/or recommended cover of berms and slopes.
9. Indicate the requirement to provide a depth gage with a prominent mark at 1 foot depth for sediment removal.
10. Indicate catch basins that are to be protected.
11. Provide details of the catch basin protection sufficient to install and maintain.

Surface Water Control

1. Locate all pipes, ditches, and interceptor ditches and swales that will be used to convey stormwater.
2. Provide details sufficient to install and maintain all conveyance systems.
3. Indicate locations of outlet protection and provide detail of protections.
4. Indicate locations and outlets of any possible dewatering systems.
5. Indicate the location of any level spreaders and provide details sufficient to install and maintain.
6. Provide all temporary pipe inverts.
7. Provide location and specifications for the interception of runoff from disturbed areas and the conveyance of the runoff to a non-erosive discharge point.
8. Provide location and details of rock check dams.

9. Provide front and side sections of typical rock check dams.

Wet Season Requirements

Provide a list of all applicable wet season requirements.

Sensitive Areas Restrictions

1. Specify the type, locations, and details of any measures necessary to comply with requirements to protect surface waters.
2. Specify the type, locations, and details of any measures necessary to comply with any additional protection required for steep slopes.

D.7 SMALL SITE ESC

Smaller sites tend to have similar erosion and sediment control (ESC) needs. This section provides a simplified process to apply effective erosion and sediment controls to smaller sites and guides the user through the preparation and submittal of a Small Site ESC Plan with the permit application.

D.7.1 INTRODUCTION TO SMALL SITE ESC

What is ESC and Why is it Required for My Site?

The basic erosion and sediment control requirement—that sediment shall be prevented to the maximum extent possible from leaving the site—**applies to all projects in King County**. All sites, including small sites, are required to use erosion and sediment control (ESC) Best Management Practices (BMPs). ESC BMPs prevent soil erosion during development of the site. The types of BMPs required through the small site process are generally simple to construct and easy to maintain, and with few exceptions do not require engineering or formal design. Examples of such BMPs include phasing or minimizing clearing, terracing exposed slopes, routing water around exposed soils, and placing straw or other mulching materials on exposed soils.

ESC is required because soils eroded from the site are *always* deposited downstream in pipes, streams, or lakes. Soils deposited in a pipe or channel reduce its capacity to convey flows and can increase the likelihood of flooding. Soils in streams can also clog the gravels that salmon use for spawning. Nutrients associated with soils that reach lakes can upset the chemical balance of the lake, causing excessive growth of algae and decreasing recreational uses such as swimming, boating, and fishing.

Which Projects Can Use Small Site Erosion and Sediment Control Requirements?

All proposed projects that disturb soil and add less than 5,000 square feet of impervious surface can use the Small Site ESC requirements contained in this section. These projects must apply erosion and sediment control even though they may not be subject to drainage review under the *Surface Water Design Manual.*

In addition, all proposed projects that qualify for Small Site Drainage Review can use the Small Site ESC requirements contained in this section. The Small Site Drainage Review is detailed in Appendix C of the *Surface Water Design Manual* and applies to single family residential or subdivision projects that add between 5,000 and 10,000 square feet of impervious surface per threshold discharge area[1] and clear less than 2 acres or less than 35% of the site, whichever is greater.

What Will I Be Required To Do?

It is the responsibility of both the applicant and the contractor to minimize erosion and the transport of sediment to the greatest extent possible. Erosion and sediment control is a two step process that (1) minimizes the amount of sediment mobilized, and (2) traps any mobilized sediment before it leaves the site.

Examples of erosion controls include use of mulches or other cover materials, marked/minimized clearing, and routing of water around exposed soils. Installation and maintenance of silt fencing is an example of sediment trapping. ESC techniques that are particularly suitable for small sites are described below (Section D.7.2).

[1] A threshold discharge area is an onsite area draining to a single natural discharge location or multiple natural discharge locations that combine within one-quarter-mile downstream. Small sites typically have only one threshold discharge area.

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D.7.2 SMALL SITE ESC REQUIREMENTS

One or more of the following measures will be required on small sites in order to minimize onsite erosion and prevent mobilized sediment from leaving the site:

1. Rock construction entrance
2. Mulching
3. Minimized clearing
4. Silt fencing
5. Winter (or wet season) stabilization
6. Final stabilization.

Other measures may be allowed or required if these are inappropriate for the project or fail to contain sediment on the project site. A description of other measures which may be needed for successful ESC on some sites, and a more detailed description of those included here, can be found in ESC Measures Section D.4, "ESC Measures" (p. D-5).

The placement and type of proposed ESC BMPs are shown on an **ESC plan**. Required features of this plan are outlined in Section D.7.3, "Submittal Requirements" (p. D-56).

D.7.2.1 ROCK CONSTRUCTION ENTRANCE

Purpose

Rock construction entrances help prevent transport of sediment away from the site on the tires or undercarriages of vehicles.

Application

Rock construction entrances shall be provided at all entranceways to cleared construction sites.

Design Specifications

The rock pad should measure approximately 10 feet by 25 feet, and be about 1 foot deep (see Figure D.7.A). Rocks used for pad construction will be 4 to 6 inches in diameter. Geotextile will be placed beneath the rock to prevent fine sediments from being "pumped" up through the rock by heavy vehicles. The geotextile shall meet the following standards:

Grab Tensile Strength (ASTM D4751)	200 psi min.
Grab Tensile Elongation (ASTM D4632)	30% max.
Mullen Burst Strength (ASTM D3786-80a)	400 psi min.

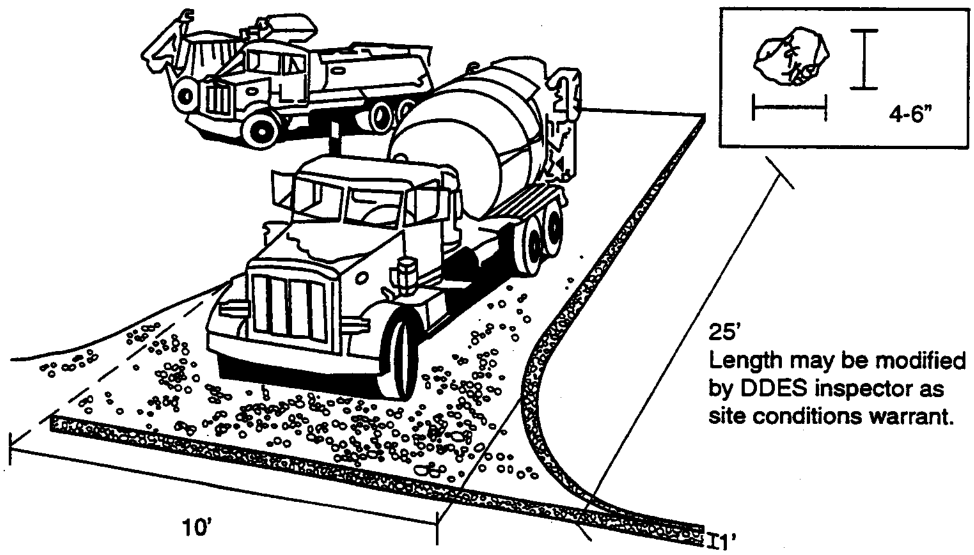
All vehicles must use the rock pad to leave the site.

Maintenance

Construction entrances must be inspected regularly, and rock must be replaced as needed.

AR 032467

FIGURE D.7.A ROCK CONSTRUCTION ENTRANCE



D.7.2.2 MULCHING

Purpose

Mulching prevents erosion by dissipating the energy of and absorbing water. Mulch prevents raindrops from falling directly on exposed soils, reducing the likelihood that soils will be dislodged and washed away. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoils in place, and moderating soil temperatures.

Application

1. On disturbed areas that are to remain unworked for more than 7 days. Mulch is to be used for areas that need cover measures for less than 30 days. Permanent seeding is required for areas that need cover for longer than 30 days.
2. As a cover for seed during the wet season and during the hot summer months.
3. During the wet season, on slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Design Specifications

The amount of mulch applied per acre (application rate) depends on the type of material used. Table D.7.A provides application rates for a variety of common mulches. Plastic can be used as a surrogate for mulch, with the following cautions:

1. If erosion at the toe of the covered slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe to reduce the velocity of runoff.
2. Seams between sheets must overlap and must be weighted and taped.
3. Toe in sheeting at the top of slope with a minimum 4"x4" trench running the length of the top of slope.

Maintenance

Mulch must be inspected regularly and more mulch added as needed to maintain the suggested application rate. All rips or tears in plastic sheeting shall be repaired. Sheeting shall be checked to ensure it is properly overlapped and weighted in place; sheeting shall be re-lapped and weights replaced as needed.

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TABLE D.7.A MULCH STANDARDS AND APPLICATION RATES		
Mulch Material	**Quality Standards**	**Application Rates**
Straw	Air-Dried; free from undesirable seed and coarse material	2"-3" thick; 2-3 bales per 1000 SF or 2-3 tons per acre
Wood Fiber Cellulose	No growth inhibiting factors	Approx. 25-30 lbs. per 1000 SF or 1000 to 1500 lbs. per acre
Compost	No visible water or dust during handling. Must be purchased from supplier with Solid Waste Handling Permit	2" thick min.; approx. 100 tons per acre (approx. 800 lbs. per yard)
Chipped Site Vegetation	Average size shall be several inches	2" minimum thickness

D.7.2.3 MARK CLEARING LIMITS / MINIMIZE CLEARING

Purpose

Minimizing clearing is the most effective method of erosion control. Undisturbed vegetation intercepts and slows rainwater. Plant roots hold soil in place, and dead vegetation on the ground acts as a mulch.

Applications

Clearing limits shall be marked and clearing minimized on any site where significant areas of undisturbed vegetation will be retained.

Design Specifications

Minimizing clearing should be incorporated into the site design. Clearing limits must be marked on both the site plan and the erosion control plan. On the ground, clearing limits must be clearly marked with brightly colored tape or plastic or metal safety fencing (also referred to as Sensitive Areas Setback Area fencing, or SASA fencing). If tape is used, it should be supported by vegetation or stakes, and should be about 3 to 6 feet high and highly visible. Equipment operators should be informed of areas of vegetation that are to be left undisturbed.

Maintenance

Fencing shall be inspected regularly and repaired or replaced as needed.

D.7.2.4 SILT FENCING

Purpose

Silt fencing catches sediment that has been mobilized by water flowing over the site. Fabric used in the construction of silt fencing has openings specifically sized to allow water to flow through while retaining the majority of particle sizes.

Application

Silt fencing shall be used to protect the perimeter of the site. It can be placed parallel to topographic contours. Silt fencing is not suitable for placement in drainage channels or for other concentrated flows.

Design Specifications

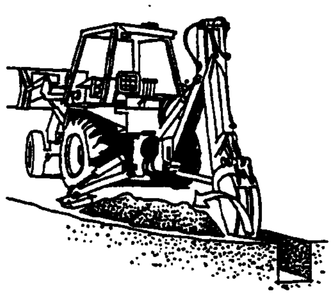
As shown in Figure D.7.B, silt fence must be towed-in to a shallow trench, and then staked and reinforced to function properly. The silt fence, which can be found at many construction supply stores, must meet th following standard specifications:

AOS (ASTM D4751)	30-100 sieve size (0.60-0.15 mm) for slit film 50-100 sieve size (0.30-0.15 mm) for other fabrics
Water Permittivity (ASTM D4491)	0.02 sec^{-1} min.
Grab Tensile Strength (ASTM D4632)	180 lbs. min. (called extra strength fabric)
Grab Tensile Elongation(ASTM D4632)	30% max.
Ultraviolet resistance (ASTM D4355)	70% min.

Maintenance

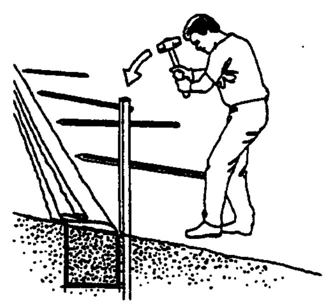
Fencing must be inspected regularly for damage. Silt fencing does break down under UV light. Sediment collected behind the fence must be removed so that this material does not push the fence over.

FIGURE D.7.B SILT FENCE INSTALLATION AND MAINTENANCE

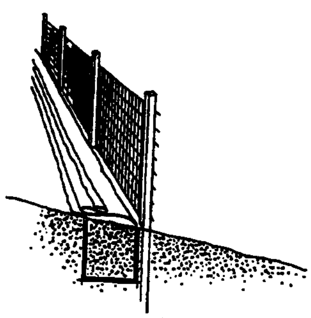


Dig trench

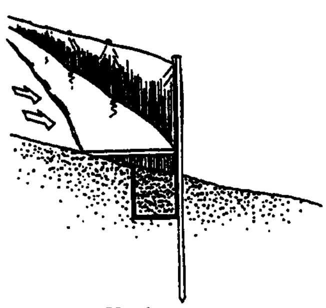
Toe-in-fabric



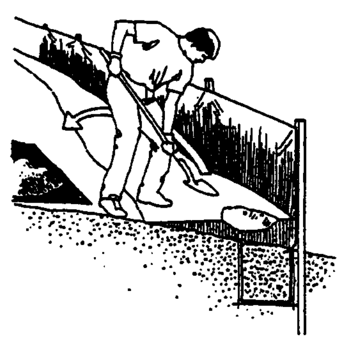
Stake



Reinforce



Monitor



Maintain and clean

D.7.2.5 WINTER STABILIZATION

Purpose

In order to minimize sediment-laden runoff, as much of the bare and disturbed portions of the site as possible should be covered during any period of precipitation. Once sediment is mobilized, it is much more difficult to effectively control.

Application

All sites require winter stabilization between October 1 and April 30 (the wet season).

Design Specifications

During the above time frame, slopes and stockpiles 3H:1V or steeper and with more than 10 feet of vertical rise shall be covered if they are to remain unworked for more than 12 hours. Other disturbed areas shall be covered or mulched according to Table D.7.A (p. D-53) if they are to remain unworked for more than two days. Cover material sufficient to cover all disturbed areas shall be stockpiled on site at the beginning of the wet season. Areas that are to be left unworked during the winter shall be seeded prior to September 23.

Maintenance

The site should be inspected weekly and immediately before, during, and after storms. Cover and other erosion control measures shall be repaired and enhanced as necessary to prevent or minimize sediment runoff and transport.

D.7.2.6 FINAL STABILIZATION

Purpose

Final stabilization minimizes sediment-laden runoff from the site after construction has been completed.

Application

All sites require final stabilization prior to final construction approval.

Design Specifications

Prior to final construction approval, the site shall be stabilized to prevent sediment-laden water from leaving the site after project completion. All disturbed areas of the site shall be vegetated or otherwise permanently stabilized. At a minimum, disturbed areas must be seeded and mulched to ensure that sufficient cover will develop shortly after final approval. Mulch without seeding is adequate for small areas to be landscaped before October 1.

All permanent surface water facilities (including catch basins, manholes, pipes, ditches, channels, flow control facilities, and water quality facilities) impacted by sedimentation during construction must be cleaned.

Maintenance

Permanent erosion control is the responsibility of the owner. The site must be kept stabilized using landscaping, mulch, or other measures to prevent sediment-laden water from leaving the site and to prevent sediment from being transported onto adjacent properties and roads.

D.7.3 SUBMITTAL REQUIREMENTS

A Small Site ESC Plan must be submitted for all projects that are eligible to use the Small Site ESC requirements in this section. This plan is part of a Small Site Drainage Plan described in *Small Site Drainage Requirements* (Appendix C of the *Surface Water Design Manual*). Directions for preparing a Small Site ESC Plan are provided below, and a sample plan is presented in Section D.7.3.3 (p. D-57).

D.7.3.1 SMALL SITE ESC PLAN MAP

The Small Site ESC Plan includes information that is routinely collected for a **single family residence site plan or a short plat plot plan** already required to be submitted with a permit application. One copy of the site plan or plot plan shall be used to show how ESC BMPs are to be applied to the site to comply with the Small Site ESC requirements. The approximate location and size of clearing limits, rock construction entrance, flow paths, silt fences, etc., should be indicated on the ESC Plan. Any plan must contain at a minimum the features listed in Section D.7.3.2.

Single family residential projects that qualify for Small Site ESC requirements should use the Residential Site Plan (see DDES Bulletin No. 9, "Obtaining a Residential Building Permit") as the base map for the ESC plan.

Proposed short plats that qualify for Small Site Drainage Review should use the Small Site Drainage Plan (see *Small Site Drainage Requirements*, detached Appendix C of the *Surface Water Design Manual*) as a base plan for the ESC plan. All projects subject to Small Site Drainage Review are required to submit these plans and a drainage assessment. If engineering plans are required for a short plat application, they may be used as a base plan for Small Site ESC plans. How the ESC BMPs are to be applied on the site are added directly to the base map. For more complicated sites, an erosion control professional should be readily able to add Small Site ESC BMPs to the base map with minimal additional effort or expense.

The ESC plans for short plats usually apply only to the site development, since siting of homes on lots created by short plats is done after the short plat is approved (when the home applies for a residential building permit). It is the responsibility of the proposed single family residence to show in detail how ESC requirements are met.

D.7.3.2 FEATURES REQUIRED ON SMALL SITE ESC PLANS

The Small Site ESC Plan should be drawn on 8-1/2" x 11", 8-1/2" x 14", or 11" x 17" paper (see the sample plan in Figure D.7.C, p. D-59), and must include the following information.

Identification

1. Name, address, and phone number of the applicant
2. Scale—use a scale that clearly illustrates drainage features and flow controls (1"=20' is standard engineering scale; minimum acceptable scale is 1"=50')
3. Parcel number
4. North arrow
5. Dimension of all property lines, easements, and building setback lines
6. Street names and existing or proposed property address
7. Section, township, and range of proposal.

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Topography

1. Corner elevations
2. Benchmark (a permanent mark indicating elevation and serving as a reference in the topographic survey)
3. Datum (assumed datum is acceptable in many cases, i.e., fire hydrant base = 100'; datum for projects in or near FEMA floodplains should be NGVD 1929)
4. If over 15% slope: 5-foot contours, top of slope, toe of slope, and any erosion or landslide areas.

Proposed ESC

1. Delineation of proposed clearing limits
2. Type and location of erosion control facilities
3. Location of any significant offsite drainage features within 200 feet of the discharge point(s) for the lot, including streams, lakes, roadside ditches.

Topography/Drainage Features

1. Outline of any stream, wetland, lake, closed depression, or other water feature (including any required buffer width)
2. Location of all steep slopes, landslide hazard areas, and coal mine hazard areas (including buffers)
3. Location of all existing and proposed drainage easements, ditches, swales, pipes, etc.
4. Location of all sensitive areas as shown on any recorded Sensitive Areas Notice on Title (SANT).

D.7.3.3 SAMPLE SMALL SITE ESC PLAN

All sites are required to control erosion and contain sediment. The planning and use of ESC BMPs will be illustrated for a single family residence. Although the specifics of any lot will differ from those shown here, the process will be similar. The first step in the process is to determine whether the site is eligible to use the Small Site ESC requirements. This evaluation and the following materials are usually included in the drainage assessment that accompanies the Small Site ESC Plan.

The proposed house is to be placed on an existing 1.69-acre lot (see Figure D.7.C). Impervious surfaces are the roof, a driveway, and a parking area. The total proposed impervious surface is 6,950 square feet as determined from the residential site plan layout of residence and driveway (the site plan provides the base map for the Small Site ESC Plan). The amount exceeds 5,000 square feet but falls below the 10,000-square-foot limit for Small Site Drainage Review. Therefore, a Small Site ESC Plan is applicable.

The proposal is not in a basin plan area or critical drainage area that might contain clearing limits. However, a portion of a wetland and an erosion hazard area have been identified on the site, and their approximate locations are shown in Figure D.7.C. While neither the wetland and its buffer, nor the erosion hazard area and its buffer would be disturbed during construction, the locations of these sensitive areas must be verified. This review will likely be minimal if the locations shown are accurate, and will be concurrent with Small Site Drainage Review.

Approximately the southern 2/3 of the site will be cleared. Trees and other native vegetation will be left intact along the northern edge, near the street. Buffers will be maintained around the wetland and erosion hazard areas, respectively. The site slopes towards the street.

In order to best prevent erosion and to encourage sedimentation, the following **BMPs** are used:

1. **Clearing will be minimized** to the extent possible, and **clearing limits marked** by fencing or other means on the ground.
2. Water will be **routed** around the erosion hazard area and around the steep section of the driveway by constructing an interceptor dike or ditch that will intersect and direct water away to the east of the site.

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3. Water will be **filtered** before it reaches the wetland. Silt fencing will be placed along slope contours at the limits of clearing in the vicinity of both the wetland and the erosion hazard area.
4. A rocked construction entrance will be placed at the end of the driveway.
5. **Mulch** will be spread over all cleared areas of the site when they are not being worked. Mulch will consist of air-dried straw and chipped site vegetation.

The BMPs shown in Figure D.7.C must be installed as clearing progresses. For example, the rock construction entrance must be installed as soon as the path for the driveway has been cleared. Additional ESC measures must be installed if the ones proposed above prove insufficient.

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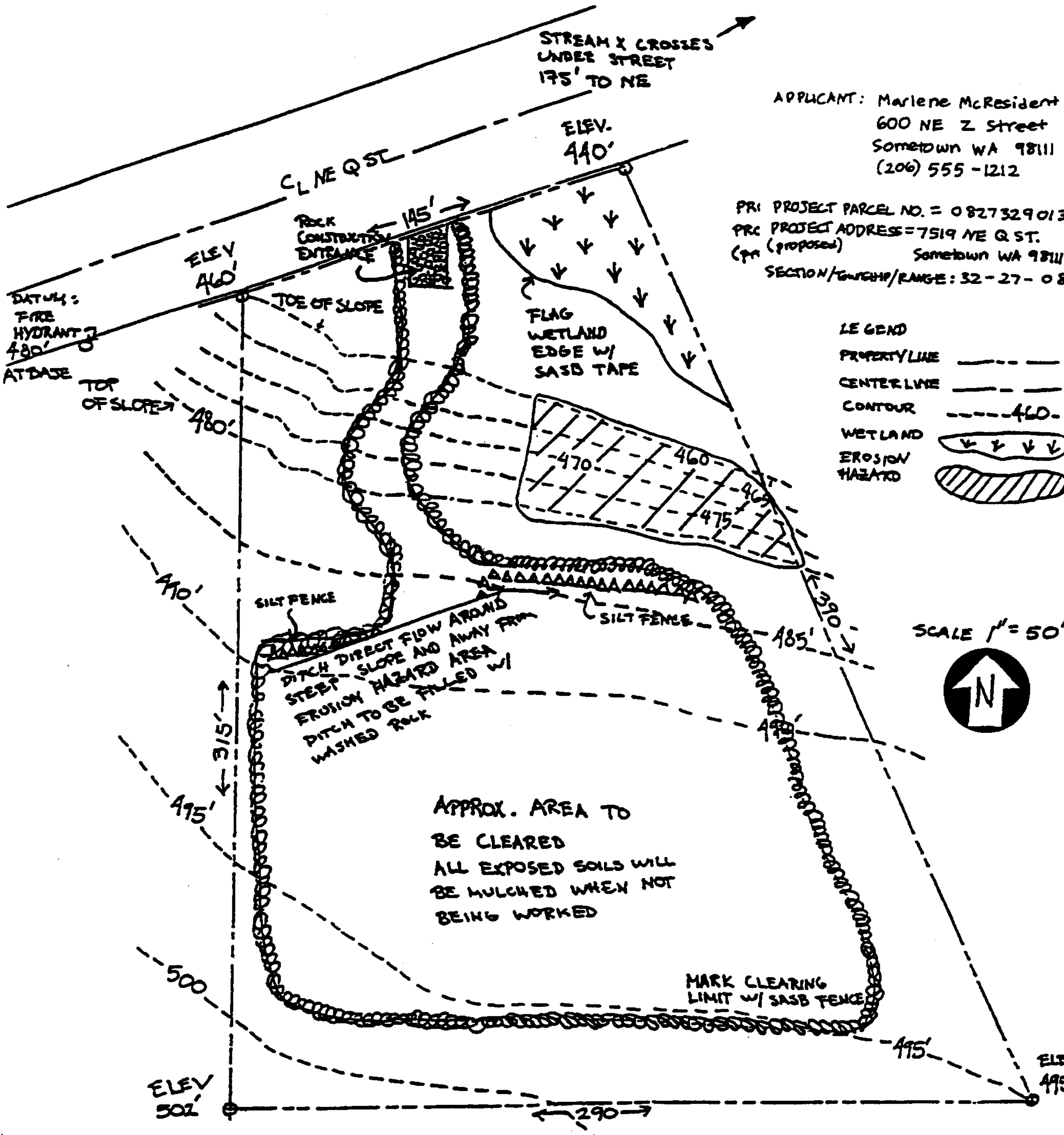
FIGURE D.7.C SAMPLE SMALL SITE ESC PLAN



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D.8 FOREST PRACTICES ESC

(This section reserved for erosion and sediment control requirements that will specifically apply to forest practices and clearing regulated by King County)

AR 032476

D.9 MINING AND EXTRACTION ESC

(This section reserved for erosion and sediment control requirements that will specifically apply to extraction operations requiring a grading permit from King County)

AR 032477

D.10 REFERENCE SECTION

This reference section provides materials useful in developing erosion and sediment control plans and for effectively implementing erosion control measures in the field. In order to make the Erosion and Sediment Control Standards a stand alone booklet, several key components relating to erosion and sediment control found in the *Surface Water Design Manual* are repeated in this section.

