Kelley

DES MOINES CREEK

Regional Capital Improvement Project
Preliminary Design Report

Alternative Analysis
Addendum

Addendum

Des Moines Creek Regional Capital Improvement Project Preliminary Design Report

November 1, 1999

Prepared for

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Executive Summary

The *Des Moines Creek Regional Capital Improvement Projects Preliminary Design Report* presents three alternatives for a Regional Retention/Detention Facility (Regional R/D Facility) to be sited north of South 200th Street at the Tyee Golf Course. After reviewing the *Preliminary Design Report*, the Des Moines Basin Committee recommended the selection of the Alternative 2 design option, provided that the design could demonstrate floodplain areas—"open water areas"—that do not attract more birds of species threatening to airplane flight. The Design Team then analyzed the existing conditions at Northwest Ponds and the Alternative 2 Regional R/D Facility. They found that ***the amount of open water would decrease with the proposed facility for all studied seasons and storm events***. In addition, the recommended mitigation actions would further minimize open water under all conditions, thereby decreasing the attraction of aircraft-threatening wildlife to the proposed R/D Facility.

Introduction

To stabilize the flow regime and reduce the channel erosion rate in Des Moines Creek, the Des Moines Creek Basin Committee recommended, and the affected elected bodies endorsed, implementing a combination of watershed improvements, described in the *1997 Des Moines Creek Basin Plan*. One of the improvements is a Regional Retention/Detention Facility (Regional R/D Facility) to be sited north of South 200th Street at the Tyee Golf Course. The *Des Moines Creek Regional Capital Improvement Projects Preliminary Design Report* discusses and evaluates three impoundment alternatives for the Regional R/D Facility.

After reviewing the *Preliminary Design Report*, the Des Moines Basin Committee recommended the selection of the Alternative 2 design option, with the provision that the design demonstrates floodplain areas—"open water areas"—that do not attract more birds of species threatening to airplane flight.

The concern with wildlife attraction and bird strikes to air traffic was presented during the initial scoping process for the design of the R/D Facility. The extended detention (in excess of 24 hours) of surface water in open ponds required for R/D performance can attract wildlife, particularly bird species such as Canada geese that can pose a threat to aircraft. The Port of Seattle highlighted the issue in a letter dated October 20, 1998:

> The Port has adopted FAA Advisory Circular 150/5200-33, "Hazardous Wildlife Attractants on or Near Airports." These standards apply to stormwater facilities located within 10,000 feet of the airport. In general, the FAA guidance calls for detention structure designs that minimize the area of open surface water and minimize wet soil conditions at the base of the pond that could attract hazardous wildlife. The circular also requires the avoidance of vegetation in and around the detention facility that could potentially provide food or cover for hazardous wildlife. In addition, the Port is requiring that all new stormwater facilities be designed to limit the duration of open water to limit wildlife attraction. The Port is evaluating the allowable duration of standing water in detention ponds. This evaluation requires the use of a continuous simulation model such as HSPF to conduct the statistical analysis. Any portion of the detention pond that retains water would be required to be covered by a net, solid cover, vault, or other permanent structure.

Follow-up correspondence between the Port and CH2M HILL described further the concern for the length of time standing water is present at an R/D facility:

> To minimize the frequency and duration of open water to acceptable levels, water that is detained by the 2-year design storm should completely drain or fall to a level that is covered by a net or solid cover within 24 hours of the end of the storm event. This would minimize hazards associated with wildlife attraction to stormwater detention ponds. (1-20-1999)

On the basis of this information and correspondence with Port of Seattle staff and their consultant, Parametrix, the Project Design Team has analyzed the wildlife attraction hazard of the proposed R/D Facility. In the interest of cost efficiency, and because of the complex nature of the wetland at Northwest Ponds and the hydrologic performance of the Regional

R/D Facility, the analysis of the wildlife attraction issue was delayed until the Basin Committee had chosen a recommended R/D Facility design alternative.

This addendum to the *Preliminary Design Report* analyzes the wildlife attraction issue by examining the open water area of Northwest Ponds under current conditions and the open water area of the Alternative 2 R/D Facility for seasonal flow, annual flow, and 10-year, 25-year, and 100- year return intervals. This report also proposes strategies directly mitigating the attraction of wildlife.

Methods

Bird strikes at Seattle-Tacoma International Airport (STIA) are a concern when open water is present for extended periods, attracting birds that present a threat to aircraft. The Design Team analyzed the occurrence of open water for the full range of water impoundment events, from low flow conditions up to the 100-year return interval. This analysis is based on the Alternative 2 design with additional topographic changes that were not incorporated in the preliminary design: the Cell 3 fill area will not be removed by this project, and Cell 1 and 2 ground surface base elevations have been raised 1 to 2 feet to reduce additional open water.

Three analyses were performed to evaluate the frequency and duration of open water at the Regional R/D Facility in the Northwest Pond wetlands and eastward to the STIA Approach Light Road:

- **Hydrologic Evaluation**: Stormwater flows were analyzed using data from the Hydrological Simulation Program—Fortran (HSPF) models conducted for the *Preliminary Design Report*. Inundation area was determined to compare existing conditions to Alternative 2 for Wet Season, Dry Season, 1-year, 10-year, 25-year, and 100-year flow events. This comparison included pond elevation, surface area, open water area, and duration assessment.

  The hydrologic modeling of current conditions in Des Moines Creek was calibrated to monitoring records of flow at the mouth and on the East Fork upstream of Tyee Pond. In addition, field topography and flood photographs were used to delineate floodplain area. The results were recorded on topographic maps for comparison of the floodplain under existing conditions and the proposed performance of Alternative 2 R/D facility.
- **Typical Water Year**: HSPF hydrographs of conditions at the Regional R/D Facility were analyzed based on a typical water year.
- **Storm Events**: HSPF hydrographs of specific storm events (1-year and 2-year events) were analyzed.

To learn more about other wetlands created next to airports, the Design Engineer and Senior Ecologist on the Design Team also visited the recently-constructed Swanson wetland mitigation site at the Snohomish County Airport (Paine Field.) Paine Field needed to construct a Runway Improvement Project to upgrade the main runway's safety areas and bring them into compliance with FAA regulations. This construction would impact 1.5 acres of open water wetland. Regulatory agencies required that this wetland be replaced in the same watershed. However, all available locations in the watershed were within 10,000 feet of the runway, and the FAA generally does not allow bird-attracting habitat to be constructed this close.

Part of the solution was to build the Swanson wetland mitigation site near the runway. To limit the bird attraction, the amount of open water was limited, and wetland vegetation designed to deter waterfowl use was planted. Although no data from the Swanson site was used in the analysis of the Des Moines Creek R/D Facility, observations of the Swanson facility complemented the information collected on wildlife attraction solutions.

Assumptions

When analyzing the Alternative 2 Regional R/D facility for wildlife attraction, the Design Team made the following assumptions:

- **The results of the Hydrological Simulation Program—Fortran (HSPF) modeling performed for the *Preliminary Design Report* were used** to analyze the impact Alternative 2 would have on wildlife attraction to the area.
- **Cell 3 was eliminated** due to uncertainties in obtaining the property. Also, to reduce additional open water (dead storage) that would attract birds, **the depth of excavation in Cells 1 and 2 was changed** from 243 feet to an average of 244.5 feet. These changes result in about 11% less active storage in Northwest Ponds than was originally modeled.
- **The water surface elevations used in the analysis for various events are taken from the earlier modeling that included Cell 3 excavation and deeper Cells 1 and 2.** However, the tables and figures in this addendum reflect the proposed Regional R/D Facility without Cell 3 and with higher ground surface elevations in Cells 1 and 2. For the purposes of comparing existing floodplain conditions to those proposed under Alternative 2, the approximate 11% change in active storage was not judged significant enough to warrant rerunning the model at this point. The Design Team feels that this effort and cost should be reserved for the final design modeling.
- **The open water area is the only area that is considered a bird attraction.** *Open water areas* include emergent wetland, golf course grass areas, and maintenance areas inundated with water during flood events. Forest and scrub-shrub wetland are not considered open water and thus would not attract wildlife due to the vegetation canopy over the water. By these definitions, the areas of grass and emergent wetland between the Approach Light Road and Northwest Ponds are open water areas when inundated.
- **Scrub-shrub vegetation was assumed to be effective in deterring birds, regardless of the depth of water** (see the open area calculations in Table 1, page 9). In reality, some of the lower 4- to 6-foot tall vegetation near the edge of the open water ponds would be covered when the water depth reaches an elevation of 249 to 251 feet. These water levels would not occur unless the rainstorm event is greater than a 2- to 5-year return period. The Port of Seattle is primarily concerned with the amount and duration of open water below the 2-year event. Farther away from the ponds, the vegetation should eventually be tall enough to be exposed even in a 100-year event.

  The planting list for the facility is not yet complete, but it will be comprised of species that are tolerant of the expected water level fluctuations and that do not attract the more hazardous species of birds which may increase the birdstrike potential—for example, the community will not include fruit-bearing species or those species that provide nesting or roosting habitat for raptors and other large bodied birds. The scrub-shrub community will also discourage water foul, particularly Canada geese, by eliminating the large open areas both within and adjacent to open water. To the extent possible, the community will also mix plant species of varying heights.

In large part, the vegetation chosen for the facility will be dependant upon the fluctuations predicted by the final models. Final decisions on the plant species will be made in consultation with regulatory agencies, the Port of Seattle, and its consultants.

- **Within Northwest Ponds, all excavated areas will be planted with scrub-shrub vegetation** so as not produce additional open water, therefore reducing the attraction of waterfowl.
- **The area between the Approach Light Road and Northwest Ponds will be planted with scrub-shrub vegetation,** as proposed by the Port of Seattle in the *Natural Resources Mitigation Plan for STIA: Master Plan Update Improvements*. However, the figures in this addendum do not show the scrub-shrub vegetation in this area.

Results

Hydrologic Evaluation

Analysis of stormwater flows showed that under Alternative 2:

- Open water area would decrease under all conditions analyzed (see Table 1 and Figures 1 through 9). This would be accomplished by lowering the outlet of Northwest Ponds, making the outlet channel more efficient, and planting the newly excavated areas within Cells 1 and 2 with scrub-shrub vegetation.
- Graphic measurement of the open water that occurs during annual storm events demonstrates a reduction in the open water areas commonly occurring around the perimeter of Northwest Ponds and the adjacent fairways of Tyee Golf Course. Modeling shows that the duration of the 1-year flood event would increase from approximately 12 to 53 hours, however, the total open water area would be reduced by two-thirds.
- Because of the proposed, more restrictive Northwest Ponds outlet control, during 10-year and larger events the water elevation in the ponds will rise 3 to 4 feet, increasing the total area inundated in this section (see Figures 7 through 9). Any new bird attraction hazard will be mitigated by the fact that virtually all of the newly inundated areas will be covered by either existing forest or the proposed scrub-shrub vegetation.
- During the 2-year and smaller events, the water surface elevation in the Northwest Ponds will drop significantly due to the lower, more efficient outlet channel.
- In the excavated areas of Cells 1 and 2 that will be below the new water elevation, the area inundated will expand, but the excavated areas will also be planted with scrub-shrub vegetation to deter bird use (see Figures 1 through 4).
- The frequent flooding on the golf course that currently attracts waterfowl would be eliminated or reduced under all conditions and rainfall events (see Table 1, Figures 3 and 4, and Figures 6 through 9). This will happen because the new channel elevation and gradient will cause the water to drop about one foot.

Table 1
Des Moines Regional R/D
Current and Proposed Inundation Areas and Durations

	Northwest Ponds							
	Innundation Area						Average duration** of rises	
	Current	Proposed	Current	Proposed	Current	Proposed	Current	Proposed
Event	Elevation (ft)		Total Area (acres)		Open Area* (acres)		(Hours)	
1-yr	249.1	245.4	10.3	12.7	7.3	3.3	12	53
10-yr	249.8	253.4	11.7	18.9	7.6	4.0	2.1	4.3
25-yr	249.9	254.0	11.9	21.4	7.6	4.6	2.1	3.0
100-yr	250.1	254.2	12.2	21.9	7.6	4.8	2.0	<1

	Approach Light Road							
	Innundation Area						Average duration** of rises	
	Current	Proposed	Current	Proposed	Current	Proposed	Current	Proposed
Event	Elevation (ft)		Total Area (acres)		Open Area* (acres)		(Hours)	
1-yr	249.1	***	3.0	0.0	3.0	0.0	12	***
10-yr	249.8	248.4	4.1	1.7	4.1	0.0	2.1	4.5
25-yr	249.9	248.9	4.2	2.5	4.2	0.0	2.1	3.2
100-yr	250.1	249.4	4.5	3.2	4.5	0.0	2.0	1.8

	Northwest Ponds and Approach Light Road			
	Current	Proposed	Current	Proposed
Event	Total Area (acres)		Open Area* (acres)	
1-yr	13.3	12.7	10.3	3.3
10-yr	15.9	20.7	11.7	4.0
25-yr	16.1	23.9	11.8	4.6
100-yr	16.8	25.1	12.1	4.8

*Open Area = open water, emergent wetand, grass
(Existing and planned forested and scrub-shrub wetland are not considered open area)

**The duration is the length of time water is at or above the stated elevation

***Flow confined in channel

Assumptions
Current - below Northwest Ponds everything is open
Proposed - below Northwest Ponds outlet will be planted with scrub-shrub vegetation

Proposed - in Northwest Ponds all excavated area will be planted with scrub-shrub vegetation

Figures 1 and 2 show the average wet season (October to March) and average dry season (April to September) inundation areas for both current and proposed conditions. These averages were calculated by using HSPF hourly results to compute monthly averages. The proposed scrub-shrub planting is shown with brown cross-hatching. The cross-hatching going the opposite direction at the outside of the excavated area depicts the planting on the berm and cut side-slopes.

Figure 3 shows the current and proposed 1-year inundated areas based on HSPF modeled water surface elevations. The figure also shows the locations of the cross-sections shown in Figure 5 (Northwest Ponds) and Figure 6 (Approach Light Road Cell impoundment area): these figures have exaggerated vertical scales.

The distinction of "open-water area", area considered a waterfowl attraction, is provided in Figure 4. This graphic when compared to Figure 3, clearly shows the importance of providing vegetative cover in shallow floodplain areas as a deterrent to water fowl attraction. Similar to Figure 3, Figure 4 also demonstrates the reduction in shallow flooding that occurs under existing conditions. These areas are the perimeter of Northwest Ponds and fairways on the west side of Tyee Golf Course.

Figures 7 through 9 display current and proposed inundated areas for 10-year, 25-year, and 100-year events, based on HSPF-modeled water surface elevations.

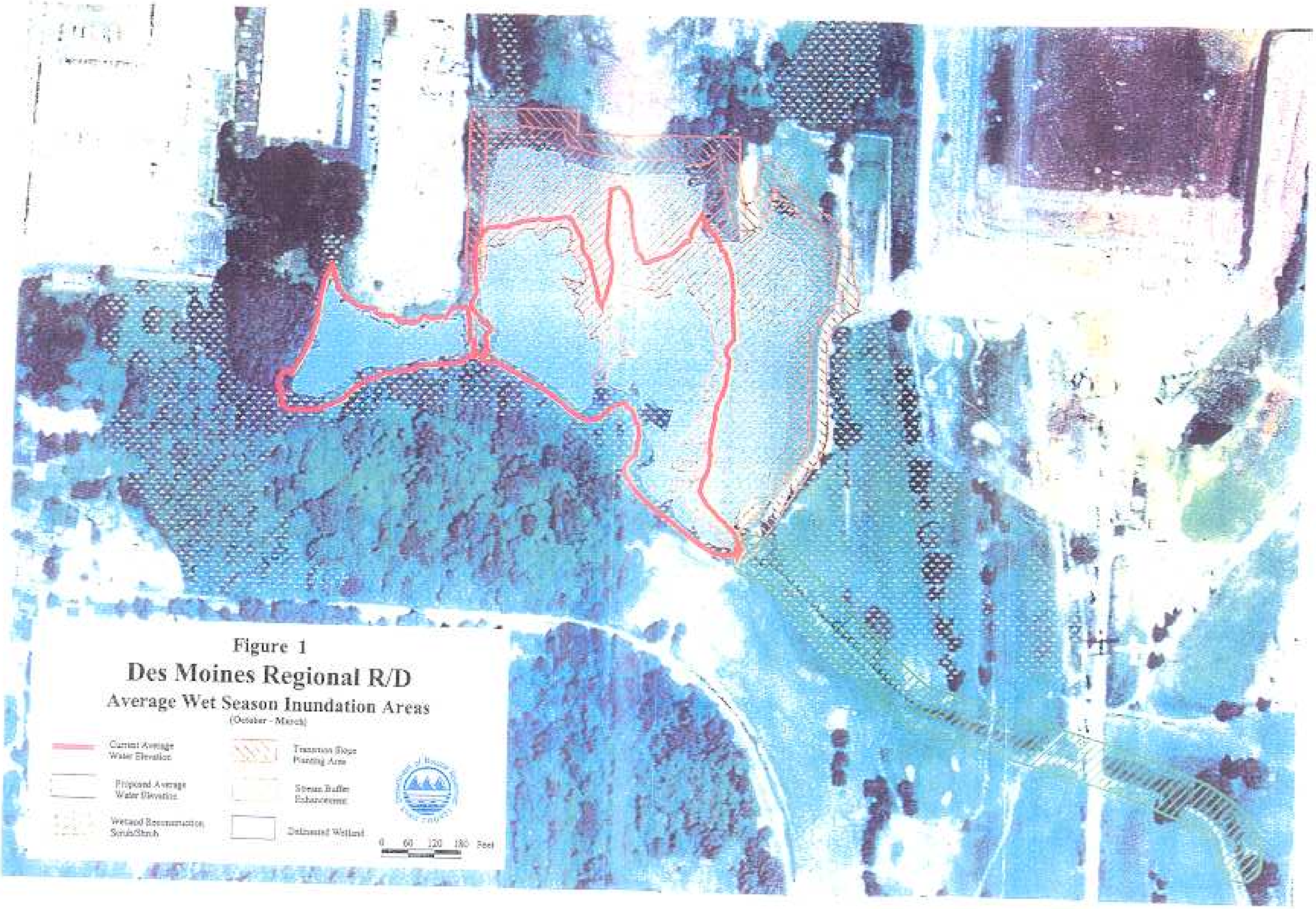


Figure 1

Des Moines Regional R/D

Average Wet Season Inundation Areas

(October - March)

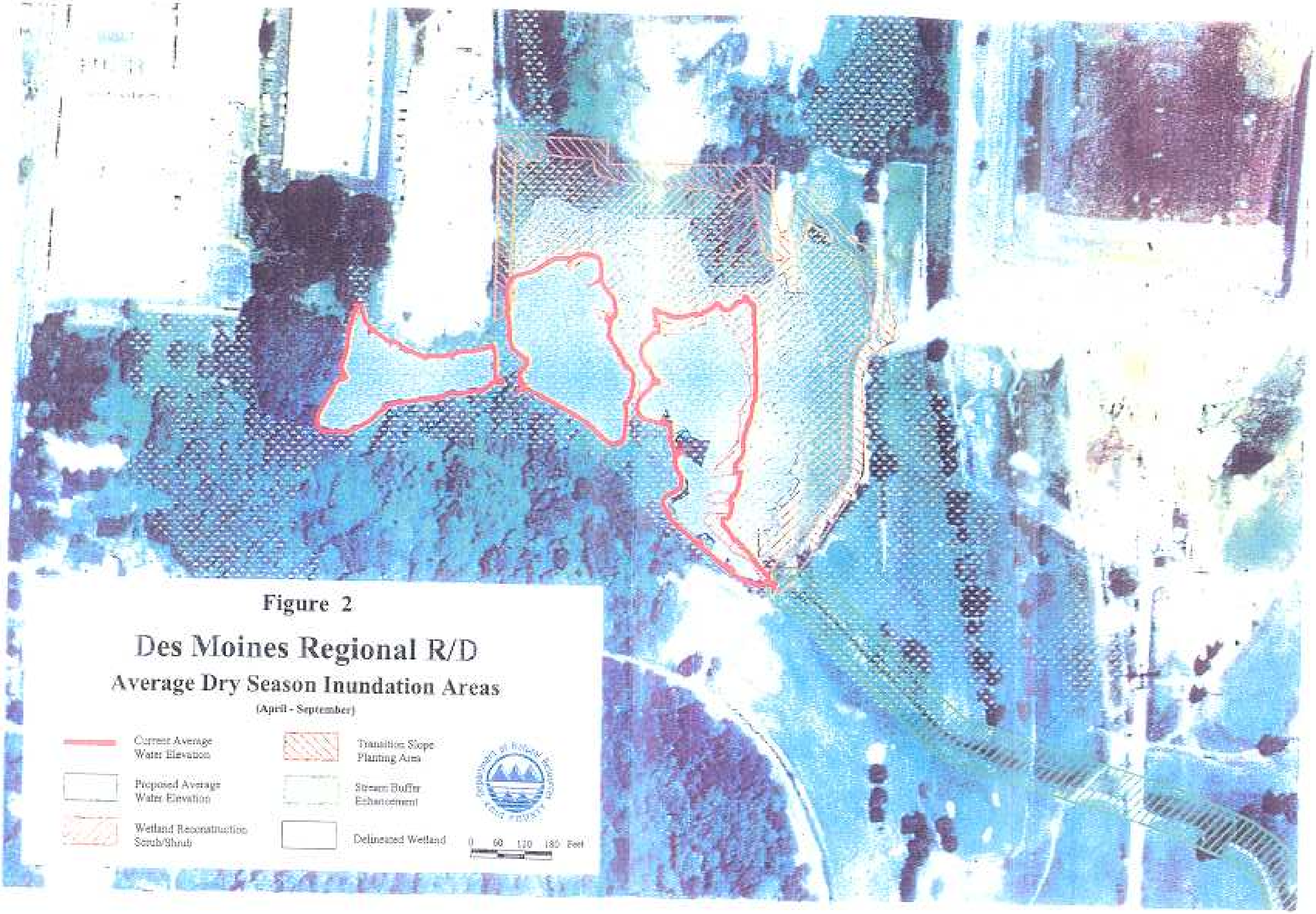


Figure 2

Des Moines Regional R/D

Average Dry Season Inundation Areas

(April - September)