1. Core Requirement #5: Erosion and Sediment Control Requirements
2. ESC maintenance report
3. Standard ESC plan notes
4. Recommended construction sequence
5. References.

Note: The administrative rule adopting the Erosion and Sediment Control Standards has not formally adopted any of the materials in this section. All of the forms, notes, and other material are provided for reference only. King County assumes no responsibility for the completeness or current status of the materials contained in this section. It is the sole responsibility of each applicant to use the most current materials in the preparation and implementation of the erosion and sediment control requirements. Copies of the current versions of these materials are available at DDES.

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D.10.1 CORE REQUIREMENT #5: EROSION AND SEDIMENT CONTROL

R E Q M T

All proposed projects that will clear, grade, or otherwise disturb the site must provide erosion and sediment controls to prevent, to the maximum extent possible, the transport of sediment from the project site to downstream drainage facilities, water resources, and adjacent properties. To prevent sediment transport, **Erosion and Sediment Control (ESC)** measures are required and shall perform as described in Section 1.2.5.2. Both temporary and permanent erosion and sediment controls shall be implemented as described in Section 1.2.5.3.

Intent: To prevent the transport of sediment to streams, wetlands, lakes, drainage systems, and adjacent properties. Erosion on construction sites can result in excessive sediment transport to adjacent properties and to surface waters. Sediment transport can result in major adverse impacts, such as flooding due to obstructed drainage ways, smothering of salmonid spawning beds, and creation of algal blooms in lakes.

D.10.1.1 ESC MEASURES

The following ESC measures shall be provided as specified below and as further detailed in Section D.4, (p. D-5):

1. **Clearing Limits:** Prior to any site clearing or grading, areas to remain undisturbed during project construction shall be delineated. At a minimum, clearing limit delineation flagging shall be provided at the edges of all sensitive area buffers.
2. **Cover Measures:** Temporary and permanent cover measures shall be provided when necessary to protect disturbed areas. Temporary cover shall be installed if an area is to remain unworked for more than seven days during the dry season (May 1 to September 30) or for more than two days during the wet season (October 1 to April 30), unless otherwise determined by the County. Any area to remain unworked for more than 30 days shall be seeded or sodded, unless the County determines that winter weather makes vegetation establishment unfeasible. **During the wet season, slopes and stockpiles 3H:1V or steeper with more than 10 feet of vertical relief** shall be covered if they are to remain unworked for more than 12 hours. The intent of these measures is to prevent erosion by having as much area as possible covered during any period of precipitation.
3. **Perimeter Protection:** When necessary, perimeter protection to filter sediment from sheet flow shall be provided downstream of all disturbed areas. Perimeter protection includes the use of vegetated strips, as well as more conventional constructed measures such as silt fences. Such protection shall be installed prior to upstream grading.
4. **Traffic Area Stabilization:** Unsurfaced entrances, roads, and parking areas used by construction traffic shall be stabilized to minimize erosion and tracking of sediment offsite.
5. **Sediment Retention:** Surface water collected from disturbed areas of the site shall be routed through a sediment pond or trap prior to release from the site. This does not apply to areas at the perimeter of the site small enough to be treated solely with perimeter protection. Sediment retention facilities shall be installed prior to grading any contributing area.
6. **Surface Water Controls:** Surface water controls shall be installed to intercept all surface water from disturbed areas, convey it to a sediment pond or trap, and discharge it downstream of any disturbed areas. However, areas at the perimeter of the site that are small enough to be treated solely with perimeter protection do not require surface water controls. Significant sources of upstream surface water that drain onto disturbed areas shall be intercepted and conveyed to a stabilized discharge point downstream of the disturbed areas. Surface water controls shall be installed concurrently with or immediately following rough grading.

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7. **Dust Control:** Preventative measures to minimize wind transport of soil shall be implemented when a traffic hazard may be created or when sediment transported by wind is likely to be deposited in water resources.

D.10.1.2 ESC PERFORMANCE

The above ESC measures shall be applied and maintained so as to prevent, to the maximum extent possible, the transport of sediment from the project site or into onsite wetlands, streams, or lakes. This performance is intended to be achieved through proper selection, installation, and operation of the above ESC measures as detailed in the *ESC Standards* (detached Appendix D) and approved by the County. However, the County may determine at any time during construction that such approved measures are not sufficient and additional action is required based on one of the following criteria:

1. IF a **sieve test** of storm and surface water discharges indicates that sand-sized sediment (soil particles coarser than the #200 sieve, 0.075 mm) is leaving the project site or entering onsite wetlands, streams, or lakes, THEN corrective actions and/or additional measures beyond those specified in Section 1.2.5.1 shall be implemented as deemed necessary by the County. *Note: The County can require that the ESC supervisor have a #200 sieve on site. Also, "leaving the project site" will be interpreted liberally. For example, if this criterion is applied to individual lots within a subdivision, it may, depending on the site, be appropriate to conduct the sieve test at the outlet of the drainage system rather than at the edge of the lot.*
2. IF the County determines that the condition of the construction site poses a **hazard to adjacent property** or may **adversely impact drainage facilities or water resources,** THEN additional measures beyond those specified in Section 1.2.5.1 can be required by the County.

D.10.1.3 IMPLEMENTATION REQUIREMENTS

ESC Plan

As specified in Chapter 2, all proposed projects must submit a plan for providing ESC measures. The ESC plan shall include a detailed construction sequence as proposed by the design engineer and shall identify required ESC measures. All ESC measures shall conform to the details and specifications in the *ESC Standards* unless an alternative is approved by King County (see "Alternative and Experimental Measures" in the *ESC Standards*, detached Appendix D). The ESC plan shall be accompanied by any calculations or information necessary to size ESC measures and demonstrate compliance with Core Requirement #5. The County may require large, complex projects to phase construction and to submit multiple ESC plans for the different stages of construction. Development of new ESC plans is not required for changes that are necessary during construction.

Wet Season Construction

During the wet season (October 1 to April 30) any site with exposed soils shall be subject to the "Wet Season Provisions" contained in Section D.5.2. In addition to the ESC cover measures, these provisions include covering any newly-seeded areas with mulch and seeding as much disturbed area as possible during the first week of October in order to provide grass cover for the wet season.

Construction within Sensitive Areas and Buffers

Any construction that will result in disturbed areas on or within a stream or associated buffer, within a Class 1 or 2 wetland or associated buffer, or within 50 feet of a lake shall be subject to the "Sensitive Area Restrictions" contained in Section D.5.3. These provisions include phasing the project whenever possible so that construction in these areas is limited to the dry season.

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Maintenance

All ESC measures shall be maintained and reviewed on a regular basis as prescribed in Section D.5.4. The applicant shall designate an ESC supervisor who shall be responsible for maintenance and review of ESC measures and for compliance with all permit conditions relating to ESC as described in the *ESC Standards.*

Final Stabilization

Prior to obtaining final construction approval, the site shall be stabilized, structural ESC measures (such as silt fences and sediment traps) shall be removed, and drainage facilities shall be cleaned as specified in the *ESC Standards.*

Flexible Compliance

Some projects may meet the intent of Core Requirement #5 while varying from specific ESC requirements contained here. If a project is designed and constructed such that it meets the intent of this core requirement, the County may determine that strict adherence to a specific ESC requirement is unnecessary; an approved adjustment (see Section 1.4) is not required in these circumstances. Certain types of projects are particularly likely to warrant this greater level of flexibility; for instance, projects on relatively flat, well drained soils, projects that are constructed in closed depressions, or projects that only disturb a small percentage of a forested site may meet the intent of this requirement with very few ESC measures. More information on intent and general ESC principles is contained in the *ESC Standards.*

Roads and Utilities

Road and utility projects often pose difficult erosion control challenges because they frequently cross surface waters and are long and narrow with limited area available to treat and store sediment-laden water. Because of these factors, road and utility projects are allowed greater flexibility in meeting the intent of Core Requirement #5 as described in the *ESC Standards.* Projects that pose a very low risk of erosion or sediment transport due to site conditions or project scope may also warrant greater flexibility.

Consideration of Other Required Permits

Consideration should be given to the requirements and conditions that may be applied by other agencies as part of other permits required for land-disturbing activities. In particular, the following permits may be required and should be considered when implementing ESC measures:

- A **Class IV Special Forest Practices Permit** is required by the Washington State Department of Natural Resources for projects that will clear more than two acres of forest or 5,000 board feet of timber. All such clearing is also subject to the State Environmental Policy Act (RCW 43.21C) and will require SEPA review. King County assumes lead agency status for Class IV permits, and the application can be consolidated with the associated King County development permit or approval.
- A **NPDES[2] General Permit for Construction** (pursuant to the Washington State Department of Ecology's Baseline General Permit for Stormwater) is required for projects that will disturb more than five acres. The five-acre threshold applies even where the five acres are to be disturbed in phases, as long as the construction is "part of a larger common plan of development or sale."

[2] *NPDES* stands for National Pollutant Discharge Elimination System.

D.10.2 ESC MAINTENANCE REPORT

DDES may require a written record of all maintenance activities to be kept to demonstrate compliance with the Maintenance Requirements (Section D.5.4). A standard ESC Maintenance Report is provided on the next page. Copies of the ESC Maintenance Report must be kept on site throughout the duration of construction.

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ESC MAINTENANCE REPORT

Performed By: ______________________
Date: ______________________
Project Name: ______________________
DDES Permit #: ______________________

Clearing Limits

Damage	OK ___	Problem
Visible	OK ___	Problem
Intrusions	OK ___	Problem
Other	OK ___	Problem

Mulch

Rills/Gullies	OK ___	Problem
Thickness	OK ___	Problem
Other	OK ___	Problem

Nets/Blankets

Rills/Gullies	OK ___	Problem
Ground Contact	OK ___	Problem
Other	OK ___	Problem

Plastic

Tears/Gaps	OK ___	Problem
Other	OK ___	Problem

Seeding

Percent Cover	OK ___	Problem
Rills/Gullies	OK ___	Problem
Mulch	OK ___	Problem
Other	OK ___	Problem

Sodding

Grass Health	OK ___	Problem
Rills/Gullies	OK ___	Problem
Other	OK ___	Problem

Silt Fence

Damage	OK ___	Problem
Sediment Build-up	OK ___	Problem
Concentrated Flow	OK ___	Problem
Other	OK ___	Problem

Brush Barrier

Damage	OK ___	Problem
Sediment Build-up	OK ___	Problem
Concentrated Flow	OK ___	Problem
Other	OK ___	Problem

Vegetated Strip

Damage	OK ___	Problem
Sediment Build-up	OK ___	Problem
Concentrated Flow	OK ___	Problem
Other	OK ___	Problem

Construction Entrance

Dimensions	OK ___	Problem
Sediment Tracking	OK ___	Problem
Vehicle Avoidance	OK ___	Problem
Other	OK ___	Problem

Construction Road

Stable Driving Surf.	OK ___	Problem
Vehicle Avoidance	OK ___	Problem
Other	OK ___	Problem

Sediment Trap/Pond

Sed. Accumulation	OK ___	Problem
Overtopping	OK ___	Problem
Inlet/Outlet Erosion	OK ___	Problem
Other	OK ___	Problem

Catch Basin Protection

Sed. Accumulation	OK ___	Problem
Damage	OK ___	Problem
Clogged Filter	OK ___	Problem
Other	OK ___	Problem

Interceptor Dike/Swale

Damage	OK ___	Problem
Sed. Accumulation	OK ___	Problem
Overtopping	OK ___	Problem
Other	OK ___	Problem

Pipe Slope Drain

Damage	OK ___	Problem
Inlet/Outlet	OK ___	Problem
Secure Fittings	OK ___	Problem
Other	OK ___	Problem

Ditches

Damage	OK ___	Problem
Sed. Accumulation	OK ___	Problem
Overtopping	OK ___	Problem
Other	OK ___	Problem

Outlet Protection

Scour	OK ___	Problem
Other	OK ___	Problem

Level Spreader

Damage	OK ___	Problem
Concentrated Flow	OK ___	Problem
Rills/Gullies	OK ___	Problem
Sed. Accumulation	OK ___	Problem
Other	OK ___	Problem

Miscellaneous

Wet Season Stockpile	OK ___	Problem
Other	OK ___	Problem

Comments:

Actions Taken:

Problems Unresolved:

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D.10.3 STANDARD ESC PLAN NOTES

The standard ESC plan notes must be included on all ESC plans. At the applicant's discretion, notes that in no way apply to the project may be omitted; however, the remaining notes must not be renumbered. For example, if ESC Note #3 were omitted, the remaining notes should be numbered 1, 2, 4, 5, 6, etc.

1. Approval of this erosion and sedimentation control (ESC) plan does not constitute an approval of permanent road or drainage design (e.g., size and location of roads, pipes, restrictors, channels, retention facilities, utilities, etc.).
2. The implementation of these ESC plans and the construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the applicant/ESC supervisor until all construction is approved.
3. The boundaries of the clearing limits shown on this plan shall be clearly flagged by a continuous length of survey tape (or fencing, if required) prior to construction. During the construction period, no disturbance beyond the clearing limits shall be permitted. The clearing limits shall be maintained by the applicant/ESC supervisor for the duration of construction.
4. The ESC facilities shown on this plan must be constructed prior to or in conjunction with all clearing and grading so as to ensure that the transport of sediment to surface waters, drainage systems, and adjacent properties is minimized.
5. The ESC facilities shown on this plan are the minimum requirements for anticipated site conditions. During the construction period, these ESC facilities shall be upgraded as needed for unexpected storm events and modified to account for changing site conditions (e.g., additional sump pumps, relocation of ditches and silt fences, etc.).
6. The ESC facilities shall be inspected daily by the applicant/ESC supervisor and maintained to ensure continued proper functioning. Written records shall be kept of weekly reviews of the ESC facilities during the wet season (Oct. 1 to April 30) and of monthly reviews during the dry season (May 1 to Sept. 30).
7. Any areas of exposed soils, including roadway embankments, that will not be disturbed for two days during the wet season or seven days during the dry season shall be immediately stabilized with the approved ESC methods (e.g., seeding, mulching, plastic covering, etc.).
8. Any area needing ESC measures that do not require immediate attention shall be addressed within fifteen (15) days.
9. The ESC facilities on inactive sites shall be inspected and maintained a minimum of once a month or within forty eight (48) hours following a storm event.
10. At no time shall more than one (1) foot of sediment be allowed to accumulate within a catch basin. All catch basins and conveyance lines shall be cleaned prior to paving. The cleaning operation shall not flush sediment-laden water into the downstream system.
11. Stabilized construction entrances and roads shall be installed at the beginning of construction and maintained for the duration of the project. Additional measures, such as wash pads, may be required to ensure that all paved areas are kept clean for the duration of the project.
12. Any permanent flow control facility used as a temporary settling basin shall be modified with the necessary erosion control measures and shall provide adequate storage capacity. If the facility is to function ultimately as an infiltration system, the temporary facility must be graded so that the bottom and sides are at least three feet above the final grade of the permanent facility.
13. Where straw mulch for temporary erosion control is required, it shall be applied at a minimum thickness of 2 to 3 inches.
14. Prior to the beginning of the wet season (Oct. 1), all disturbed areas shall be reviewed to identify which ones can be seeded in preparation for the winter rains. Disturbed areas shall be seeded within

one week of the beginning of the wet season. A sketch map of those areas to be seeded and those areas to remain uncovered shall be submitted to the DDES inspector. The DDES inspector can require seeding of additional areas in order to protect surface waters, adjacent properties, or drainage facilities.

D.10.4 CONSTRUCTION SEQUENCE

A detailed construction sequence is needed to ensure that erosion and sediment control measures are applied at the appropriate times. A recommended construction sequence is provided below:

1. Hold the pre-construction meeting.
2. Flag or fence clearing limits.
3. Post a sign with the name and phone number of the ESC supervisor.
4. Install catch basin protection, if required.
5. Grade and install construction entrance(s).
6. Install perimeter protection (silt fence, brush barrier, etc.).
7. Construct sediment ponds and traps.
8. Grade and stabilize construction roads.
9. Construct surface water controls (interceptor dikes, pipe slope drains, etc.) simultaneously with clearing and grading for project development.
10. Maintain erosion control measures in accordance with King County standards and manufacturer's recommendations.
11. Relocate surface water controls or erosion control measures, or install new measures so that as site conditions change, the erosion and sediment control is always in accordance with the *King County Erosion and Sediment Control Standards*.
12. Cover all areas that will be unworked for more than seven days during the dry season or two days during the wet season with straw, wood fiber mulch, compost, plastic sheeting, or equivalent.
13. Stabilize all areas within seven days of reaching final grade.
14. Seed or sod any areas to remain unworked for more than 30 days.
15. Upon completion of the project, stabilize all disturbed areas and remove BMPs if appropriate.

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D.10.5 REFERENCES

Goldman, S.J., Jackson, K., and Bursztynsky, T.A. 1986. Erosion and Sediment Control Handbook. McGraw-Hill Book Company, New York, New York.

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Metropolitan Washington Council of Governments. 1990. Performance of Current Sediment Control Measures at Maryland Construction Sites. Washington, D.C. Prepared by T.R. Schueler and J. Lugbill.

Horner, R.R., Guedry, J., and Kortenhof, M.H. 1990. Highway Construction Site Erosion and Pollution Control Manual. Washington State Transportation Center, Seattle, Wash. and Washington State Dept. of Transportation, Olympia, Wash. Report No. WA-RD 200.2.

Appendix C
Small Site Drainage Requirements

King County, Washington
Surface Water Design Manual

KING COUNTY
Department of Natural Resources

APPENDIX C

SMALL SITE DRAINAGE REQUIREMENTS

KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

King County
Department of Natural Resources
Department of Development and Environmental Services

September 1998

APPENDIX C

SMALL SITE DRAINAGE REQUIREMENTS

KING COUNTY, WASHINGTON

SURFACE WATER DESIGN MANUAL

Which Projects can use Small Sites Drainage Review?

Single family residential and **small subdivision projects**[1] requiring drainage review may qualify to use this appendix to meet the flow control, water quality, and erosion and sediment control requirements of the *Surface Water Design Manual (SWDM).*

Drainage review is required for any permit application that:

1. Adds 5,000 square feet[2] or more of **new impervious surface**, OR
2. Proposes to **construct or modify** a drainage pipe/ditch that is 12 inches or more in size/depth, or receives surface and storm water runoff from a drainage pipe/ditch that is 12 inches or more in size/depth, OR
3. Contains or is adjacent to a floodplain, stream, lake, wetland, or closed depression, or another **sensitive area** as defined by the Sensitive Areas Ordinance (codified in KCC 21A.24), excluding seismic, coal mining, and volcanic hazard areas, OR
4. Is located within a **Landslide Hazard Drainage Area**[3] and adds 2,000 square feet or more of new impervious surface, OR
5. Is located within a **Critical Drainage Area**,[4] OR
6. Is located within the **rural zoned area of a basin plan or community plan**[5] where drainage requirements are applied through KCC 16.82.150(C) to projects that clear more than 7,000 square feet or 35% of the project site, whichever is greater.

Single family residential and **small subdivision projects** may address the SWDM flow control, water quality, and erosion control requirements by using the Best Management Practices (BMPs) outlined in this appendix[6] **IF** the project:

1. Adds no more than 10,000 square feet of total impervious surface to a threshold discharge area, AND
2. Clears less than 2 acres or 35% of the site, whichever is greater. (*Note: An open space tract or easement may be required to protect uncleared areas. Some areas of King County have more stringent clearing limitations.)*

Many projects that qualify for Small Site Drainage Review can completely meet drainage requirements using the BMPs outlined in this Appendix.[7] Other small site projects may require use of a combination of these BMPs and professional engineering design.

Targeted Drainage Review is required when drainage conditions are more complex and require evaluation by a professional engineer registered in the State of Washington. Examples of typical drainage issues addressed through Targeted Drainage Review include:

- Sensitive areas on or adjacent to the site.
- Floodplain on or adjacent to the site.
- Construction or modification of a drainage system collecting or concentrating surface runoff as part of the proposal (small site BMPs and driveway culverts excluded)

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1 Other projects may use BMPs from this appendix when specifically allowed in the *Surface Water Design Manual.*

2 The addition of 5,000 square feet or more of *new impervious surface* shall be applied by *threshold discharge area* and shall include all impervious surface that will ultimately result from the proposed project (e.g., impervious surface that will result from future homes within a plat or short plat).

3 Landslide Hazard Drainage Areas are delineated on a map issued with the SWDM (see map pocket on inside of back cover).

4 See Reference Section 3 for a list of critical drainage areas.

5 See Reference Section 1 for a list of basin plan and community plan areas where this threshold applies.

6 Projects that exceed these thresholds **must** undergo drainage review in accordance with the *King County Surface Water Design Manual*, which typically requires engineering analysis and plans.

7 If an onsite sewage system is to be used, storm drainage measures must be designed to accommodate the Seattle-King County Department of Public Health requirements. Reference B summarizes onsite sewage system requirements.

- Projects located within an adopted basin plan area, critical drainage area, community plan P-suffix area, or special district overlay, or other area with adopted drainage requirements that require engineering review or analysis. *See Reference Sections 2 and 3 of the Surface Water Design Manual for areas with special drainage requirements.*

Figure C.1.A on page C-6 is a flow chart showing the typical Small Site Drainage Review process for a small subdivision or single family residence. Figure C.2.A (p. C-8) shows how to determine small site flow control requirements based on site conditions. Reference C is a questionnaire to help assess if a project will be eligible for Small Site Drainage Review and if so, what small site or targeted review information is required for the site.

C.1 INTRODUCTION

C.1.1 WHAT IS SMALL SITE DRAINAGE REVIEW?