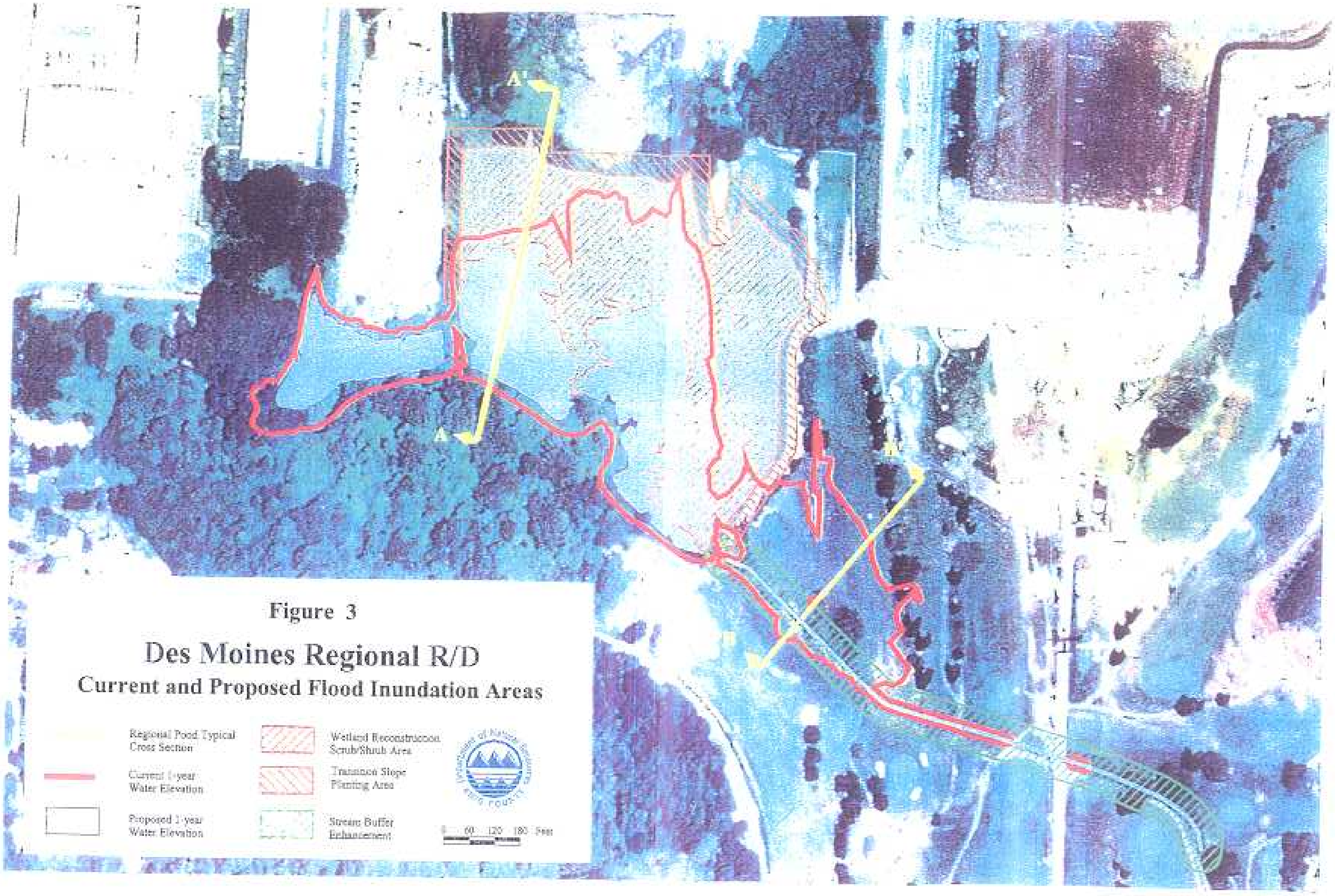


Figure 3

Des Moines Regional R/D

Current and Proposed Flood Inundation Areas

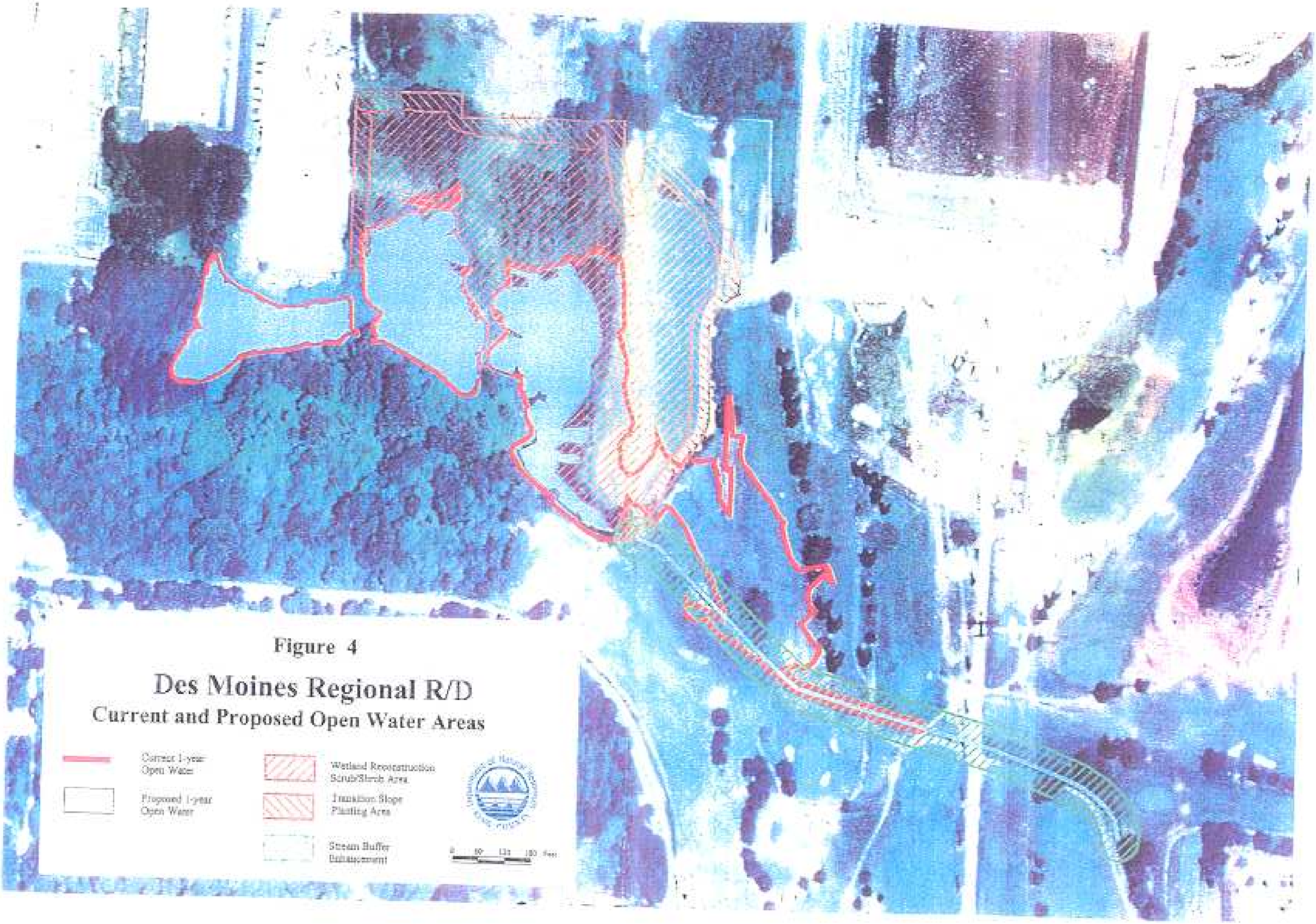
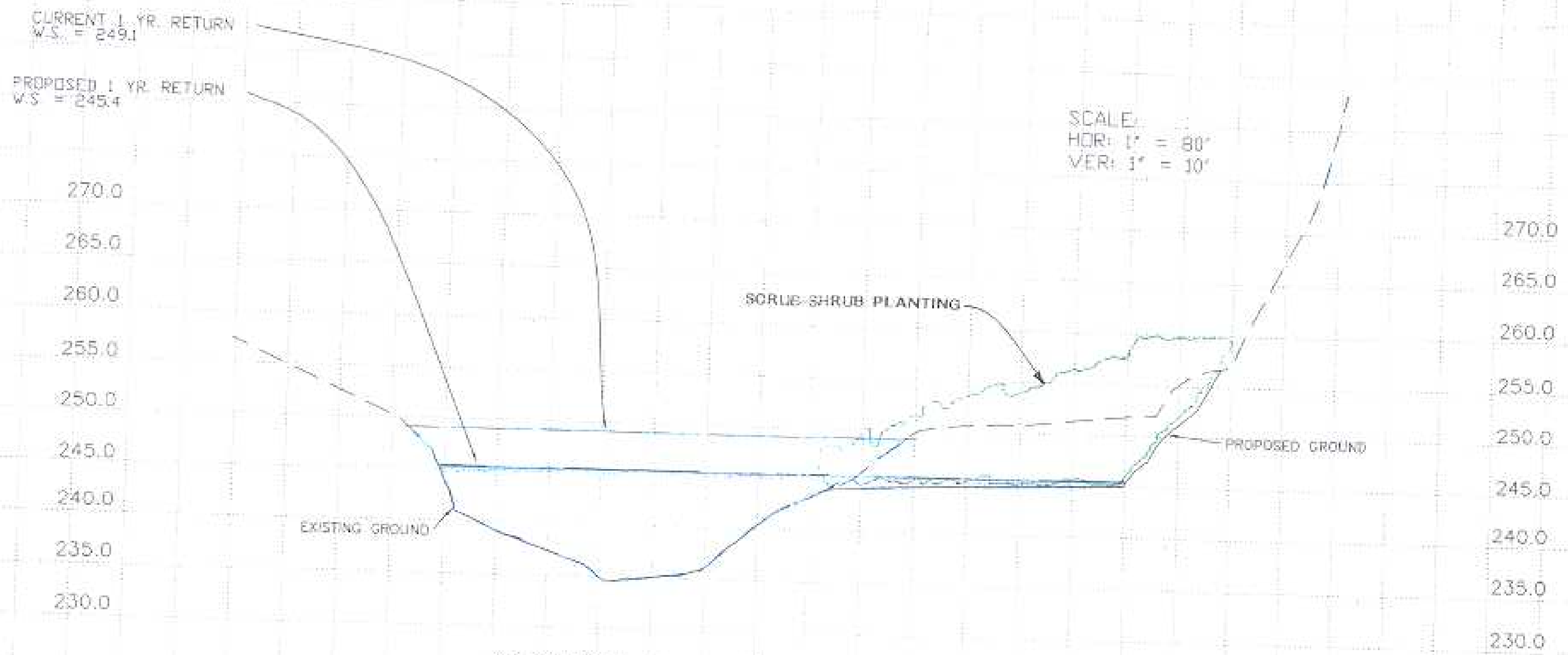


Figure 4

Des Moines Regional R/D

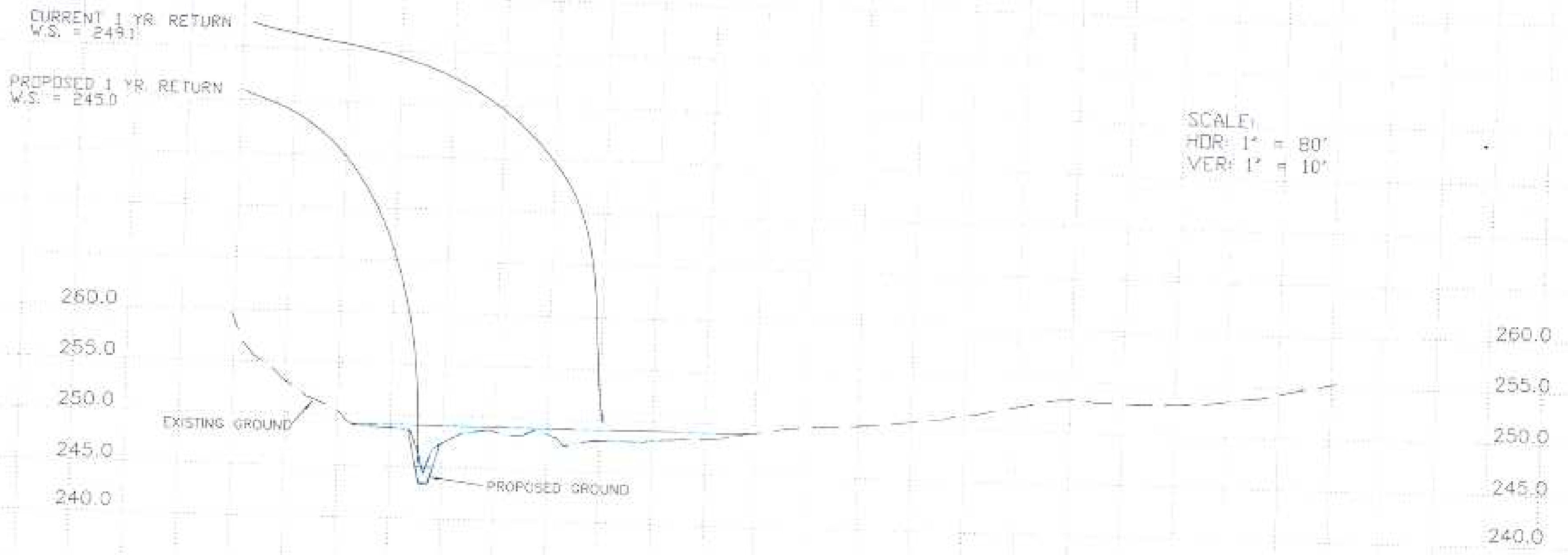
Current and Proposed Open Water Areas

FIGURE 5

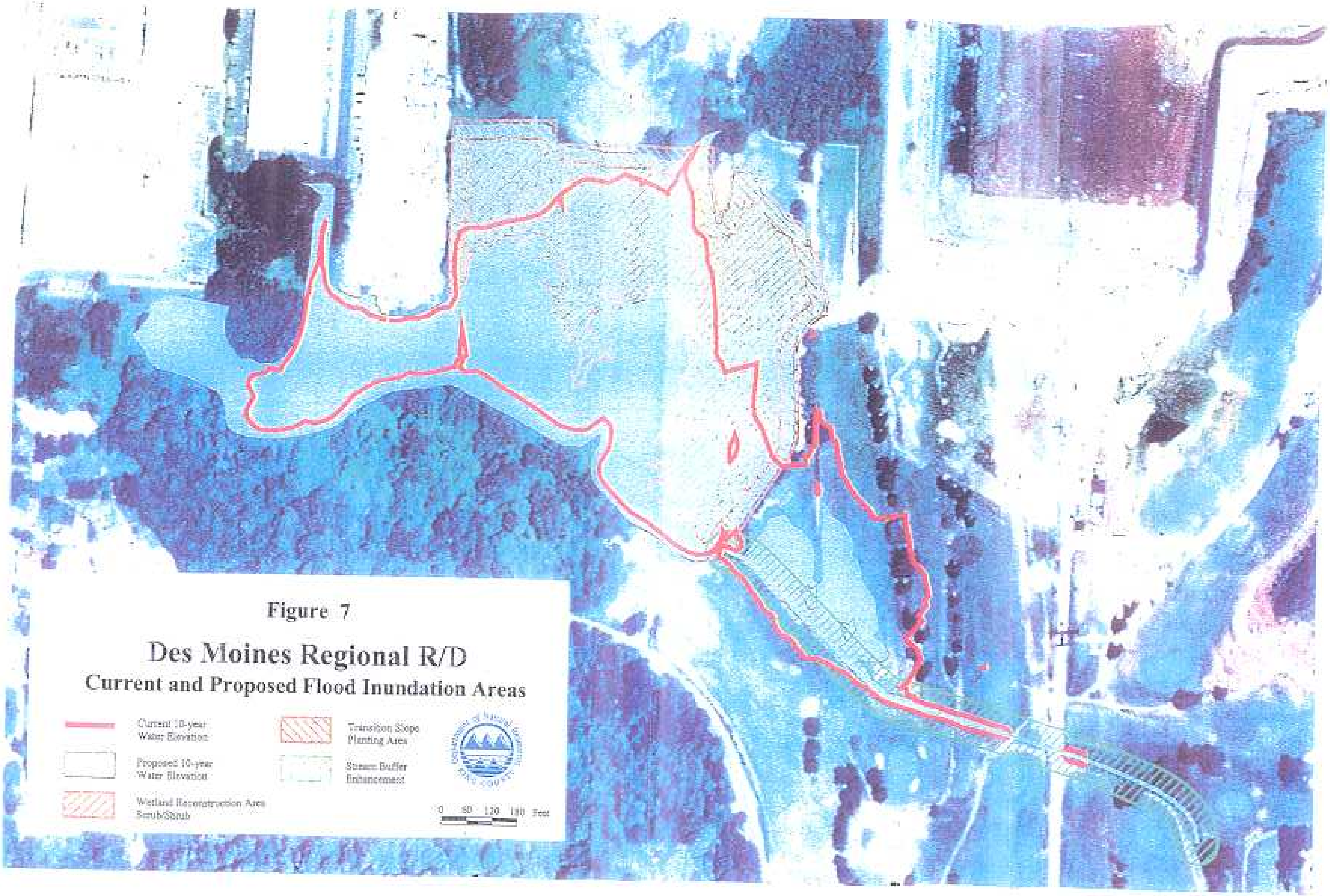


SECTION A – A'
THROUGH NORTHWEST PONDS

FIGURE 6



SECTION B – B'
THROUGH APPROACH LIGHT CELL



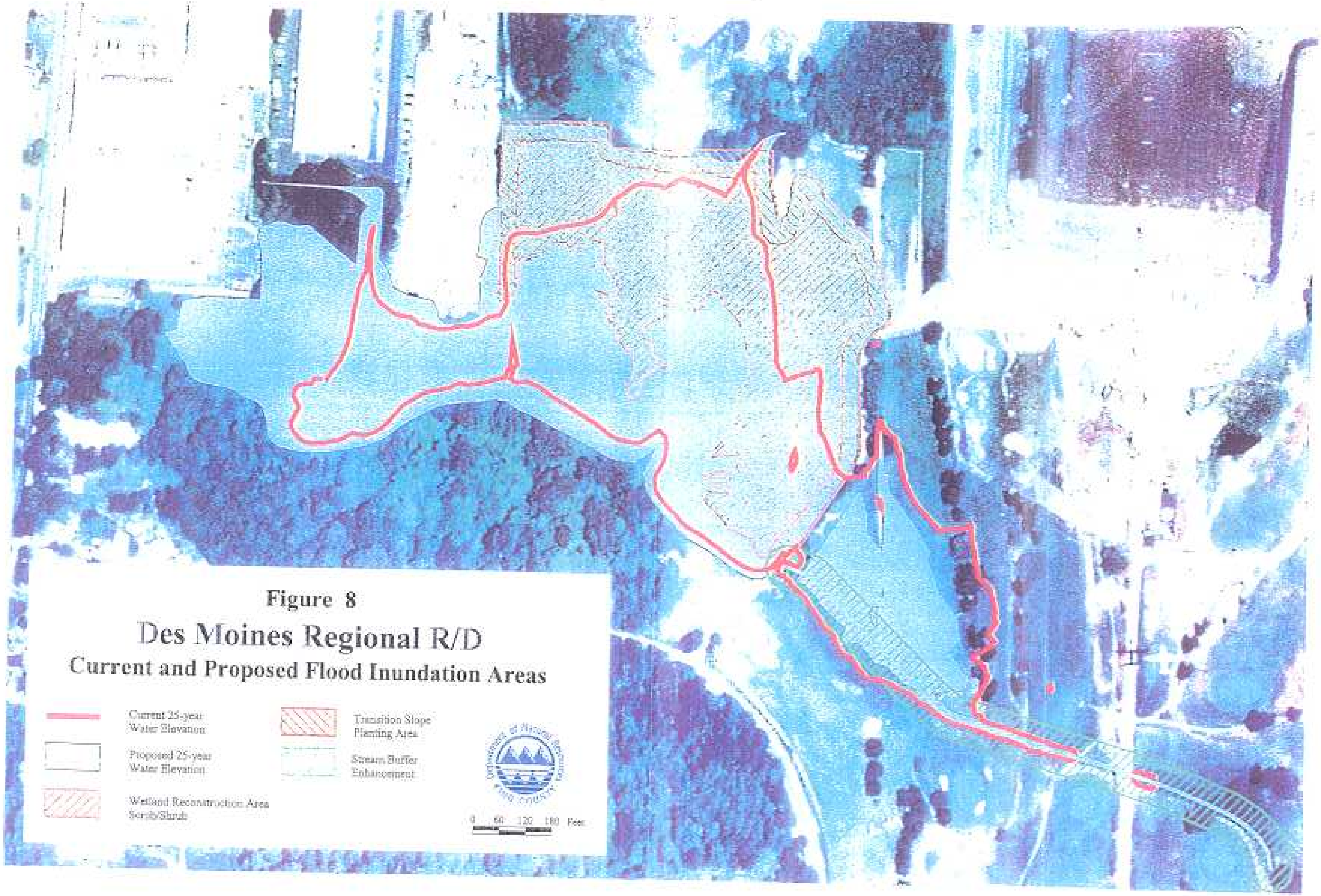


Figure 8

Des Moines Regional R/D

Current and Proposed Flood Inundation Areas

Figure 9

Des Moines Regional R/D

Current and Proposed Flood Inundation Areas

Typical Water Year

For the Alternative 2 R/D Facility, the hydrograph analysis of Northwest Ponds in a typical water year (1995) showed:

- Flows above 10 cubic feet per second (cfs) would be dampened (see Figure 10)
- The water elevation in Northwest Ponds would be lowered as a result of the changes to the outlet of Northwest Ponds and the downstream channel (see Figure 11)
- The open water area would be reduced (see Figure 12).

Figure 10 is an outflow hydrograph for Northwest Ponds in 1995, and Figure 11 is a stage hydrograph for the same typical water year. In Figure 12, an area hydrograph for the same year, the left axis shows the total area inundated, and the right axis shows the open water area. Under proposed conditions, the open water area would be less than current. The proposed open water area does not increase with stage, because all the area it expands into would be covered with existing forest or new scrub-shrub planting.

Figure 10
1995 MEAN DAILY DISCHARGE
NORTHWEST PONDS, TYPICAL WATER YEAR

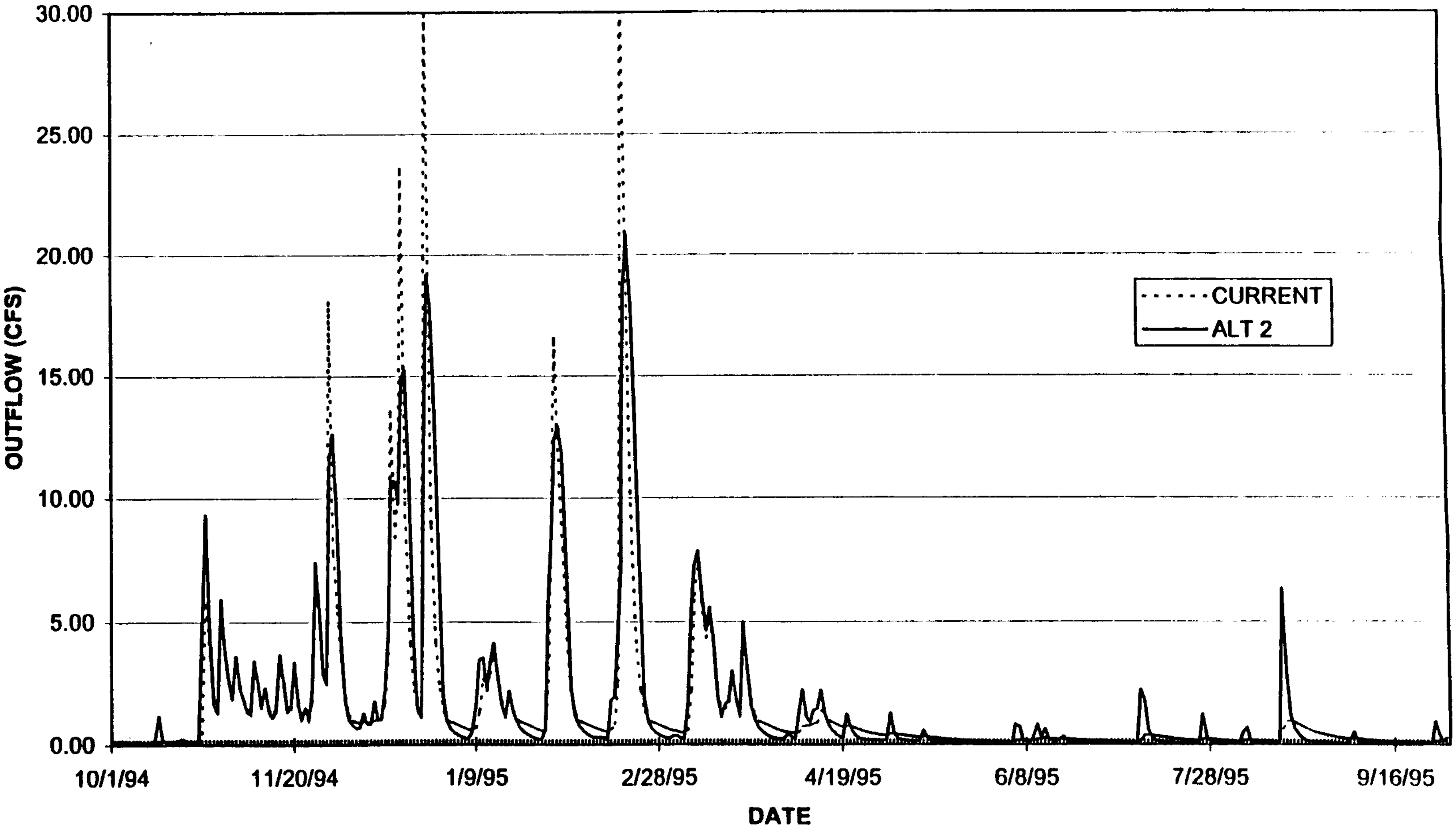


Figure 11
1995 MEAN DAILY WATER SURFACE ELEVATIONS NORTHWEST PONDS, TYPICAL WATER YEAR

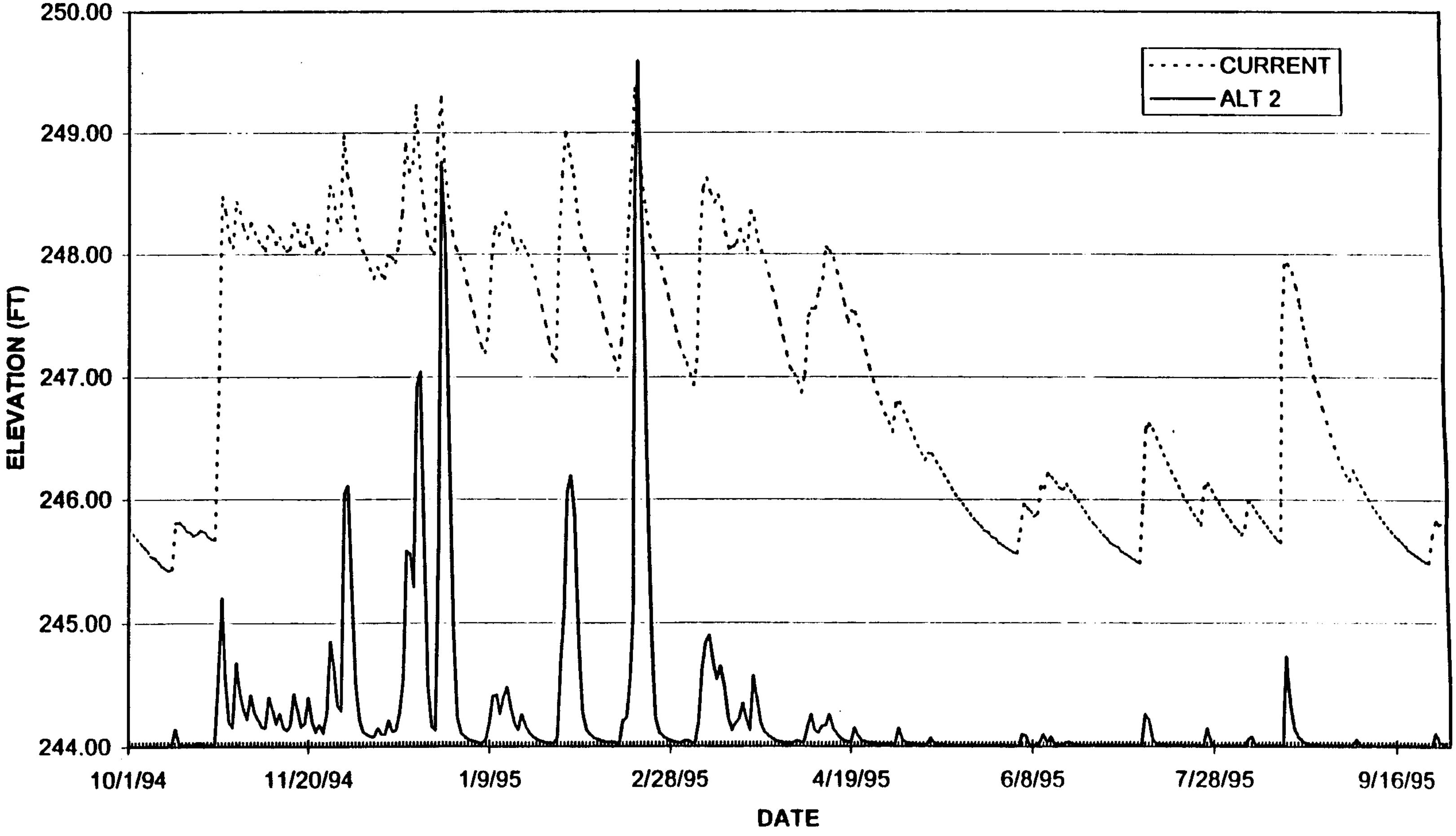
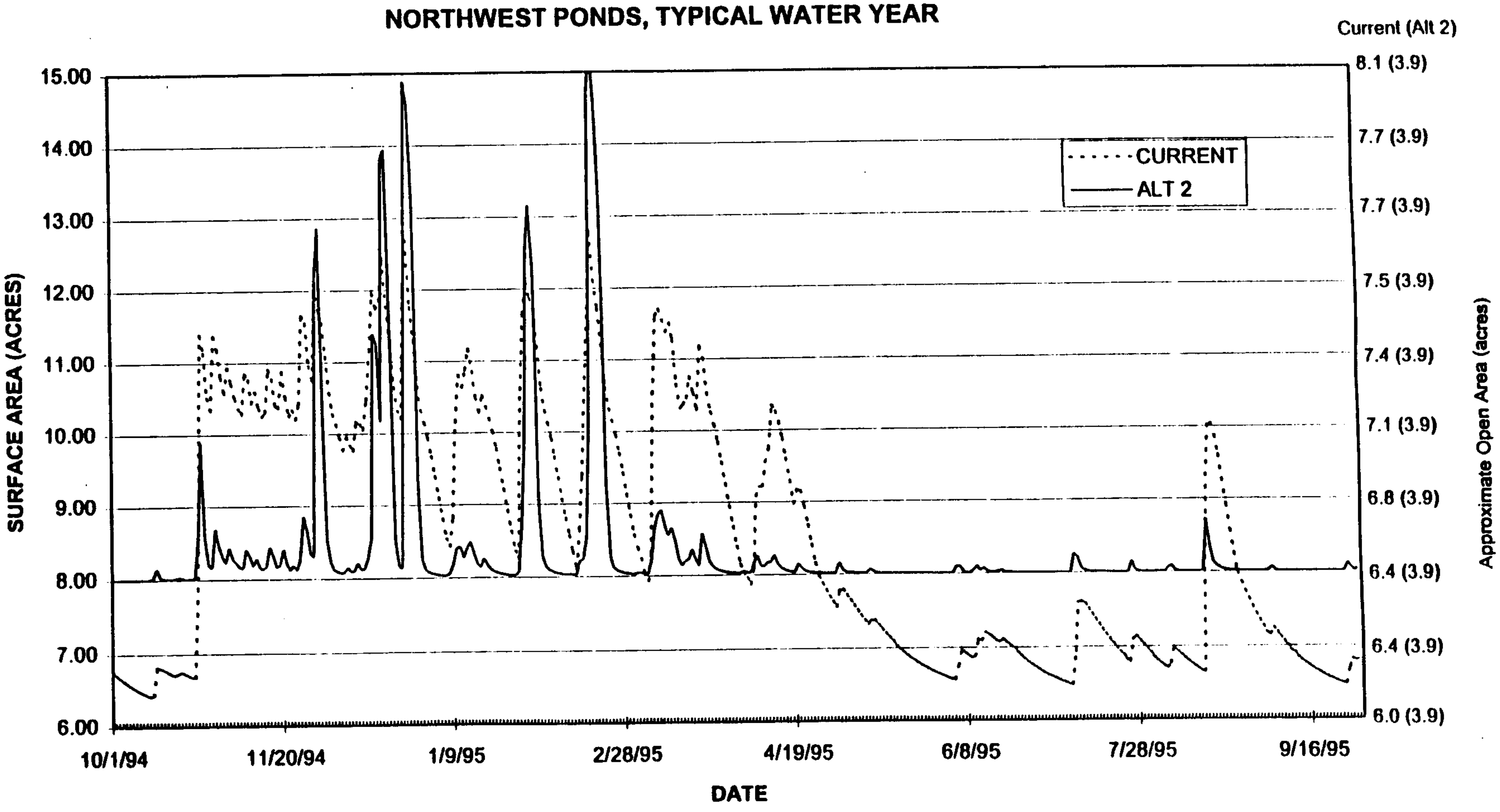


Figure 12

1995 WATER MEAN DAILY SURFACE AREAS
NORTHWEST PONDS, TYPICAL WATER YEAR



Storm Events

The analysis of typical 1- and 2-year storms shows:

- The water elevation and open water areas both decrease under proposed Alternative 2 conditions
- Water level fluctuation is greater as the pond stores water in order to reduce release rates downstream in Des Moines Creek.