Small Site Drainage Review is an abbreviated review process that addresses stormwater runoff (flow control and water quality) and erosion control requirements for small projects (small residential projects or 2-lot short plats). This appendix outlines simple Best Management Practices (BMPs) to mitigate drainage impacts without the construction of expensive stormwater facilities (i.e., detention ponds/tanks and water quality facilities). Also included are requirements for the preservation of open space and basic erosion control techniques, which are commonly used to meet the erosion and sediment control requirement that sediment-laden water must not leave the site.

In addition, typical small site sensitive area drainage restrictions for slopes, erosion and landslide hazard area sites are included.

Note: Targeted Drainage Review is usually required when a site naturally discharges to a sensitive area to review the application of small site BMPs (or engineered systems) to specific site conditions.

Small Site Drainage Review examines the amount and type of proposed impervious surface (rooftops, driveways, patios, etc.), and how stormwater runoff from these surfaces can be dispersed and temporarily retained by site soils and vegetation. Section C.2 (p. C-7) discusses the types of BMPs for controlling runoff which can be used for projects being reviewed using the small site process. These BMPs are generally simple to construct and do not require site specific engineering design.

For erosion and sediment control, Small Site Drainage Review examines the submitted plan, the topography (existing and proposed), and soil conditions to determine how best to control sediment-laden water so that it does not leave the site. Section C.3 (p. C-25) provides erosion control BMPs to reduce impacts to downstream properties and sensitive areas.

Projects that qualify for Small Site Drainage Review but have drainage issues that must be analyzed by a professional engineer may still be able to use small site BMPs in conjunction with the required engineering information or recommendations. Engineering analysis is typically required to map or inventory sensitive areas, floodplains, closed depressions, and constructed drainage systems or to evaluate special flow control thresholds. In some cases, DDES engineering review staff may perform the engineering analysis for small site projects. This may expedite review and reduce drainage review fees.

Reference Section C, "Small Site Drainage Review Assessment/Requirements," is a series of questions that cover most of the drainage issues related to small sites. These questions can be used to help determine which issues may be addressed through small site BMPs and which will require engineering analysis by a professional engineer registered in the State of Washington.

C.1.2 WHY IS FLOW CONTROL NECESSARY FOR SMALL PROJECTS?

On undeveloped land, most rainwater soaks into the ground and flows slowly to nearby lakes and streams through the upper layers of soil. When that same area is cleared or covered with an impervious surface, the rainwater is not captured by vegetation and forest duff, but flows quickly across the site and through pipes and channels to lakes or streams. The total amount of surface runoff from the site is increased, and when combined with uncontrolled runoff from other sites, can overflow the pipes and channels that carry it. This can result in flooding and erosion of downstream properties. Larger developments address this problem by collecting runoff from the developed site in retention/detention systems including ponds, vaults or tanks. Water is then released slowly so as not to overwhelm downstream conveyance systems.

Controlling flows from small sites is just as important as for large developments, because the cumulative effect of uncontrolled flows from many small sites can be equivalent to those from a large site. For most small sites, however, retention/detention ponds may not be warranted, since the natural storage capacity of soils and vegetation can be used to effectively slow and filter runoff.

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C.1.3 WHAT IS ESC AND WHY IS IT REQUIRED?

All sites, including small sites, are required to use erosion and sediment control (ESC) BMPs to prevent onsite soils and sediment-laden runoff from leaving the site during and after construction. Temporary erosion and sediment control (TESC) BMPs prevent soil erosion during development of the site. Small site ESC concentrates on TESC because landscaping usually stabilizes the site after construction. For sites that are not landscaped, permanent ESC measures are required. Examples of temporary BMPs include phasing or minimizing clearing, terracing exposed slopes, and placing straw or other mulching materials on exposed soils.

TESC is required because soils eroded from the site are *always* deposited downstream in pipes, streams, or lakes. Soils deposited in a pipe or channel reduce its capacity to convey flows, and can increase the likelihood of flooding. Soils in streams can also clog the gravels that salmon use for spawning. Nutrients associated with soils that reach lakes can upset the chemical balance of the lake, causing excessive growth of algae, milfoil, and other plants, and decreasing recreational uses such as swimming, boating, and fishing.

C.1.4 WHAT IS SMALL SITE/TARGETED REVIEW?

Some small sites may have specific drainage-related issues not addressed by the small site BMPs. These may be adjacent floodplains or sensitive areas, potential downstream drainage problems, drainage to closed depressions, construction or modification of a drainage system, or area-specific special requirements. In limited cases, DDES engineering staff may be able to place conditions on the project, which adequately address the targeted engineering issues. County staff may sometimes supply the following kinds of engineering analysis:

- Geotechnical review and conditioning of small sites adjacent to steep slopes, or
- Determination of whether a site may use the exception from a minor floodplain analysis for an assumed 100-year floodplain elevation.

Otherwise, the applicant is responsible for hiring a professional engineer registered in the State of Washington to address some or all of the identified engineering issues.

C.1.5 WHAT HAPPENS DURING DRAINAGE REVIEW?

The typical Small Site Drainage Review process for single family residential projects and short plats are described below. Figure C.1.A (p. C-6) outlines the general drainage review process common to both permit types. Other development requirements, such as road construction, may disqualify a project from Small Site Drainage Review.

Single Family Residential Permits

When a residential permit requires drainage review, as defined by the thresholds given on page C-1, the DDES Site Engineering staff plot the project location on various maps (Assessor's, Kroll, topography, soils, etc.), research sensitive areas on or near the site, and check for adopted area-specific conditions which might affect the drainage requirements for the site. A DDES engineer reviews this information with respect to the proposed application. In most cases, a visit to the site is made to check existing conditions and drainage concerns.

The DDES engineer makes a determination of the type of drainage review required for the site and will either:

- Approve the permit subject to complying with an approved small site drainage plan or engineered plan,
- Request additional information, as needed,
- Request that a small site drainage plan (see Section C.5, p. C-35) be submitted,

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- Request that an engineered drainage plan be submitted in accordance with the *Surface Water Design Manual*, OR
- Deny the permit application because it cannot meet required codes (e.g., a proposed new residence located in a FEMA floodway or in a channel migration hazard area).

Short Plats

Preapplication: The short plat process requires a mandatory preapplication meeting prior to formal submittal. The purpose of the preapplication meeting is to identify potential site constraints and regulatory requirements for the proposed project. If the short plat is potentially eligible for Small Site Drainage Review, the applicant may use this appendix or other information necessary to complete the small site drainage plan.

Preliminary Approval: After formal permit application, a more detailed review of the site and a determination of the type of drainage review required for the proposed project is made. If eligible for Small Site Drainage Review, the application may be placed on hold pending the completion of the small site drainage plan.

The applicant is responsible for submitting a small site drainage plan as outlined in Section C.5 (p. C-35). Upon completion and approval of a small site drainage plan (and other application requirements), preliminary approval may be granted, subject to the conditions of the small site drainage plan. For simple projects without drainage issues triggering Targeted Drainage Review, engineered drainage plans are not usually required.

For projects requiring some engineering analysis, preliminary approval may be granted subject to the approval of engineering plans and a small site drainage plan. The applicant may choose to have the small site drainage plan incorporated into the engineered plans, or may elect to have a separate small site drainage plan, which need not be prepared by an engineer.

Projects that qualify for Small Site Drainage Review but cannot or elect not to comply with the small site drainage requirements will be subject to Full Drainage Review. Any projects unable to comply with all applicable regulations (drainage or non-drainage) may be denied.

Engineering Review: Projects receiving preliminary approval subject to the completion of a small site drainage plan and/or engineering plans are subject to engineering review. When separate plans are being prepared, submittals for engineering review should include both sets of plans to minimize review time and re-submittal fees.

Final Recording: All short plat applications must complete the requirements of final recording. Small site projects will require additional note(s) be placed on the recorded documents which reference the approved small site drainage plan for future lot construction.

Note: Future building permit applications which do not comply with the conditions of the approved small site drainage plan (e.g., impervious coverage limits, location of BMPs, etc.) may be subject to Full Drainage Review.

Engineering Plan Submittal with Permit Application

If the drainage requirements for a specific project are determined during a preapplication meeting, small site drainage plans (see Section C.5) or Full Drainage Review engineering plans [site improvement plans, erosion and sediment control plans, and a technical information report (as necessary)—see *SWDM* Section 2.3] may be submitted with the application. Reference C is a series of questions that may help assess the requirements for a potential small site project. Submitting plans with the permit application may expedite the review of the proposed application. However, there is risk that the plans prepared may exceed, or not adequately address, the yet-to-be-determined conditions of preliminary approval.

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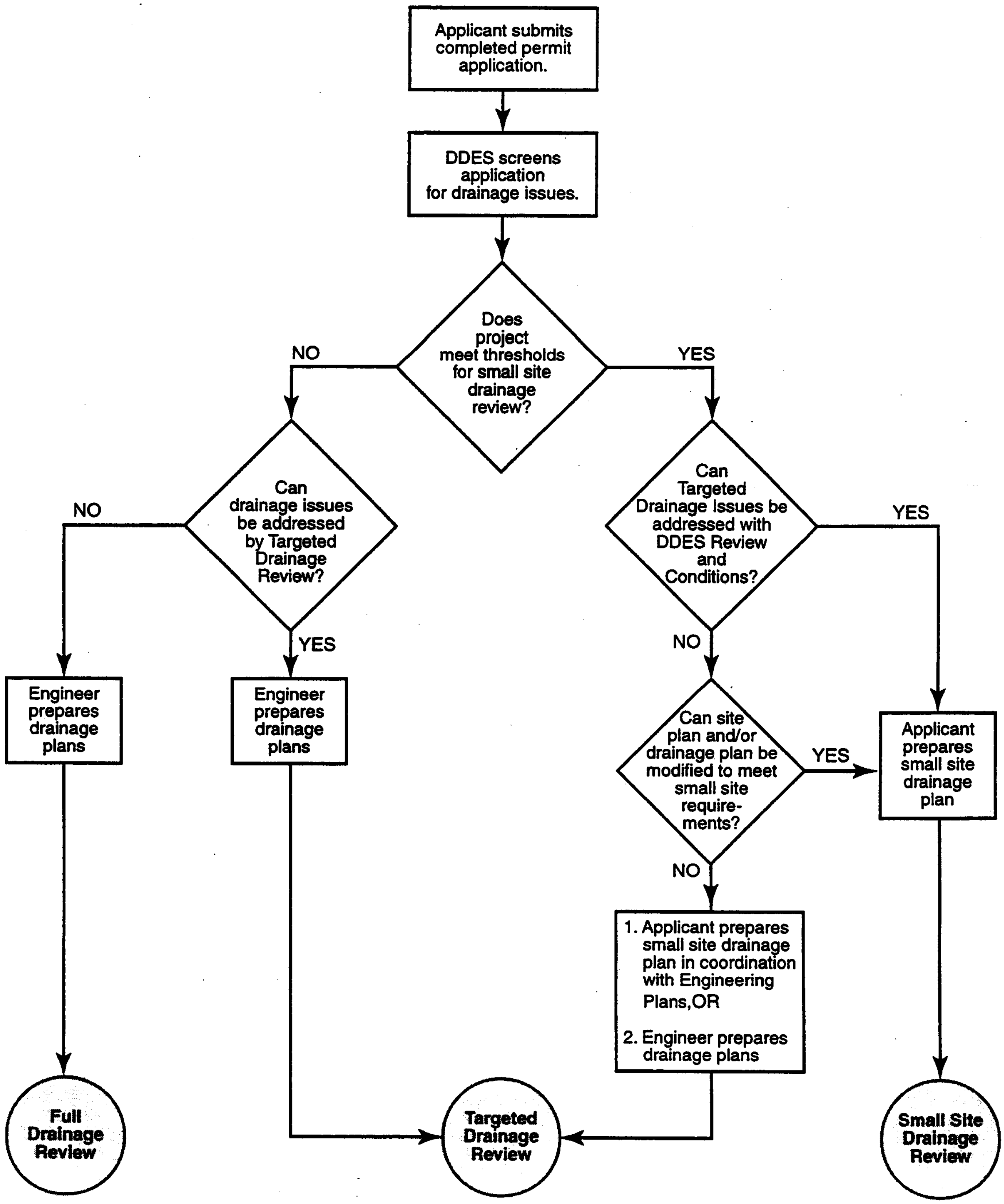
FIGURE C.1.A SIMPLIFIED DRAINAGE REVIEW PROCESS



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C.2 FLOW CONTROL BMPs

There are four basic types of flow control BMPs required for small sites: open space retention on larger lots, dispersion, infiltration, and perforated tightline systems. Figure C.2 provides guidelines for determining appropriate BMPs for the proposed project. The type of system(s) used will depend on the lot size, soil type, setback requirements, and topography of the site. In addition, if an onsite sewage system will be used, flow control BMPs must be designed to maintain setbacks and proper functioning of that system.

The BMPs in this appendix are designed to mitigate changes in surface water runoff. Flow control BMPs **should not** be connected to sub-surface drains (e.g., footing drains, French drains, etc.) as these connections may adversely affect the performance of the BMPs, and in some cases may cause reverse flow into the footing drains during storm events.

Note: Projects which require Targeted Drainage Review may be required to submit engineering plans (site improvement plans, erosion control plans, and a technical information report) signed and stamped by a professional engineer registered in the State of Washington to address drainage issues not covered by this appendix.

Native growth open space BMPs are required for small site projects over 2 acres in size (see Section C.2.2, p. C-9). The open space shall be protected in a separate tract or through easement on individual lots. Projects that set aside open space may qualify for tax relief under the Public Benefit Rating System.

Dispersion or infiltration BMPs are required for small site proposals applying for single family residential building permits or short plats **except** in the following case:

> If the existing lot is smaller than 22,000 square feet, or if the short plat creates lots less than 22,000 square feet, then ***infiltration* is required if suitable soils are present**. If soils will not support infiltration, then other flow control BMPs must be considered. If site constraints make dispersion and infiltration unfeasible, then the site may be connected to the storm drainage system with perforated tightline connection (see Section C.2.5, p. C-23).

The intent of small site flow control requirements is **to reduce runoff leaving the site to the greatest extent practical**, given constraints of the site. For large single family residences on large lots, or rural short plats creating large lots, retaining open space with native vegetation combined with flow dispersion BMPs should be functional, inexpensive, and easy to construct and locate on the site. However, urban short plats creating small lots will likely not be able to meet design specifications for dispersion for all added impervious surface (e.g., driveways). In these cases, flow control BMPs are required to the extent achievable.

In all cases, DDES review staff must approve the use of small site BMPs for the proposed project. If the project cannot incorporate the small site BMPs, or if there is a potential for impacts to a neighboring property, then additional drainage review and engineered mitigation may be required.

C.2.1 DESIGN SPECIFICATIONS FOR SMALL SITE FLOW CONTROL BMPS

The following sections contain detailed information on small site flow control BMPs. These are divided into four basic types: open space retention (for larger lots), dispersion, infiltration, and perforated tightline connections. Feasibility of dispersion and/or infiltration must be evaluated before use of a perforated tightline connection can be considered. If none of the BMPs can be effectively applied to the site or there are additional drainage concerns, a professional engineer may be required to provide a workable drainage design and plan. **A geologist or geotechnical engineer must evaluate flow control BMPs proposed on slopes greater than 20%.** In addition, any proposed small site BMP within 50 feet of a slope greater than 20% may be subject to geotechnical review. In some cases, the DDES Geologist may perform these evaluations.

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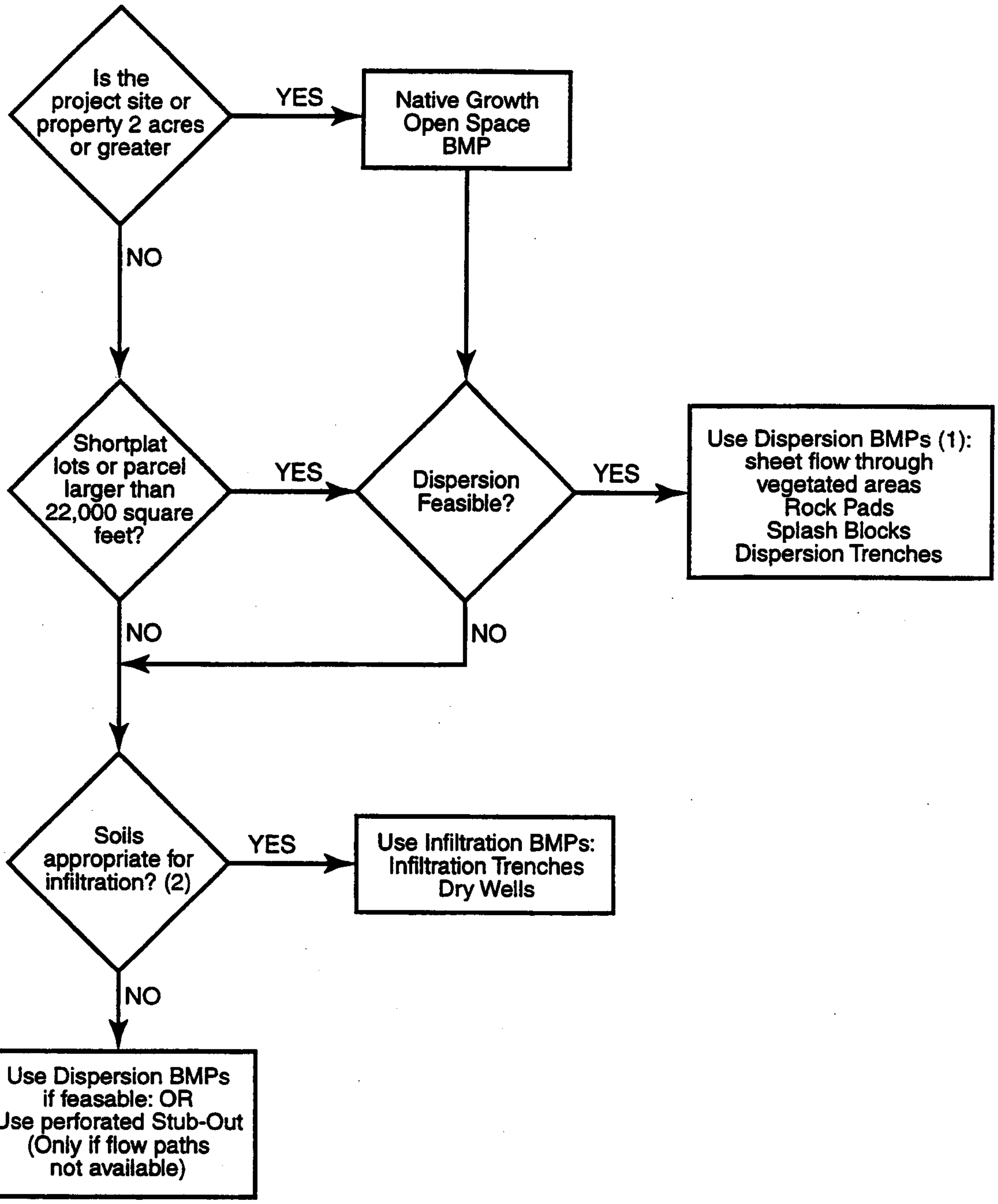
FIGURE C.2.A FLOWCHART FOR DETERMINING SMALL SITE FLOW CONTROL REQUIREMENTS



(1) Infiltration BMPs are also acceptable but are not required.
(2) A soils report is required. See section C.5.4 - Submittal Requirements

Note: Some projects may need to route flows down or around slopes or past onsite sewage systems. These projects will require non-perforated pipes to route flows past areas of concern. Small site dispersion or infiltration BMPs may not be appropriate for these sites, and shall not be used where flows may cause erosion problems or impact onsite sewage systems. A licensed onsite sewage system designer, Seattle-King County Department of Public Health (SKCDPH) and/or DDES engineering review staff must be consulted in cases where there is a potential conflict between onsite sewage systems and small site flow control BMPs.

The placement and type of proposed flow control BMPs may need to be shown on a *small site drainage plan*. Required features of this plan are outlined in Section C.5, "Submittal Requirements" (p. C-35). For some projects, DDES may apply small site BMP requirements as conditions of permit approval without the need for a specific plan. For other projects, applicants should use this appendix to prepare a small site drainage plan to the best of their ability.

C.2.2 NATIVE GROWTH OPEN SPACE BMPs

Except for some areas where forest retention is mandatory (see *Surface Water Design Manual* Reference Section 2-A), King County has adopted an incentive-based approach to forest and open space retention. The preservation of forested cover in our watersheds is important for protecting the quality of our natural stream systems. Forested and native growth areas allow rainwater to naturally percolate into the soil, recharging groundwater for summer stream flows and lessening increases of surface water that create erosion and flooding. Forested and native growth areas also may be effective as stormwater buffers around smaller developments. By preserving 65% or more of the site as native growth, preferably forested, and applying flow control BMPs, an equivalent level of protection for our streams can be achieved without constructing engineered stormwater facilities.

Projects in Small Site Drainage Review must clear less than 2 acres or less than 35%[8] of the site, whichever is greater. The remainder of the site must be preserved as **native growth retention area** subject to the following **criteria and conditions:**

1. The native growth retention area shall **include remaining forested areas on the site**. Those portions of the site that are currently cleared (not in violation of King County Code) may be excluded from the native growth retention area requirements. However, no additional clearing may be performed on the site that will result in the maximum clearing allowances (2 acres or 35% of the site, whichever is greater) being exceeded, except as approved by DDES in conjunction with a reforestation plan for an equivalent area of existing clearing. Projects that propose to clear in excess of this threshold will be subject to Full Drainage Review.
2. The native growth retention area **must be placed in a separate tract or protected through recorded easements** for individual lots. Native growth retention areas on individual lots can be established through conservation easements, with tax benefits available through the Public Benefit Rating System program. An example native growth retention area covenant is located in Reference Section A.
3. Whether set aside in tracts or established by easement on individual lots, the native growth retention area must be **shown on the small site drainage plan and described in recorded documents** as "a native vegetation retention area established for purposes of dispersing and treating stormwater flows."
4. The **principle restriction** on native growth retention areas is **removal of vegetation and trees**. If feasible, the open space should be located downslope from the building sites, since flow control and water quality is enhanced by flow dispersion through duff, undisturbed soils, and native vegetation.
5. The native growth retention area **may include onsite SAO sensitive areas** and should be contiguous with sensitive areas, as feasible. For sensitive areas designated under KCC Title 21A, allowable uses shall be limited to those specified in KCC 21A.24.
6. All trees within the native growth retention area at the time of permit application shall be retained, aside from approved timber harvest activities and the removal of dangerous and diseased trees. If the

[8] Projects requiring geotechnical review may be subject to increased open space as needed to provide increased protection for landslide hazard areas or other sensitive slopes.

site is located within an area of mandatory clearing limits and has been illegally cleared; a restoration plan may be required.

7. The native growth retention area shall be shown on all property maps and shall be clearly marked during clearing and construction on the lots.
8. The native growth retention area **may be used for passive recreation** and related facilities, including pedestrian and bicycle trails, nature viewing areas, fishing and camping areas, and other similar activities that do not require permanent structures, provided that cleared areas and areas of compacted soil associated with these areas and facilities do not exceed eight percent of the native growth retention area.
9. The native growth retention area **may contain utilities and utility easements**, including flow control BMPs.
10. **Roof downspout dispersion** and **driveway dispersion** must be provided as described in this appendix. A note conditioning future single family residential building permits on compliance with small site requirements shall be recorded with the short plat.
11. If allowed under other regulations, the native growth retention area restrictions may be removed to accommodate future development provided drainage review evaluates the requirements for stormwater facilities (flow control and water quality) according to regulations in effect at the time of future application. For facility design, "existing conditions" shall be defined as those site conditions that existed prior to the approval of the original Small Site Drainage Review.