Figure 13 is an HSPF-simulated stage graph for current and proposed conditions at Northwest Ponds for an approximately 1-year storm event in 1952. The approximate open water area at each foot of stage was added to the right axis of the graph. Figure 14 is a similar stage graph for an approximately 2-year storm event in 1965.

Figure 13
STAGE-AREA GRAPH FOR 1.01-YEAR EVENT AT NORTHWEST PONDS

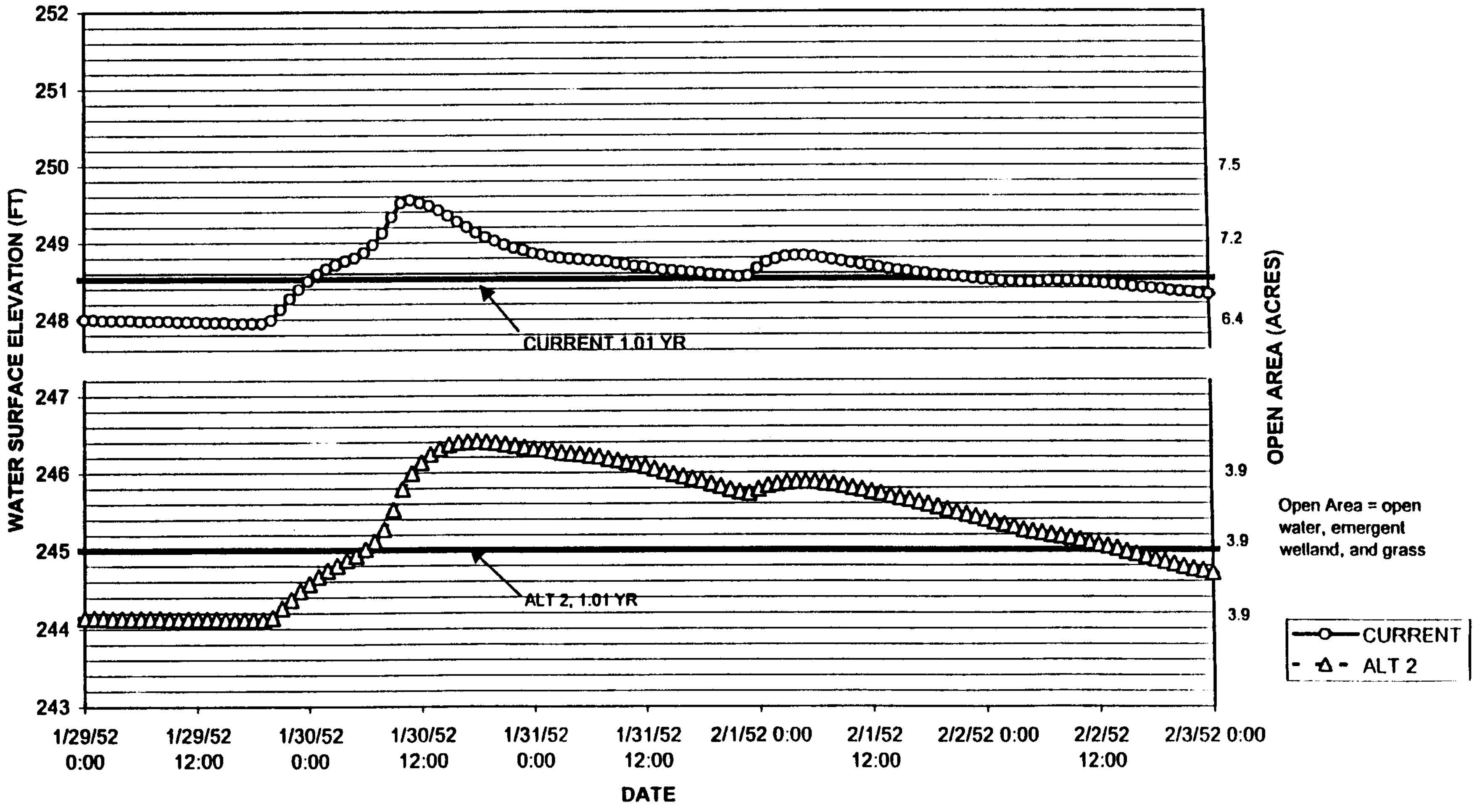
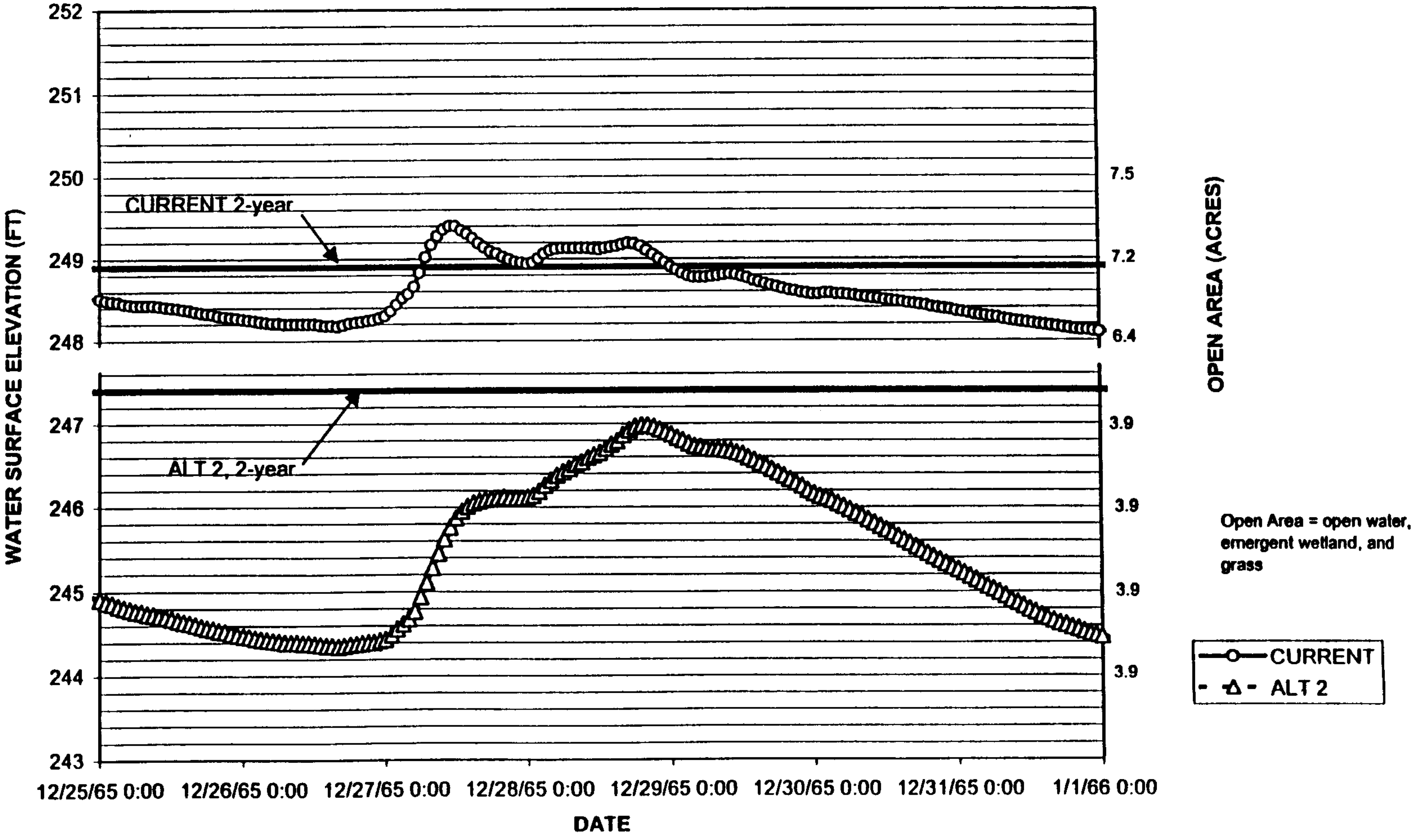


Figure 14
STAGE-AREA GRAPH FOR 2-YEAR EVENT AT NORTHWEST PONDS



Swanson Site Observations

Currently, about one year after site construction, the vegetation at the Swanson wetland mitigation site near Paine Field still needs to grow more before it becomes thick enough to cover the periodic open water. In the interim someone visits the site daily to scare away the waterfowl. The Swanson site also has very rocky glacial outwash soils, which are not particularly conducive to the growth of wetland plants.

At the Des Moines Creek R/D Facility site we plan to plant more densely than the Swanson site, so it should not take so long for the vegetation to be dense enough to deter waterfowl. The Sea-Tac site also has excellent organic soils that are expected to support healthy wetland plant growth. However, until the vegetation matures enough to cover the area sufficiently, the area excavated in Cells 1 and 2 would require nets or a regular wildlife deterrence program.

Conclusions

Although the total area inundated will be greater, the open water that would attract birds will be reduced, because much of the new areas that would be inundated will be planted with scrub-shrub vegetation to deter bird use. The frequent flooding on the golf course (see Figure 15) that currently attracts waterfowl will not occur until about the 10-year storm, and even then it will be much smaller than the current flooding.

Of course, it would take some time for the vegetation to mature enough to cover the area sufficiently. In the interim, the area excavated in Cells 1 and 2 would either need to be covered with nets, or have a regular wildlife deterrence program implemented. In addition, the plants will need some time to become established before they are subjected to frequent fluctuations. This could be accommodated by not diverting flows from the East Fork into Northwest Ponds and having less restrictive outlet controls for the first year or two.

Recommendations

After additional performance review of the Alternative 2 R/D Facility, the Design Team identified the following design changes that would address the wildlife attraction concern:

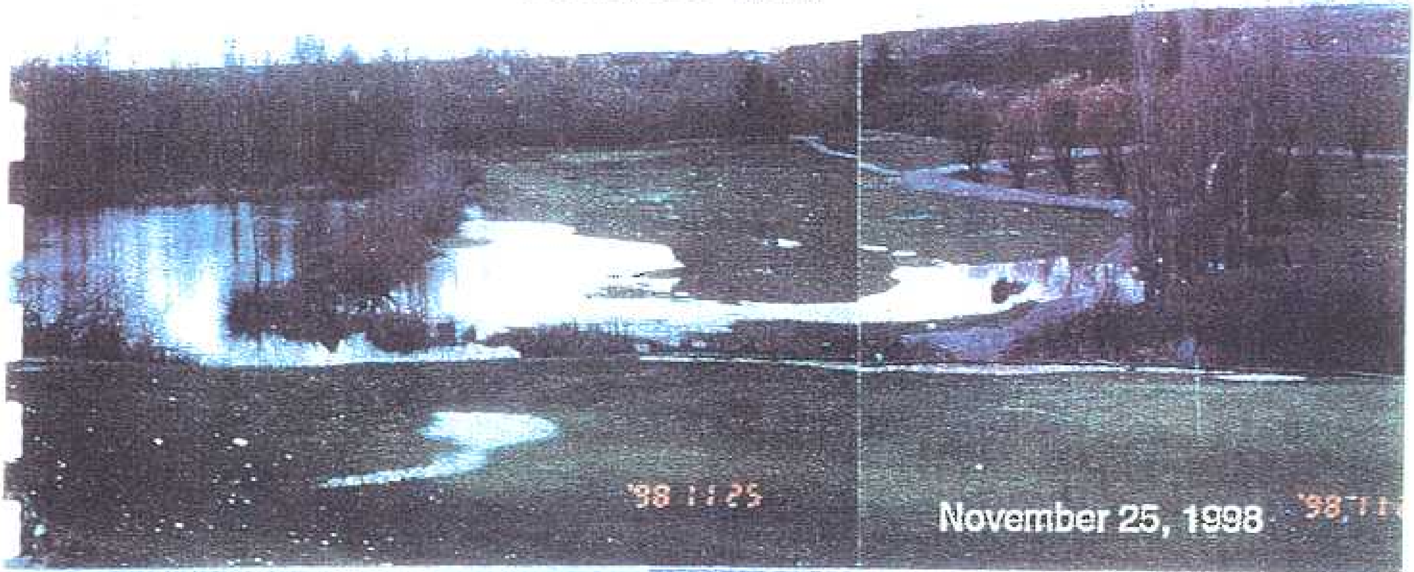
- **Raise the base elevation of the excavated Cells 1 and 2 to a mean elevation of 244.5 feet.** The previous design elevation proposed was 243 feet, which would create at least one foot of dead storage in the newly constructed area.
- **Reconstruct the outlet stream from Northwest Ponds downstream to 200th Street,** thus lowering the stream channel and increasing its conveyance capacity. This, along with construction of Berm A, will eliminate the commonly occurring winter open water. (See Figure 15 for the typical winter flooding and Figure 3 for the annual floodplain).
- **Plant a scrub-shrub vegetation community** in the excavated areas of Cells 1 and 2 and in the Approach Light Road impoundment area to deter threatening bird species.
- **Modify the outflow restrictor at Northwest Ponds during summer low flow conditions.** Manual adjustment of the outlet restrictor at Northwest Ponds to less restrictive settings will reduce the open water area occurring during summer rain events (this adjustment was not included in the HSPF model or in the figures).

The lowering of the outlet of the Northwest Ponds from 245 to 244 feet, the improved conveyance system of the outlet channel, and the scrub-shrub planting in the Northwest Ponds area would reduce the summer low flow open water area by 1.6 acres (see Figure 2). If the summer outlet is enlarged enough to drop the water surface elevation to the 244-foot invert, the open water would be reduced by 2.5 acres.

These actions will impact the hydrologic performance of the R/D Facility due to an approximately 11 percent reduction in the available live storage. During the final design modeling, a decision will need to be made about how to divide the impact of the lost storage potential between lower reduction of flows in Des Moines Creek, and greater water fluctuations in Northwest Ponds.

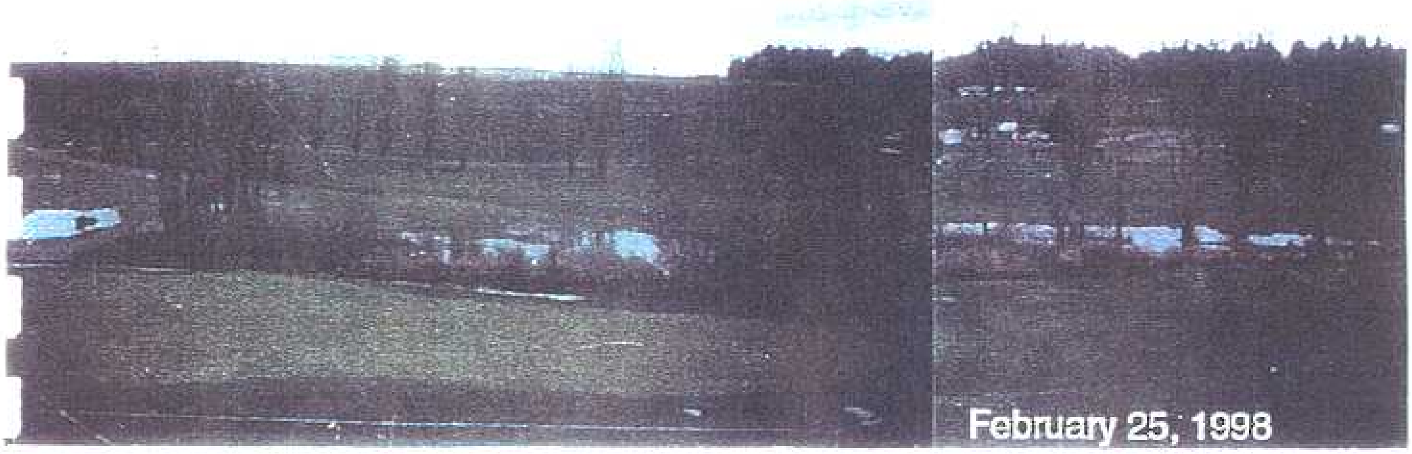
Tyee Golf Course
-WINTER FLOOD EVENTS-

Figure 15



November 25, 1998

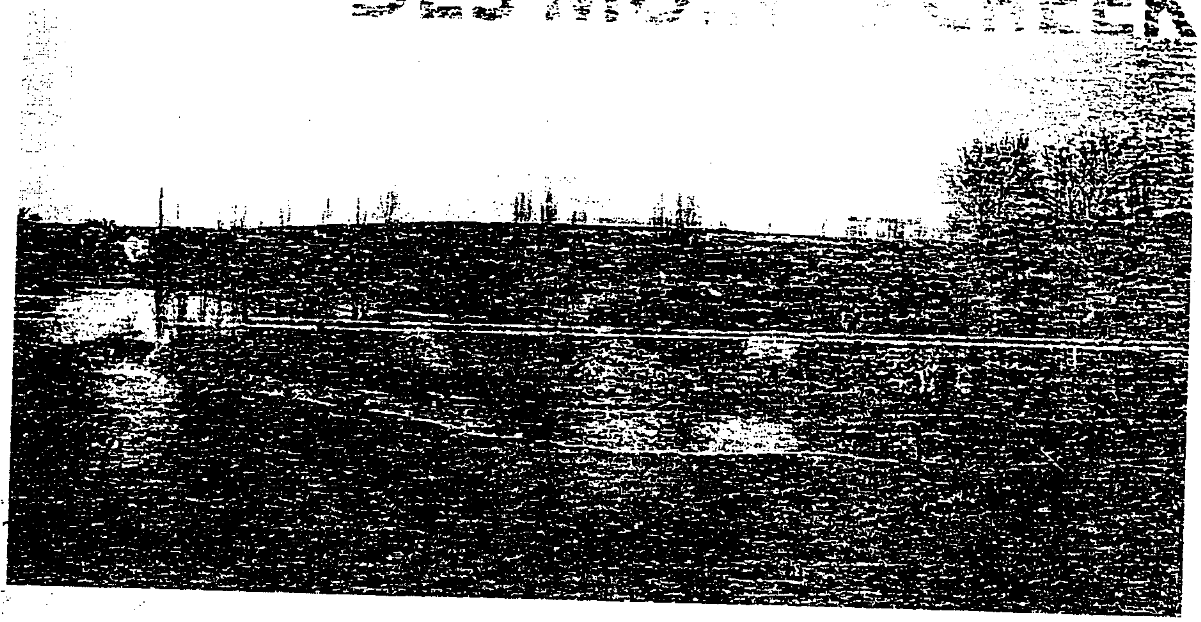
March 1, 1998



February 25, 1998

Kelley

DES MOINES CREEK



Regional Capital Improvement Project
Preliminary Design Report

Alternative Analysis

DES MOINES CREEK REGIONAL CIP PRELIMINARY DESIGN REPORT

Appendix A
Hydrologic Modeling

Appendix A

Appendix_. Hydrologic Modeling, Analysis and Assessment

Introduction

A continuous, hourly, hydrologic simulation model of the Des Moines Creek Basin provided the primary means for comparing the effectiveness of the design alternatives described in this report. This was the only type of model capable of synthesizing long term, continuous records of stream flow and wetland levels necessary to quantify both the downstream restoration potential and upstream environmental impacts of each design alternative.

Model Background

The hydrologic model selected for this study was a modified version of the HSPF model (King County, 1997) utilized and documented in the Des Moines Creek Basin Plan. This model was selected for application in this study because of the its suitability, efficiency, and continuity with previous work. We judged the model suitable because of its ability to realistically represent the design alternatives, relevant basin physical characteristics (soils, cover, drainage, etc.) and to generate stream flows and wetland levels in response to decades-long records of precipitation data. Use of model was efficient because it had been developed, calibrated, and tested in earlier studies thus obviating the large effort necessary to construct and test a new model. Finally, this model was also favored because it had been used in previous studies of the basin such as the Des Moines Creek Basin Plan and had achieved a substantial level of credibility among both technical and non-technical basin stakeholders.

Only a few adjustments were made to the Basin Plan HSPF model of current basin conditions for purposes of this study. These included the following:

1. Incorporation of bathymetric data to improve the model's representation of Northwest Ponds water storage.
2. Use of recent topographic data in Tyee Valley Golf course to more realistically represent culvert inverts water surface elevations.
3. Use of flow monitoring data and hydraulic analysis to improve the accuracy of flow routing and wetland levels on the west branch of the creek.

For a more detailed description of the model, the reader is referred to the Des Moines Creek Basin Plan (1997).

Model Application

The range of applications of the calibrated Des Moines Creek basin HSPF model are practically limitless. The model is in effect a mathematical stream flow and wetland water level generator that only requires rainfall and pan evaporation data to synthesize continuous water levels and hydrographs at any location in the schematized drainage network. Additionally, the availability of the long term rainfall record at Seatac airport (hourly rainfall amounts from October, 1948 to present) allows the simulation of corresponding long-term water level and flow records from which descriptive hydrologic statistics may be easily extracted. In general, application of the model involves four steps; identification of locations where flow data are required, definition of basin conditions or scenarios to be investigated, model operation on each scenario, and analysis in which flow statistics are extracted discussed and compared.

Key Flow Points

For this report, the key locations of interest were the mainstem of Des Moines Creek at the upstream end of the ravine, and the Northwest Ponds wetland. As discussed in the basin plan, flow characteristics at the head of the ravine are largely responsible for the most serious flow-related problems that occur in the mainstem downstream of this location: channel erosion, instability, and gravel scour. Therefore, this site was chosen as the location that best characterizes the effectiveness of each design alternative in restoring stable flows. The Northwest Ponds wetland represents the location of the most sensitive regulatory issues associated with the design alternatives- alteration of existing wetland hydroperiods with their related biotic impacts and potential aggravation of pooled water conditions that affect risks to aircraft from bird strikes.

Modeling Scenarios

Five scenarios were simulated for comparison purposes: Historical Forested Conditions, Current Conditions, and the three restoration project alternatives- Alt. 1, Alt. 2, and Alt. 3.

Historical Forested Conditions- The forest scenario estimates hydrologic conditions prior to any significant land disturbance. This is approximated by replacing all grass and impervious surfaces by hydrologically mature coniferous forest cover in the model. Also, major drainage structures such as Tyee Pond and the Marine View Drive culvert are removed from the modeled drainage network. Forest condition flows at the head of the ravine provide a reference level defining the maximum, upper limit to flow regime restoration.

Current Conditions- The current scenario incorporates land use as assayed by satellite images, air photos, and field visits. All major drainage structures such as lakes, and large ponds, are represented in the model.

Alt. 1 assumes the same land use as Current Conditions but includes a new diversion pipe connecting Tyee Pond to Northwest Ponds, a bypass pipe from Northwest Ponds to Puget Sound, enhancement of active detention storage at Northwest Ponds, and hydraulic conveyance improvement between Northwest Ponds and the confluence west and east branches of the creek.

Alt. 2 is the same as Alt. 1 except that the bypass pipe to Puget Sound begins at Tyee Pond instead of Northwest Ponds.

Alt. 3 raises a berm at the Approach Light Road and merges storage behind the berm with Northwest Ponds storage into a single pond during high flows. The bypass pipe connects the Approach Light Road to Puget Sound.

For more details describing each Alternative Scenario, please see section IV.

Model Operations
Long term hydrologic simulations of each scenario were carried out utilizing 50 years of hourly precipitation data spanning water years 1949 through 1998 from National Weather Service database for Seatac Airport. The NWS Seatac record is considered a valid for basin hydrologic analysis within the western portion of King County and is certainly appropriate for the Des Moines Creek basin given the proximity of the NWS site to the basin.

For a discussion of model results, see the Des Moines Creek Regional Capital Improvement Project Preliminary Design Report, April 1999.

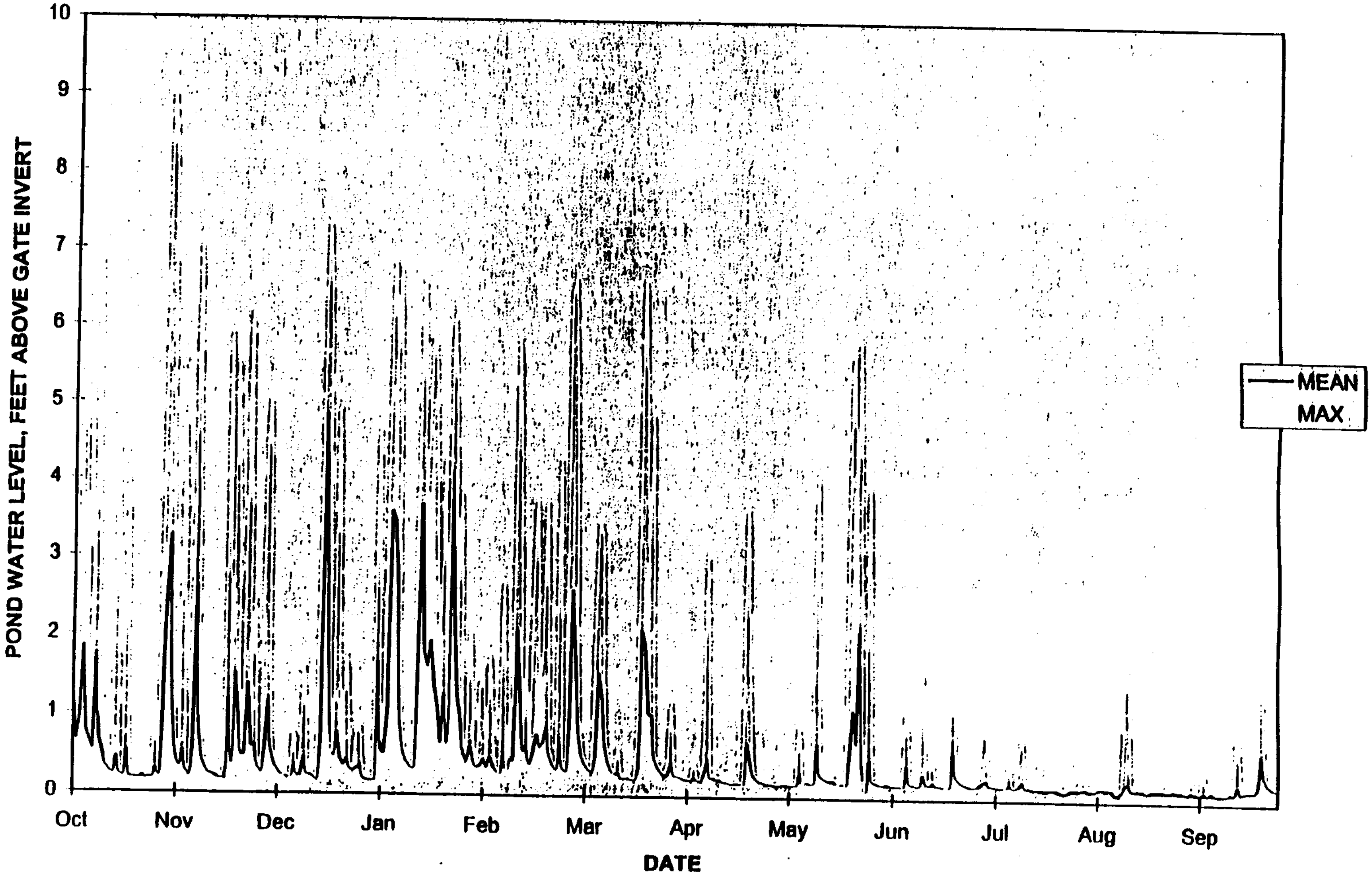
Appendix B

DES MOINES CREEK REGIONAL CIP PRELIMINARY DESIGN REPORT

Appendix B

Hydrologic Monitoring

GAGE 11B - DES MOINES CREEK AT TYEE POND Water Year 1998
OCTOBER 1997 - SEPTEMBER 1998
Mean Daily Water Level and Maximum Daily Water Level