Public Benefit Rating System

The Public Benefit Rating System (PBRS) provides tax credit for properties which preserve 4 acres or more of contiguous open space in rural areas. Additional credits are granted under the forested open space category, provided a Forest Management Plan is developed that shall maintain the open space in a fully forested condition.

C.2.3 INFILTRATION TRENCHES AND DRYWELLS

If soils are appropriate, either **infiltration trenches** or **drywells** must be used for flow control on new lots (proposed by short plats) or existing lots (for single family residences) smaller than 22,000 square feet.

Infiltration trenches and drywells are sized to allow runoff to soak into the ground, and they perform adequately only in soils that allow water to infiltrate well.[9] **Infiltration trenches** are the better infiltration option where the depth to the maximum wet-season water table or hardpan is between 3 and 6 feet. **Drywells** are deeper and generally more compact than infiltration trenches. Drywells can be used in areas where the depth to the maximum wet-season water table is 6 feet or greater.

Typical Uses: Roof downspouts, parking areas, driveways.

Infiltration BMPs may not be placed on or above slopes greater than 20% without evaluation by a geotechnical engineer or qualified geologist and approval by DDES.

Coarse sands/cobbles or medium sands are considered appropriate for infiltration trenches and drywells. While other soil types will also infiltrate runoff, infiltration in coarse to medium sands provides greater assurance that trenches will perform in the long term. (Infiltration may be used on larger lots with some finer soil types. Section 5.1.1 of the *King County Surface Water Design Manual* contains design specifications for infiltration systems in soils other than coarse or medium sands).

A soils report is necessary to identify soil types and depth to impermeable layers or groundwater. The report is required for all lots less than 22,000 square feet and for any lot proposing to use infiltration for flow control. If the soils report indicates soils unsuitable for infiltration, other flow control BMPs must be used.

[9] Many locations in King County have till soils where an impervious (hard pan) layer sits below 2 to 3 feet of well-draining soil. Runoff will infiltrate down to the hard pan. During the wetter months, water will perch above this impervious layer and saturate the ground. This type of soil is not considered an infiltrative soil.

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C.2.3.1 SOIL REQUIREMENTS

- A soils report must be prepared by an onsite sewage designer or by other suitably trained people working under the supervision of a professional engineer registered in the State of Washington to determine if soils suitable for infiltration are present on the site. See Section C.5.4, "Soils Report" (p. C-37), for details of soils report requirements.
- To be used in infiltration systems on lots smaller than 22,000 square feet, soils must be either coarse sands or cobbles or medium sands.
- Trenches and drywells are not allowed in fill materials except in engineered sand and gravel fill. See Section 5.4.1 of the *Surface Water Design Manual* for specifications for engineering and placement of fill materials.

C.2.3.2 TRENCH REQUIREMENTS

Figure C.2.B (p.C-13) and Figure C.2.C (p. C-14) illustrate the requirements for infiltration trench systems as outlined below:

- The **trench bottom** must be a minimum of 1 foot above seasonal high groundwater level or impermeable soil layers.
- There must be 20 feet of trench per 1,000 square feet of impervious surface for coarse sands or cobbles, and 30 feet of trench per 1,000 square feet of impervious surface for medium sands.
- **Trench lengths** shall not exceed 100 feet from the inlet sump.
- **Filter fabric** (geotextile) shall be placed on top of the drain rock and on trench sides prior to backfilling.
- **Spacing** between trench centerlines shall be a minimum of 6 feet.
- To prevent damage to overlying pavement, **trenches located beneath pavement** shall be constructed such that the trench pipe is connected to a small yard drain or catch basin with a grate cover so that if the trench infiltration capacity is exceeded, the overflow would occur out of the catch basin at an elevation at least one foot below that of any overlying pavement, and in a location which provides a safe path for the overflow.
- **Runoff from pollution generating surfaces** (driveways and parking areas) shall pass through a yard drain or catch basin fitted with a down-turned elbow prior to entering the infiltration trench (see Figure C.2.B, p. C-13). The elbow is to trap spilled material in the catch basin sump so that the spilled material can be cleaned up more easily by the homeowner.
- A minimum 5-foot **setback** shall be maintained between any part of an infiltration trench and any structure or property line. Trenches may not be placed in sensitive area buffers. A 50-foot setback is required between an infiltration trench and an SAO steep slope or landslide hazard area (this may be reduced with a geotechnical engineering report and approval of DDES).
- Downspout infiltration trenches are not allowed on slopes greater than 25% (4:1). Infiltration trenches may not be placed on or above a landslide hazard area or slopes greater than 15% without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems**, infiltration trenches must be located downgradient of the primary and reserve drainfield areas. DDES permit review staff can waive this requirement if site topography clearly prohibits subsurface flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

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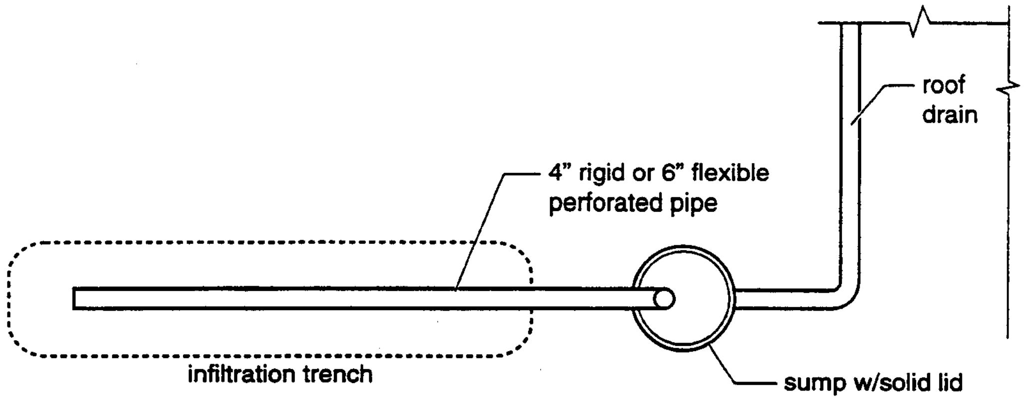
C.2.3.3 DRYWELL REQUIREMENTS

Figure C.2.D on page C-15 illustrates the requirements for drywell infiltration systems as outlined below:

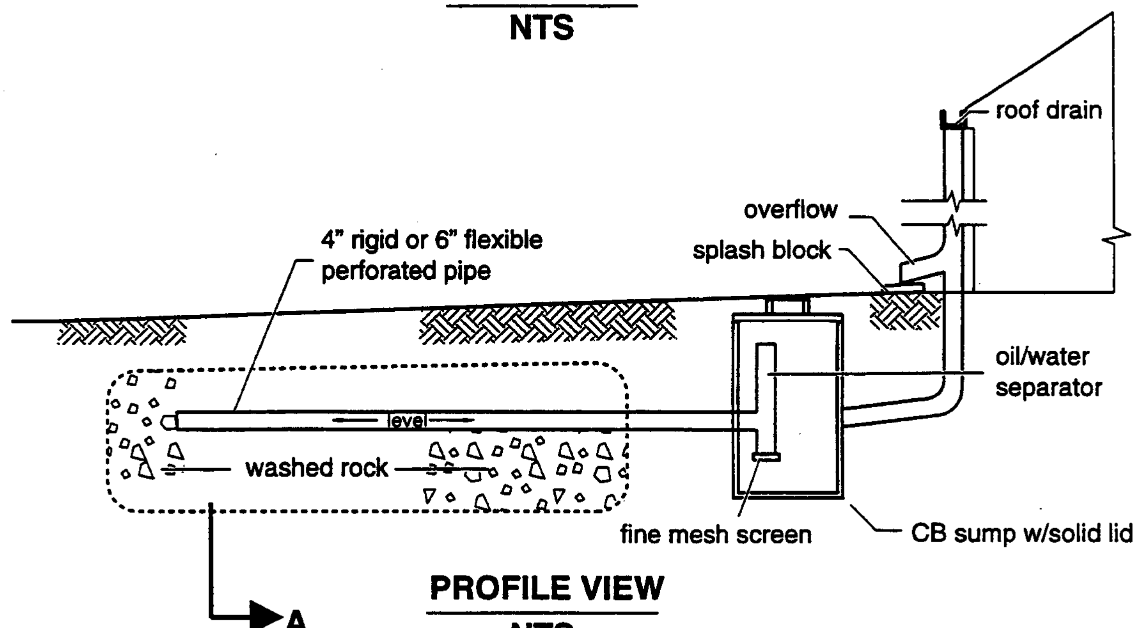
- **Drywell bottoms** must be a minimum of 1 foot above seasonal high groundwater level or impermeable soil layers.
- If using drywells, each drywell may serve up to 1000 square feet of impervious surface for either medium sands or coarse sands
- Typically drywells are 48 inches in diameter (minimum) and have a depth of 5 feet (4 feet of gravel and 1 foot of suitable cover material). See the detail in Figure C.2.D (p. C-15).
- **Filter fabric** (geotextile) shall be placed on top of the drain rock and on trench or drywell sides prior to backfilling.
- **Spacing** between drywells shall be a minimum of 4 feet.
- A minimum 5-foot **setback** shall be maintained between any part of a drywell and any structure or property line. Drywells may not be placed in sensitive area buffers. A 50-foot setback is required between a drywell and an SAO steep slope or landslide hazard area (this may be reduced with a geotechnical engineering report and approval of DDES).
- Downspout infiltration trenches are not allowed on slopes greater than 25% (4:1). Drywells may not be placed on or above a landslide hazard area or slopes greater than 15% without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems**, drywells must be located downgradient of the primary and reserve drainfield areas. This requirement can be waived by DDES permit review staff if site topography clearly prohibits subsurface flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

AR 032502

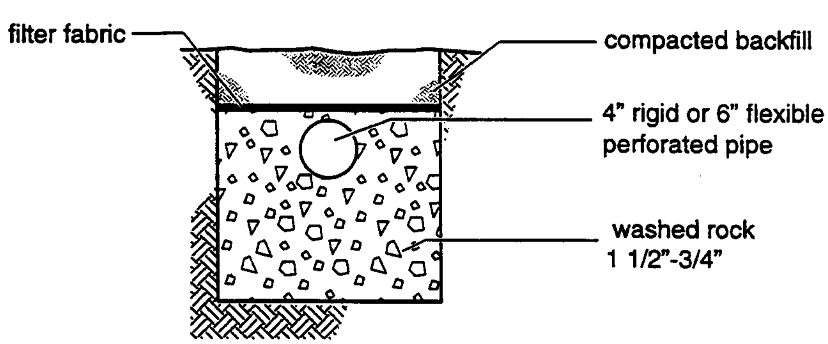
FIGURE C.2.B TYPICAL DOWNSPOUT INFILTRATION SYSTEM



PLAN VIEW
NTS



PROFILE VIEW
NTS



SECTION A
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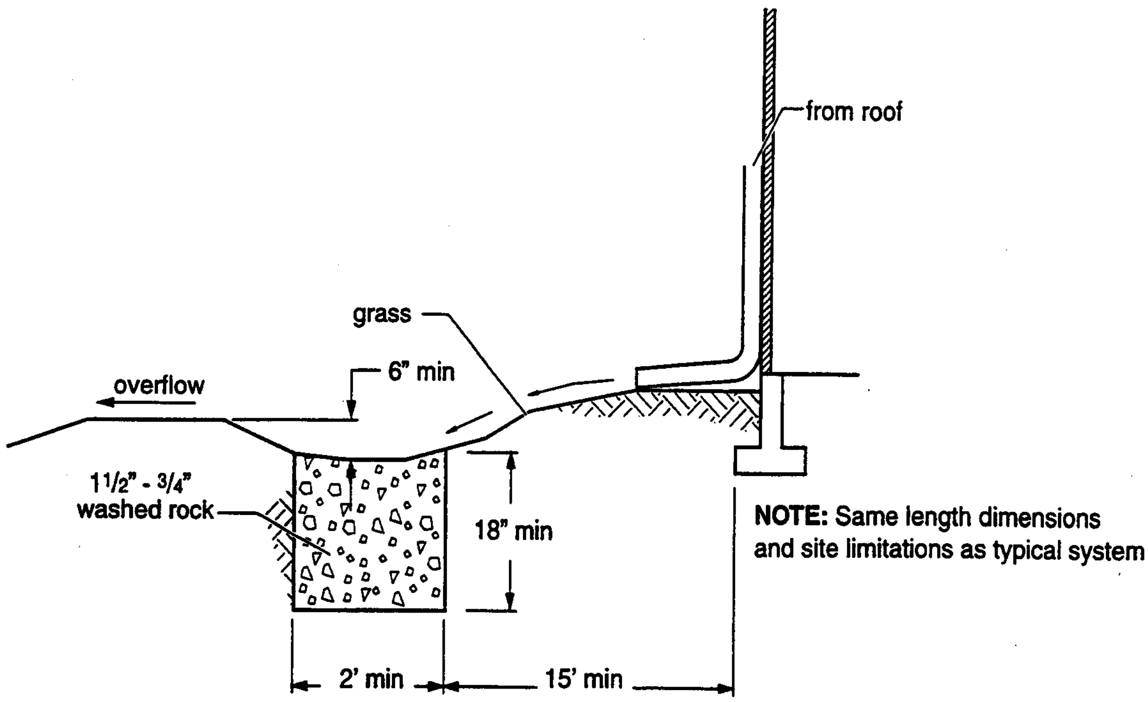
AR 032503

FIGURE C.2.C ALTERNATIVE DOWNSPOUT INFILTRATION SYSTEM



X-SECTION
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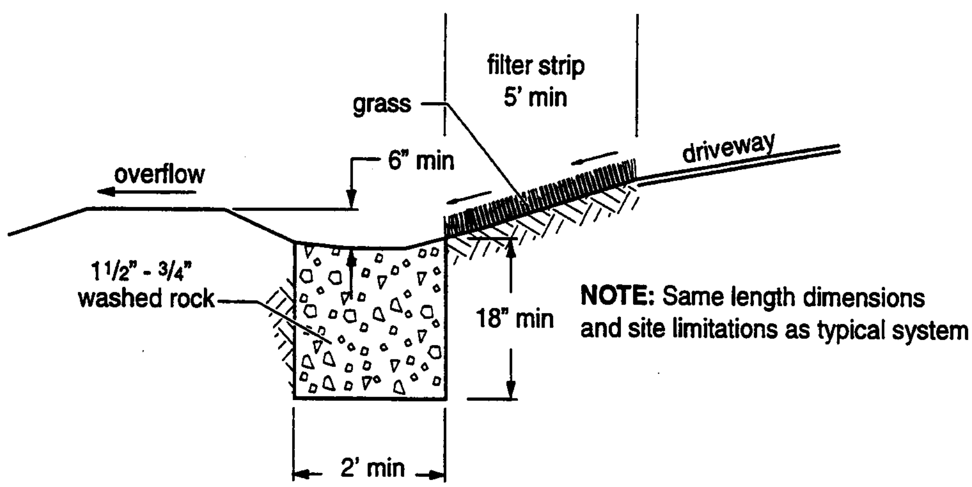

X-SECTION
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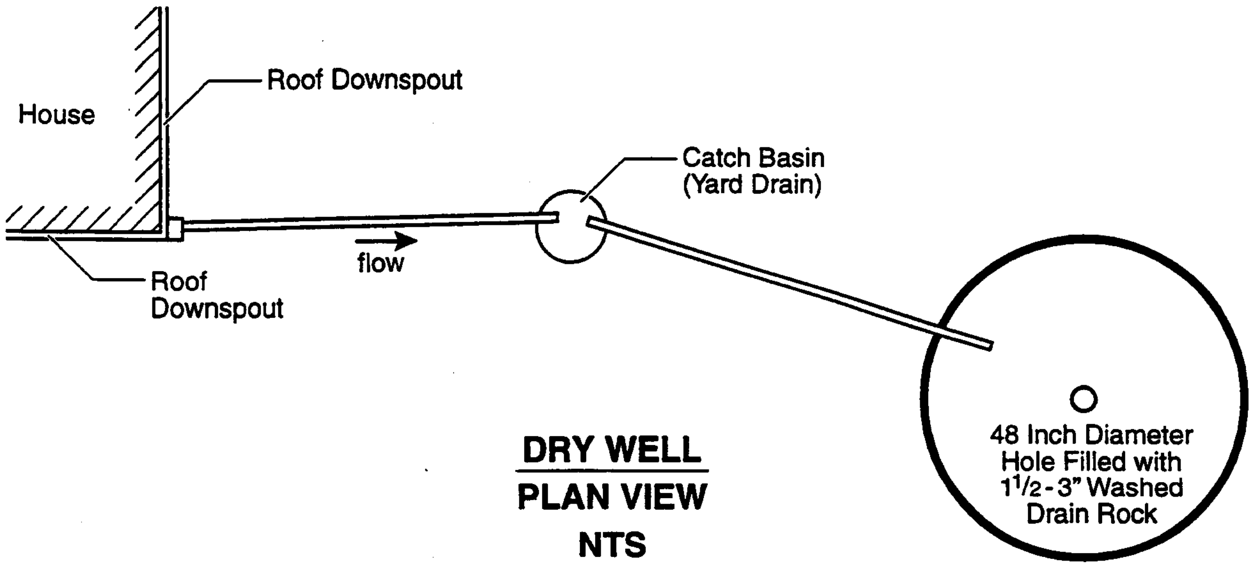
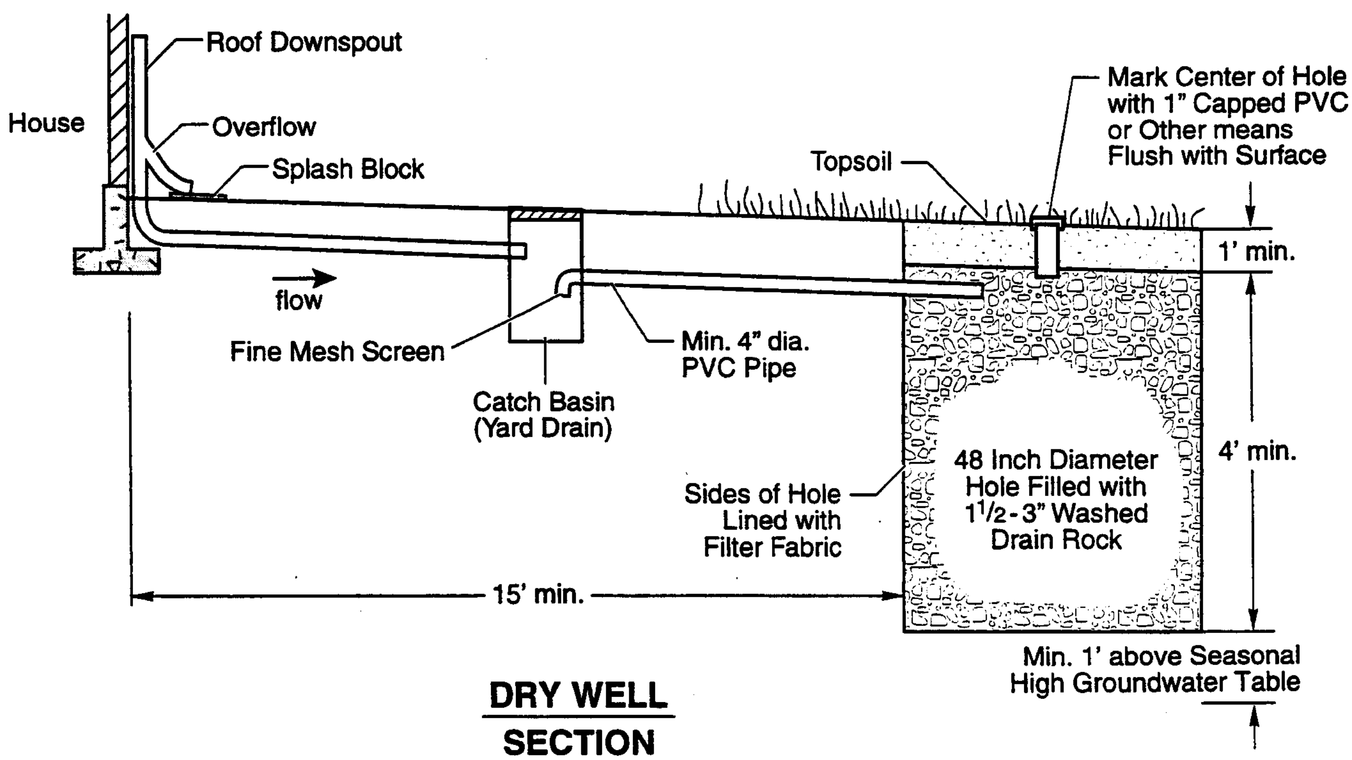
FIGURE C.2.D TYPICAL DRYWELL INFILTRATION SYSTEM



DRY WELL
PLAN VIEW
NTS



DRY WELL
SECTION
NTS

AR 032505

C.2.4 DISPERSION BMPS

Dispersion is the simplest and least expensive small site flow control BMP. Flows concentrate when gutters, ditches, or pipes collect and funnel runoff to a single discharge point. Methods such as splashblocks, rockpads and dispersion trenches can disperse these flows. Dispersed flows travel slowly through vegetation and upper soil layers, slowing runoff rates and providing water quality benefits.

Note: Dispersion BMPs may not be placed on or above slopes greater than 20% without evaluation and approval by a geotechnical engineer or qualified geologist. Any proposed small site BMP within 50 feet of a slope greater than 20% may be subject to geotechnical review.

C.2.4.1 SPLASHBLOCKS

Splashblocks are the simplest way to disperse flows from a roof area. Downspout splashblocks or downspout/drain extensions with splashblocks are often the only hardware required for this type of system. Vegetated flowpaths do the work of slowing and cleaning stormwater runoff.

Typical Uses: Roof downspouts

Design Specifications

Figure C.2.E (p. C-19) shows details of a roof downspout and splashblock. In general, if the ground is sloped away from the foundation, and there is adequate vegetation and area for effective dispersion, splashblocks will adequately disperse storm runoff. If the ground is fairly level, if the structure includes a basement, or if foundation drains are proposed, splashblocks with downspout extensions may be a better choice because the discharge point is moved away from the foundation. Downspout extensions can include piping to a splashblock/discharge point a considerable distance from the downspout, as long as the runoff can travel through a well-vegetated area as described below.

The following conditions must be met to use splashblocks:

- A **vegetated flowpath**[10] of at least 50 feet must be maintained between the discharge point and any property line, structure, steep slope, stream, wetland, lake, or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
- A maximum of 700 square feet of roof area may drain to each splashblock.
- A splashblock or a pad of crushed rock (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each downspout discharge point.
- No erosion or flooding of downstream properties may result.
- **Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist.** Splashblocks may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems**, the discharge point must be downslope of the primary and reserve drainfield areas. This requirement can be waived by DDES permit review staff if site topography clearly prohibits flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

[10] The vegetated flowpath must be covered with well-established lawn or pasture, landscaping with well-established groundcover, or native vegetation with natural groundcover. The groundcover shall be dense enough to help disperse and infiltrate flows and to prevent erosion.

AR 032506

C.2.4.2 DISPERSION OF CONCENTRATED FLOWS THROUGH VEGETATION

Concentrated flow dispersion can also be used with steep driveways (>15% slope). Figure C.2.G (p. C-21) shows two possible ways of spreading flows from steep driveways.

Note: Dispersion for driveways will generally only be effective for proposed single family residences on large lots and in rural short plats; lots proposed by short plats in urban zoning will generally be too small to provide effective dispersion of driveway runoff.