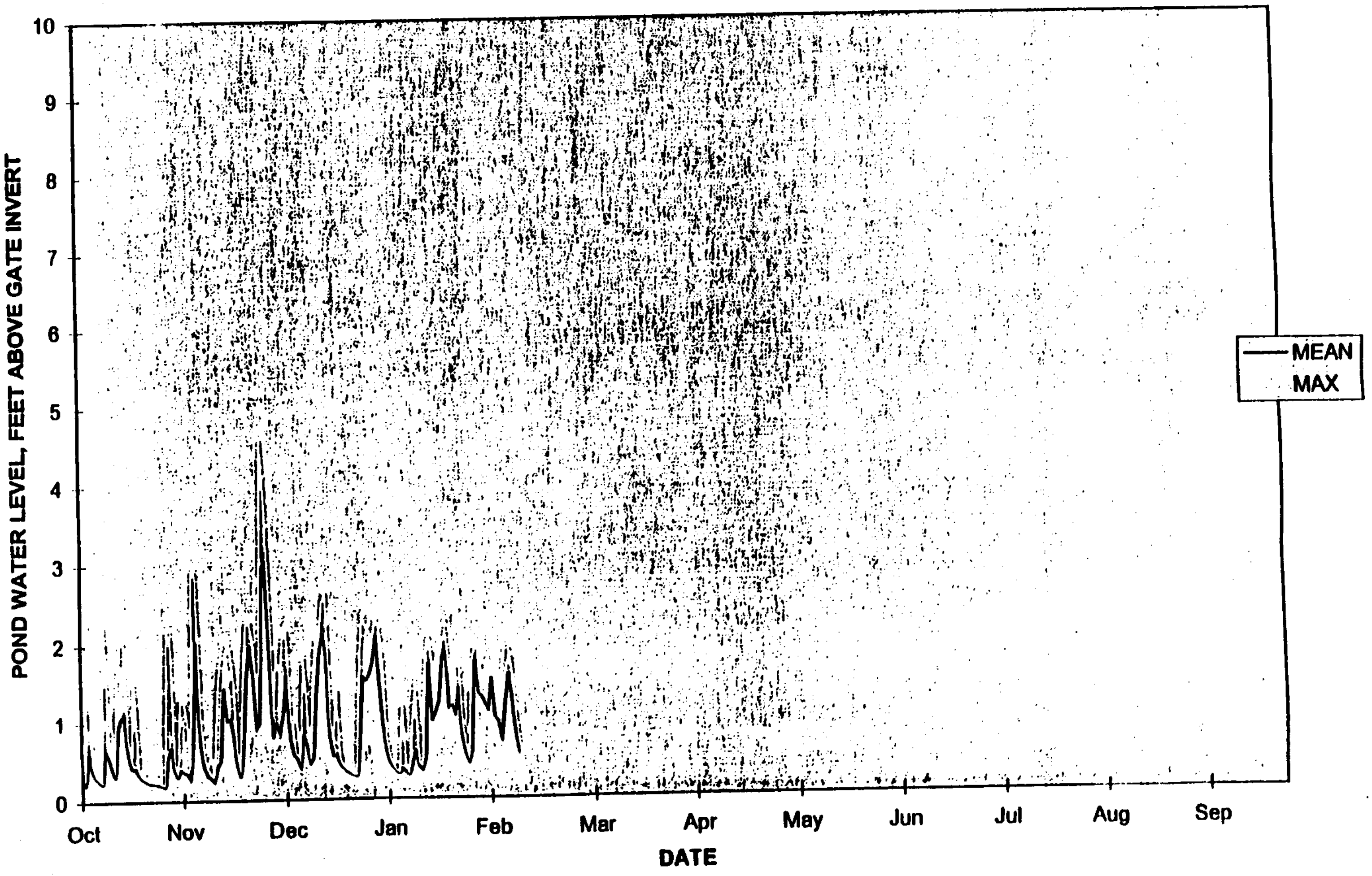
4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11b98STG.xls

KING COUNTY WLRD STREAM GAUGING REPORT

GAGE 11B - DES MOINES CREEK AT TYEE POND Water Year 1999
OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Water Level and Maximum Daily Water Level

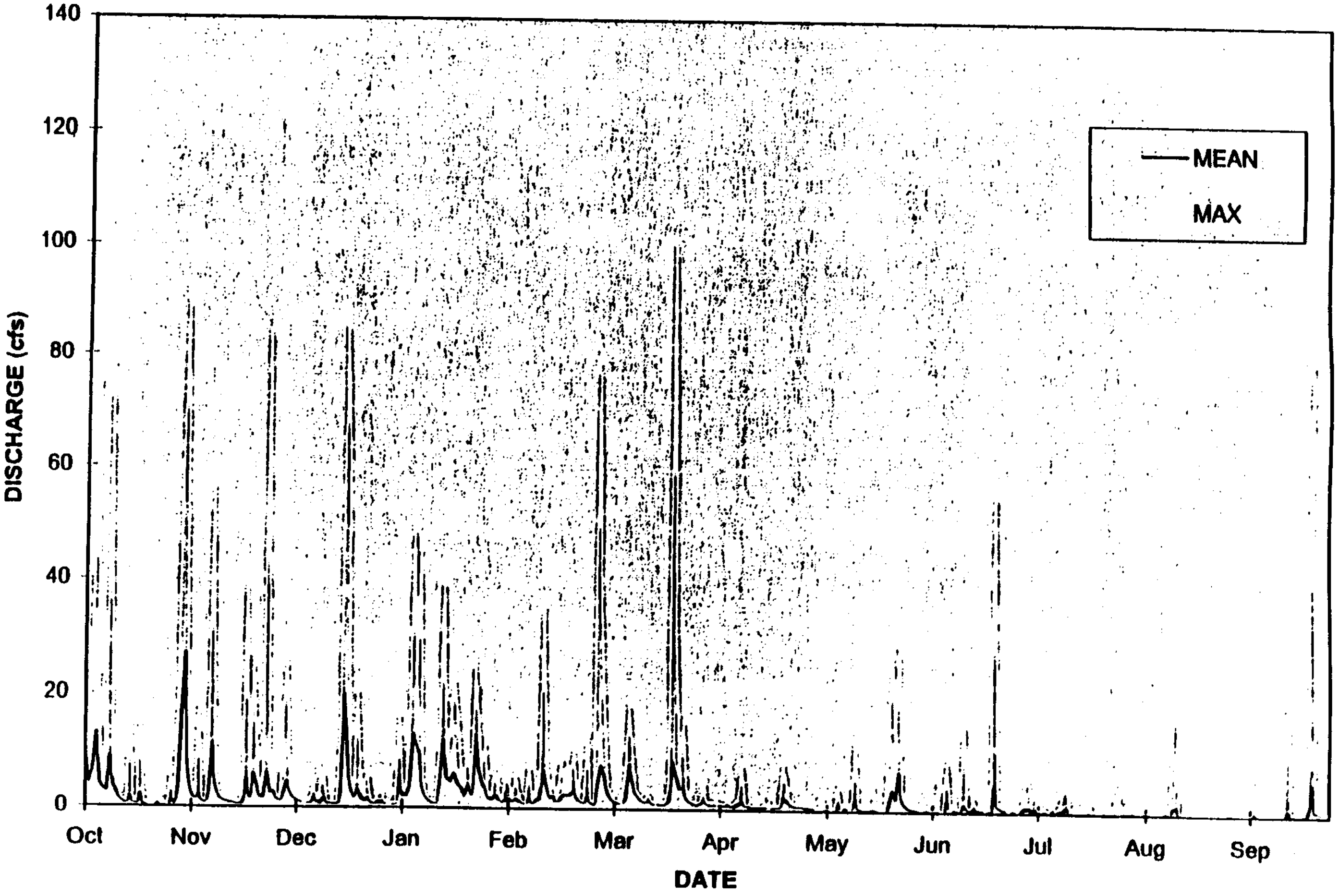


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11b9[illegible]G.xls

GAGE 11C - DES MOINES CREEK ABOVE TYEE POND
Water Year 1998 OCTOBER 1997 - SEPTEMBER 1998
Mean Daily Discharge and Maximum Daily Discharge



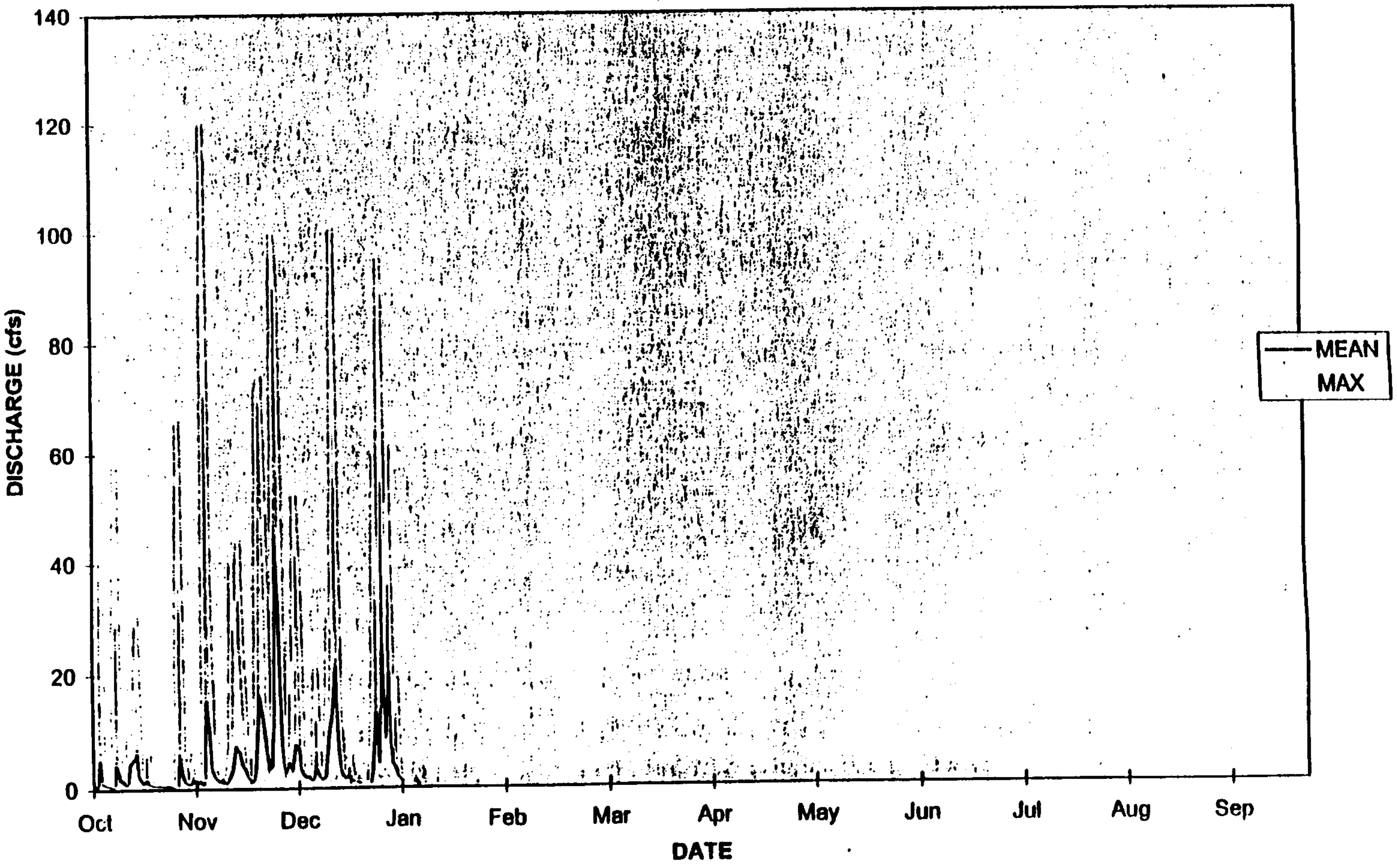
4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11C98.xls

KING COUNTY WLRD STREAM GAUGING REPORT

GAGE 11C - DES MOINES CREEK ABOVE TYEE POND
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Discharge and Maximum Daily Discharge

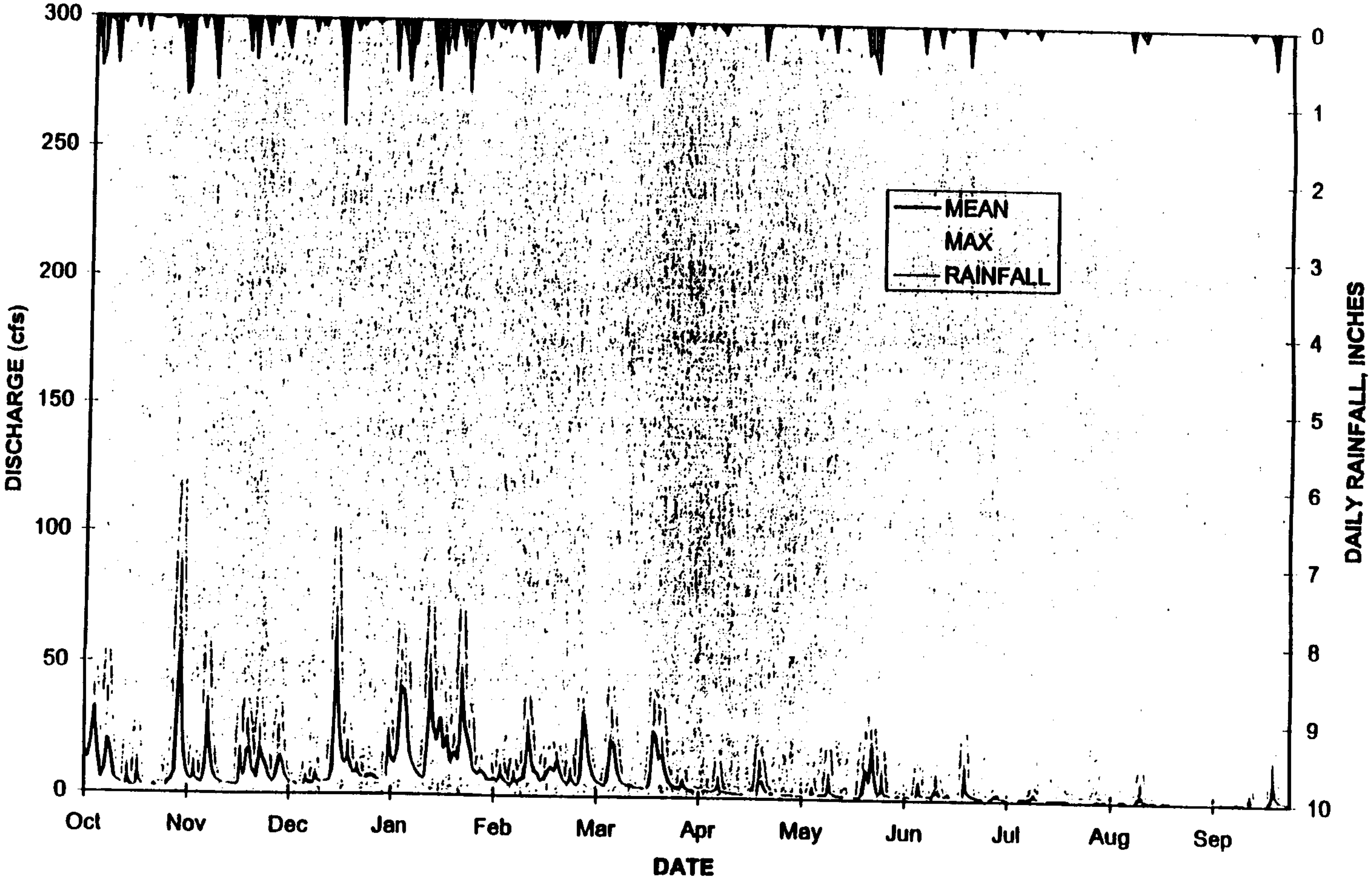


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: None. 1[illegible]99.xls

GAGE 11D - DES MOINES CREEK AT MOUTH
Water Year 1998 OCTOBER 1997 - SEPTEMBER 1998
Mean Daily Discharge and Maximum Daily Discharge



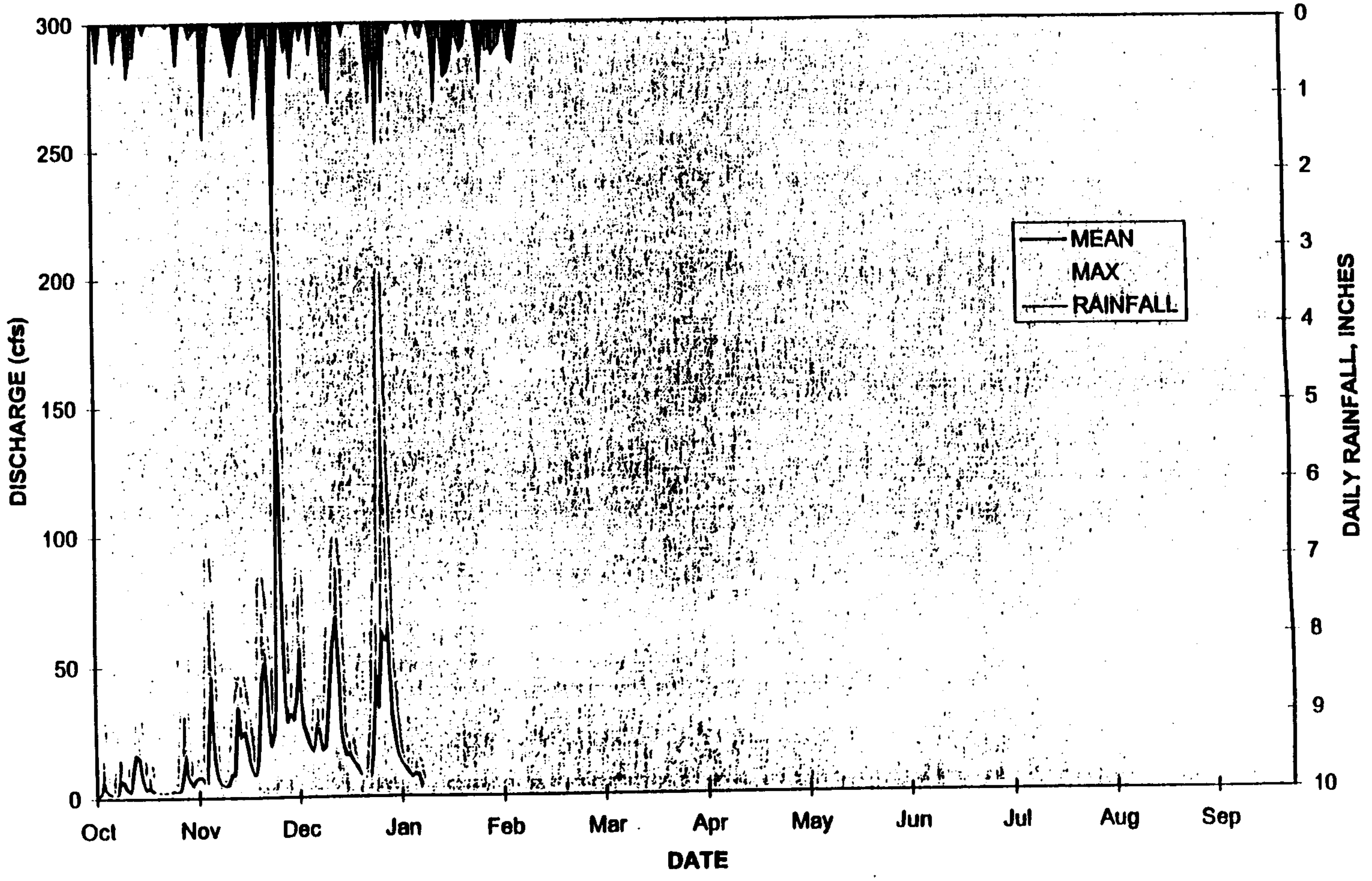
4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11D98.xls

KING COUNTY WLRD STREAM GAUGING REPORT

GAGE 11D - DES MOINES CREEK AT MOUTH
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Discharge and Maximum Daily Discharge

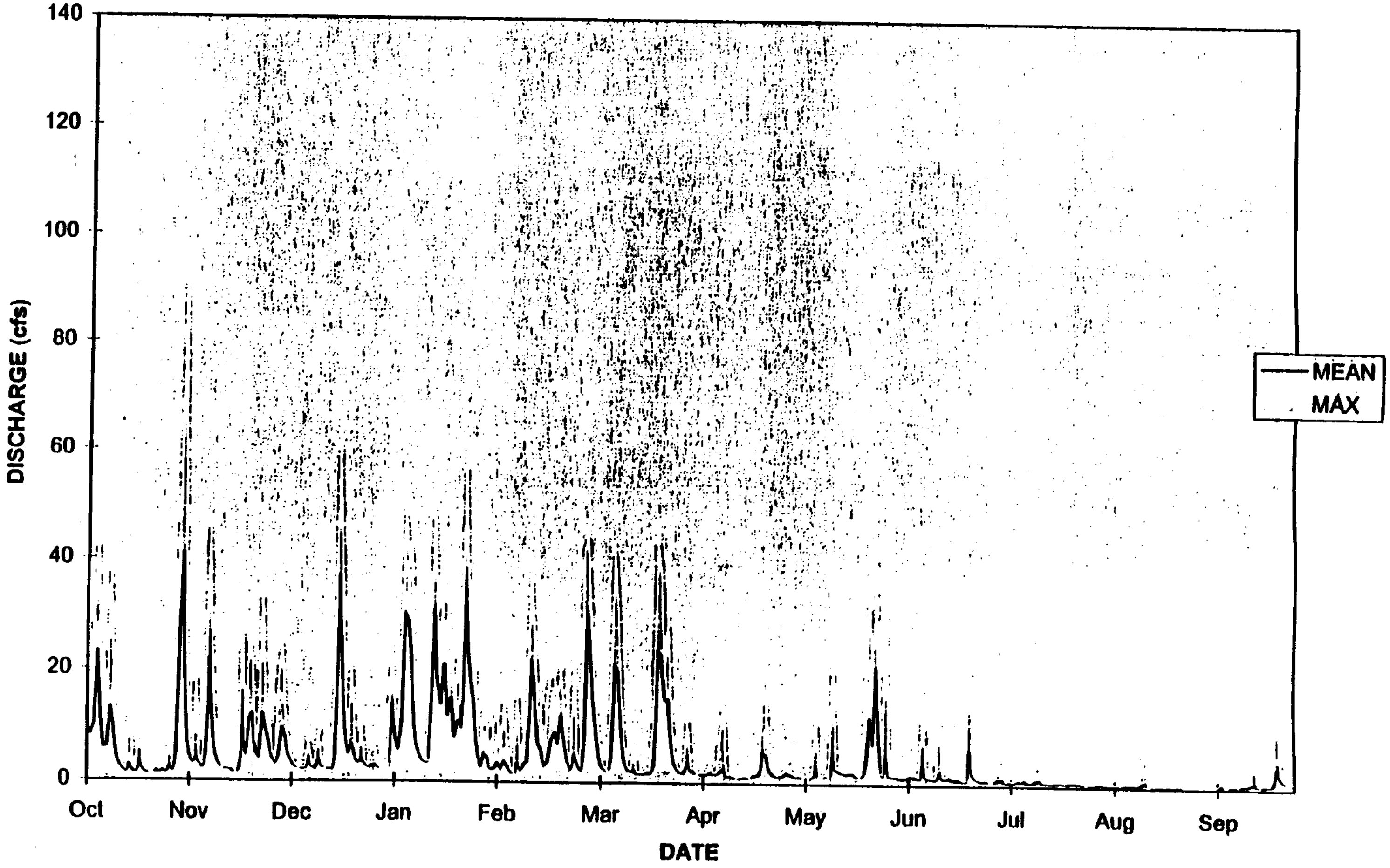


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11D99.xls

GAGE 11F - DES MOINES CREEK AT TYEE WEIR
Water Year 1998 OCTOBER 1997 - SEPTEMBER 1998
Mean Daily Discharge and Maximum Daily Discharge

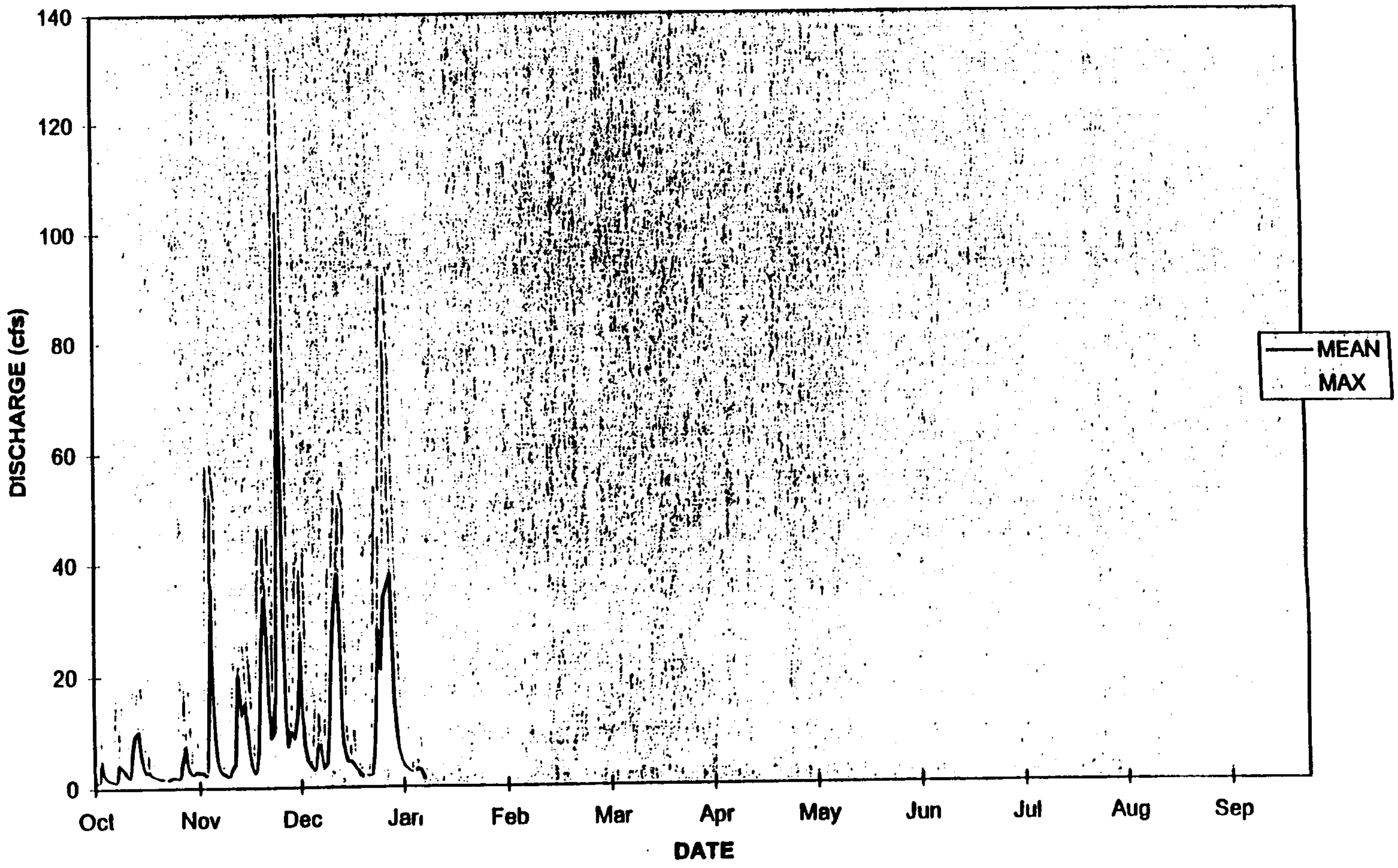


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11F98.xls

GAGE 11F - DES MOINES CREEK AT TYEE WEIR
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Discharge and Maximum Daily Discharge