Typical Uses: Steep rural driveways (>15% slope), and any situation where concentrated flows can be dispersed through vegetation

Design Specifications

The following conditions must be met to use dispersion of concentrated flows through vegetation:

- A **vegetated flowpath** of at least 50 feet, as illustrated in Figure C.2.G (p. C-21) must be maintained between the discharge point and any property line, structure, steep slope, stream, lake, wetland, lake or other impervious surface. Sensitive area buffers may count toward flowpath lengths.
- A maximum of 700 square feet of impervious area may drain to each dispersion BMP.
- A **pad of crushed rock** (2 feet wide by 3 feet long by 6 inches deep) shall be placed at each discharge point.
- No erosion or flooding of downstream properties may result.
- **Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist.** The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems,** the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by DDES permit review staff if site topography clearly prohibits flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

C.2.4.3 DISPERSION TRENCHES

Where dispersion of concentrated flows through 50 feet of vegetation is not feasible, such as on a small or highly constrained site, a **dispersion trench** may be used to "unconcentrate" flows. Dispersion trenches provide some storage for runoff, promote infiltration, and spread concentrated flows so that a shorter vegetated path length can be used at the trench outlet. This BMP is more expensive than the simple dispersion systems described above, and must be carefully constructed to be effective.

Typical Uses: Roof downspouts, steep driveways, or any situation where flows are concentrated but where dispersion through vegetation (previous section) is not feasible.

Design Specifications

Figure C.2.F (p. C-20) provides details for dispersion trenches. In addition, the following requirements must be met:

- A **vegetated flowpath** of at least 25 feet in length must be maintained between the outlet of the trench and any property line, structure, stream, wetland, or impervious surface. A vegetated flowpath of at least 50 feet in length must be maintained between the outlet of the trench and any steep slope. Sensitive area buffers may count towards flowpath lengths.
- Each trench can serve up to 700 square feet of impervious area. For larger impervious areas, Figure 4.2.2.C in the *Surface Water Design Manual* includes design details for a flow dispersal trench which can be installed on small sites at a ratio of 10 feet of trench per 700 square feet of impervious area.
- A **setback** of at least 5 feet must be maintained between any edge of the trench and any structure or property line.

- No erosion or flooding of downstream properties may result.
- **Runoff discharged towards landslide hazard areas must be evaluated by a geotechnical engineer or qualified geologist.** The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems**, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by DDES permit review staff if site topography will clearly prohibit flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

C.2.4.4 SHEET FLOW DISPERSION

Sheet flow dispersion is the simplest method of flow control. This BMP can be used for any impervious surface that is graded so as to avoid concentrating flows. Because flows are already dispersed as they leave the impervious surface, they need only traverse a narrow band of adjacent vegetation for effective attenuation and treatment.

Typical Uses: Flat or moderately sloping surfaces (< 15% slope) such as driveways, sport courts, patios, and roofs without gutters; or any situation where concentration of flows can be avoided.

Design Specifications

Figure C.2.H (p. C-22) and the following guidelines apply to surfaces graded to avoid concentrating runoff:

- A 2-foot-wide **transition zone** to discourage channeling should be provided between the edge of the driveway pavement and the downslope vegetation, or under building eaves. This may be an extension of subgrade material (crushed rock), modular pavement, drain rock, or other material acceptable to DDES.
- A **vegetated buffer width of 10 feet** must be provided for up to 20 feet of width of paved or impervious surface. An additional 5 feet of width must be added for each additional 20 feet of width or fraction thereof.
- No erosion or flooding of downstream properties may result.
- **Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist.** The discharge point may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems**, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by DDES permit review staff if site topography will clearly prohibit flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

FIGURE C.2.E TYPICAL ROOF DOWNSPOUT SPLASHBLOCK DISPERSION

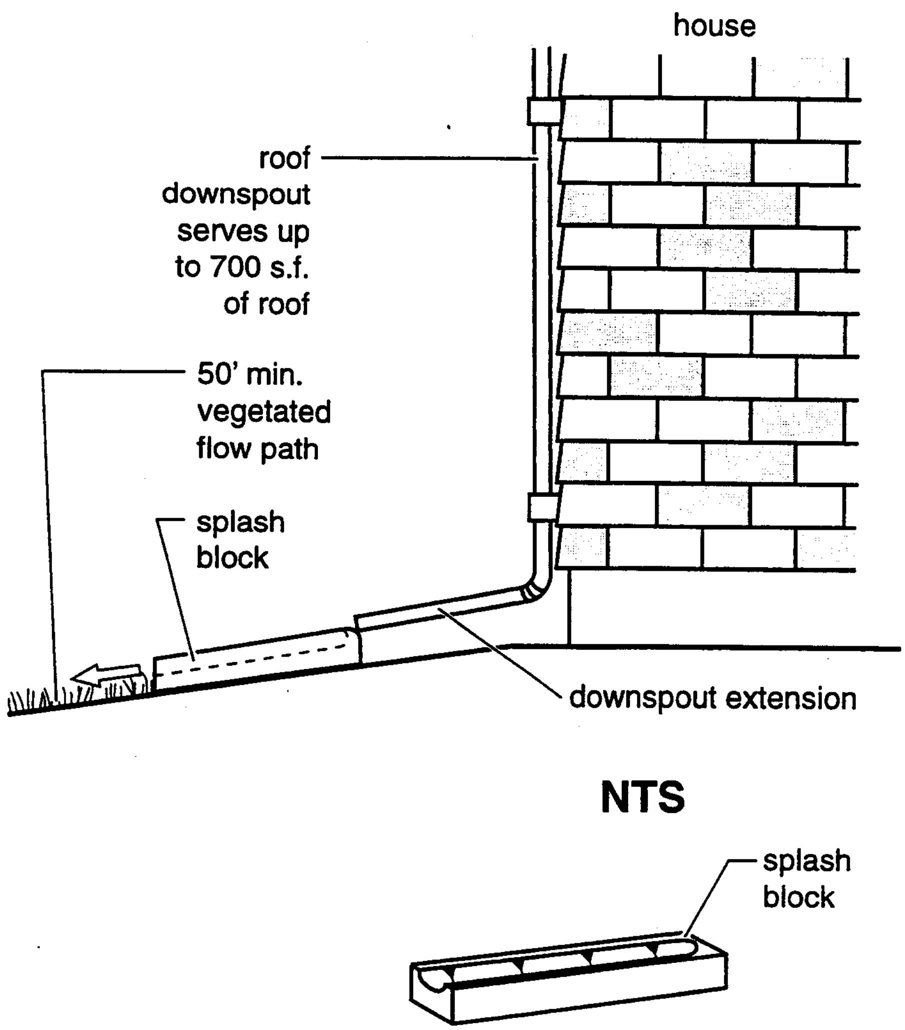
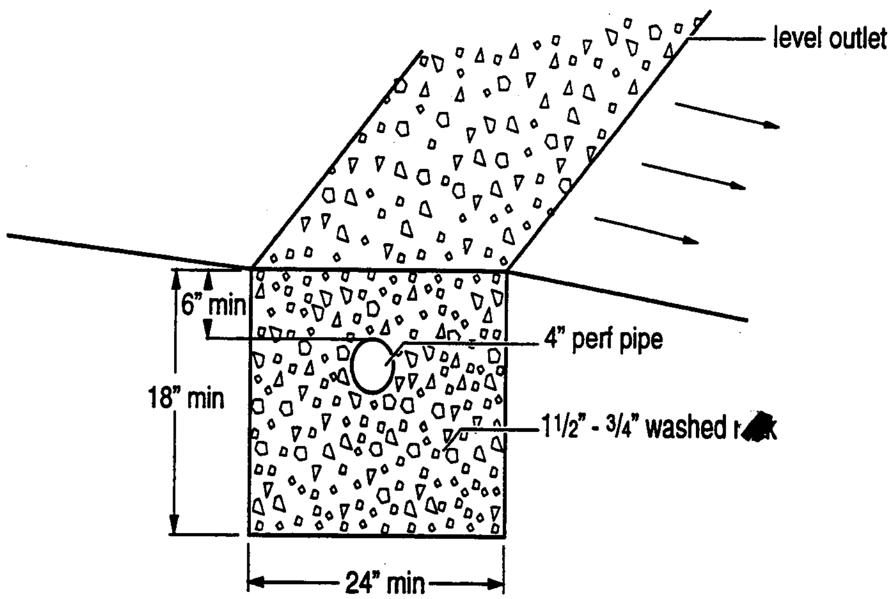


FIGURE C.2.F TYPICAL DOWNSPOUT DISPERSION TRENCH



TRENCH X-SECTION
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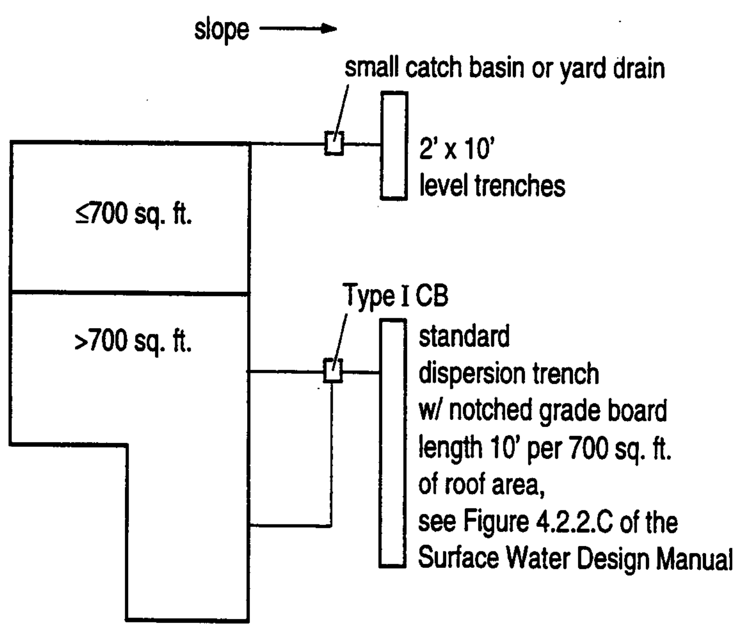

PLAN VIEW OF ROOF
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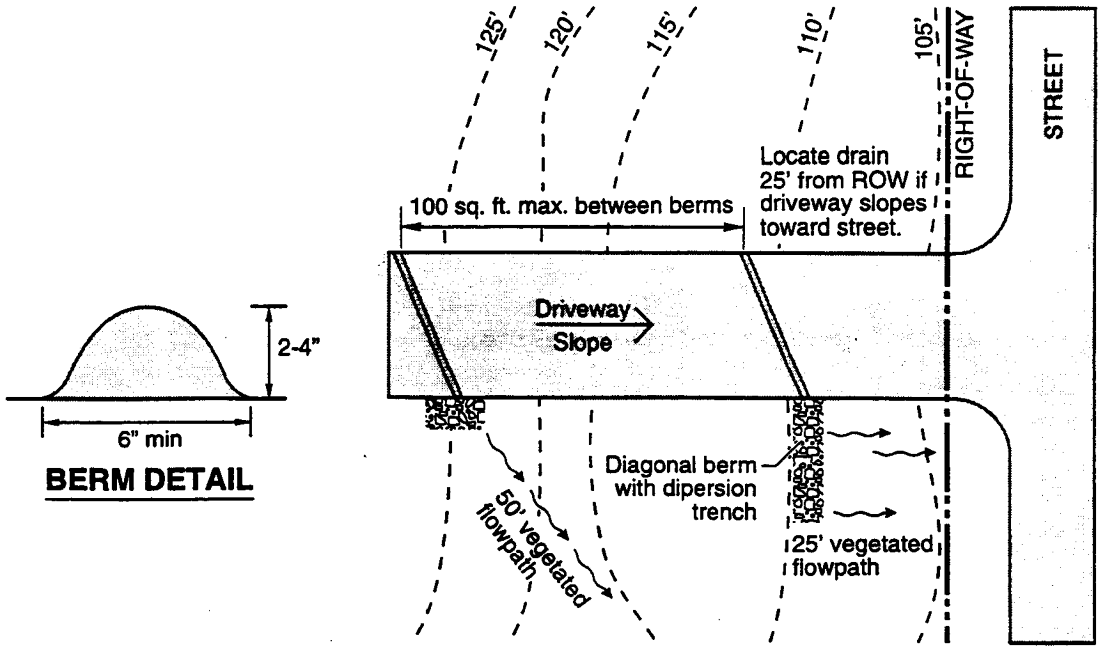
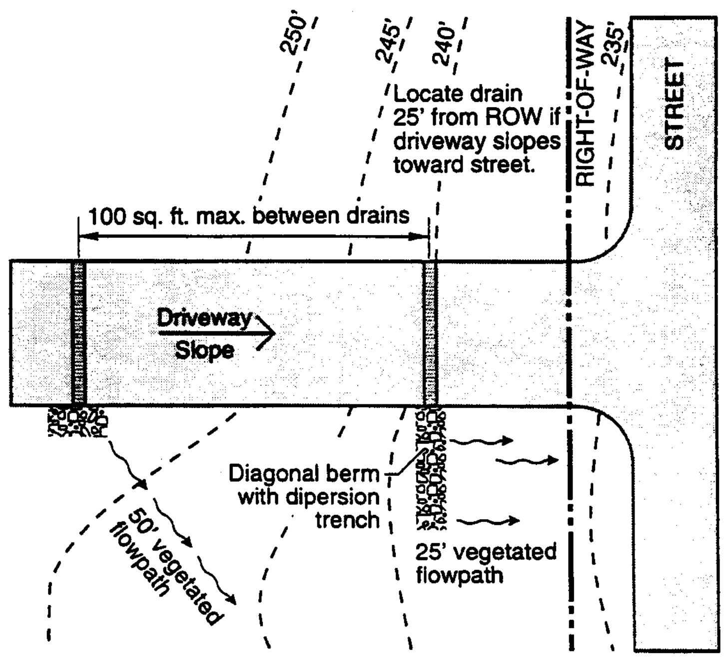
FIGURE C.2.G TYPICAL DISPERSION FOR STEEP DRIVEWAYS



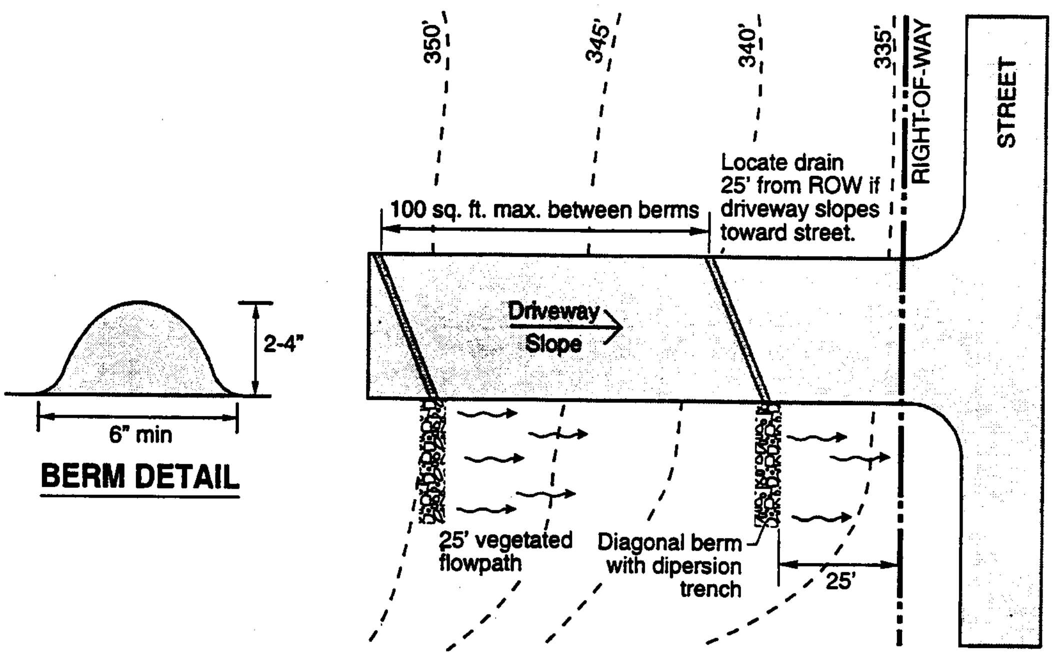
PLAN
Steep Driveway with Diagonal Berms



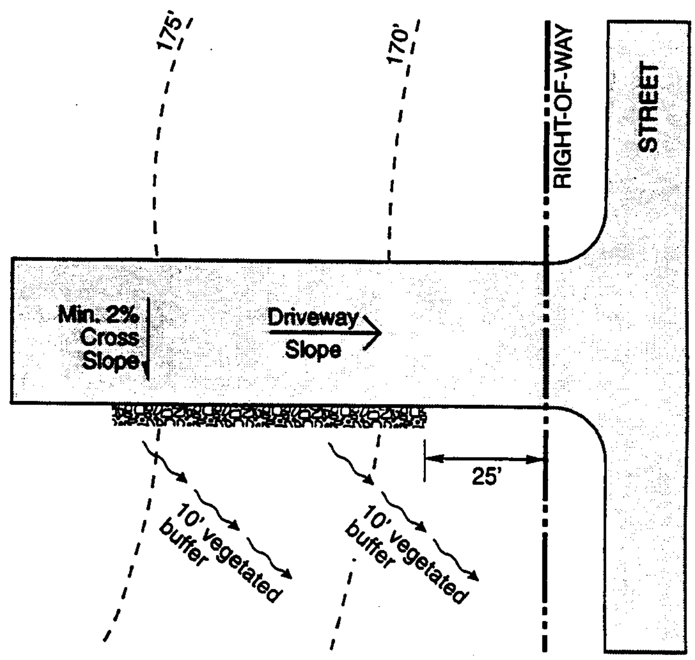
PLAN
Steep Driveway with Slotted Drains

AR 032511

FIGURE C.2.H TYPICAL FLOW DISPERSION FOR DRIVEWAYS



PLAN
Driveway Dispersion Trench
Driveway Slope Varies and Slopes Toward Street



PLAN
Sheet Flow Dispersion from a Driveway
Flat to Moderately Sloping Driveways

AR 032512

C.2.5 PERFORATED TIGHTLINE CONNECTION

Perforated tightline connections convey flows directly to a downstream drainage system such as a ditch or roadway pipe system. They are a last resort, and are appropriate on sites so small or constrained that dispersion will be ineffective or will create problems on neighboring properties. Perforated tightline connections are intended to provide for some infiltration during drier periods (late spring through early fall). During the wet winter months, these BMPs may provide little to no flow control or water quality benefits.

Typical Uses: Flows from impervious surfaces on small urban lots where vegetated flowpaths are not available for surface dispersion **and** where infiltration is not feasible.

Design Specifications

Connection to a storm drainage system with perforated pipe can be used for all types of impervious surface. Figure C.2.I (p. C-24) provides details on perforated tightline connections. Perforated tightline connections must be placed using the following constraints:

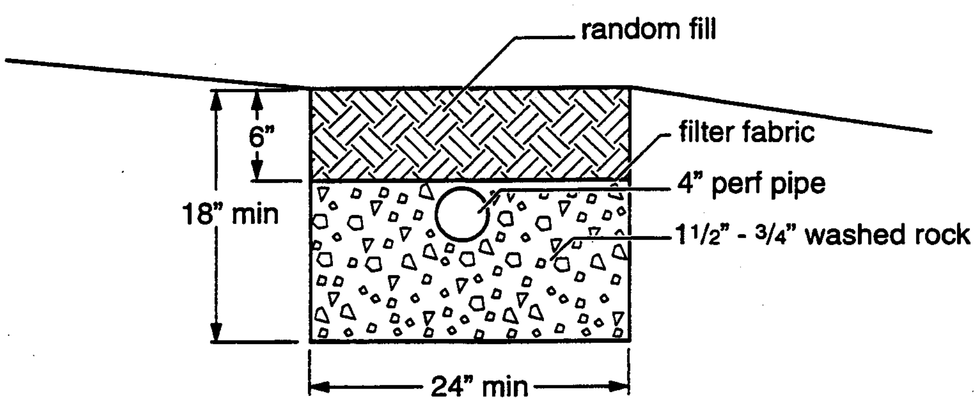
- The perforated stub-out connection shall be placed in native soil to maximize infiltration and dispersion of water.
- **Setbacks** from features other than septic systems shall be as listed in Reference Section B.

  Note: To facilitate maintenance, the perforated pipe portion of the system may not be located under impervious or heavily compacted (e.g., driveways and parking areas) surfaces.
- **Runoff discharge toward landslide hazard areas must be evaluated by a geotechnical engineer or a qualified geologist.** The perforated portion of the pipe may not be placed on or above slopes greater than 20% or above erosion hazard areas without evaluation by a geotechnical engineer or qualified geologist and DDES approval.
- For **sites with septic systems**, the discharge point must be downgradient of the drainfield primary and reserve areas. This requirement can be waived by DDES permit review staff if site topography will clearly prohibit flows from intersecting the drainfield. See Reference B for a summary of SKCDPH onsite sewage system requirements.

C.2.6 ENGINEERING ANALYSIS

Projects that cannot comply with or elect not to use the small site drainage requirements and projects where DDES determines the small site BMPs will not adequately protect the downstream drainage path will be subject to Full Drainage Review. A drainage analysis and engineering plans may be required to be submitted by a professional engineer registered in the State of Washington.

FIGURE C.2.I PERFORATED TIGHTLINE CONNECTION



TRENCH X-SECTION
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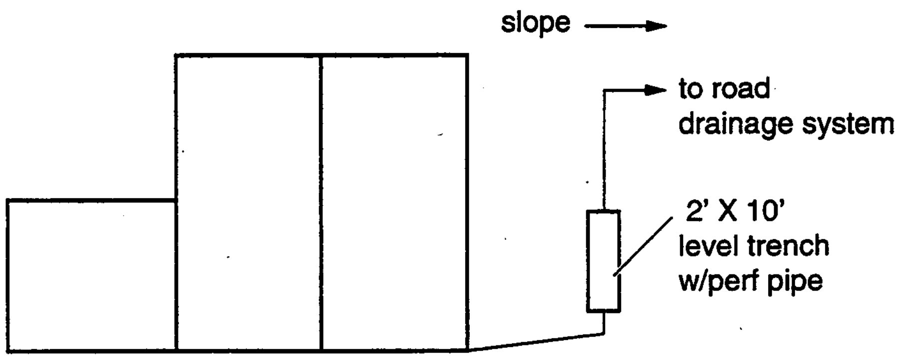

PLAN VIEW OF ROOF
NTS

AR 032514

C.3 EROSION AND SEDIMENT CONTROL MEASURES

It is the responsibility of both the applicant and contractor to prevent the erosion and transport of sediment to the greatest extent possible. Erosion control measures shall be used both during and after construction.

Temporary Erosion and Sediment Control (TESC) measures are used during construction to minimize the amount of sediment mobilized and trap any mobilized sediment before it leaves the site. Examples of temporary erosion controls include the use of mulches or other cover materials, marked/minimized clearing limits, and routing of water around exposed soils. Installation and maintenance of silt fencing is an example of sediment trapping. TESC techniques that are particularly suitable for small sites are described in Section C.3.1.

Permanent Erosion and Sediment Control (final stabilization) measures are used to stabilize the site at the end of construction. Examples of permanent ESC measures include landscaping, mulching, and seeding.

C.3.1 TEMPORARY EROSION AND SEDIMENT CONTROL (TESC) REQUIREMENTS

The following measures will be required on small sites in order to minimize onsite erosion and prevent mobilized sediment from leaving the site:

- Rock construction entrance
- Mulching
- Minimized clearing
- Silt fencing
- Winter stabilization.

Typically, a combination of all of the above BMPs are required during construction, unless specific site conditions exist which make a particular BMP unnecessary, as determined by DDES engineering review staff. Other sediment control measures may be allowed or required if these are inappropriate for the project or fail to contain sediment on the project site. A description of other measures and a more detailed descriptions of those included here can be found in *Erosion and Sediment Control Standards* (detached Appendix D of the *King County Surface Water Design Manual*).

The placement and type of proposed ESC BMPs are to be shown on the **small site ESC plan**. Required features of this plan are outlined in Section C.5, "Submittal Requirements" (p. C-35).

C.3.1.1 ROCK CONSTRUCTION ENTRANCE

Purpose

Rock construction entrances help prevent transport of sediment away from the site on the tires or undercarriages of vehicles.

Application

Rock construction entrances shall be provided at all entranceways to a cleared construction site from a private or public road.

Design Specifications

Rock pads are normally 12 feet by 50 feet and 1 foot deep; however, for small site projects, the pad may be reduced to 12 feet by 25 feet (see Figure C.3.A, p.C-29), or as approved by the DDES Inspector, provided no sediment is leaving the site. Rocks used for pad construction will be 4 to 6 inches in diameter.

Geotextile[11] must be placed beneath the rock to prevent fine sediments from being "pumped" up through the rock by heavy vehicles. All vehicles must use the rock pad to leave the site.

Maintenance

Construction entrances must be inspected regularly, and rock must be replaced as needed.

C.3.1.2 MULCHING

Purpose

Mulching prevents erosion by dissipating the energy of and absorbing water. Mulch prevents raindrops from falling directly on exposed soils, reducing the likelihood that soils will be dislodged and washed away. Mulch also enhances plant establishment by conserving moisture, holding fertilizer, seed, and topsoils in place, and moderating soil temperatures.

Application

Mulch may be applied:

- On disturbed areas that will remain unworked for more than 7 days (2 days during the wet season, see Section C.3.1.5, "Winter Stabilization").
- On disturbed areas that need cover measures for less than 30 days.
- As a cover for seed during the wet season and during the hot summer months.
- During the wet season, on disturbed slopes steeper than 3H:1V with more than 10 feet of vertical relief.

Design Specifications

The amount of mulch applied per acre (application rate) depends on the type of material used. Table C.1 provides application rates for a variety of common mulches. Plastic can be used as a surrogate for mulch, with the following cautions:

- If erosion at the toe of the covered slope is likely, a gravel berm, riprap, or other suitable protection shall be installed at the toe to reduce the velocity of runoff.
- Seams between sheets must overlap and must be weighted or taped/stapled together.
- Toe in sheeting at the top of slope with a minimum 4"x 4" trench running the length of the top of slope.

Maintenance

Mulch must be inspected regularly and more mulch added as needed to maintain the suggested application rate. All rips or tears in plastic sheeting shall be repaired. Sheeting shall be checked to ensure it is properly overlapped and weighted in place; sheeting shall be re-lapped and weights replaced as needed.

11 The geotextile shall meet the following standards:
Grab tensile strength (ASTM D-4751) = 200 psi min.
Grab Tensile Elongation (ASTM D-4632 = 30% max.
Mullen Burst Strength (ASTM D-3786-80a) = 400 psi min.

AR 032516

TABLE C.1 APPLICATION RATES AND QUALITY STANDARDS FOR MULCH MATERIALS

Mulch Material	Quality Standards	Application Rates
Straw	Air-Dried; free from undesirable seed and coarse material	2"-3" thick; 2-3 bales per 1000 sf, or 2-3 tons per acre
Wood Fiber Cellulose	No growth inhibiting factors	Approx. 25-30 lbs. per 1000 sf, or 1000-1500 lbs. per acre
Compost	No visible water or dust during handling. Must be purchased from supplier with solid waste handling permit.	2" thick min.; approx. 100 tons per acre (approx. 800 lbs. per yard)
Chipped Site Vegetation	Average size shall be several inches	2" minimum thickness

C.3.1.3 MARK CLEARING LIMITS/MINIMIZE CLEARING

Purpose

Minimizing clearing is the most effective method of erosion control. Undisturbed vegetation intercepts and slows rainwater. Plant roots hold soil in place, and dead vegetation on the ground acts as a mulch.

Applications

Clearing limits shall be marked and clearing minimized on any site where significant areas of undisturbed vegetation will be retained.

Design Specifications

Minimizing clearing should be incorporated into the site design. Clearing limits must be marked on both the site plan and the erosion control plan. On the ground, clearing limits must be clearly marked with brightly colored tape or plastic or metal safety fencing (also referred to as Sensitive Areas Setback, or SASB fencing). If tape is used, it should be supported by vegetation or stakes, and should be about 3 to 6 feet high and highly visible. Equipment operators should be informed of areas of vegetation that are to be left undisturbed.

Maintenance

Fencing shall be inspected regularly and repaired or replaced as needed.

C.3.1.4 SILT FENCING

Purpose

Silt fencing catches sediment that has been mobilized by water flowing over the site. Fabric used in the construction of silt fencing has openings specifically sized to allow water to flow through while retaining the majority of particle sizes.

Application

Silt fencing shall be used to protect the perimeter of the site. It can be placed parallel to topographic contours. Silt fencing is not suitable for placement in drainage channels or for other concentrated flows.

Design Specifications

As shown in Figure C.3.B (p. C-30), silt fence must be towed-in to a shallow trench, and then staked and reinforced to function properly. The silt fence, which can be found at many construction supply stores, must meet the following standard specifications:

AOS (ASTM D4751)	30-100 sieve size (0.60-0.15 mm) for slit film 50-100 sieve size (0.30-0.15 mm) for other fabrics
Water Permittivity (ASTM D4491)	0.02 sec^{-1} minimum.
Grab Tensile Strength (ASTM D4632)	180 lbs min. for extra strength fabric 100 lbs min. for standard strength fabric
Grab Tensile Elongation(ASTM D4632)	30% max.
Ultraviolet resistance (ASTM D4355)	70% min.

Maintenance

Fencing must be inspected regularly for damage. Silt fencing does break down under UV light. Sediment collected behind the fence must be removed so that this material does not push the fence over.

C.3.1.5 WINTER STABILIZATION

Purpose

In order to minimize sediment-laden runoff, as much of the bare and disturbed portions of the site as possible should be covered during any period of precipitation. Once sediment is mobilized, it is much more difficult to effectively control.

Application

All sites require winter stabilization between October 1 and April 30 (the wet season).

Design Specifications

During the above time frame, slopes and stockpiles 3H:1V or steeper and with more than 10 feet of vertical rise shall be covered if they are to remain unworked for more than 12 hours. Other disturbed areas shall be covered or mulched according to Table C.1 (p. C-27) if they are to remain unworked for more than two days. Cover material sufficient to cover all disturbed areas shall be stockpiled on site at the beginning of the wet season. Areas that are to be left unworked during the winter shall be seeded prior to September 23.

Maintenance

The site should be inspected weekly and immediately before, during, and after storms. Cover and other erosion control measures shall be repaired and enhanced as necessary to prevent or minimize sediment runoff and transport.

C.3.2 FINAL STABILIZATION

Purpose

Final stabilization minimizes sediment-laden runoff from the site after construction has been completed.

Application

All sites require final stabilization prior to final construction approval.

Design Specifications

Prior to final construction approval, the site shall be stabilized to prevent sediment-laden water from leaving the site after project completion. All disturbed areas of the site shall be vegetated or otherwise permanently stabilized. At a minimum, disturbed areas must be seeded and mulched to ensure that sufficient cover will develop shortly after final approval. Mulch without seeding is adequate for small areas to be landscaped before October 1.

All permanent surface water facilities (including catch basins, manholes, pipes, ditches, channels, flow control facilities, and water quality facilities) impacted by sedimentation during construction must be cleaned.

Maintenance

Permanent erosion control is the responsibility of the owner. The site must be kept stabilized using landscaping, mulch, or other measures to prevent sediment-laden water from leaving the site and to prevent sediment from being transported onto adjacent properties and roads.

FIGURE C.3.A ROCK CONSTRUCTION ENTRANCE

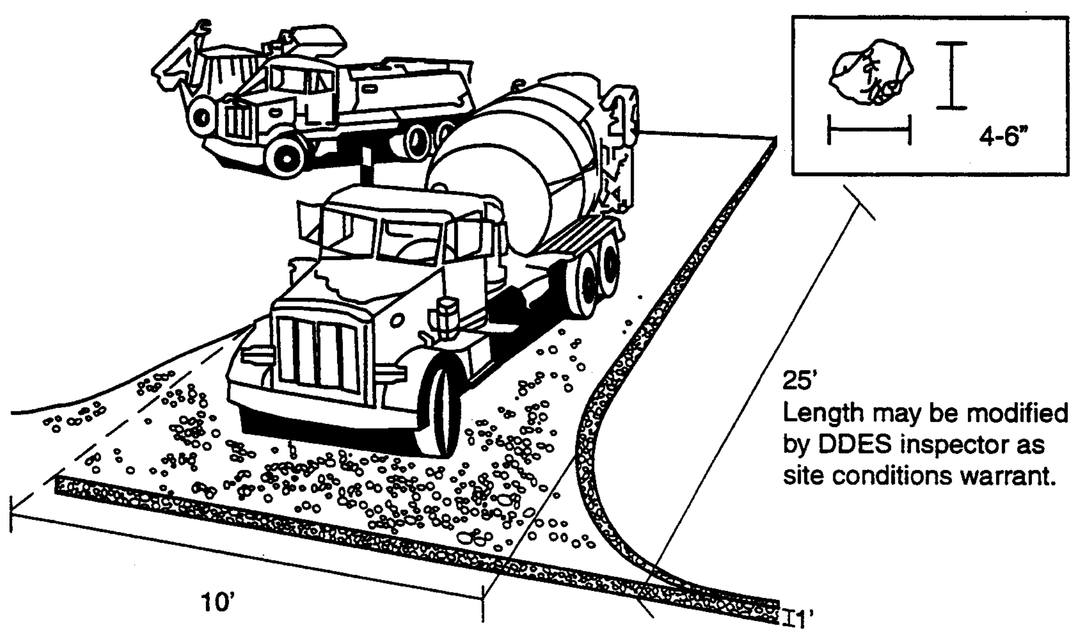

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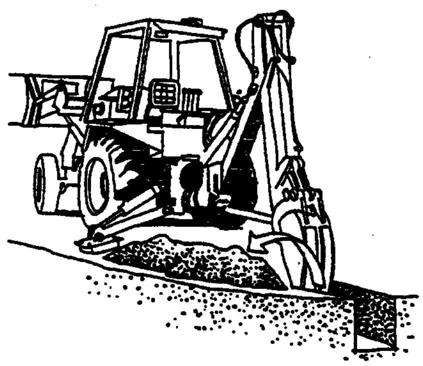
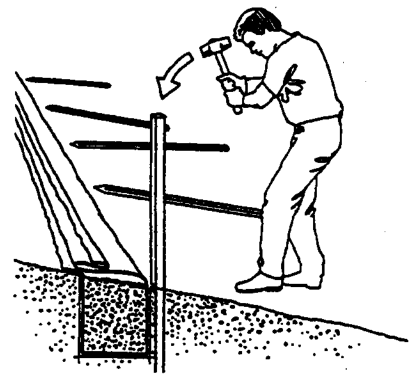
FIGURE C.3.B SILT FENCE INSTALLATION AND MAINTENANCE

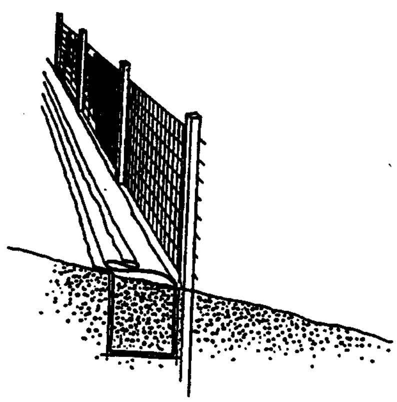


Dig trench

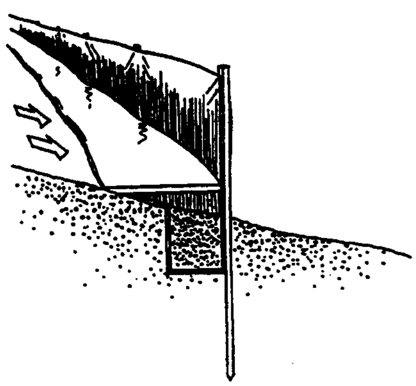
Toe-in-fabric



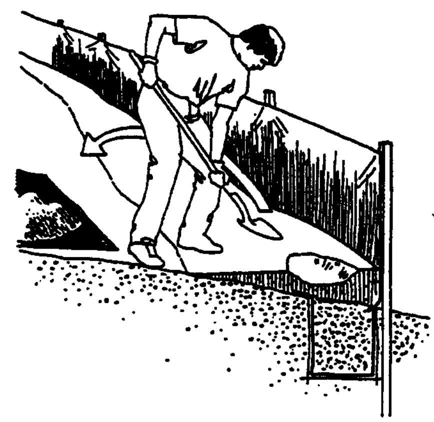
Stake



Reinforce



Monitor



Maintain and clean

C.4 TARGETED REVIEW FOR SMALL SITES

Small sites which contain sensitive areas (streams, lakes, wetlands, steep slopes, landslide hazard areas, erosion hazard areas, channel migration hazard areas, floodplain hazard areas), are located in an area with special drainage requirements, or are proposing to construct or modify a drainage system must meet specific (targeted) drainage requirements for these areas. In some cases, DDES review staff may approve the small site BMPs combined with increased setbacks and/or other conditions. In other cases, a professional engineer may be required to perform the targeted analysis and submit engineering plans.

Note: Drainage review is not a complete Sensitive Areas review. Small sites proposals are not exempted from applicable requirements of KCC 21A.24 (sensitive areas regulations) including Sensitive Area Setback Areas (SASA), building setbacks, Sensitive Areas Notice on Title, permitted alterations and uses.

C.4.1 LAKES, WETLANDS, STREAMS, AND CLOSED DEPRESSIONS WITH AN APPROVED 100-YEAR FLOODPLAIN STUDY

Some small sites contain or abut a lake or stream which has been mapped to show the Federal Emergency Management Agency (FEMA) 100-year floodplain, or has been mapped in a flood hazard study by King County Department of Natural Resources, Water and Land Resources Division (WLRD), or has a King County approved 100-year floodplain analysis completed (consistent with current regulations) for this property.

If DDES staff determines that the proposed project meets FEMA and County regulations for building in or near a floodplain, the permit can be approved with specific conditions such that the project does not impact the floodplain and that a flood will have minimum impact on the developed site. Examples of conditions could include:

- Building on a portion of the site where the existing ground is higher than the 100-year flood elevation,
- Building within the flood fringe using post and pile foundation to provide unrestricted flow through the foundation area,
- Placing no fill within any portion of the floodplain without providing equivalent compensating storage.

For permits proposing a structure within or adjacent to the 100-year FEMA floodplain, an "Elevation Certificate" must usually be completed and submitted to DDES after the foundation is constructed but prior to the framing approval. A surveyor, or other qualified person under the supervision of a licensed surveyor, must specify the elevation of the lowest finished floor of the structure. This information is often required by mortgage companies, and it helps the homeowner obtain proper flood insurance and maintain accurate insurance ratings for flood-prone areas.

If DDES staff determines that the proposed project does not meet FEMA or County regulations for building in or near a floodplain, the applicant may be required to hire a professional engineer to perform a 100-year floodplain/floodway analysis. If the site is located in the 100-year floodway, the permit may be denied; Federal and County regulations prohibit building structures in the floodway.

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C.4.2 LAKES, WETLANDS, STREAMS, AND CLOSED DEPRESSIONS WITHOUT AN APPROVED 100-YEAR FLOODPLAIN STUDY

In many cases, the site contains or abuts a stream, lake, wetland, and/or closed depression that has not been analyzed for the 100-year floodplain. An exception from performing a 100-year floodplain analysis exists for small site projects which have a nearby drainage feature but which are in no danger of flooding due to topographic conditions which clearly prevent water from rising to the elevation of the proposed building site(s).

> **Exception:** An engineered floodplain analysis would not be required if it is demonstrated that the proposed building site is located at an elevation at least 10 feet[12] above the ordinary high water mark of the stream, lake, or wetland; or at least 2 feet above the downstream overflow elevation of a conveyance system, stream, lake, wetland or closed depression, whichever is less. DDES may approve this exception provided that downstream flow restrictions, information from previous flood events, and potential for future flow increases clearly indicate this to be a conservative assumed 100-year flood elevation.

The intent of the "10/2" rule stated above is to eliminate the need to analyze the 100-year floodplain when a site is clearly in no danger of flooding because of significant topographic relief. The minimum 10 feet of separation from ordinary high water usually eliminates the need for engineering analysis for those projects adjacent to streams confined to deep channels or ravines, or near lakes or wetlands which have well-defined broad outflow channels. The 2-foot elevation above downstream overflow is intended to provide protection to projects located upstream of drainage systems that may become plugged, such as roadway culverts and to prevent construction below the maximum overflow elevation of lakes, wetlands, or closed depressions. *Note: The 2-foot exception is not intended to be applied to restricted overflows; the overflow should be a broad weir or channel without obstructions.*

Where it is determined by DDES staff that the "10/2" rule may not provide a conservative assumed flood elevation, the project must be revised and/or a professional engineer registered in the State of Washington must submit a 100-year floodplain study as described in Section 4.4.2 of the *Surface Water Design Manual.*

Upon approval, either by the "10/2" rule or by engineering analysis, a Sensitive Areas Notice on Title must be recorded for the site. For short plats, the area of the proposed project site that is at or below the assumed base flood elevation must be delineated as a floodplain and appropriate conditions recorded with the short plat. For single family residential permits, the assumed floodplain need not be delineated, but the Sensitive Areas Notice on Title and approved site plan must note that a floodplain exists, and no fill or alteration is allowed. The assumed base flood elevation must be noted if determined.

[12] In some cases, ten feet may not be adequate to contain the 100-year flood (e.g., Fish Lake near Enumclaw, small streams flowing into large rivers that may backwater in flood events, constricted/confined streams or ponds).

C.4.3 STEEP SLOPES AND LANDSLIDE HAZARD AREAS

All drainage systems on or near steep slopes or landslide hazard areas must be approved by the DDES Geologist.

Steep slopes and landslide hazard areas can be very sensitive to water. Storm runoff not properly controlled can cause erosion, landslides, raveling, and instability. Point discharge is not allowed above or onto these areas. Dispersion and infiltration may be allowed if installed according to the requirements in Section C.2.

If dispersion or infiltration is not feasible, a tightline conveyance system may be constructed to convey the runoff to a stable discharge point with adequate energy dissipation.[13] This tightline system shall be approved by a geotechnical engineer or geologist. The tightline shall conform to the materials and design requirements of Section 4.2 of the *Surface Water Design Manual.*

Tightlines are engineered systems that typically require design by a professional engineer registered in the State of Washington as described in Section 4.2.2.1 of the *Surface Water Design Manual.* For simple downspout installations serving one lot, DDES engineering and/or geotechnical staff may provide a standardized design if it is determined that the standardized tightline and energy dissipation system is appropriate.

Note: For most small sites with less than 10,000 square feet of impervious surface, the tightline system can be constructed using 6-inch diameter SWPE with a standard outfall. See Figure 4.2.2.D of the Surface Water Design Manual for an example tightline outfall.

C.4.4 EROSION HAZARD AREAS

Vegetation removal and grading make erosion hazard areas prone to erosion and sediment transport upon. Point discharge of stormwater runoff can cause erosion on well-vegetated slopes. Small sites determined to drain to these areas must provide appropriate flow control measures as described in Section C.2 (p. C-7), and will be conditioned for strict ESC measures as well as require a Sensitive Area Notice on Title. If flow control and erosion and sediment control can not be adequately address by the BMPs in this appendix, DDES may require a professional engineer registered in the State of Washington to provide a site-specific construction sequence and site improvement and erosion control plans.

C.4.5 CHANNEL MIGRATION HAZARD AREAS

Sites located in Channel Migration Hazard Areas must meet the regulations in KCC 21A.24.

C.4.6 WATER FROM PIPE/DITCH THAT IS 12 INCHES OR MORE IN SIZE/DEPTH

Small site projects proposing to construct or modify a drainage system that collects or concentrates water from a pipe/ditch that is 12 inches or more in size/depth or that receives surface water from a pipe/ditch that is 12 inches or more in size/depth, must submit engineering plans meeting the requirements outlined for Targeted Drainage Review Category #2 (Table 1.1.2.A in Chapter 1 of the *Surface Water Design Manual*).

Driveway culverts less than 25 feet in length that match downstream and upstream culvert sizes may not have to provide engineering plans if approved by DDES engineering staff.

13 The location of the outfall must be onsite or drainage easement(s) must be provided, the downstream system must be determined adequate, and the pipe installation and outfall must meet all sensitive areas requirements.

C.4.7 AREA WITH ADOPTED AREA-SPECIFIC DRAINAGE REQUIREMENTS

Projects located in areas with adopted area-specific drainage requirements[14] (e.g., adopted Basin Plan area, Community Plan area, or Critical Drainage Area), and that meet the threshold(s) for requiring engineering analysis must submit a technical information report (TIR) and engineering plans meeting the requirements outlined for Targeted Drainage Review Project Category #1 (Table 1.1.2.A in Chapter 1 of the *Surface Water Design Manual).*

Whether or not engineering analysis is required must be assessed on an individual basis for specific information needed for drainage review. DDES engineering review staff will make this determination after formal submittal and review of the project. Projects that do not meet the thresholds for requiring engineering analysis may be required to demonstrate that thresholds will not be exceeded and to notify the applicant, contractors, and inspectors of these limitations. If required, a technical information report and engineering plans must be submitted by a professional engineer registered in the State of Washington and reviewed and approved by DDES engineering review staff.

[14] See *Surface Water Design Manual,* Reference Sections 2 and 3 for area-specific drainage requirements.

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C.5 SUBMITTAL REQUIREMENTS

Projects in Small Site Drainage Review must meet the requirements for flow control, erosion and sediment control, and Targeted Drainage Review, if applicable. Small site drainage plans[15] are required for projects in Small Site Drainage Review and may utilize the short plat *plot plan* or single family residence *site plan* which was submitted with the application. The location and types of flow control BMPs, and necessary information to install the BMPs and Targeted Drainage Review requirements must be shown on one copy (site improvement plan), and a second copy must show how ESC BMPs will be used to comply with small site ESC requirements (ESC plan). If lots are smaller than 22,000 square feet in size, a soils report must also be submitted to determine if infiltration is required (see Section C.5.4, p. C-37). A written drainage assessment may also be required for some short plat projects.

C.5.1 SHORT PLATS

Proposed short plats that qualify for Small Site Drainage Review must submit **small site drainage plans** (site improvement plan, erosion and sediment control plan, and written drainage assessment). Typically, small site short plats that do not require engineering plans or analysis will be asked to complete small site drainage plans prior to preliminary approval.

For projects required to complete **engineering plans**, small site drainage plans may be submitted in conjunction with the engineering plans. Projects submitting small site drainage plans after preliminary approval shall include a drainage assessment which describes (in narrative) the proposed project, any changes made after preliminary approval, and how the small site BMPs were selected. Any necessary soils reports and special studies may also be included in the drainage assessment.

The **site improvement plan** shall clearly show the approximate size and location of houses, driveways, site improvements (frontage improvements and onsite and offsite road and drainage improvements, if any), and existing drainage features such as infiltration trenches, dispersion trenches, flowpaths, etc. The plan shall also include necessary standard details for proposed improvements (i.e., infiltration trenches, dispersion trenches, driveway culverts, etc.).