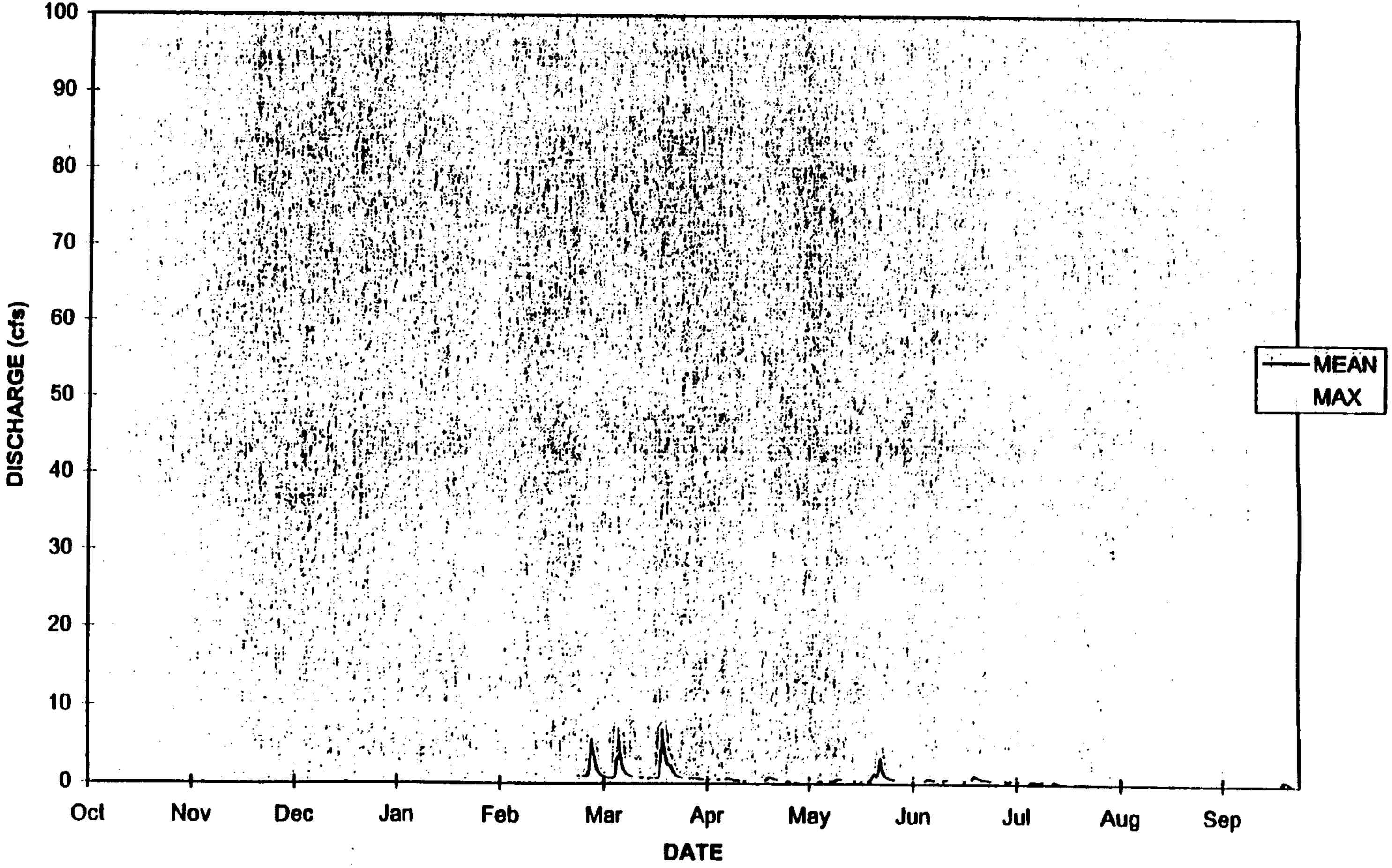


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 1[illegible]9.xls

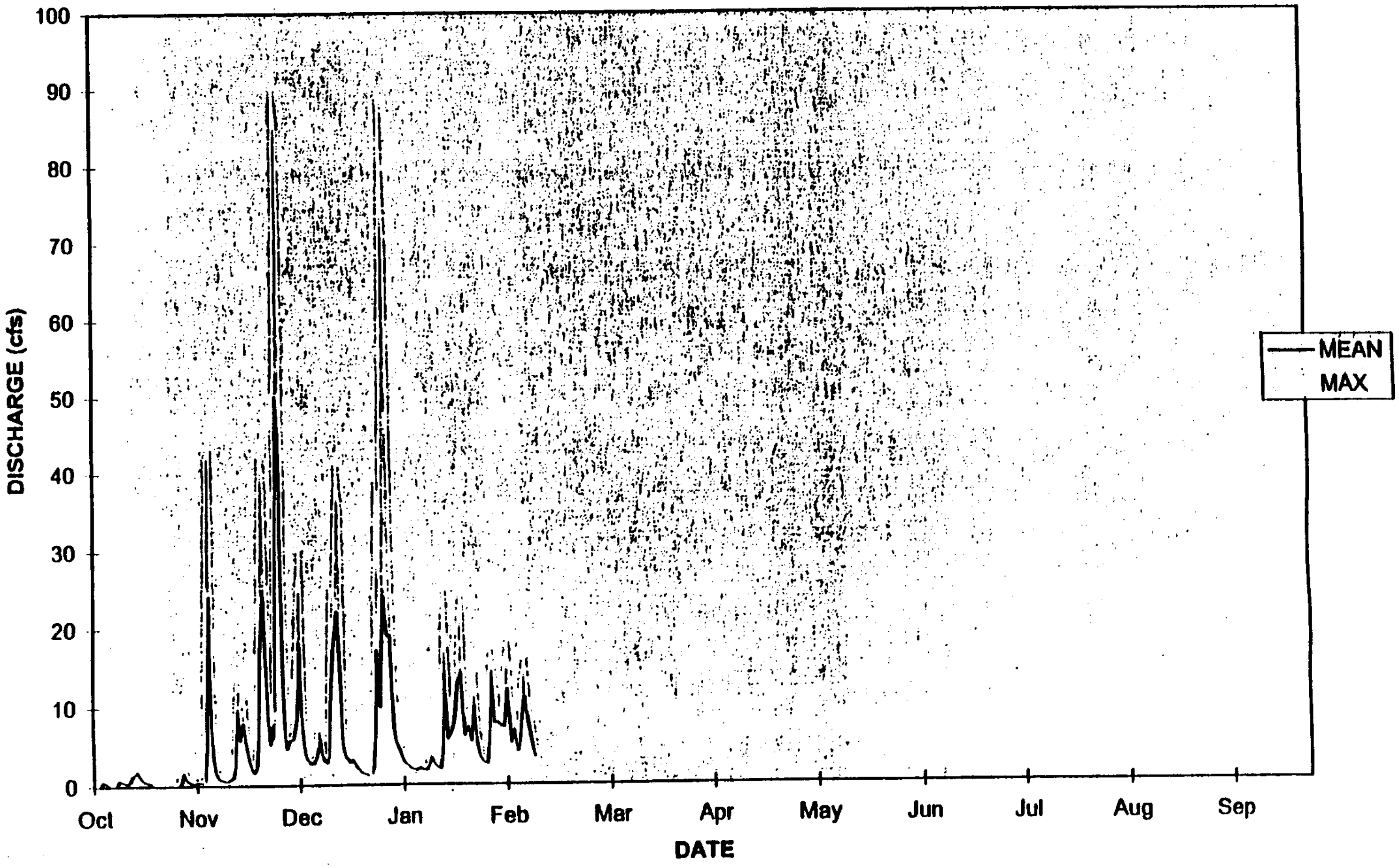
GAGE 11G - DES MOINES CREEK AT NORTHWEST PONDS OUTLET
Water Year 1998 OCTOBER 1997 - SEPTEMBER 1998
Mean Daily Discharge and Maximum Daily Discharge



4/1/99 PROVISIONAL DATA ESTIMATED DATA: NONE . 11G98.xls

KING COUNTY WLRD STREAM GAUGING REPORT

GAGE 11G - DES MOINES CREEK AT NORTHWEST PONDS OUTLET
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Discharge and Maximum Daily Discharge

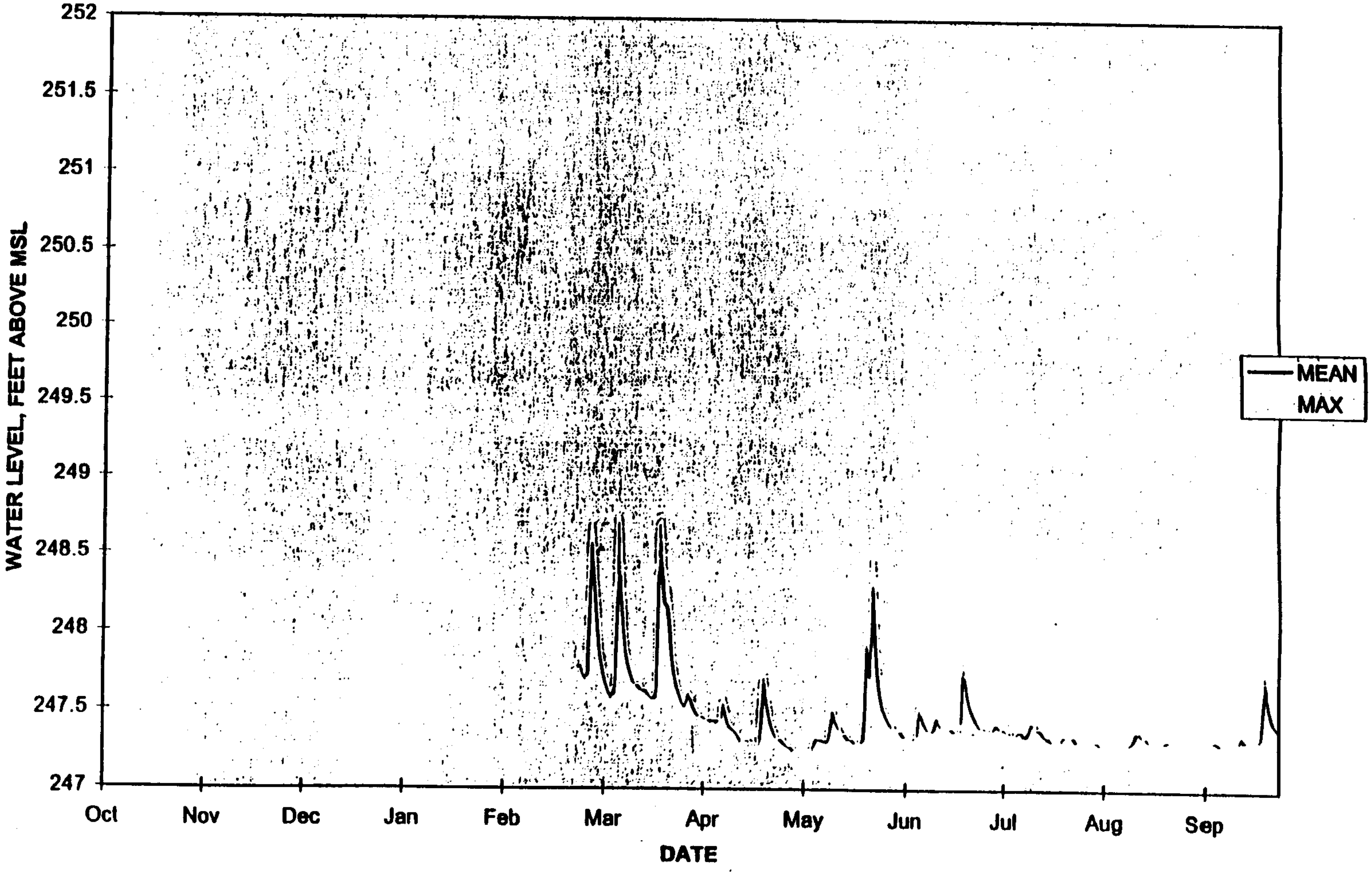


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11G99.xls

GAGE 11G - DES MOINES CREEK AT NORTHWEST PONDS OUTLET
Water Year 1998 FEBRUARY 24,1998 - SEPTEMBER 1998
Mean Daily Water Level and Maximum Daily Water Level

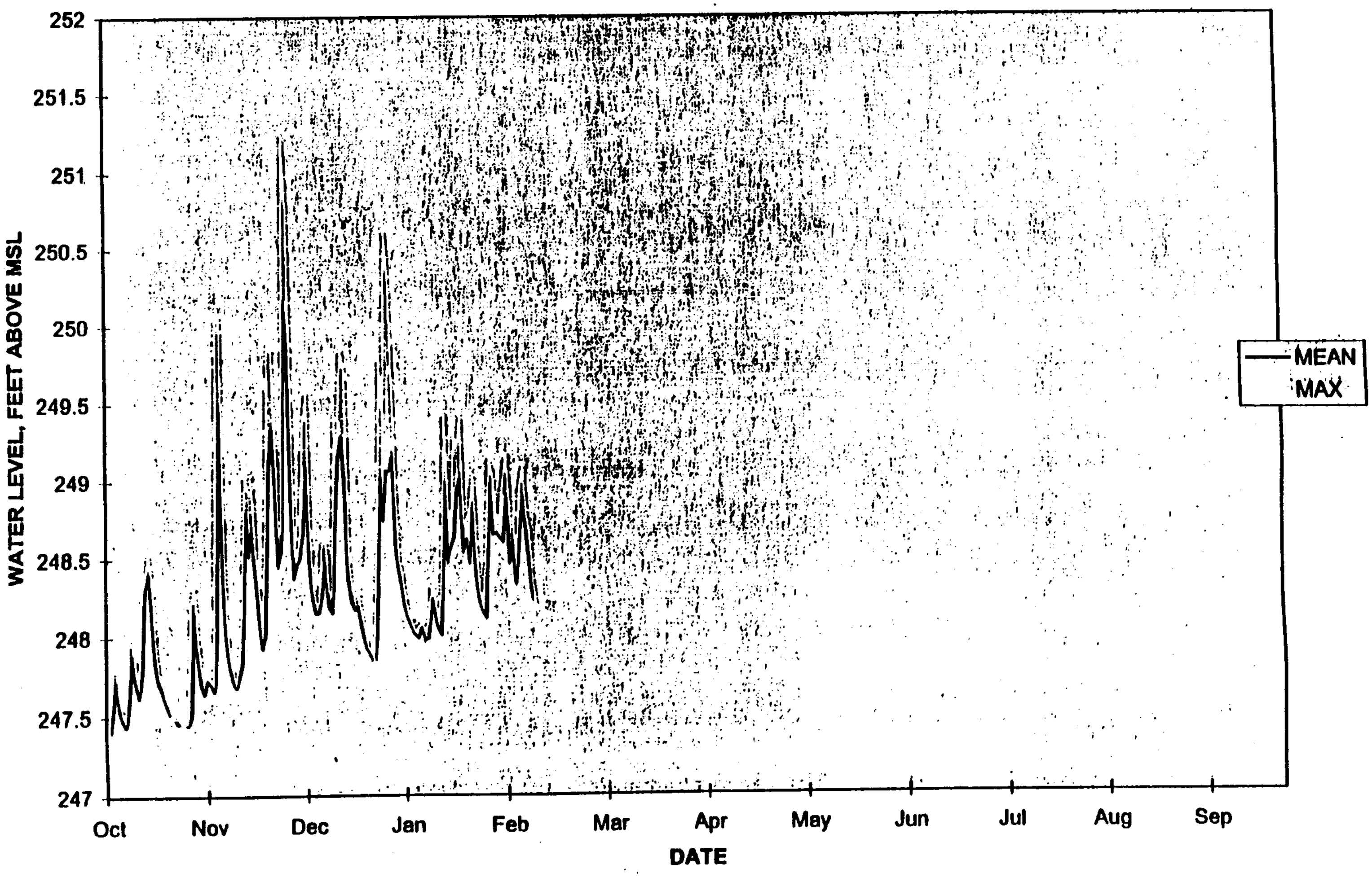


4/1/99

PROVISIONAL DATA Gage Installed February 24, 1998 ESTIMATED DATA: NONE . 11G98STG.xls

KING COUNTY WLRD STREAM GAUGING REPORT

GAGE 11G - DES MOINES CREEK AT NORTHWEST PONDS OUTLET
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Water Level and Maximum Daily Water Level

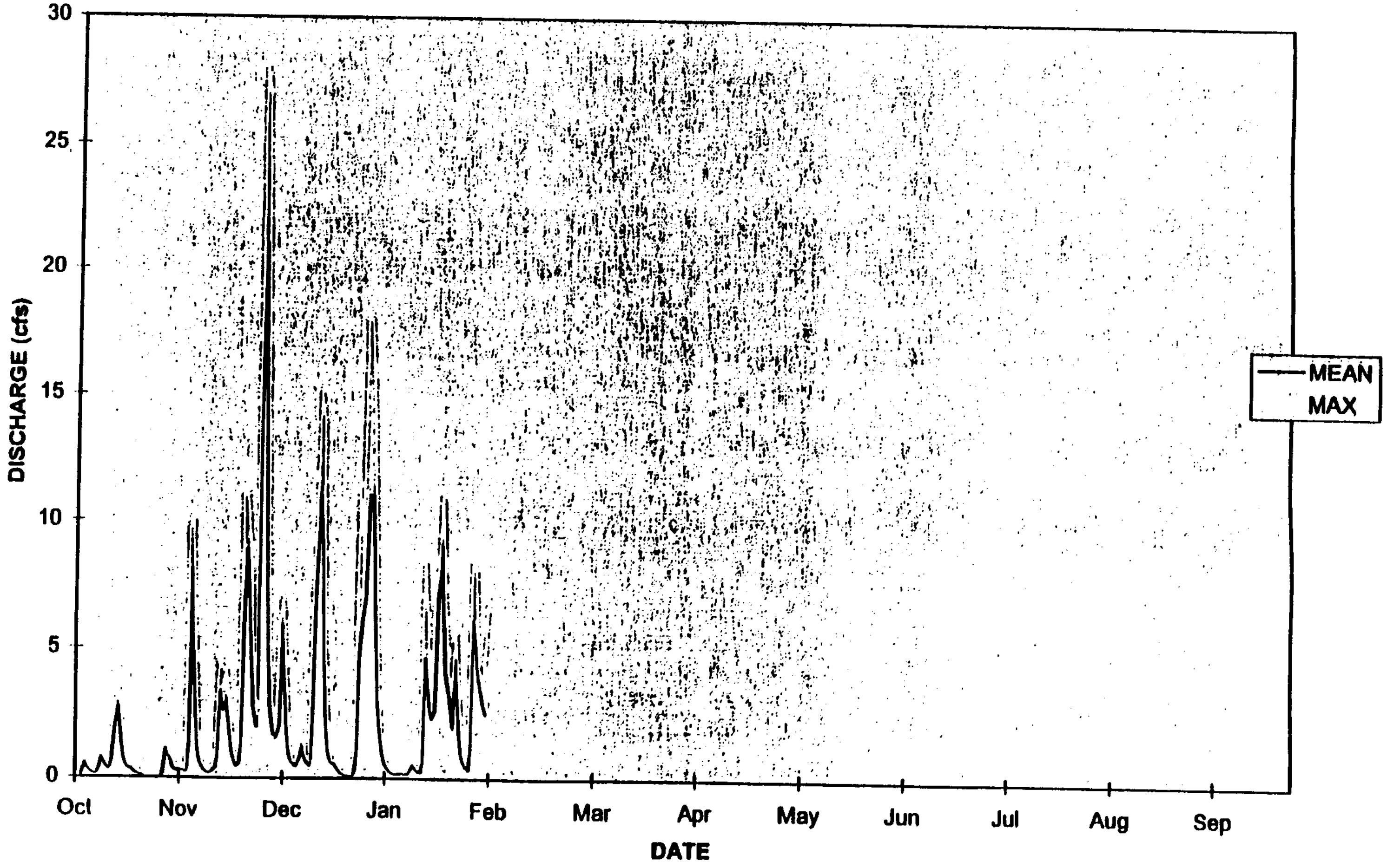


4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11G99[illegible]TG.xls

GAGE 11H Bow Lake Outlet
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Discharge and Maximum Daily Discharge



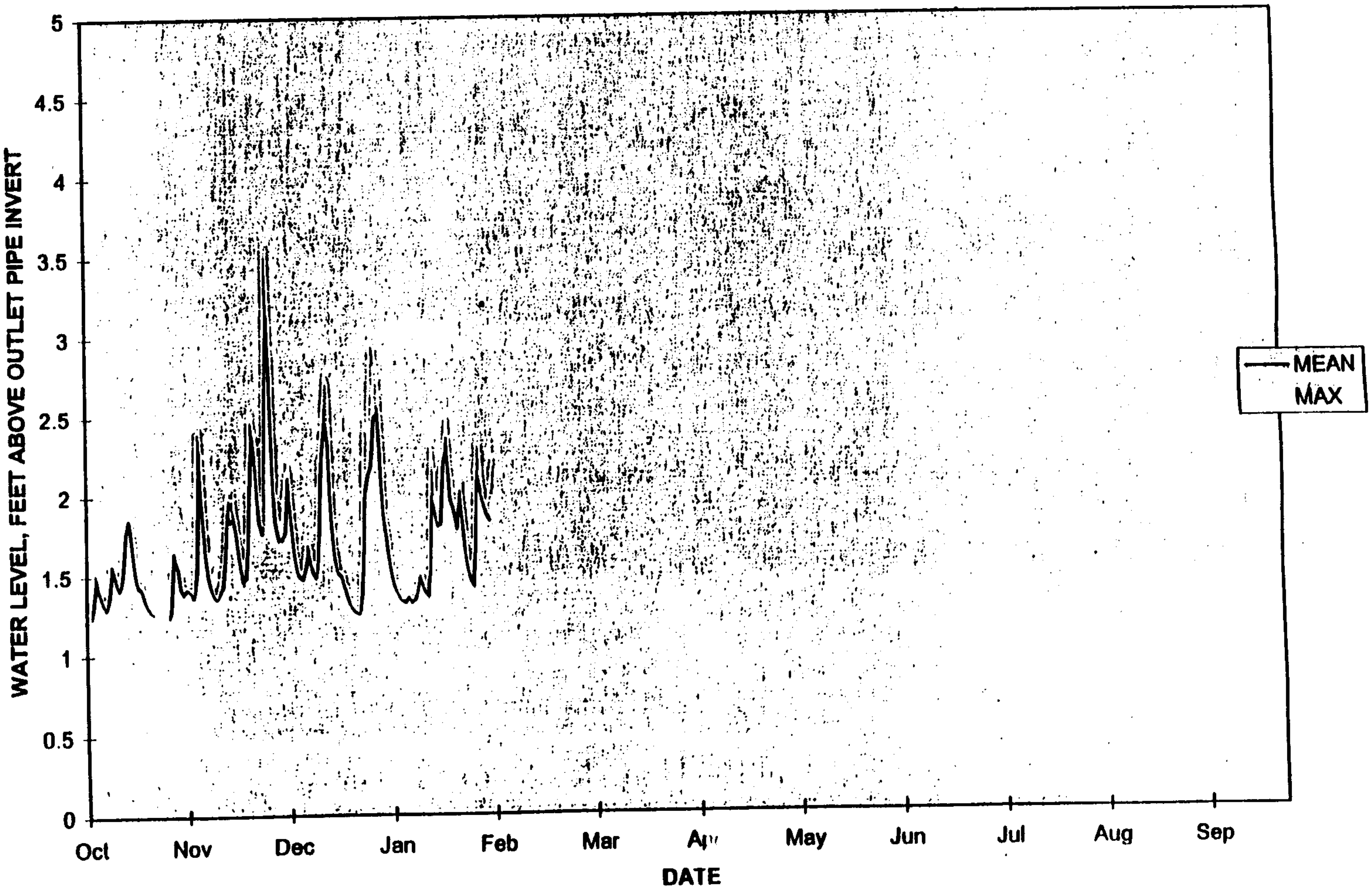
4/1/99

PROVISIONAL DATA

ESTIMATED DATA: NONE . 11h99.xls

KING COUNTY WLRD STREAM GAUGING REPORT

GAGE 11H - BOW LAKE WATER LEVEL FLUCTUATION
Water Year 1999 OCTOBER 1998 - SEPTEMBER 1999
Mean Daily Water Level and Maximum Daily Water Level

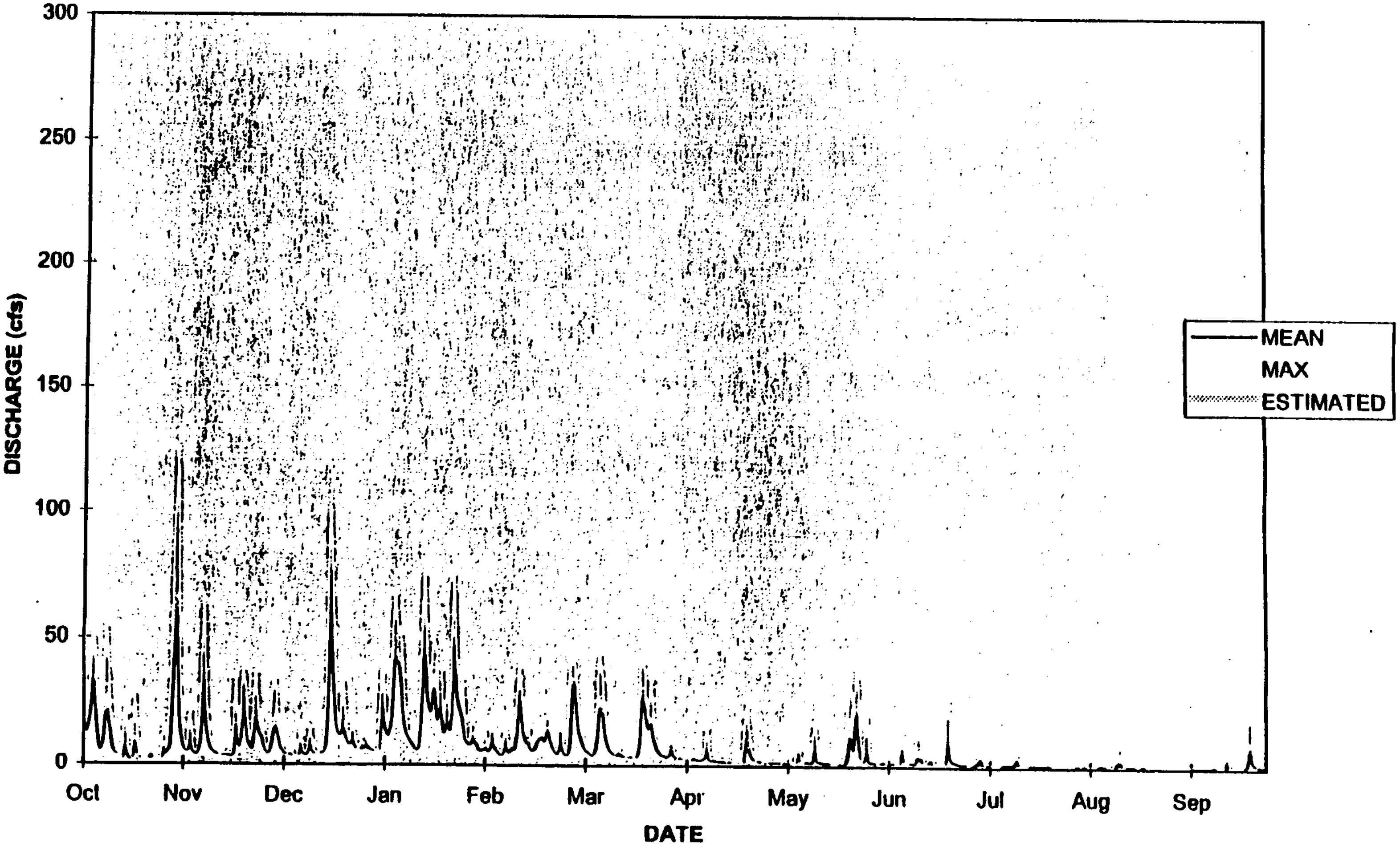


4/1/99

PROVISIONAL DATA Sta[illegible] = outlet pipe invert + 1.0 feet.

ESTIMATED DATA: NONE . 11P[illegible]STG.xls

DES MOINES CREEK AT MOUTH Water Year 1998
OCTOBER 1997 - SEPTEMBER 1998
Mean Daily Discharge and Maximum Daily Discharge



PR[illegible] DAT[illegible] E[illegible] ATE [illegible]TA[illegible] IF

Appendix B

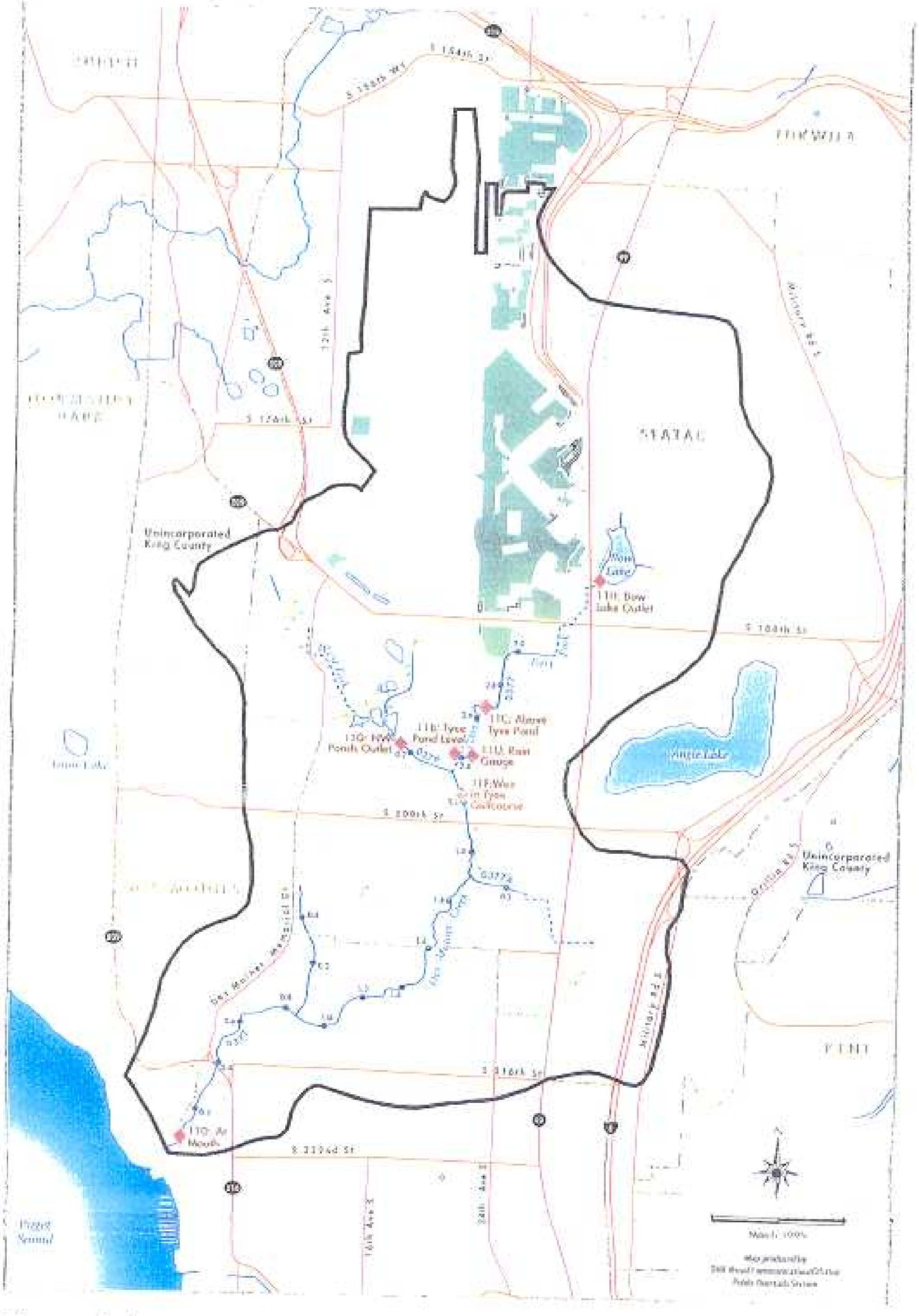


Figure B-1

DES MOINES CREEK BASIN

Stream Gauges

◆	Stream Gauge
━	Basin Boundary
∼	Stream
┄	Piped Stream
0377	Stream Number
● 2.4	River Mile
┆	Incorporated Area
━	Industrial Wastewater System
○	Lake
○	R/D Facility
┄	Wetland

Base Map Notes

Wetland Source:

Stream and Pipe Locations Source:

Roadway Source:

Industrial Wastewater System Source:

Common Lines Source

Incorporated Areas Source

DES MOINES CREEK REGIONAL CIP PRELIMINARY DESIGN REPORT

Appendix C
Wetland Studies

WETLAND DELINEATION REPORT
FOR THE
DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON
CIP #1A1767

Submitted To:

King County Department of Natural Resources
Surface Water Engineering and Environmental Services

Prepared By:

Jon Raybourn, Ecological Technician

Reviewed By:

Jon Hansen, Senior Ecologist
Ecological Services Unit

March 1999

King County Department of Natural Resources
Surface Water Engineering and Environmental Services
700 Fifth Avenue, Suite 2200
Seattle, WA 98104-5022

KING COUNTY
Department of Natural Resources

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SUMMARY

The King County Department of Natural Resources, Water and Land Resources Division, in an interlocal agreement with the Cities of SeaTac and Des Moines, and the Port of Seattle, proposes restoration of salmon habitat in Des Moines Creek by constructing a regional detention pond upstream of the confluence of the west and east forks. The detention pond will decrease the erosive potential of high flows and allow for subsequent habitat enhancement in reaches of the creek downstream of the confluence. The pond will be constructed predominantly on Port of Seattle property, in the vicinity of several wetlands that currently receive flows from the west fork of Des Moines Creek and the south end of Seattle-Tacoma International Airport (Sea-Tac Airport). The Port property is located south of the airport and north of South 200th Street, on the west side of the Tyee Golf Course in SeaTac, King County, Washington.

A wetland delineation was performed by Surface Water Engineering and Environmental Services (SWEES) personnel to determine impacts of the pond on the wetlands and to assist in the design and planning of mitigation. Three wetlands were found during the field work for the delineation that was performed during May and June 1998. The wetland boundaries were surveyed in July 1998, immediately after the delineation was completed. A fourth wetland was found that had already been delineated by a consultant to the Port of Seattle. The survey of this wetland will be matched to the recent delineations and presented as it becomes available. In addition, SWEES collaborated with Parametrix, Inc., in January 1999 to redefine the boundary of the wetland within the Tyee Golf Course.

1.0 INTRODUCTION

The King County Department of Natural Resources, Water and Land Resources Division, in an interlocal agreement with the Cities of SeaTac and Des Moines, and the Port of Seattle, proposes to construct a regional detention pond on Port of Seattle property. The pond will impact wetlands that currently receive flows from the west fork of Des Moines Creek and the south end of SeaTac International Airport. The Port property is located south of the airport and north of South 200th Street, on the west side of the Tyee Golf Course in SeaTac, King County, Washington, Sections 4 and 5, Township 23 North, Range 4 East (Figure 1).

The regional detention pond will decrease the erosive potential of high flows and allow for subsequent habitat enhancement in reaches of the creek downstream of the confluence. Current conditions in Des Moines Creek include poor water quality, channel degradation, and loss of instream complexity. The detention pond will be part of a group of projects recommended in the *Des Moines Creek Basin Plan* to address the decline of salmon habitat in the creek.

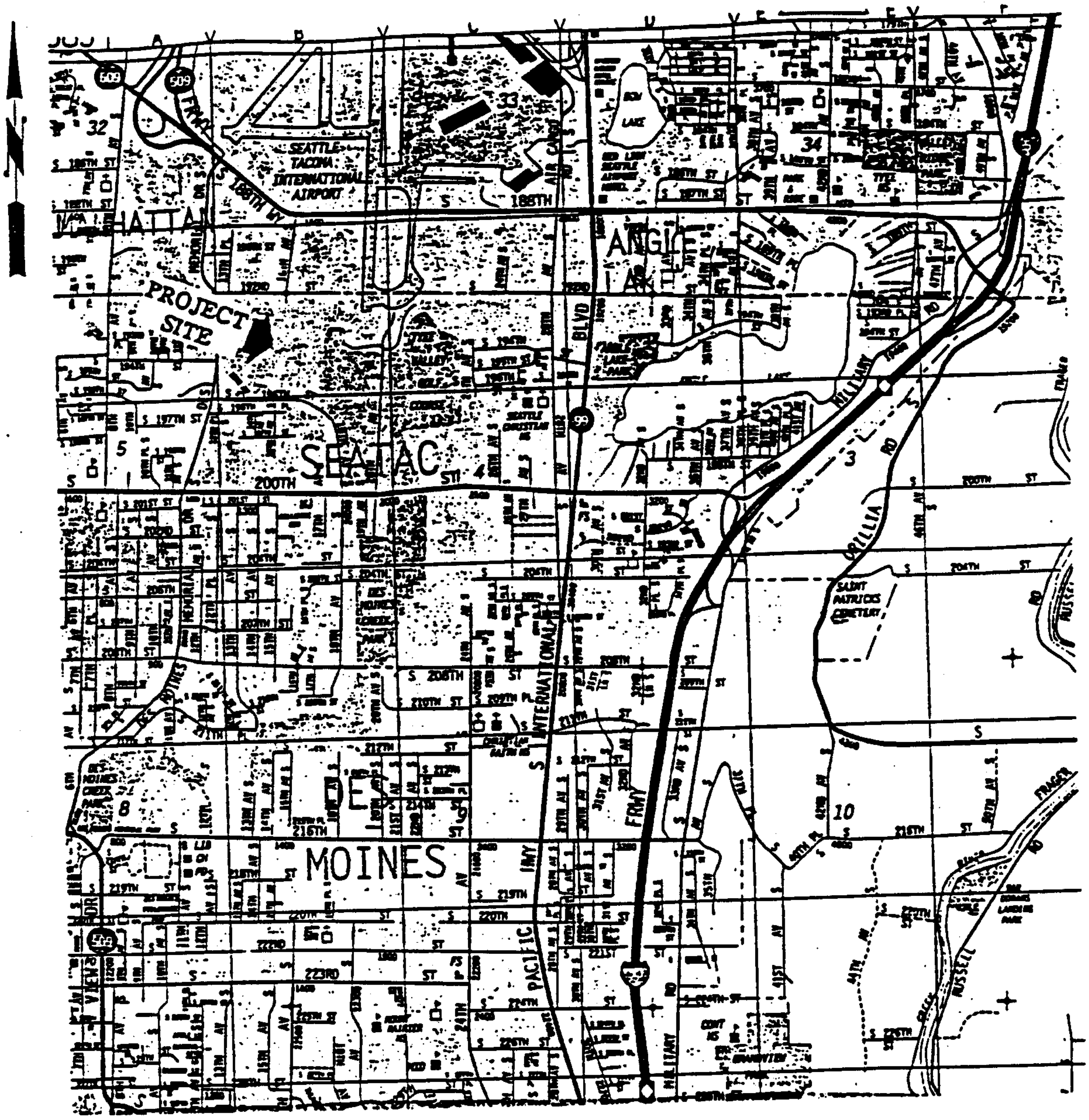
To satisfy Sensitive Areas Review requirements of the City of SeaTac Zoning Code regulations (Chapter 15.30), the project site was evaluated for the presence of streams and wetlands. The stream survey report appears under a separate cover.

2.0 SPECIAL STUDY METHODOLOGY AND MATERIALS

2.1 REVIEW OF EXISTING INFORMATION

The following information (Appendix A) was reviewed prior to performing field work, in order to identify natural drainage system features and determine the probable presence of wetlands, streams, and other sensitive areas:

- *King County Wetlands Inventory*, Volume 3, South (King County, 1990a);
- *King County Sensitive Areas Map Folio*, Map Number 5 (King County, 1990b);
- *National Wetland Inventory*, Des Moines, Washington Quadrangle (Fish and Wildlife Service, 1987);
- *King County Basin Reconnaissance Program Summary*, Volume 2, Duwamish River Basin (King County, 1987);
- King County. 1997. *Des Moines Creek Basin Plan.* King County Department of Natural Resources, Water and Land Resources Division, Seattle, Washington;
- *Soil Survey, King County Area, Washington*, Sheet Number 1 (Snyder *et al.*, 1973);
- *United States Geological Survey (USGS), 7.5 Minute Series*, Des Moines, Washington, Quadrangle (USGS, 1949);
- *A Catalogue of Washington Streams and Salmon Utilization* (Water Resources Inventory Areas [WRIA]), Volume I, WRIA-09, Lower Duwamish River, Duwamish River Basin (Washington Department of Fisheries, 1975).



Scale: 1"=2400'

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KING COUNTY
DEPT. OF NATURAL RESOURCES
SURFACE WATER - ENGINEERING &
ENVIRONMENTAL SERVICES

FIGURE 1
VICINITY MAP

DES MOINES CREEK
REGIONAL DETENTION POND

2.2 EVALUATION OF FIELD CONDITIONS

Jon Hansen, Jon Raybourn, and Laura Hartema, of the King County Department of Natural Resources' Ecological Services Unit (ESU), performed a wetland delineation of three wetlands on the site from May 11 through June 25, 1998. The wetland boundaries were immediately surveyed by King County. In each area that appeared to have wetland characteristics, data on vegetation, soil conditions in test pits, and evidence of hydrological conditions were collected. Data were recorded on modified Routine Onsite Determination Method data forms. Adjacent upland areas were similarly sampled and data recorded. In addition, a record was made of all wildlife species and/or signs observed during the field visits. In December 1998, Jon Raybourn joined ecologists from Parametrix to delineate the portion of the wetland within the Tyee Golf Course. The same methods as above were used in the delineation, and the results will be presented by Parametrix and incorporated into the overall site study.

2.3 WETLAND DELINEATION AND CLASSIFICATION

Onsite assessments were conducted according to the three-parameter methodology of the 1997 Washington State Department of Ecology (WSDOE) *Wetland Delineation Manual*. The delineation was performed to satisfy regulatory requirements of federal, state, and local jurisdictions. For the purposes of regulation, the manual defines wetlands as follows:

> *Those areas that are inundated or saturated by surface or groundwater 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.*

The wetland delineation methodology requires an examination for evidence of three parameters: hydrophytic vegetation, hydric soils, and wetland hydrology. Under normal conditions, evidence of all three parameters must be present for an area to be identified as a wetland. Hydrophytic vegetation is an assemblage of macrophytic plants, dominated by species that can grow where the frequency and duration of inundation or soil saturation produces permanently or periodically saturated soils long enough to produce anaerobic soil conditions. Hydric soils are those soils that are flooded, ponded, or saturated long enough during the growing season to become anaerobic in the upper part. Wetland hydrology includes seasonal, periodic, or permanent inundation or saturation to the surface, which creates anaerobic conditions in the soil for a significant period during the growing season (at least 5 percent of the growing season, usually about two weeks).

The wetland evaluation method employed in this study was a modified routine-level field sampling determination method. Ten study plots were established throughout the project vicinity (Figure 2). Of the ten plots, five were located in wetland habitats, and five were located in nearby upland habitats. Plots were located in areas that represented each community. Vegetation, soils, and hydrology were sampled at each plot. Data were recorded on field data forms (Appendix C), and wetland boundaries from the resulting determinations were flagged in the field. Locations of wetland delineation plots, upland plots, and streams were also marked in the field with flagging. Locations of wetland flags were surveyed and the wetland boundaries mapped using AutoCAD. Specific sampling methods for the three parameters are detailed below.

2.3.1 Vegetation

Each vegetation sample plot consisted of concentric circles located around a soil pit. The herb layer was sampled within a circle with a radius of approximately 2 meters. Trees and shrubs were sampled within a circle with a radius of approximately 9 meters. Because of the size or shape of the plant community being evaluated, where appropriate, vegetation sampling plots were modified to include only that portion of the circle that was representative of the community being sampled. The plant species in each plot were identified and the percent coverage of the total plot area of each species estimated. Species dominance was determined by using the midpoint values assigned to each percent coverage as described on the Routine Onsite Determination Method data form (Appendix C). The wetland indicator status of individual plant species as designated by the Fish and Wildlife Service (Reed, 1988 and 1993) was noted. If more than 50 percent of the dominant species were facultative species, facultative wetland species, or obligate wetland species, the hydrophytic vegetation criterion was satisfied. Plant indicator status categories are described in Table 1.

2.3.2 Soils

Soils in each study plot were sampled and evaluated for hydric indicators. Soil pits were dug with a long-bladed shovel to a depth of approximately 18 inches. Soil textures were described and moist soil colors identified using Munsell Soil Color Charts (United States Department of Agriculture [USDA], 1992). Hydric soil indicators include: organic soils; the presence of sulfidic material; direct observation of intermittent flooding or inundation; gleyed, low chroma, and low chroma mottled soils; and aquic and peraquic moisture regimes. Mottles are spots or blotches of contrasting color occurring within the soil matrix. Gleyed soils are predominantly neutral gray in color. Soils having aquic or peraquic moisture regimes are saturated to the surface and anoxic during the growing season. Low chroma is defined as a chroma of 2, with mottles, or a chroma of 1, with or without mottles (WSDOE, 1997).

A soil is hydric, as defined by the National Technical Committee for Hydric Soils, if it is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part (USDA, 1985). Low chroma colors immediately below the dark surface horizon can be an indicator of hydric mineral soil. It is possible, however, for mineral soils to be hydric while lacking the typical color indicators, or for a hydric soil to be drained sufficiently to be non-hydric while retaining color indicators.

Soil indicators were recorded on field data sheets (Appendix C). Soil characteristics were compared to Soil Conservation Service (SCS) descriptions of mapped soils (Snyder *et al.*, 1973) to confirm mapping or to determine whether a soil inclusion was present. Most soils mapped by the SCS include areas of other soils, which may comprise from 2 to 50 percent of the mapped unit.

Table 1: Plant Species Wetland Indicator Categories (Reed, 1988)

INDICATOR CATEGORY*	OCCURRENCE	ESTIMATED PROBABILITY IN WETLAND
OBL	Obligate. Occur almost always in wetlands, under natural conditions.	>99%
FACW	Facultative wetland. Usually occur in wetlands, but occasionally found in non-wetlands.	67-99%
FAC	Facultative. Equally likely to occur in wetlands and non-wetlands.	34-66%
FACU	Facultative upland. Usually occur in non-wetlands, but sometimes found in wetlands.	1-33%
UPL	Upland. Occur in wetlands in another region, but occur almost always, under natural conditions, in non-wetlands in this region (Region 9).	<1%
NI	No indicator. No indicator assigned.	

* A positive (+) or negative (-) sign, when used with indicators, indicates "slightly more frequently found in wetlands" and "slightly less frequently found in wetlands," respectively. An asterisk (*) following an indicator identifies a tentative assignment based upon either limited information or conflicting reviews.

2.3.3 Hydrology

Direct evidence of wetland hydrology includes observation of inundation, soil saturation to the surface, and presence of the water table near the surface. To satisfy wetland hydrology criteria, hydrology must be present for more than 5 percent of the growing season (approximately two weeks) under the *1997 Washington State Wetland Delineation Manual*. Direct observation of wetland hydrology may not be possible during much of the dry season, but other hydrologic indicators may be present throughout the year that confirm the occurrence of saturation or inundation for sufficient periods of time to satisfy the hydrology criteria of the 1997 Manual. Indicators inferring wetland hydrology include oxidized root channels associated with living roots and rhizomes, sediment deposits on substrate and plant surfaces, wetland drainage patterns, drift lines, surface-scoured areas, water-stained leaves, morphological plant adaptations, and hydric soil characteristics.

2.3.4 Wetland Determination

Results of vegetation, soils, and hydrology sampling were used to make a wetland determination for each plot. Upon completion of plot determinations, an overall assessment of the area was conducted, and wetland boundaries were estimated in the field based on plot information and visual observations of site characteristics. Survey flags were placed at appropriate intervals to mark wetland boundaries.

Since a wetland is a dynamic system that functions within a fluctuating ecological landscape, wetland characteristics may vary with season and with changes to the surrounding landscape. Wetland determinations are based on site conditions at the time of evaluation. Although seasonal variability and adjacent land use, as well as site-specific information obtained from public resource documents, are considered at the time of wetland determination, all potential eventualities cannot be predicted or anticipated.

2.3.5 Wetland Classification

Wetlands were classified according to the United States Fish and Wildlife Service classification system (Cowardin *et al.*, 1979) and the City of SeaTac classification system. In addition, in order to accommodate jurisdiction at the state level, wetlands were given designations according to the Washington State classification system. Field data forms for the Washington State Wetland Rating System are attached in Appendix G.

2.3.6 Functional Value Assessment

The functions of onsite wetlands were evaluated using current knowledge of wetland functional values. Wetland functions include stormwater and floodwater control, water quality improvement, groundwater exchange, biological habitat and hydrological support, erosion control, and economic and recreational opportunities.

Wetland functions are described by evaluation categories ranging from "low value" to "high value." These broad categories are interpreted within the context of professional experience with a wide range of wetlands, and with reference to scientific literature (Reppert *et al.*, 1979; Adamus and Stockwell, 1983; Sather and Smith, 1984). Evaluation of onsite wetlands in their present configuration provides a context from which to evaluate the probable effects of the proposed project on specific wetland areas.

Although it is still in draft form, ESU also applied the Washington State Wetland Functional Assessment Method. This method is currently being tested and evaluated by the Washington State Department of Ecology. Results from this assessment are attached in Appendix F.

3.0 RESULTS

3.1 ANALYSIS OF EXISTING INFORMATION

The *National Wetland Inventory* (United States Fish and Wildlife Service, 1989) includes two types of wetlands on the site, Palustrine open water, unknown bottom, artificially flooded, impounded (POW), and Palustrine Scrub-Shrub, seasonally flooded (PSS). Neither the *King County Sensitive Areas Map Folio* (King County, 1990b) nor the *King County Wetlands Inventory* (King County, 1990a) provides coverage of the site because it is located within the incorporated City of SeaTac (Appendix A).

3.2 ANALYSIS OF OVERALL FIELD CONDITIONS

The study site is located in the heavily urbanized upper watershed of Des Moines Creek, bordered on the north by the commercial properties adjacent to South 188th Way and 16th Avenue South, and by the Industrial Wastewater System holding pond and the southernmost runway of Sea-Tac Airport. Des Moines Memorial Drive South forms the western border of the site. The southern boundary is formed by South 196th Street and a forested property owned by the Port of Seattle. The airport approach light road, which bisects the Tyee Golf Course, runs along the eastern border of the study site.

During the site evaluations on May 11 through June 25, 1998, three palustrine wetlands were identified and delineated. All of these wetlands (Wetlands A-C) were also assessed for functional values and classified (Figure 2, Table 4). A portion of Wetland A that had been delineated and surveyed previously by a consultant to the Port of Seattle was evaluated during field visits. This portion, the northeast arm, is contiguous with the main body of Wetland A. It is designated as Wetland D, and information will be incorporated as it becomes available (Figure 2).

Wetlands A, B, C, and D were probably all part of one wetland complex prior to human disturbance. Aerial photos from the 1940s indicate that truck farming was the dominant land use of the site. Wetland A was mined for peat as late as the 1970s and impounded to allow the construction of the Tyee Golf Course and provide stormwater detention. Wetland B represents that part of the wetland that was eventually developed to build the western portion of the golf course. Many areas were graded and tiled to construct the golf course and provide its drainage. Wetlands C and D are currently defined by the surrounding fill of the airport and adjacent development, and are restricted to ditches. However, they are hydrologically connected to Wetland A and appear to be remnants of the original wetland on the site.

The three wetlands delineated range in size from 32,993 square feet (0.8 acres) to 726,198 square feet (16.7 acres). Total wetland area on the site is 31.4 acres. All of the wetlands on the site are regulated by the Corps of Engineers, pursuant to the Clean Water Act. The City of SeaTac regulates them via the Environmentally Sensitive Areas Code (SeaTac Municipal Code, Chapter 15.30). The wetlands on the site were classified according to the City of SeaTac wetland classification system outlined in Chapter 15.10.675 of the SeaTac Municipal Code, and additionally, according to the Washington State Wetland Rating System (Appendix G).

Wetland locations are shown in Figure 2, drainage patterns are shown in Figure 3, wetland delineation results are presented in Table 2, wetland determination results are summarized in Table 3, and wetland photographs are presented in Appendix D.

Table 2: Wetland Delineation Results. Des Moines Regional Detention Pond, CIP #1A1767

Wetland	Type*	Acres (ft^2)	Class**	Buffer	Mitigation Ratio***
A	PSS/PEM/POW	16.7 (726,198 ft^2)	1,II	100-foot	2:1, 2:1
	PFO				2:1, 3:1
B	PEM/PSS	9.8 (424,710 ft^2)	1,II	100-foot	2:1, 2:1
C	PFO	0.8 (32,993 ft^2)	1,II	100-foot	2:1, 3:1
D	PSS	4.1 (179,903 ft^2)	1,II	100-foot	2:1, 2:1

* = Type as defined in Cowardin *et al.*, 1979.

** = Class as defined in Chapter 15.10.675 of the City of SeaTac Municipal Code and the Washington State Wetland Classification System, respectively.

*** = Minimum Mitigation Ratio required per Chapter 15.30.320 City of SeaTac Municipal Code and Replacement Ratios recommended by Washington State Department of Ecology, respectively.

3.2.1 Vegetation

Although the site has a history of disturbance and is surrounded by commercial and industrial development, the vegetation is fairly diverse and many plant communities are represented. Figure 4 shows the approximate extent of the plant communities present. All forested areas are dominated by black cottonwood (*Populus trichocarpa*) and red alder (*Alnus rubra*), with, in disturbed areas, an understory of Himalayan blackberry (*Rubus discolor*). Disturbed areas that are open to full sun, such as along the southwest corner of the site and to the west of the runway, are completely choked with monotypic stands of Himalayan blackberry. A large area of mixed deciduous forest on the south side of the site appears to be the least disturbed. The understory is dominated by Indian plum (*Oemleria cerasiformis*), red-osier dogwood (*Cornus stolonifera*), red elderberry (*Sambucus racemosa*), and includes scattered beaked hazelnuts (*Corylus cornuta*) and stands of salmonberry (*Rubus spectabilis*). The herb layer ranges from weedy species typical of disturbed sites, such as reed canarygrass (*Phalaris arundinacea*), to those more often found in regenerated areas, such as false lily-of-the-valley (*Maianthemum dilatatum*). Willows (*Salix spp.*) typify the vegetation at the edge of the central body of open water. Much of the shallow water is dominated by cattail (*Typha latifolia*), but the edges associated with the golf course also have a variety of rushes and sedges. The wetland areas within the golf course are dominated by maintained turf grasses, which were not identified specifically. All plant species identified within the ten study plots, as well as other plants found on the site, are listed in Appendix E with their indicator statuses.

3.2.2 Soils

The *Soil Survey, King County Area, Washington* (Snyder *et al.*, 1973), maps much of the site as Urban Land, having been modified through grading and filling to accommodate industrial installations. Layers of peat and muck are still evident beneath many of the filled areas. The open water area of the site is mapped as Norma sandy loam and Bellingham silt loam, both poorly drained hydric soils. The southern portion of the site, which corresponds with a diverse scrub-shrub wetland plant community, is mapped as Indianola loamy fine sand, 4 to 15 percent slopes. Indianolas are well-drained forest soils.

In the majority of the soil pits dug on the site, silt and clay were the dominant constituents, with textures ranging from sand to silt loam and silty clay in the top 18 inches. In most wetland soil pits, muck and peat were encountered. Some soil pits within graded areas revealed fill material consisting of sand and gravel. Soil characteristics observed in the ten study plots are described in Appendix C.

3.2.3 Hydrology

The largest input of water to the wetlands on the site is via the west fork of Des Moines Creek (WRIA 09.379). The watershed of this branch of the creek is highly urbanized, and the hydrology is typical of stormwater dominated systems. The southern portion of site does not have the obvious stormwater inputs, but receives water from surface runoff and the numerous seeps that surface along the slope, which is the dominant feature of the south side. Wetland B, on the western edge of the golf course, receives water from surface runoff and the overflow of the ponds that comprise the open water of Wetland A. Peat layers beneath the golf course fill retain precipitation and are charged by the adjacent ponds. Wetlands C and D, which are restricted to ditches connected to Wetland A on the northwest and northeast corners, receive local runoff and surface water discharge from the airport. Numerous seeps along the slope adjacent to Wetland D have been reported.

Direct observations of wetland hydrology during site evaluation included inundation by water and soil saturation to the surface. Field indicators of hydrology observed during evaluations included wetland drainage patterns, closed depressional topography, and water-stained leaves.