The site improvement plan may be prepared for the expected size and location of future home construction. However, if at the time of the building permit, the actual home size or location is different, it may invalidate the approved small site drainage plan. **An alternate approach is to prepare the small site drainage plan for a range of impervious surfaces** (roofs, driveways, patios, etc. not to exceed 10,000 square feet total) located within a larger building envelope. The small site drainage plan must demonstrate that the small site BMPs can be constructed for a home sited anywhere within the identified building envelope (flowpath lengths and slopes, soils logs, and location of infiltration facilities, etc.). It is the responsibility of the applicant for the proposed single family residence to show in detail how the small site requirements will be met.

The **erosion and sediment control plan** (ESC plan) shall show approximate locations of the proposed ESC BMPs to be used to prevent sediment from leaving the site. The plan shall include necessary standard details for construction of proposed ESC measures.

The written drainage assessment[16] shall include a project overview statement (outlining the existing site conditions and the proposed improvements), a description of the existing drainage features (offsite flows, ditches, swales, streams, ponding areas, culverts, etc.), and a description of the proposed small site flow control and ESC BMPs. The drainage assessment should also include a copy of the soils report and any special studies.

A note conditioning future single family residential permit approval on compliance with small site drainage requirements shall be recorded with the short plat. The following note shall be recorded for each undeveloped lot:

---

[15] Small site drainage plans are typically non-engineered site improvement plans that show the layout of the proposed project including small site BMPs, clearing limits, etc. See Section C.5.5 (p. C-38) for small site drainage plan examples.

[16] If engineering plans are required, the information requested in the written drainage assessment should be incorporated in the technical information report.

Future residential building permits shall comply with the approved small site drainage plan for this lot. The approved size and location of runoff control BMPs is indicated on the short plat drainage plans. Noncompliance with the small site drainage requirements invalidates drainage approval for this lot. Information on small site drainage requirements is available from King County DDES.

C.5.2 SINGLE FAMILY RESIDENTIAL

Single-family residential projects that qualify for Small Site Drainage Review are required to complete small site drainage plans. However, if an accurate site plan[17] is submitted with the application, DDES staff may be able to condition residential permits for flow control and erosion control measures without the need for the applicant to prepare the drainage plans.

Most of the information required for the small site drainage plan is also required for the residential site plan (see DDES Bulletin No. 9, "Obtaining a Residential Building Permit"), which may be used as a base map for the drainage and ESC plans.

C.5.3 PLANS SUBMITTED FOR SMALL SITE DRAINAGE REVIEW

The plan should be drawn on 8½" x 11", 8½" x 14", or 11" x 17" paper (see the sample small site drainage plans in Figure C.5.A through Figure C.5.C) and must include the following information:

Identification (show on both the site improvement plan and ESC plan):

- Name, address, and phone number of applicant
- Scale—use a scale that clearly illustrates drainage features and flow controls (1"=20' is standard scale; minimum acceptable scale is 1"=50')
- Parcel number
- North arrow
- Dimension of all property lines, easements, and building setback lines
- Street names and existing or proposed property address
- Section, township, and range of proposal.

Building and Site Development Features (show on small site improvement plan only):

- Footprint of all structures (existing and proposed)
- Location of any retaining walls and rockeries (existing and proposed)
- Parking and driveways (existing and proposed)
- Sport courts and any other paved or impervious surfaces (existing and proposed)
- Existing or proposed septic system, including all system components and both primary and reserve drainfields
- Utility structures (poles, fire hydrants, etc.)
- Existing wells or wells to be abandoned.

Topography (show on both plans):

- Corner elevations of site and individual lots
- Benchmark (a permanent mark indicating elevation and serving as a reference in the topographic survey)
- Datum [assumed datum is acceptable in many cases (i.e., fire hydrant base = 100'); datum for projects in or near FEMA floodplain should be NGVD 1929]

[17] Site plans include all items specified in Section C.5.3, except for flow control and erosion/sediment control BMPs.

- If over 15% slope: show 5-foot contours, top of slope, toe of slope, and any erosion or landslide areas.

Sensitive Areas and Drainage Features (show on both the site improvement plan and ESC plan):

- All streams, wetlands, lakes, closed depressions, or other water features (including any required buffer widths)
- Location of all steep slopes, landslide hazard areas, coalmine hazard areas, and their buffers and building setback lines
- Location of all drainage easements
- Location of all existing and proposed ditches, swales, pipes, etc.
- Location of all sensitive areas as shown on any recorded Sensitive Areas Notice on Title (SANT).

Proposed Flow Control (show on small site improvement plan only):

- Type and location of flow control systems that will serve impervious surfaces (dispersion, sheet flow dispersion, infiltration, etc.)
- Location of any vegetated flowpaths or buffers required for flow control systems
- Setback lengths between flow control systems and any property line, structure, steep slope, stream, wetland, or septic system.

Proposed Erosion and Sediment Control (show on small site ESC plan only):

- Delineation of proposed clearing limits
- Type and location of erosion control facilities
- Location of any significant offsite drainage features within 200 feet of the discharge point(s) for the lot, including streams, lakes, roadside ditches.

Written Drainage Assessment:

- Narrative description of proposed project
- Any proposed changes after preliminary approval
- Description of proposed small site BMPs shown on the plans
- Any necessary special studies or soils reports.

C.5.4 SOILS REPORT

A **soils report** is required for all proposed or existing lots less than 22,000 square feet. Soils reports are also required for larger lots proposing infiltration systems.

The soils report must include at least one **soils log** for each proposed infiltration trench location. Each log shall be a minimum of 4 feet deep (6 feet for drywells). The report shall describe the SCS series of the soil and the textural class of each horizon through the depth of the log, and it shall include notes of any evidence of a high groundwater table, such as mottling. Soils reports must be prepared by an onsite sewage system designer or by another suitably trained person working under the supervision of a professional engineer.

Note: A soils report produced for siting and design of an onsite sewage system may also be used to satisfy this soils report requirement, provided that the depth of the soil log(s) is at least 4 feet, the depth to seasonal high water table is determined, and the location of the soil logs is adequate to determine the feasibility of the infiltration system.

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C.5.5 SAMPLE SMALL SITE DRAINAGE PLANS

Small site drainage plans are a simplified form of the drainage plans required by the *Surface Water Design Manual*, and they can be prepared by a non-engineer from a set of pre-engineered design details. They include a **small site improvement plan, a small site ESC plan,** and a written **drainage assessment** (if required).

C.5.5.1 SMALL SITE SHORT PLAT DRAINAGE PLANS

The purpose of this section is to illustrate the application of small site drainage requirements to a 2-lot short plat. The site improvement plan is presented in Figure C.5.A (p. C-40), and the written drainage assessment is as follows:

Drainage Assessment
John Smith Short Plat
KC Permit #L98S7160

A 15,000-squarefoot parcel will be divided into 2 lots. The parcel is currently pasture with eleven 12-inch diameter and larger trees. The site is sloped to the northeast to the roadside ditch of Y Avenue. The roadside ditch appears to drain northerly away from the property. The neighboring property has two 12-inch driveway culverts. The ditch then enters a 12-inch drainage pipe under Pine Street at the intersection with Y Avenue. A Level 1 downstream analysis was prepared for the permit application and is attached.

The preliminary approved site plan has been used to prepare the small site drainage plans. The proposed lots will each be 7500 square feet. It is estimated that each lot will contain a 2500-square-foot house/garage with a 400-square-foot driveway. The total amount of impervious area proposed will be approximately 6,000 square feet, which is less than the 10,000-square-foot limit for small sites drainage review. Engineering plans for Targeted Drainage Review are being prepared by DWCH Engineering for frontage improvements along X Street. There are no sensitive areas or existing drainage systems on the site.

The lots are less than 22,000 square feet and infiltration is feasible. According to the soils analysis by CCC Septic Design and Construction (report attached), the soils on both lots are coarse sands and cobbles, and are suitable for use of downspout infiltration facilities. The driveways will sheet flow to a slot drain and be tightlined to the infiltration trenches. A catch basin with a down-turned elbow will be installed to provide spill control for driveway areas. A total of 20 feet of trench will be required for each 1000 square feet of roof area and driveway. The total trench length required for 3000 square feet will be 3.0 x 20, or 60 feet of trench. The trench will fit well in the back yard, as sketched in the attached figure (refers to Figure C.5.A, p. C-40).

Any overflow from the infiltration trenches will overflow through lawn towards X Street. There are no downstream structures or features that will be impacted by overflow. The lots and the adjacent properties are served by public sewers. No impact to any onsite sewage disposal system is expected.

This short plat is a simple division of property with no proposed or required onsite improvements. No clearing or grading is proposed to be done during the short plat process. The ESC plan for lot construction uses silt fencing around the downslope side of the building sites. Clearing and site disturbance should be minimized during construction, and cover measures will be used as needed to minimize exposed soils.

The final recording documents will include a statement that the approved small site drainage plan will be used for any future building permits or other site alterations.

AR 032528

C.5.5.2 SMALL SITE RESIDENTIAL DRAINAGE PLAN

The purpose of this section is to illustrate the application of small site drainage requirements to a house being built on an existing lot. The site improvement plan is presented in Figure C.5.B (p. C-41) and the ESC plan in Figure C.5.C (p. C-42). The written drainage assessment is as follows:

Drainage Assessment
John and Sally Applicant Residence
12345 NE Steep Slope Road
Permit # B98R7184

The project is located east of Duvall on a 1.69-acre lot. The lot is forested with a pond and wetland at the base of a 35-40% slope on the east side of the property. The site slopes northerly towards the street. The slope on the west side of the property is 14-18%. Approximately, two-thirds of the site (the southern portion) will be cleared. Trees and other native vegetation will be left intact along the northern edge, near the street. Neither the wetland/buffer nor the slopes (except for driveway construction) will be disturbed. The driveway will traverse the more moderate slope with the proposed house approximately 100 feet from the top of the slope. The driveway will be approximately 10 feet by 180 feet (1,800 square feet) of impervious surfaces, the parking area 1,300 square feet, and the house 3,750 square feet. The total proposed impervious surface is 6,850 square feet, which falls within the limits for Small Site Drainage Review.

All stormwater flows will be dispersed through vegetation. To avoid saturating soils near the foundation of the house, roof runoff will be directed towards vegetated flowpaths via downspout extensions. An onsite mound septic system is proposed. All small site drainage facilities will be located downgradient of the septic tank and drainfields.

The upper portion of the driveway is relatively flat. Therefore, runoff from this area can simply be allowed to sheet flow to the west side towards the existing swale and away from steeper slopes. The lower portion of the driveway is fairly steep. Runoff will be collected using small berms that will direct runoff to dispersion trenches with a 25-foot vegetated flowpath. This will prevent concentration of the runoff onto the slopes and will prevent water from running out of the driveway and into the street.

In order to prevent erosion and trap sediments within the project site, the following BMPs will be used approximately as shown on the ESC plan:

- Clearing limits will be marked by fencing or other means on the ground.
- The driveway will be constructed and graveled immediately. Dispersion trenches shall be placed according to flow control requirements. Areas accepting sheet flow from the driveway and parking area (that are not being left in native vegetation) will be seeded and mulched.
- Water will not be allowed to point discharge onto the slopes. A rock-lined ditch will intercept and direct water from the steeper portions of the driveway down to the dispersal trench at the bottom of the slope.
- Silt fencing will be placed along slope contours at the limits of clearing in the vicinity of both the wetland and the slopes.
- A rocked construction entrance will be placed at the end of the driveway.
- Mulch will be spread over all cleared areas of the site when they are not being worked. Mulch will consist of air-dried straw and chipped site vegetation.

FIGURE C.5.A SHORT PLAT SMALL SITE IMPROVEMENT PLAN

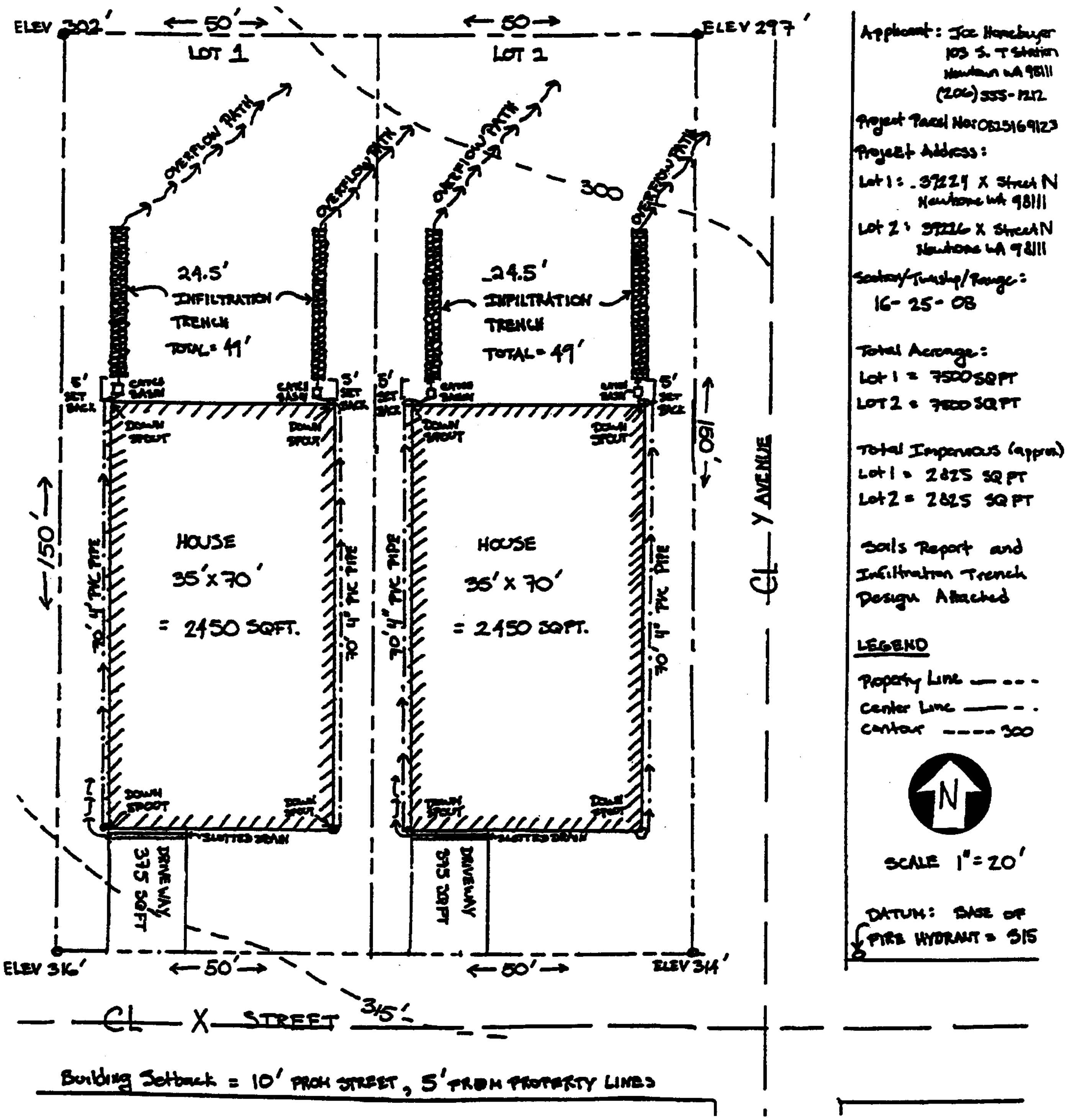

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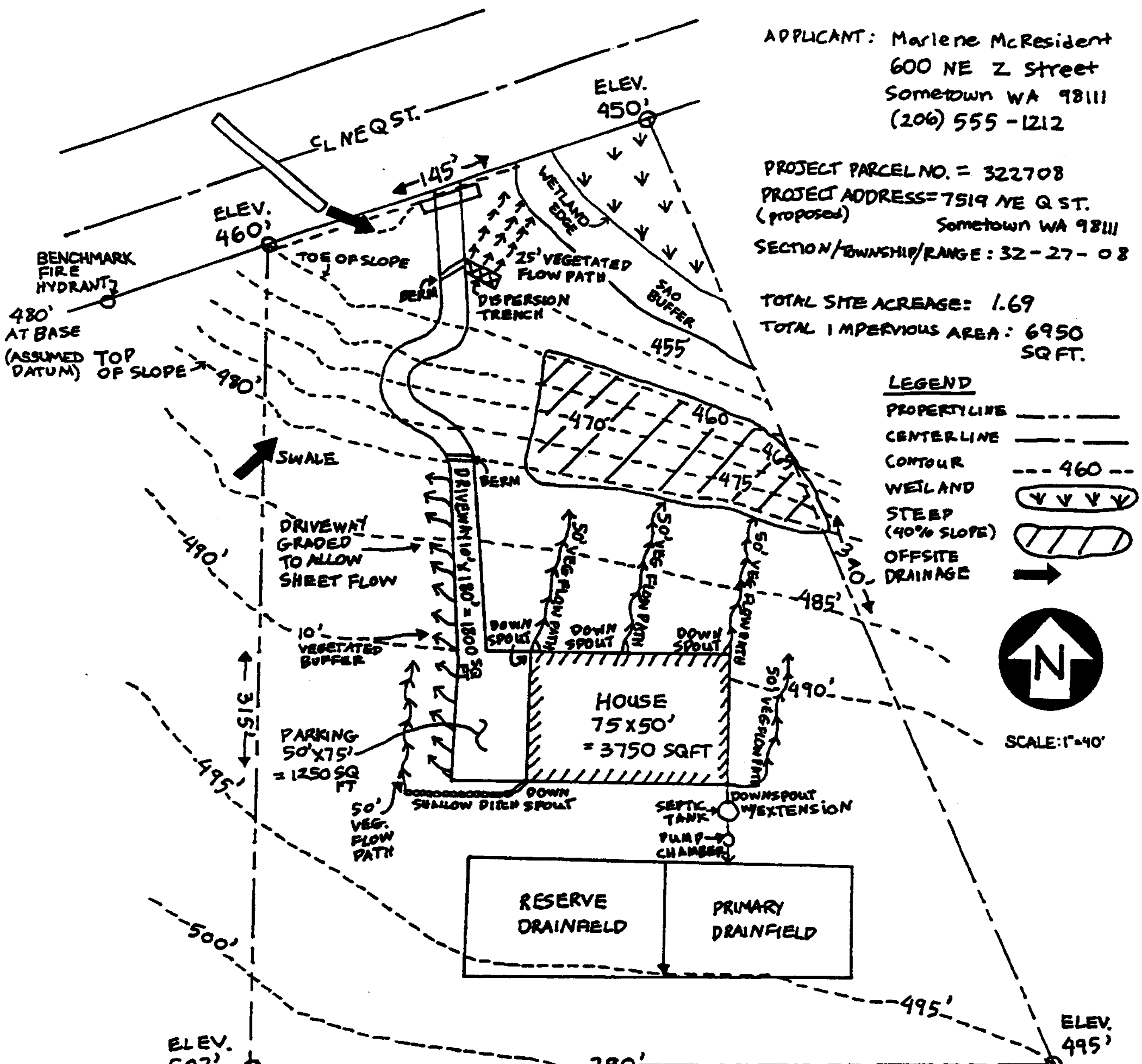
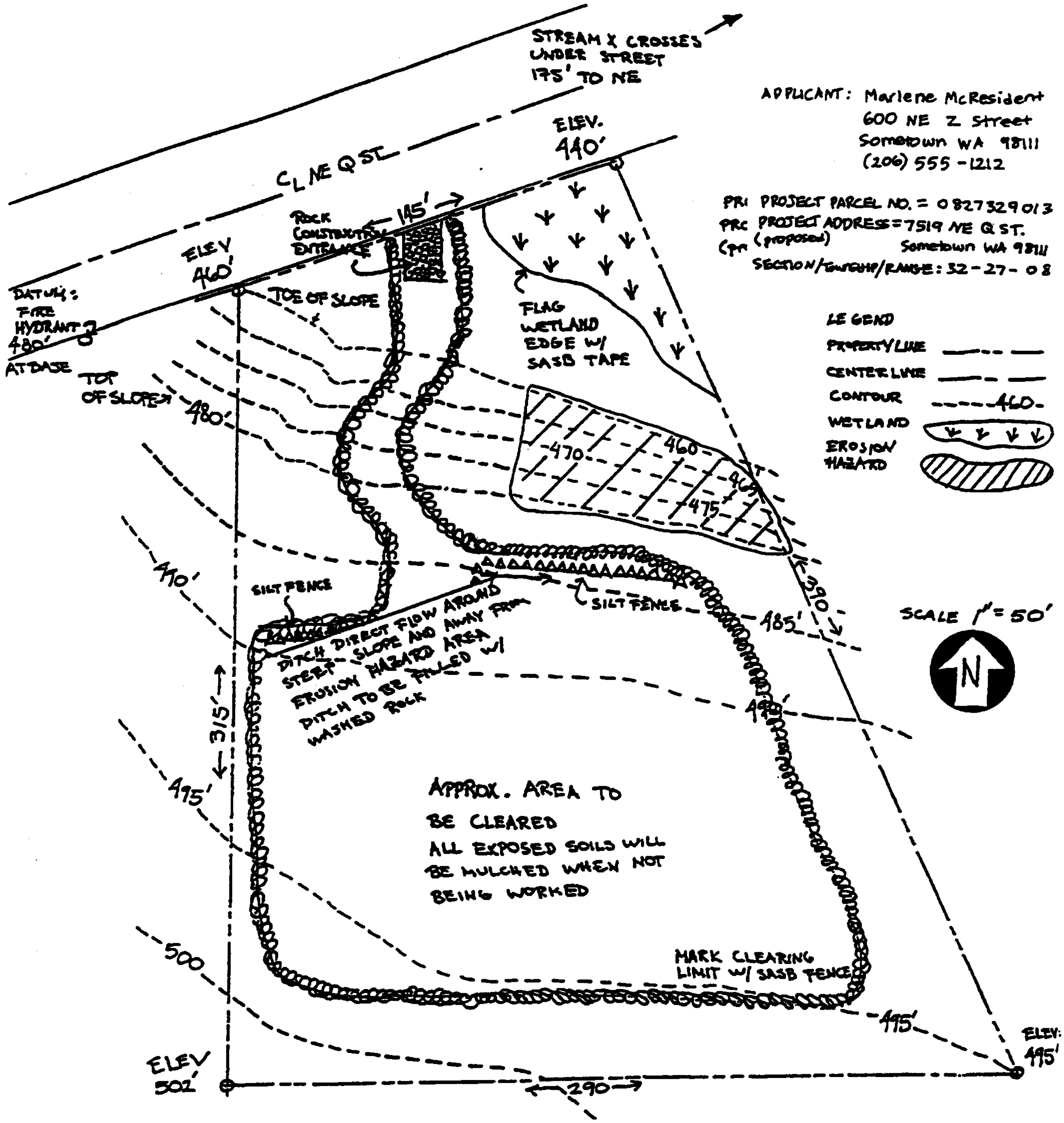
FIGURE C.5.B SINGLE FAMILY RESIDENCE SITE DRAINAGE PLAN



BUILDING SETBACK = 30' FROM STREET 35' FROM INTERIOR PROPERTY LINES
SOILS REPORT FOR ON-SITE SEWAGE SYSTEM ATTACHED

AR 032531

FIGURE C.5.C SMALL SITE EROSION AND SEDIMENT CONTROL PLAN



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C.5.6 PLAN CHANGES

Approval of small site drainage plans is based on the specific proposed project. Changes to the project (additional impervious surface or clearing, right-of-way improvements) may require additional review by DDES engineering staff, or they may initiate Full Drainage Review, where a professional engineer registered in the State of Washington must analyze the project and submit engineering plans. This will add additional review time and expense to the review process.