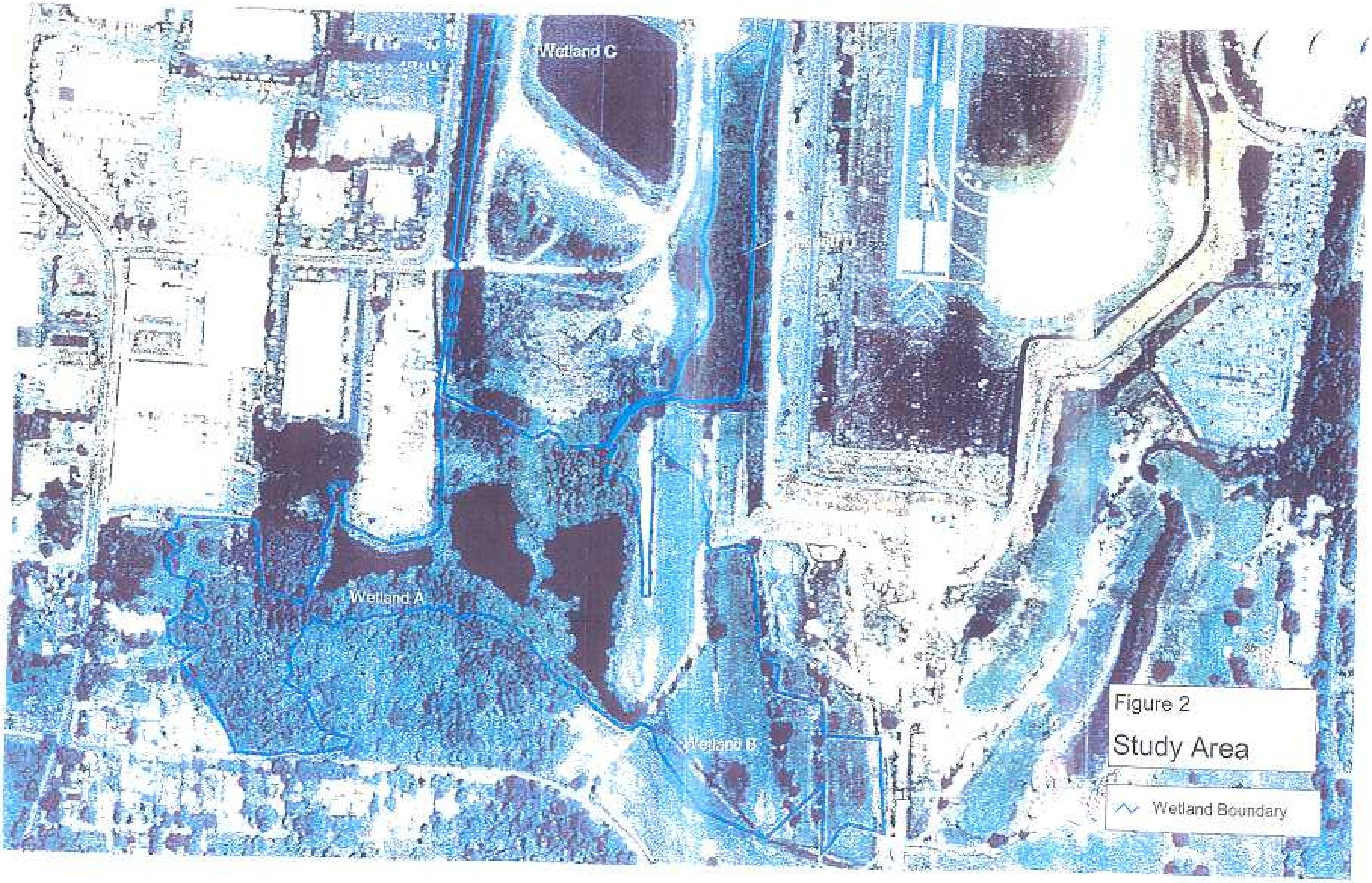
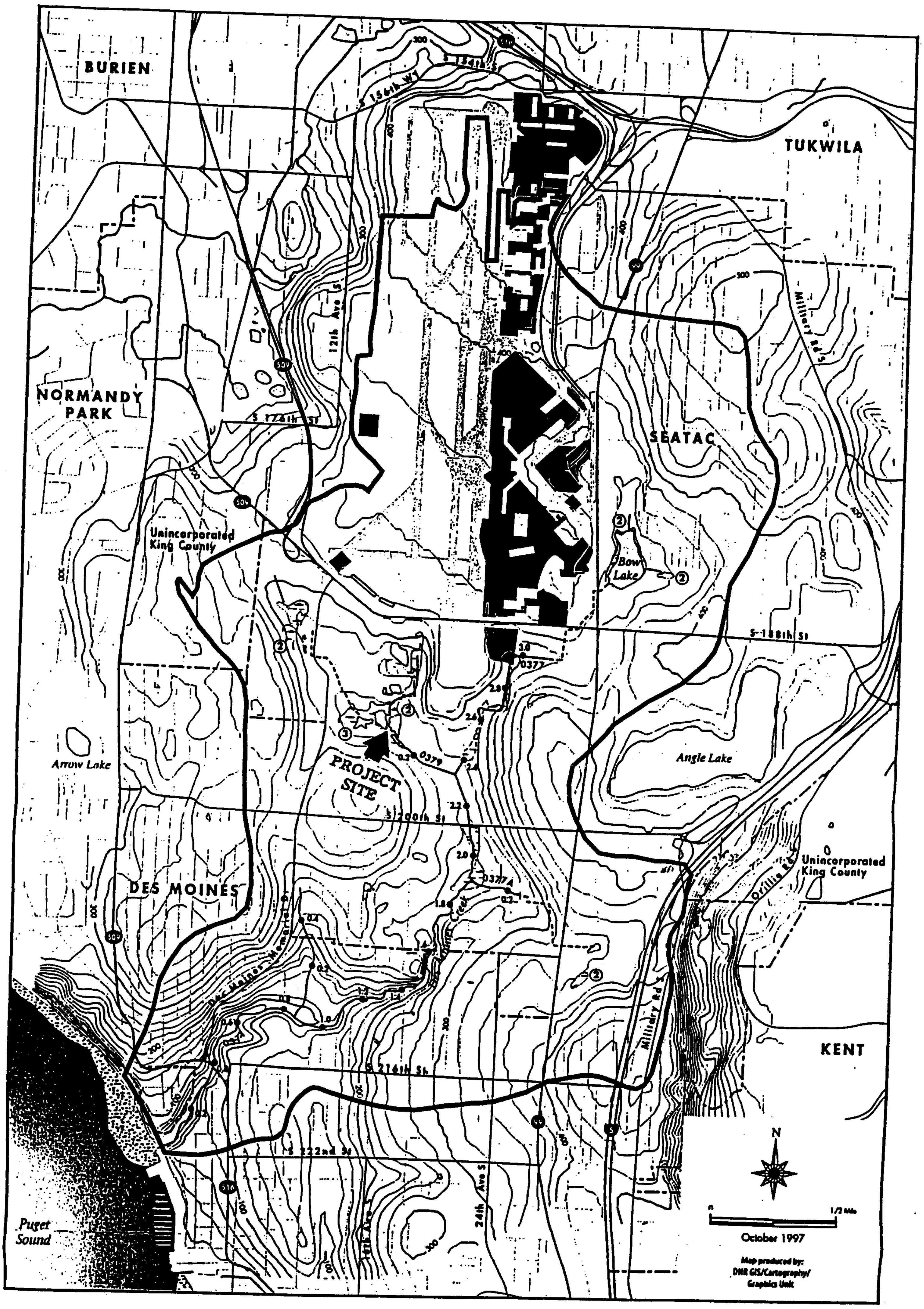


Figure 2

Study Area



DES MOINES CREEK BASIN

Water Features

Basin Boundary
Stream
Piped Stream
0377 Stream Number
• 2.6 River Mile
20-foot Contour
Incorporated Area
Industrial Wastewater System
Lake
R/D Facility
Wetland
② Wetland Rating (where available)

KING COUNTY
DEPT. OF NATURAL RESOURCES
SURFACE WATER - ENGINEERING & ENVIRONMENTAL SERVICES

FIGURE 3
DRAINAGE PATTERNS

DES MOINES CREEK
REGIONAL DETENTION POND

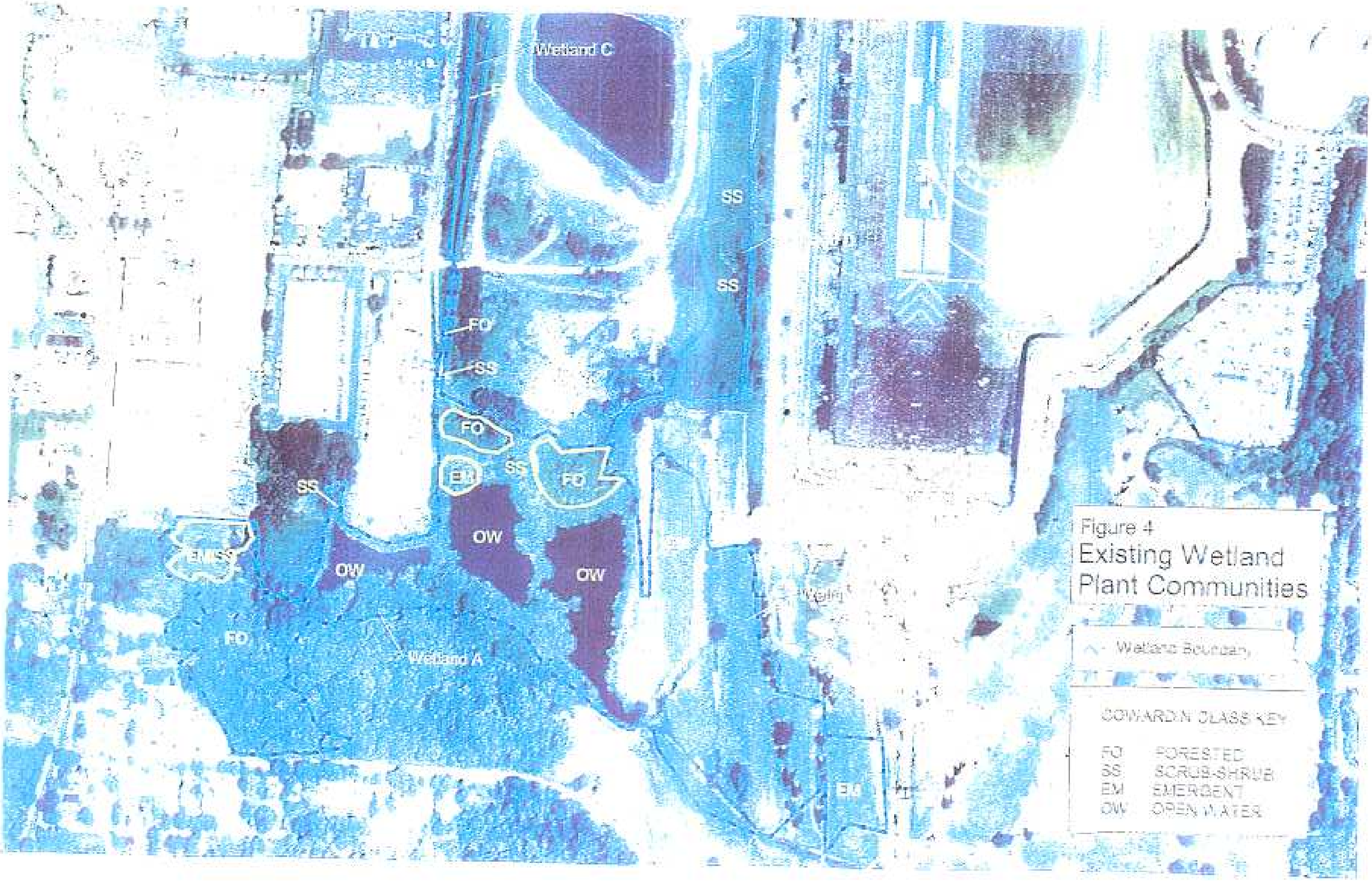


Figure 4
Existing Wetland Plant Communities

3.3 WETLAND DESCRIPTIONS

3.3.1 Wetland A

Wetland A is the largest wetland on the site at 16.7 acres. It has four classes of vegetation and is over 10 acres in area, so it is rated as a Class 1 wetland. Wetland A is a palustrine wetland with forested, scrub-shrub, emergent, and open water components. It is artificially flooded and impounded. It receives water from the west fork of Des Moines Creek, stormwater runoff from the surrounding development, and groundwater. Surface water flows from Wetland A via the west fork of Des Moines Creek at the outlet located on the west side of the Tyee Golf Course.

Vegetation

The dominant canopy species in the wetland's plots (DP-1, DP-3, DP-5) were black cottonwood and red alder, with one plot lacking a tree layer. The dominant understory species were Himalayan blackberry, cottonwood saplings, and Indian plum. The dominant species in the herb layer were reed canarygrass, lady fern (*Athyria felix-femina*), Watson's willow-herb (*Epilobium watsonii*), and tall buttercup (*Ranunculus acris*). All the wetland study plots satisfied the hydrophytic vegetation criterion.

The dominant canopy species in the adjacent upland study plots (DP-2, DP-4, DP-6) were black cottonwood and red alder. The dominant understory species were Himalayan blackberry and salmonberry. The dominant species in the herb layer were stinging nettle (*Urtica dioica*) and false lily-of-the-valley, with one plot entirely lacking an herb layer. Two of the three upland plots satisfied the hydrophytic vegetation criterion as a result of dominance by facultative species.

Soils

The soils in the wetland soil pits typically were black (10YR 2/1) muck, peat, and silt loam. The peat and muck were without horizons from 0 to 20 inches. The silt loam overlaid a very dark grayish-brown (10YR 3/2) silty clay from 14 to 20 inches. The hydric soil criterion was satisfied in all of the wetland soil pits, based on the presence of either low chromas or organic soil.

The soils in the soil pits from the adjacent upland areas were either non-native fill containing debris or a mixture of black (10YR 2/1) organics, very dark brown to very dark gray (10YR 2/2, 10YR 3/1 dry) clay loam and silty clay overlaying dark brown (10YR 3/3 dry) sand. In two of the three upland pits, the soils did not satisfy the hydric soil criterion. In one of the pits, the soil did satisfy the hydric soil criterion based on low chroma.

Hydrology

All of the wetland plots had surface water present or saturation of the soil to the surface. Each wetland plot was determined to have wetland hydrology based on the direct observation of water, as well as drainage patterns.

There was no evidence of wetland hydrology in any of the adjacent upland areas; therefore, none of them satisfied the wetland hydrology criterion.

Wetland Determination
The study plots in Wetland A were determined to be wetlands based on the presence of hydrophytic vegetation, hydric soils, and wetland hydrology. All three parameters were met in each plot.

None of the adjacent upland study plots were determined to be wetland. Wetland hydrology was lacking in all three, even though hydrophytic vegetation was present in one, and both hydrophytic vegetation and hydric soils were present in another. In the latter case, where two of the three criteria were satisfied, the plot was judged to be non-wetland because even though hydric soils were present, an underlying sand layer acted as a drain and kept the upper layers from being saturated. Hydrology was expected but not found; therefore, the plot was not determined to be a wetland.

Wetland Classification
Wetland A is a palustrine wetland with forested, scrub-shrub, emergent, and open water components. It is artificially flooded and impounded. The *National Wetland Inventory* (Appendix A) classifies Wetland A according to major plant communities and divides it into two wetlands: palustrine open water (POW) and palustrine scrub-shrub (PSS) (Cowardin *et al.*, 1979). According to SeaTac Municipal Code 15.10.675, all hydrologically connected portions of a wetland and all plant communities must be considered when making the wetland classification. According to that system, Wetland A is rated as a Class 1 wetland because it is over 10 acres and has four classes of vegetation (PFO/PSS/PEM/POW). As such, this wetland requires a minimum 100-foot buffer, pursuant to SeaTac Municipal Code 15.30.290.

Wetland Buffer
The 100-foot buffer required around Wetland A is bordered on the north side by several commercial developments and undeveloped fill. The western side of the buffer is adjacent to Des Moines Memorial Drive South and a forested slope, plus some residential properties located north of South 196th Street. The buffer to the south is contiguous, with a forested slope extending from South 196th Street to the wetland. The east side of the buffer overlaps with Wetland B, which is contiguous with Wetland A and is the portion of the wetland within the Tyee Golf Course.

3.3.2 Wetland B

Wetland B is 9.8 acres in area, located entirely within the Tyee Golf Course. It has only two classes of vegetation, but since it is hydrologically connected to Wetland A, it is rated as a Class 1 wetland. Wetland B is a palustrine emergent wetland with a scrub-shrub component. It receives water from the west fork of Des Moines Creek, local runoff, and groundwater exchange. Wetland B is contiguous with Wetland A at the east side of the Northwest Ponds. The boundary between the two wetlands is not ecological as much as one of a change in land use, Wetland B being located entirely within the golf course. This boundary is applied for the convenience of calculating the area of the wetland currently in use as a golf course. The surface water connection between the two wetlands is the west fork of Des Moines Creek, which flows out of the Northwest Ponds and through the golf course, bisecting Wetland B. During much of the year, flooding extends beyond the pond edge of Wetland A and into Wetland B, connecting the two.

Vegetation

There was no canopy in the wetland study plot (DP-7). The dominant understory species was Sitka willow (*Salix sitchensis*). The dominant species in the herb layer were soft rush (*Juncus effusus*) and small-fruited bulrush (*Scirpus microcarpus*). Other species within the plot included sawbeak sedge (*Carex stipata*), birdsfoot trefoil (*Lotus corniculatus*), and cattail. Since more than 50 percent of the dominant species have a facultative, facultative wet, or obligate wetland plant status, this study plot satisfied the hydrophytic vegetation criterion.

The wetland study plot described above (DP-7) was representative of the wetland plant community on unmaintained portions of the golf course, such as along the stream and the Northwest Ponds. However, most of the area included in Wetland B is within maintained fairways of the golf course. As a result, the predominant vegetation in these areas was turf grass. Vegetation was not the basis of wetland determinations in these areas.

There was no canopy or understory vegetation in the upland study plot (DP-8) adjacent to Wetland B. Since the plot was in a golf course fairway, the dominant species in the herb layer was turf grass. No attempt was made to identify the mowed grass because it was entirely maintained and not a result of wetland presence or absence. This study plot did not satisfy the hydrophytic vegetation criterion because the grass species of the maintained fairway had an areal coverage of 100 percent, and no other hydrophytic vegetation was found.

Soils

The soil in the wetland study plot was a black (10YR 2/1) muck from 0 to 18 inches. Since the soil had a low chroma, the study plot satisfied the hydric soil criterion. In the adjacent upland plot, the soil was a dark brown (10YR 3/3 dry) fill from 0 to 18 inches. Since no indicators of hydric soils were found, the study plot did not satisfy the hydric soil criterion.

Areas of the golf course that were later included in Wetland B as a result of the field work with Parametrix had soils similar to those found in the data plot described above (DP-7). Soil cores taken in fairways from the west side of the wetland had a surface layer of black muck over a layer of dark brown peaty muck to a depth of 20 inches. Soil cores closer to the approach light road had a surface layer of dark brown peaty muck over a layer of dark gray clay with bright mottles to a depth of 20 inches. Some cores in this area revealed a subsurface layer of light gray silt resembling diatomite. Upland areas adjacent to the fairway wetland areas were comprised of fill and had soils similar to those of the upland data plot described above (DP-8).

Hydrology

In the wetland study plot, the soil was saturated to the surface, and standing water was present at a depth of 1 inch below the surface. Since evidence of hydrology was present during the growing season, the study plot satisfied the wetland hydrology criterion.

In the adjacent upland study plot, a well-drained portion of the golf course fairway, there were no indicators of wetland hydrology.

The manipulation of drainage on the golf course made wetland determinations in the fairways particularly difficult. In much of the fairway area on the west side of Wetland B, wetland hydrology was not observed during the field visits in June 1998. However, early in the growing season in 1999, water was found standing 1 inch below the surface. In the fairway closest to the approach light road, drainage had been manipulated with drain tiles to the extent that during the June 1998 field visits, field indicators of wetland hydrology were not observed. Early in the growing season in 1999, however, water was found 1 to 12 inches below the surface. Based on the field visits in early 1999, SWEES and Parametrix ecologists concluded that the manipulation of water on the golf course had not been sufficient to remove wetland hydrology completely from the fairways west of the approach light road. As a result of satisfying the hydrology criterion, these areas were included in Wetland B.

Wetland Determination

The Wetland B study plot was determined to be wetland because it has hydrophytic vegetation, hydric soil, and wetland hydrology, meeting all three criteria. The adjacent upland study plot was determined to be a non-wetland since the vegetation criterion was not applicable and no other criteria were met.

Some of the fairways of the golf course were not determined to be wetland during the June 1998 field visits because, even though the vegetation was maintained turf grass and organic hydric soils were present, no indications of wetland hydrology were found. These fairway areas were later determined to be wetland and included in Wetland B when wetland hydrology was found during field visits earlier in the growing season.

Wetland Classification

Wetland B is a palustrine emergent wetland with a scrub-shrub component (Cowardin *et al.*, 1979). Based on the wetland classification system used by the City of SeaTac, Wetland B would be classified as PEM/PSS, since both communities are present. Wetland B is rated as a Class 1 wetland because it is hydrologically connected to Wetland A. The distinction between Wetland A and Wetland B is in fact one of convenience, based primarily on Wetland B being wholly within the Tyee Golf Course.

As with Wetland A, Wetland B requires a 100-foot buffer, according to SeaTac Municipal Code 15.30.290.

Wetland Buffer

The 100-foot buffer required around Wetland B is bordered on three sides by the fairways of the Tyee Golf Course. On the west side, the wetland is contiguous with the Northwest Ponds of Wetland A, the boundary at this point applied for the convenience of calculating wetland acreage on the golf course. Des Moines Creek bisects the wetland and flows through the buffer on the downstream end. On the upstream end of the wetland, the buffer overlaps with Wetland A.

3.3.3 Wetland C

Wetland C is 0.8 acres in area, located entirely within a ditch that runs parallel to 16th Avenue South from the center of Wetland A. It has only one class of vegetation, but since it is hydrologically connected to Wetland A, it is rated as a Class 1 wetland. Wetland C is a palustrine forested wetland. It receives water from local runoff and stormwater inputs from the airport. Wetland C is connected to Wetland A via a culvert under an access road to the airport industrial wastewater system. Wetland C appears to be a remnant of historic wetlands, being defined currently by the fill prism of commercial and airport development.

Vegetation

The dominant species in the canopy of the wetland study plot (DP-9) was cottonwood. The dominant understory species was Oregon ash (*Fraxinus latifolia*). The dominant species in the herb layer was Oregon ash seedlings. Other species within the plot included Watson's willow-herb and traces of lady fern. Since more than 50 percent of the dominant species have a facultative, facultative wet, or obligate wetland plant status, this study plot satisfied the hydrophytic vegetation criterion.

The dominant species in the canopy of the upland study plot (DP-10) adjacent to Wetland C was cottonwood. The dominant species in the understory was Himalayan blackberry. The dominant species in the herb layer was field horsetail (*Equisetum arvense*). Also present were Indian plum and Scotch broom (*Cytisus scoparius*) in the shrub layer and traces of trailing blackberry (*Rubus ursinus*), English ivy (*Hedera helix*), and sword fern (*Polystichum munitum*) in the herb layer. The hydrophytic criterion was not satisfied in the upland study plot.

Soils

The soil in the wetland study plot was a very dark gray (10YR 3/1) silt loam from 0 to 4 inches, overlaying a white (Gley N 8/) sand from 4 to 18 inches. Since the soil had a low chroma, the study plot satisfied the hydric soil criterion.

In the adjacent upland plot, the soil was a very dark grayish-brown (10YR 3/2) gravelly sand road fill from 0 to refusal at 4 inches. Since no indicators of hydric soils were found, the study plot did not satisfy the hydric soil criterion.

Hydrology

Much of the ground surface of Wetland C was inundated. In the wetland study plot, the soil was saturated to the surface, and standing water was present at a depth of 2 inches below the surface. Since evidence of hydrology was present during the growing season, the study plot satisfied the wetland hydrology criterion.

In the adjacent upland study plot, on the side slope of the ditch, there were no indicators of wetland hydrology.

Wetland Determination

The Wetland C study plot was determined to be wetland because it has hydrophytic vegetation, hydric soil, and wetland hydrology, meeting all three criteria. The adjacent upland study plot was determined to be a non-wetland because only one of three criteria was met.

Wetland Classification

Wetland C is a palustrine forested wetland. It is over one acre in area and has one class of vegetation. Wetland C is rated as a Class 1 wetland because it is hydrologically connected to Wetland A, therefore requiring a 100-foot buffer.

Wetland Buffer

The 100-foot buffer required around Wetland C is bordered on the west by 16th Avenue South and contiguous with the road embankment. On the east side, the buffer is bordered by a holding pond of the airport industrial wastewater system, which is cleared of vegetation.

3.3.4 Wetland D

Wetland D was not delineated in the current study, but its flagged boundary was found in the course of delineating Wetland A. It extends north from Wetland A flags A-136, on the east side of the ditch, and A-138, approximately 50 feet to the west of the ditch, with A-137 marking the west side of the ditch. Flag A-138 corresponds to flag S-129 in the previously flagged boundary. Information on this wetland will be reported as it becomes available.

Wetland D is 4.1 acres in area, located entirely within a ditch that runs parallel to the runways on the east side, and is bordered by the airport industrial wastewater system holding pond to the west. It extends north from the northeast corner of Wetland A. It has only one class of vegetation, but since it is hydrologically connected to Wetland A, it is rated by King County as a Class 1 wetland. Wetland D is a palustrine scrub-shrub wetland. It receives water from local runoff and stormwater inputs from the airport. Wetland D is connected to Wetland A via an open channel and flows into the eastern pond of the Northwest Ponds (Wetland A). Wetland D appears to be a remnant of historic wetlands, being defined currently by the fill prism of airport development.

Vegetation

The canopy of Wetland D is dominated by Scouler willow, with common reed (*Phragmites communis*) in the understory. The herb layer is mostly bare sandy soil, with some grasses present.

The dominant species in the fill adjacent to Wetland D are similar to those in the vicinity of Wetland C, with cottonwood and red alder in the canopy, and Himalayan blackberry and Scotch broom in the understory.

Soils

The top layer of the soil in Wetland D is comprised of sand and silt. The probable soils are low chroma silt loam and sand deposits.

In the upland area adjacent to Wetland D, soils are likely to be consistent with road fill, being compacted gravel and sand.

Hydrology

Based on water levels observed in the downstream end of Wetland D, sections that are further upgrade are expected to be saturated to the surface during the early growing season. During a January 1999 site visit, water was flowing from the stormwater outfall in the upper section, and much of the ground surface of Wetland D was inundated.

In the upland fill, which forms the sides of Wetland D, no wetland hydrology would be expected.

Wetland Determination

Based on confirmation of the flagged boundaries observed at the downstream end of the Wetland D channel, and given that the entire area in question is restricted to a wide ditch for its entire length, it seems likely that all three wetland criteria are met. It is also likely the filled area forming the sides of the ditch are non-wetland, even with the possibility that the vegetation is hydrophytic.

Wetland Classification

Wetland D is a palustrine scrub-shrub wetland. It is over one acre in area and has one class of vegetation. Wetland D is rated as a Class 1 wetland because it is hydrologically connected to Wetland A, therefore requiring a 100-foot buffer.

Wetland Buffer

The 100-foot buffer required around Wetland D is bordered on the west and north by a portion of the airport industrial wastewater system, which is cleared of vegetation. Its southern border is a fairway of the Tyee Golf Course, and the east side abuts the southernmost runway of the airport.

Table 3: Wetland Determination Sample Plot Results, Des Moines Regional Detention Pond, CIP #1A1767

PLOT	VEGETATION	SOILS	HYDROLOGY*	DETERMINATION
DP-1	Hydrophytic	Hydric	Observed	Wetland
DP-2	Hydrophytic	Non-Hydric	Not Observed	Non-Wetland
DP-3	Hydrophytic	Hydric	Observed	Wetland
DP-4	Non-Hydrophytic	Non-Hydric	Not Observed	Non-Wetland
DP-5	Hydrophytic	Hydric	Observed	Wetland
DP-6	Hydrophytic	Hydric	Not Observed	Non-Wetland
DP-7	Hydrophytic	Hydric	Observed	Wetland
DP-8	Not Determined	Non-Hydric	Not Observed	Non-Wetland
DP-9	Hydrophytic	Hydric	Observed	Wetland
DP-10	Hydrophytic	Non-Hydric	Not Observed	Non-Wetland

* = The notation "Observed" includes cases when only field indicators of hydrology were present; the notation "Not Observed" indicates that neither hydrology nor field indicators were observed.