Changes proposed prior to permit issuance shall be submitted through the standard revision process for the type of application.

Changes proposed after permit issuance (during construction) shall be submitted through the DDES site inspector. Proposed changes shall not be implemented prior to DDES engineering approval. Changes performed without engineering approval may be subject to Stop Work notices and accompanying fees and reviews.

KING COUNTY, WASHINGTON
SURFACE WATER DESIGN MANUAL

SMALL SITE REFERENCE SECTION

REFERENCE SECTION A

EXAMPLE
NATIVE GROWTH RETENTION AREA
COVENANT

IN CONSIDERATION OF the approved King County residential building permit for application No. _________ relating to real property legally described as follows:

____

____

____

____

____

The undersigned as Grantor(s), declares that the above described property is hereby established as a native growth retention area for the purpose of dispersing and treating stormwater flows and is subject to restrictions applying to vegetation removal in all designated areas shown in Attachment A, and hereby covenants and agrees as follows:

1) Any alterations to sensitive areas and their buffers shall be pursuant to King County Code 21.A.24.

2) The remaining property outside of the sensitive areas and their buffers, residences, roadways, drainage facilities, drainfield areas, lawns and pastures shall be maintained in a forested condition. The following activities are allowed:

    a) On slopes which have been disturbed by human activity or infested by noxious weeds, replacement with appropriate native species or other appropriate vegetation.

    b) Construction of private trails, provided that they are guided by construction and maintenance standards in the US Forest Service "Trails Management Handbook" (FSH 2309.18, June 1987, as amended) and "Standard Specifications for Construction of Trails" (EM-7720-102, June 1984, as amended); but in no case shall trails be constructed of concrete, asphalt or other impervious surface which would contribute to surface water runoff unless such construction is necessary for soil stabilization or soil erosion prevention.

c) Limited trimming and pruning of vegetation for the creation and maintenance of views per 21.A.24310.D.4.

d) Replacement of individual trees with native trees on a limited basis. Forested hydrologic conditions and soil stability shall be maintained.

This easement/restriction is binding upon the GRANTOR(s), its heirs, successors and assigns unless or until a new drainage or site plan is reviewed and approved by the Department of Development and Environmental Services or its successor.

____

GRANTOR

____

GRANTOR

STATE OF WASHINGTON)
COUNTY OF KING) ss.

On this date, personally appeared before me:

______________________________________, to me known to be the individual(s) described in and who executed the within and foregoing instrument and acknowledged that they signed the same as their free and voluntary act and deed, for the uses and purposes therein stated.

Given under my hand and official seal this ____________ day of ____________, 199___.

____

NOTARY PUBLIC in and for the State of
Washington, residing at ____________
My Commission Expires: ____________

AR 032536

REFERENCE B

SUMMARY OF ON-SITE SEWAGE SYSTEM REQUIREMENTS AUGUST 1997

This section is for reference only. The Seattle-King County Department of Public Health (SKCDPH) has responsibility for the review and approval of septic designs. The purpose of this section is to summarize on-site sewage requirements that may effect small site drainage facilities and requirements. The most likely sections of on-site sewage regulations that may effect small sites drainage are soils report requirements, soil conditions/requirements, vertical separation requirements, and setback requirements. This section is not meant to serve as a complete guide for designing an on-site sewage system, but rather is meant to alert the applicant to potential conflicts. **With few exceptions, a licensed on-site sewage system designer must be retained to design any on-site sewage disposal system.** DDES may require that a licensed designer be retained to evaluate compatibility between the on-site sewage disposal system and any small site drainage facilities.

Complete text of regulations for on-site sewage systems can be found in Title 13 of the King County Code. Additional information on on-site sewage system regulations is available by calling the Seattle/King County Department of Public Health, Environmental Health Division, at (206) 296-4722.

Soil Report Requirements

A log of the soil must be submitted as part of the application for design approval. It shall show soils types encountered in the drainfield and reserve area, at least two (2) to three (3) feet below the level of the bottom of the proposed drainfield trench, or a minimum of four (4) feet below final grade, whichever is deeper. The log must describe soil type and depth of each type. Classification may be in general terms such as loose sand, cemented sand, sandy silt, silt clay, silt, clay hardpan, claypan, rock, etc., or classification may be in specific terms such "Alderwood gravely sandy loam" or "Buckley silt loam" as described in the United States Department of Agriculture Soil Conservation Service Soil Survey. Any evidence of seasonal water table must be noted and described. Sieve tests or percolation tests may be required by the health officer in cases where identification of soil types is in question.

Soil logs for single-family dwellings must be made from four (4) or more test holes located in representative parts of the drainfield and reserve area, and must be separated by at least twenty feet (20'). Holes must be a minimum of twenty-four inches (24") in diameter for the observer to obtain representative samples from the soil profile and determine color, texture, structure, and, in addition, elevation of water table if it is encountered. This requirement may be waived by the health officer in those soils where the color, structure, texture, and elevation of water table can clearly be seen with a smaller diameter soil log.

NOTE: A soils report produced for the purpose of siting and designing of an on-site sewage system also may be used to satisfy the soils report requirement for small sites drainage requirements provided that the depth of the soil logs is at least four (4) feet.

Allowable Soils/Depths to Groundwater

The minimum allowable vertical separation between a septic drainfield and any impervious layer or the water table depends on the soil type and on the size of the lot as listed in the table below. A minimum of eighteen (18) inches of original permeable soil is required above any seasonal high water table or impervious layer of soils on all sites to be considered for on-site sewage disposal systems.

Where marginal soil conditions exist, a soil study may need to be performed with a health officer present. The health officer will direct the amount of investigation and the number of percolation tests and soil logs necessary to determine representative conditions.

		Vertical Separation Between Drainfields and Impervious Layer or Water Table (1) (2)	
Soil Texture Type (3)	**Minimum Lot Size** (4)	**Gravity**	**Pressure Distribution** (5)
Soil Texture Type 1 (6) coarse sands or coarser	1/2 acre 1 acre	n/a 3' (48")	n/a 2' (30")
Soil Texture Type 2 medium-fine sand	12,500 sf 1 acre	3' (48") 2' (36")	2' (30")
Soil Texture Type 3 loamy sand	15,000 sf 1 acre	3' (48") 2' (36")	2' (30")
Soil Texture Type 4 sandy loam, loam	18,000 sf 1 acre	3' (48") 2' (36")	2' (30")
Soil Texture Type 5 (7) porous well-developed structure in silt and silt loams	20,000 sf	n/a	n/a

Notes for Soil Type Table:

(1) The vertical separation requirements for on-site systems using mounds or sand filters is partially met through design features. These systems must have a minimum original permeable soils depth of eighteen (18) inches.

(2) The number in parentheses indicate the minimum original permeable soil necessary to meet the required vertical separation.

(3) soils which are classed as excessively permeable, regardless of texture type, must meet all the requirements of soil texture type 1.

(4) Minimum lot size requirements are based on soil texture type per unit volume of sewage (450 gallons per day) or single family residence.

(5) The minimum vertical separation requirement for one acre lots using on-site systems with pressure distribution can be met by installing the trenches in the top nine (9) inches of soil with a twenty-one (21) inch minimum vertical separation or by installing in the top six (6) inches of soil with a minimum of twenty-four (24) inch separation.

(6) Lots with soil texture type 1 (and other excessively permeable soils) and which have 1/2 acre or less lot size, must be developed with an alternative on-site sewage system which provides a degree of treatment to the sewage equal to or greater than the treatment provided by a mound or sandfilter.

(7) On-site systems in soil texture type 5 soils must consist of a mound system, sand filter, or equivalent.

Downgradient Setbacks

The table below contains approximate required setbacks between on-site sewage disposal systems and various types of site features. These setbacks may be increased or decreased at the discretion of the health officer.

Type of Feature	**Minimum Setbacks:**		
	Septic Tank (1)	**Drainfield**	**Building Drain, Building Sewer and Pump Lines**
Surface Water (2)	50' (3) (4)	100' (3) (4) (5)	
Seasonal Water	5' (4)	30' (3) (4)	
Potable Water Source:			
private well	100'	100'	50' or 100'
public well	100'	100'	100'
springs	200' (6)	200' (6)	200' (6)
Property Lines/Easement Lines	5'	10' (7) (8)	--
Building Foundations	5'	10'	--

Setback Table (continued)

Type of Feature	**Minimum Setbacks:**		
	Septic Tank (1)	**Drainfield**	**Building Drain, Building Sewer and Pump Lines**
Septic Tanks (1)	--	5'	--
Water Line	10'	10'	10'
Interceptor Drains Curtain Drains Footing Drains (9):			
level or upslope from system	--	10'	--
downslope from system	5'	30'	--
Cuts or Banks:			
less than 5' vertical height	--	15' + height of bank	--
greater than 5' vertical height with minimum of 5' of original, undisturbed soil above restrictive layer or layer due to a structural chance	--	15' + height of bank with minimum setback of 25' (10)	--
greater than 5' in vertical height with less than 5' of original, undisturbed soil above restrictive layer or layer due to a structural or textural change and that layer is intersected	--	15' + height of bank with minimum setback of 50' (10)	--

Notes for Setback Table:

(1) Setbacks apply to dosing tanks.

(2) With excessively permeable soils or other sites where conditions indicate a greater potential for ground or surface water contamination or pollution, the distance from any water supply or surface water may be increased by the health officer.

(3) This separation cannot be reduced by culverting of streams without written approval from King County Surface Water Management Division, but in no case shall this separation be less than fifteen (15) feet.

(4) Setback measured from ordinary high-water mark of surface water. Greater setback may be required to prevent pollution provided health officer must give reasons for greater setback to applicant in writing.

(5) A reduced setback can be allowed by the health officer if it can be demonstrated that the reduction will not have an adverse effect. However, in no case shall the setback be less than seventy-five (75) feet.

(6) Setbacks from private springs utilized as a source of drinking water shall comply with Section 13.28-070C1 of King County Code.

(7) May be reduced five (5) feet by the health officer in repairs to existing systems and in setbacks to easements where it can be demonstrated that the reduction will not have an adverse effect.

(8) This distance can be increased to thirty (30) feet by the health officer where cuts on neighboring property may effect the system.

(9) Based on relative elevation of bottom of drainfield trench and bottom of interceptor/curtain drain.

(10) Need not exceed one-hundred (100) feet.

Reference Section C: Small Site Drainage Review Assessment/Requirements
This table is a flow chart to help assess if a project is eligible for small sites review and if so what specific targeted and/or small sites information must be submitted.

Question #	Question	YES	NO
1	Does the project meet (a) threshold requiring drainage review?	Determine the required information by answering **EACH** of the following questions and providing the requested information.	The project does not need to meet the Surface Water Design Manual requirements. No information is required to be submitted.
2	Does the project propose to add >10,000 SF of new impervious surface or >2 acres of clearing?	A **Full Drainage Review** is required. Engineering plans signed and stamped by a professional engineer registered in the State of Washington are required. **(Project not eligible for "Small Site Drainage Review.)**	Go to next question.
3	Is the site being developed greater than 2 acres in size?	See Native Growth Open-Space BMP requirements of this appendix.	Go to next question.
4	Is there (a) drainage feature(s) on site (stream, lake, wetland, drainage swale, closed depression?	Go to next question.	Skip to question 8.
5	Does the project contain or abut a lake, stream or wetland within the FEMA floodplain and/or zero-rise floodplain area AND are there predetermined base flood elevations for the building site?	Go to next question	The floodplain/elevation will need to be determined by a PE or other authorized agency. Go to next question.
6	Is the site compatible with the (pre)determined base flood elevations?	DDES will require an Elevation Certificate and a Sensitive Area Notice on Title (SANT). Go to next question.	The project will need to be evaluated by a PE with respect to the determined elevation. A SANT and Elevation Certificate will be required. Go to next question.

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Reference Section C: Small Site Drainage Review Assessment/Requirements
This table is a flow chart to help assess if a project is eligible for small sites review and if so what specific targeted and/or small sites information must be submitted.

Question #	Question	YES	NO
7	Does the site contain or abut a stream, lake, wetland or closed depression outside of the FEMA floodplain and zero-rise floodplain areas AND is the building site >10 feet above the ordinary high water mark for the stream, lake or wetland or >2 feet above the downstream overflow for the stream, lake, wetland or closed depression?	DDES may condition the permit for elevation and require a SANT. (Note: sites which meet this threshold may not be allowed this exemption if there is information or additional knowledge that shows this exemption to be inadequate for flood protection. Go to next question.	A PE must assess the site per the SWDM minor floodplain and/or closed depression requirements. A SANT will be required. go to next question.
8	Is the site located in a channel migration hazard area?	Site must meet channel migration hazard area requirements. A SANT will be required. Go to next question.	Go to next question.
9	Does the site contain an Erosion Hazard Area?	DDES will require a SANT and erosion hazard area control conditions. Go to next question.	Go to next question.
10	Does the site contain or abut steep slopes?	The project must be approved by the DDES geologist. The project may be required to provide a geotechnical analysis. The project must meet all geotechnical requirements and a SANT will be required. Go to next question.	Go to next question.
11	Does the site contain or abut a Landslide Hazard Area?	The project must be approved by the DDES geologist. The project may be required to provide a geotechnical analysis. The project must meet all geotechnical requirements and a SANT will be required. Go to next question.	Go to next question.

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Reference Section C: Small Site Drainage Review Assessment/Requirements
This table is a flow chart to help assess if a project is eligible for small sites review and if so what specific targeted and/or small sites information must be submitted.

Question #	Question	YES	NO
12	Is the site located in a basin planning area, community planning area, critical drainage area (CDA), or in an area with other adopted drainage related requirements AND does the project exceed the minimum thresholds for these drainage requirements?	The project must meet the specified drainage related design requirements. Engineering plans signed and stamped by a PE registered in the State of Washington may be required. The drainage design must be based on the most restrictive of the design requirements.	Go to next question.
13	Is the project proposing to construct or modify a drainage pipe or ditch that is >= 12 inches in diameter/depth or does the project receive surface and storm water runoff from a drainage pipe or ditch that is >= 12 inches in diameter/depth?	Engineering plans signed and stamped by a PE registered in the State of Washington are required.	Go to next question.
14	Are there any other stormwater runoff/drainage features on site (swales, ditches...) which may impact the proposed project or downstream properties or be impacted by the project	Engineering analysis by a Professional Engineer may be required. DDES staff will need to assess features. Go to next question.	Go to next question.
15	Have storm water runoff control and water quality requirements been addressed through a TIR due to one of the above requirements?	DDES will condition and approve the drainage portion of the permit based on the TIR and any other requirements determined during the review process.	Go to next question.
16	Is infiltration required? (lot is less than 22,000 SF with suitable soils) or is infiltration desired (lot is greater than 22,000 SF with suitable soils)	DDES will condition and approve the drainage portion of the permit for infiltration and for any other requirements determined during the review process.	Go to next question.

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Reference Section C: Small Site Drainage Review Assessment/Requirements
This table is a flow chart to help assess if a project is eligible for small sites review and if so what specific targeted and/or small sites information must be submitted.

Question #	Question	YES	NO
17	Can storm water control and water quality issues be addressed with splashblocks, dispersion trenches and/or sheetflow?	DDES will condition and approve the drainage portion of the permit for appropriate runoff control and water quality measures and for any other requirements determined during the review process..	Go to next question.
17	Can storm water runoff and water quality issues be addressed with a perforated stubout and/or sheetflow?	DDES will condition and approve the drainage portion of the permit for perforated stubout and/or other measures and for any other requirements determined during the review process.	DDES will contact the applicant for additional information to determine if there are other options to address storm water and water quality issues. Go to next question.
18	Can storm water runoff and water quality issues be addressed by DDES review staff?	DDES will condition and approve the permit for appropriate runoff and water quality measures and any other requirements determined during the review process	A PE must submit an engineering analysis addressing the concern(s). DDES will condition and approve the permit for appropriate runoff and water quality measures as determined by the engineering analysis and for any other requirements determined during the review process.

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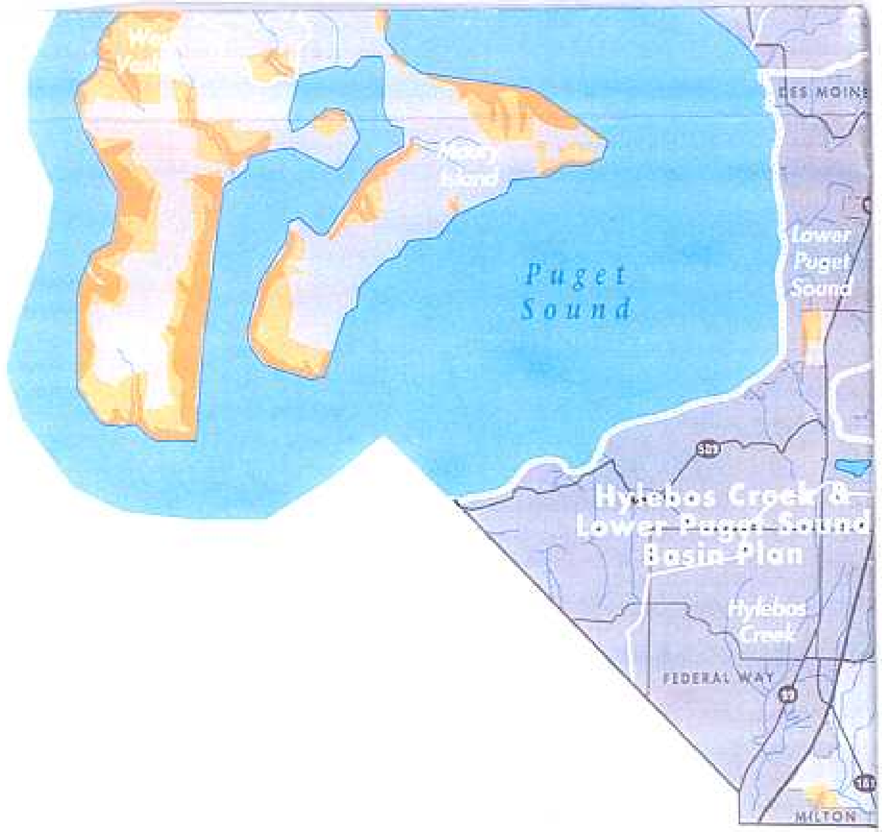

King County

Landslide Hazard Drainage Areas Map

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- Basin Boundary (thicker line designates areas with published Basin Plans)
- Urban Growth Area Boundary
- Incorporated Area
- Unincorporated Area
- Forest Production Zone Area

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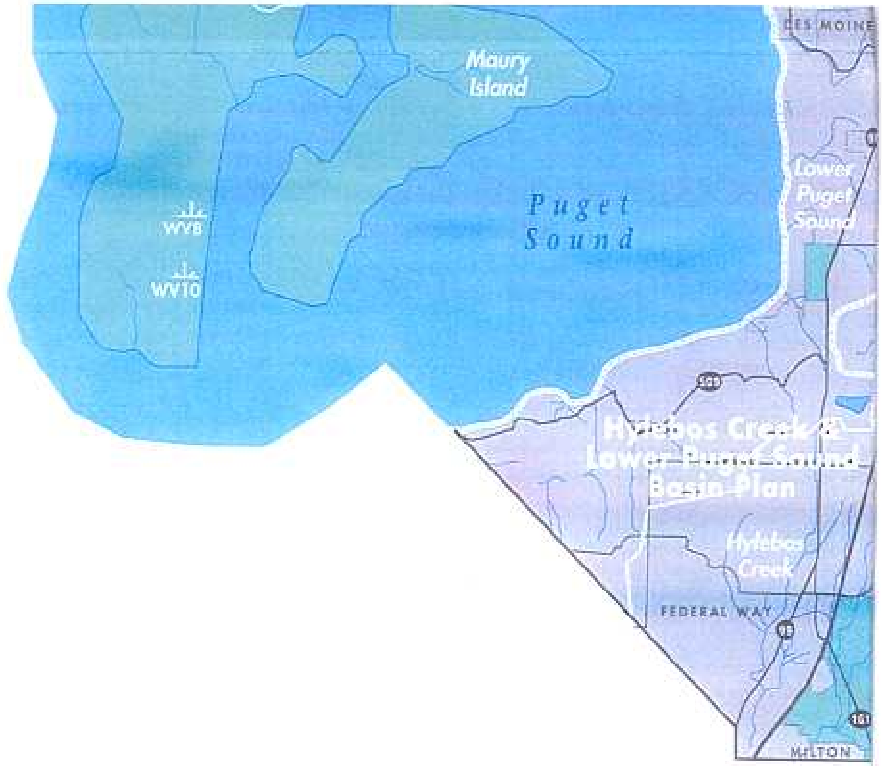

King County

Water Quality Applications Map

Basin Boundary (thicker line designates areas with published Basin Plans)

Lake Management Plan Boundary

Urban Growth Area Boundary

Incorporated Area

Forest Production Zone Area

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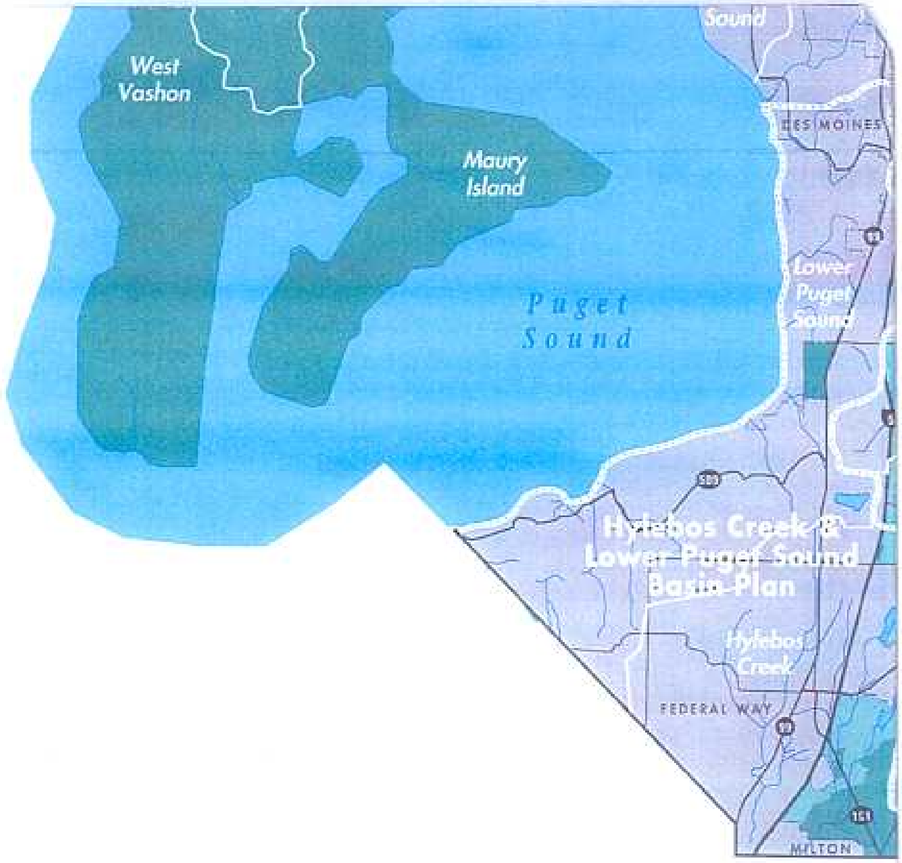
Department of Natural Resources



King County

Flow Control Applications Map

Basin Boundary (thicker line designates areas with published Basin Plans)

Urban Growth Area Boundary

Incorporated Area

Forest Production Zone Area

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