4.0 WILDLIFE

Use of the site wetlands by wildlife is probably moderate but locally significant. The wetland/upland habitat complex is located in an industrialized area near major arterials and the airport, which limits its use as refuge for many species. However, with the fact that it is a parcel of remaining open space in an otherwise highly developed area, the site as a whole provides cover, forage, and nesting and rearing habitat for several species of birds, small mammals, reptiles, and invertebrates.

The following species were either observed or their sign was found on-site during field visits: common garter snake (*Thamnophis sirtalis*), bullfrog (*Rana catesbiana*), moles (*Scapanus spp.*), voles (*Microtis spp.*), river otter (*Lutra canadensis*), raccoon (*Procyon lotor*), Virginia rail (*Rallus limicola*), Canada goose (*Branta canadensis*), red-tailed hawk (*Buteo jamaicensis*), killdeer (*Charadrius vociferus*), great blue heron (*Ardea herodias*), violet-green swallow (*Tachycineta thalassina*), barn swallow (*Hirundo rustica*), winter wren (*Troglodytes troglodytes*), American robin (*Turdus migratorius*), Swainson's thrush (*Catharus ustulatus*), black-headed grosbeak (*Pheucticus melanocephalus*), yellow-headed blackbird (*Xanthocephalus xanthocephalus*), red-winged blackbird (*Agelaius phoeniceus*), red-breasted nuthatch (*Sitta canadensis*), rufous-sided towhee (*Pipilo erythrophthalmus*), song sparrow (*Melospiza melodia*), and house finch (*Carpodacus mexicanus*).

In the spring of 1995 and 1996, a consultant to the Port of Seattle surveyed the Northwest Ponds for the presence of amphibians. Standardized methods were used to sample for vocalizing and non-vocalizing frogs and toads, as well as for salamanders. Both adult and juvenile bullfrogs were found. No other amphibians were found during the survey.

5.0 PROJECT IMPACTS

Ecological functions and values performed by wetlands include water quality improvement, flood flow moderation, biological support, groundwater exchange, and cultural and recreational values.

All wetlands were evaluated for functional values, and the results were compiled in a single assessment for the entire site (Appendix C). Current functional values of the wetlands are summarized in Table 4.

Although it is still in draft form, ESU also applied the Washington State Wetland Functional Assessment Method. This method is currently being tested and evaluated by the Washington State Department of Ecology. In general, the results of the Washington State Method were similar to those obtained through the standard method used by SWEES (Reppert *et al.*, 1979). Evaluated as a depressional outflow, the site wetland ranked high in functions that improve water quality and provide suitable habitat for birds, fish, invertebrates, and plants. An interesting exception to the habitat suitability was that for amphibians it was assessed as zero. Results from this assessment are attached in Appendix F.

Table 4: Wetland Functional Values, Des Moines Regional Detention Pond, CIP #1A1767

WETLAND FUNCTIONAL VALUES						
Wetland	Water Quality Improvement	Flood Flow Moderation	Biological Support		Ground-water Exchange	Cultural/ Recreational
			Habitat	Productivity		
Overall	M-H	H	M-H	M-H	M-H	L

L = Low; M = Moderate; H = High

5.1 WATER QUALITY

Through a variety of physical, biological, and chemical processes, wetlands function to purify water by removing organic and mineral particulate matter and waterborne pollutants. Water quality improvement occurs as a result of the natural processes of sedimentation, ion exchange, algal and bacterial degradation of pollutants, aerobic decomposition, particulate absorption and adsorption, and nutrient uptake and recycling (Reppert *et al.*, 1979).

The site wetlands have the potential to improve water quality due to their depressional topography, constricted outlet, and fairly dense vegetation. The performance of this function is moderate to high, due to the inputs of sediment and pollutants from the runoff and stormwater of the surrounding area. This rating does not address the other water quality concerns associated with the high levels of nutrients found in the wetlands, such as low dissolved oxygen levels in Des Moines Creek downstream of the wetlands.

5.2 FLOOD FLOW MODERATION/STORMWATER

Wetlands moderate flood flow by temporarily storing flood waters, slowing flood velocities, and reducing flood energy. As a result, flood peaks are desynchronized and reduced, while flow duration is increased. The storage capacity and the surface roughness (type and amount of vegetation) of wetlands are important variables in the ability of a wetland to perform this function (Reppert *et al.*, 1979; Sather and Smith, 1984). In watersheds where wetlands have been lost, flood peaks may increase by as much as 80 percent (Adamus and Stockwell, 1983).

Large amounts of persistent vegetation, position in topographic depressions, large wetland size, and proximity to urban areas are factors that can enhance inherent ability and opportunity to perform the flood flow moderation function.

The value for flood flow moderation for the site wetlands is high. The large size of the wetlands and their high position in the urbanized watershed increase the opportunity to perform flood flow moderation.

5.3 BIOLOGICAL SUPPORT

The biological support function of wetlands is multifaceted. They provide important wildlife and plant habitat, may be abundantly productive, and provide export of vital nutrients to downstream or surrounding areas. Wetlands provide essential habitat and food for wildlife species; biological support of fish and waterfowl is of particular economic and recreational value.

The number of plant species present, the arrangement (layering, density, and pattern) of the vegetation, and the numbers of distinct vegetation types all influence habitat value. For example, forested wetlands with three distinct layers (overstory, shrub layer, and herbaceous layer), wetlands with more than one vegetation type (for example, forested and scrub/shrub), and wetlands with a well-vegetated buffer at the wetland/upland edge (ecotone) all provide a diversity of habitats.

The site wetlands overall have a moderate to high value as wildlife habitat. Wetland A has a higher value than Wetland B due to its size and open water component. All the wetlands except B have a high plant structural diversity and habitat features such as snags, woody debris, and shrubby cover. The site has been subjected to periodic disturbance as development has progressed in the surrounding properties, resulting in habitat detractions such as broad areas of Himalayan blackberry. However, because the wetlands are connected to other open space that is nearly surrounded by development, they serve as one of the few remaining refuges for wildlife in the area.

The productivity function of wetlands is generally evaluated by production of above-ground biomass and nutrient export. The productivity of the site wetlands may be moderated by the amount of open water compared to dense vegetation in relation to the size of the wetland, but the opportunity for export of nutrients is high due to the presence of surface water connections off-site.

The value for overall biological support for the wetlands on-site is moderate to high.

5.4 GROUNDWATER EXCHANGE

Groundwater exchange consists of both groundwater discharge and groundwater recharge. Groundwater recharge replenishes groundwater stores, while groundwater discharge not only creates and maintains wetlands but can also maintain streamflows, support plant and animal populations in upland and wetland communities, and provide surface water for multiple uses (Sather and Smith, 1984). The best evidence to date suggests that wetlands are generally discharge areas. However, some wetlands are recharge areas and some wetlands support both functions simultaneously or at different times of the year (Sather and Smith, 1984). The permeability of underlying soils and the location of the water table determine a wetland's groundwater exchange capacity.

It is suspected that undeveloped upland areas are more efficient groundwater recharge areas than wetland areas. The rationale for this assertion is that soils under most wetlands are relatively impermeable, which is one reason why standing water is present to begin with (Mitsch and Gosselink, 1986). It has therefore been suggested that groundwater recharge occurring in wetlands is associated with upland boundaries of the wetlands. In the few studies available, recharge was related to the wetland edge-to-volume ratio, so that small wetlands may make a disproportionately greater contribution to groundwater recharge than large wetlands (Weller, 1981, quoted in Mitsch and Gosselink, 1986).

Groundwater exchange value of the onsite wetlands is moderate to high. Since the wetlands are maintained through surface water input and not primarily groundwater connection, they perform a groundwater recharge function. The opportunity to perform this function is increased by the numerous stormwater inputs, coupled with the constricted outlet and peat soils. During dry months, the wetland should perform the groundwater discharge function as the peat soils release moisture. Discharge is probably moderated, however, by the fact that much of the peat area is within the golf course, and, lacking plant cover, loses its moisture to evapotranspiration.

5.5 CULTURAL/RECREATIONAL

Wetland cultural and recreational values are related to the quantitative and qualitative benefits they provide. Wetlands have been set aside for scientific study, education, and the protection of aquatic and terrestrial habitats. Some wetlands are important archaeological or historical sites; others provide recreational opportunities such as bird watching, hiking, photography, boating, fishing, and hunting.

Wetlands provide both consumptive and non-consumptive socio-economic values. Consumptive uses include harvestable resources produced in association with wetlands, such as commercial fisheries, renewable resources, and agriculture. Non-consumptive uses include scenic, recreational, educational, aesthetic, archeological, heritage, and historical values.

The onsite wetlands have a low rating for cultural values and a low value for recreational opportunity. The site lacks attributes such as plant diversity, commercial fisheries, and historic sites, which would increase the cultural and socio-economic values. The recreational opportunities that exist on-site, such as bird and wildlife viewing, would be enhanced if public access were provided, but close proximity to the south runway of SeaTac International Airport makes this impractical and undesirable.

6.0 STREAMS

The west fork of Des Moines Creek (WRIA 09.379) daylights to the northwest of Wetland A and then flows in a ditched channel approximately 300 feet before entering the wetland at the Northwest Ponds. The stream flows from the outlet of the Northwest Ponds at the southeast corner of Wetland A. Bisecting Wetland B, the stream joins the east fork of Des Moines Creek while still on the Tyee Golf Course, then flows under South 200th Street. The length of the stream from the outlet of the Northwest Ponds of Wetland A to the culvert under South 200th Street is approximately 2,400 feet. This reach of the stream is entirely within the golf course.

The stream is in a ditch through the golf course. Most of the stream has no buffer vegetation, as fairway grass is maintained up to the ditch. There is a narrow forested buffer just before the stream leaves the golf course, and Sitka willow is established within the channel in other sections. The gradient throughout the golf course is 1 to 2 percent, and the entire channel is characterized as low gradient riffles and slow glides. The substrate is comprised almost entirely of silts and fine sand. The channel has no woody debris and little woody vegetation along its banks. Despite its current condition and very low water quality during the summer months, resident cutthroat trout (*Oncorhynchus clarki*) have been found in portions of this channel (Alan Johnson, personal communication).

A complete stream survey of Des Moines Creek will be presented under separate cover.

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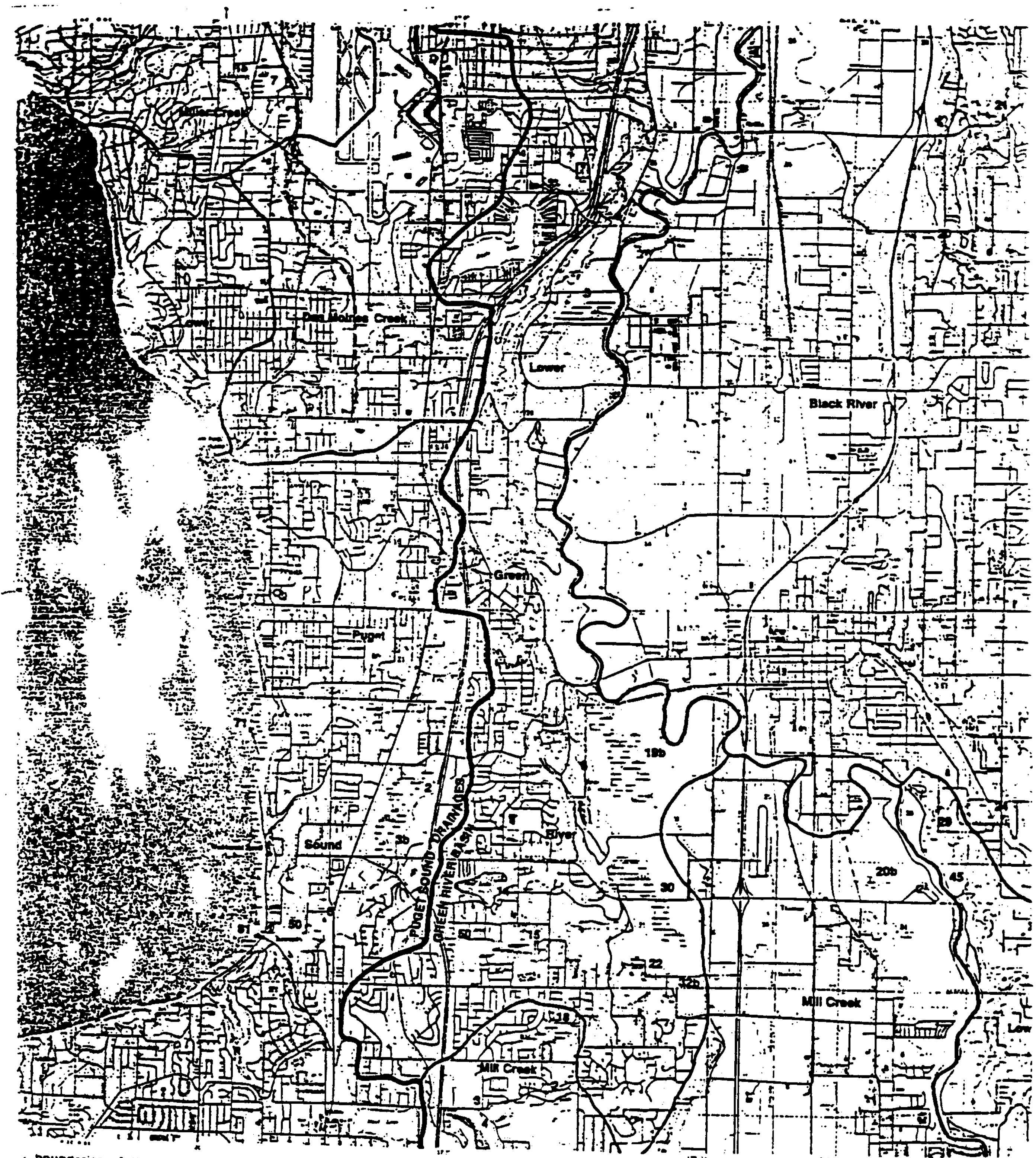
APPENDIX A:

RESOURCE AGENCY AND INVENTORY BACKGROUND INFORMATION

DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767



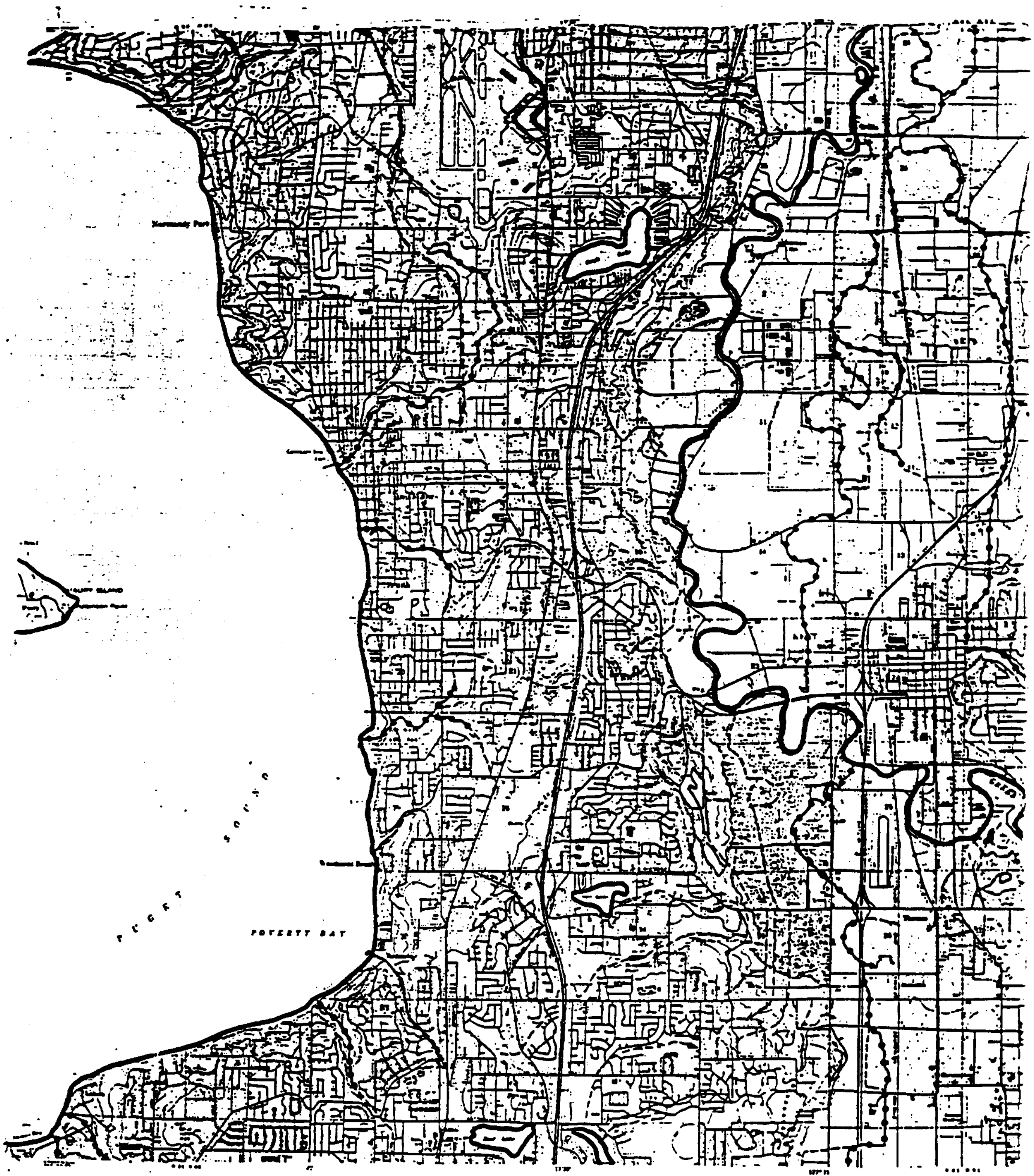
boundaries of the sensitive areas dis-
yed on these maps are approximate.
ditional sensitive areas that have not
en mapped may be present on a devel-
ment proposal site. Where differences
cur between what is illustrated on these
ps and the site conditions, the actual pre-
nce or absence on the site of the sensitive
a - as defined in the Sensitive Area
dinance - is the legal control.

Numbered wetlands, except those with an "a" or "b" designation are included in the *King County Wetlands Inventory*. The locations of wetlands designated "a" have been verified on the site by a variety of sources. Wetlands designated "b" are mapped in the U.S. Fish and Wildlife Service *National Wetlands Inventory*, but their locations have not been field verified.

There may be gaps in the numbering sequences within individual drainage basins.

Wetlands

▤ Wetlar
▨ Open \
━ Basin l
─ Sub-b



The boundaries of the sensitive areas displayed on these maps are approximate. Additional sensitive areas that have not been mapped may be present on a development proposal site. Where differences occur between what is illustrated on these maps and the site conditions, the actual presence or absence on the site of the sensitive area - as defined in the Sensitive Area Ordinance - is the legal control.

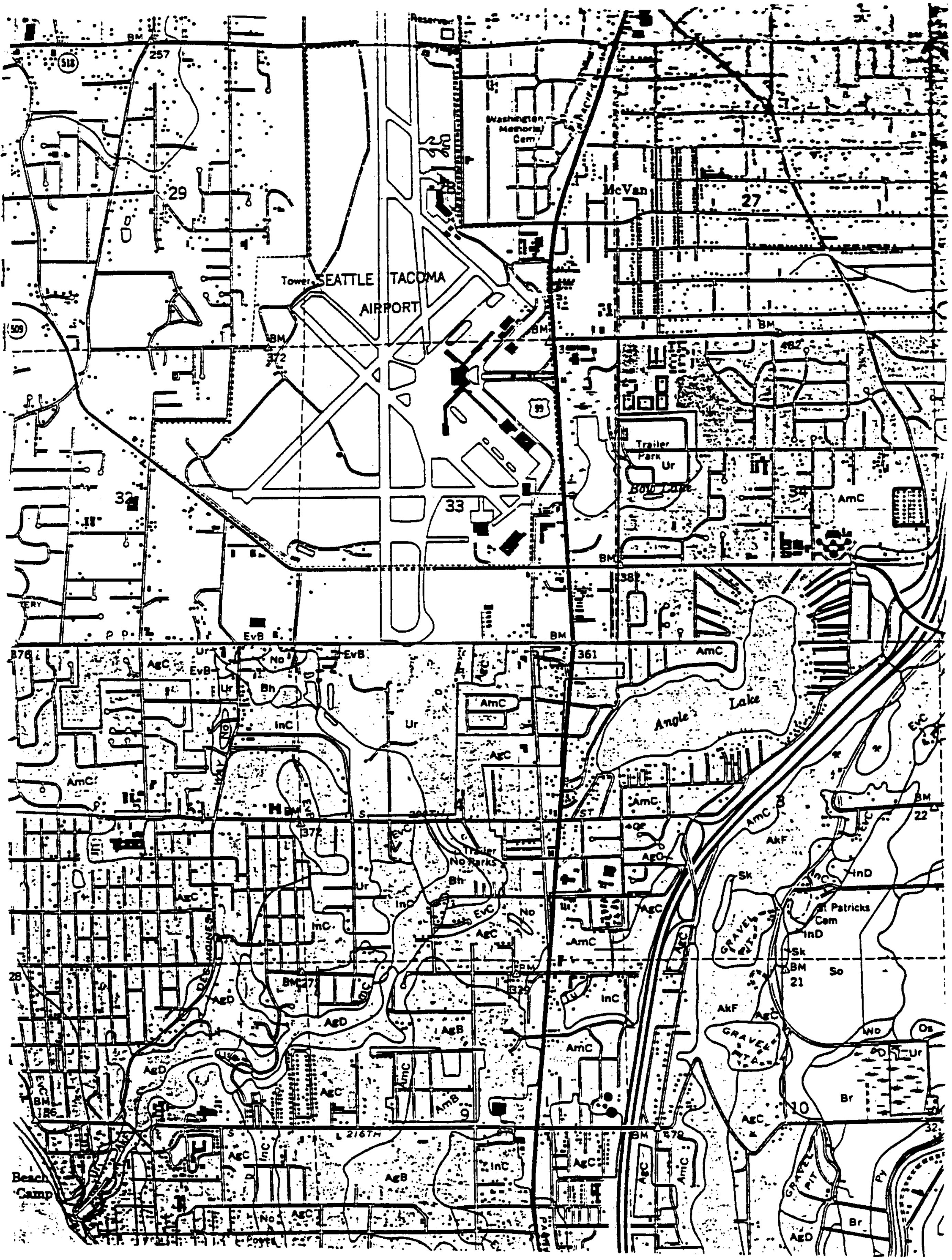
One- hundred-year floodplains extend beyond those shown on maps. Flood Insurance Rate Maps do not always show the floodplain to the headwaters of streams.

▨ 100-Year Floodplains

Streams and 100-Year Floodplains


Tower SEATTLE TACOMA
INTERNATIONAL AIRPORT
Trailer Park
Bow Lake
Arrow Lake
CEMETERY
Angle Lake
Trailer Park
200TH
S 216TH ST
Des Moines
Covenant Beach Camp
Gravel Pit
Gravel Pit
DES MOINES WAY
PACIFIC HIGHWAY
27
32
33
34
5
4
3
9
10
BM 372
BM 276
BM 272
BM 339
BM 21
BM 182
509
99
516


SEATTLE TACOMA
INTERNATIONAL AIRPORT
33
PSSC
Covenant Beach
Camp
Des Moines


Reservoir
Washington Memorial Cem
McVan
29
27
Tower
SEATTLE TACOMA AIRPORT
BM
257
372
482
509
518
99
Trailer Park
Ur
Bow Lake
32
33
34
AmC
38
EvB
361
AgC
No
Bh
InC
Angle Lake
EvC
Trailer Parks
AkF
InD
Sk
St Patricks Cem
So
21
22
Gravel Pit
AgD
AgB
AmB
AgO
Os
Br
Py
10
9
8
28
Beach Camp
S 216TH

Beausite gravelly sandy loam, 15 to 30 percent slopes (BeD).--Areas of this soil are 40 acres or more in size. Slopes are long. On the east side of Squak Mountain, south of Issaquah, and on the north side of Tiger Mountain, east of Issaquah, slopes are as steep as 50 percent.

Some areas are up to 20 percent included Alderwood soils, which have a consolidated substratum, and Ovall soils, which are underlain by andesite; some are up to 5 percent the wet Norma and Seattle soils; some are up to 5 percent Beausite soils that have a gravelly loam surface layer and subsoil; and some are up to 10 percent soils that are similar to Beausite soils, but are more than 40 inches deep over sandstone. On the east side of Squak Mountain, south of Issaquah, and on the north side of Tiger Mountain, east of Issaquah, are included areas where slopes are as steep as 50 percent.

Runoff is rapid and the hazard of erosion is severe.

This soil is used for timber and pasture. Capability unit VIe-2; woodland group 3d1.

Beausite gravelly sandy loam, 40 to 75 percent slopes (BeF).--This soil is similar to Beausite gravelly sandy loam, 6 to 15 percent slopes, but is commonly shallower over sandstone. The depth to sandstone is commonly 20 to 30 inches, but in places is as much as 40 inches. Slopes are convex. Areas are irregularly shaped and range from 100 to about 600 acres in size.

Soils included with this soil in mapping make up no more than 40 percent of the total acreage. Some areas are up to 10 percent Alderwood soils, which have a consolidated substratum; some are up to 10 percent Ovall soils that are 20 to 40 inches deep over weathered andesite and have slopes of 30 to 75 percent; some isolated areas are up to 25 percent rock outcrop; and some are up to 20 percent Beausite soils that have milder slopes.

Runoff is very rapid, and the hazard of erosion is very severe.

This soil is used for timber. Capability unit VIIe-1; woodland group 3d1.

Bellingham Series

The Bellingham series is made up of poorly drained soils that formed in alluvium, under grass and sedges. These soils are nearly level and are mostly in depressions on the upland glacial till plain. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile the surface layer is very dark brown silt loam about 11 inches thick. The subsoil is mottled gray silty clay loam about 49 inches thick.

Bellingham soils are used chiefly for pasture and occasionally for row crops.

Bellingham silt loam (Bh).--Areas of this soil are somewhat rounded and elongated and range from 1 to 40 acres in size. Slopes are less than 2 percent.

Representative profile of Bellingham silt loam, in pasture, 600 feet north and 650 feet east of the south quarter corner of sec. 10, T. 24 N., R. 6 E.:

Ap--0 to 11 inches, very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) dry; common, fine, distinct mottles, brownish yellow (10YR 6/6) dry; moderate, medium, crumb structure; hard, friable, slightly sticky, slightly plastic; many roots; medium acid; abrupt, smooth boundary. 12 to 20 inches thick.

B1--11 to 14 inches, olive-gray (5Y 5/2) loamy sand, light gray (5Y 7/2) dry; massive; hard, very friable, nonsticky, nonplastic; common roots; medium acid; clear, smooth boundary. 0 to 3 inches thick.

B2g--14 to 60 inches, gray (N 5/0) silty clay loam; many, medium and large, prominent, strong-brown mottles, light gray (5Y 7/1) and yellow (10YR 7/8) dry; massive; hard, firm, sticky, plastic; few roots; neutral.

The A horizon ranges from black to very dark grayish brown. The B horizon is grayish brown, olive gray, or gray. It is mostly silty clay loam and heavy silt loam. There are a few thin layers of loamy sand and sandy loam.

Included in mapping were small areas of Alderwood, Everett, and Seattle soils. Total inclusions do not exceed 15 percent of the total acreage.

Permeability is slow. In drained areas, roots penetrate to a depth of 60 inches and more. In undrained areas, effective rooting depth is restricted because the seasonal water table is near the surface during the rainy season. The available water capacity is high. Runoff is slow, and the hazard of erosion is slight.

This soil is used mostly for pasture. A few areas are used for row crops. Capability unit IIIw-2; woodland group 3w2.

Briscot Series

The Briscot series is made up of somewhat poorly drained soils. These soils formed in alluvium, under conifers and grass in river valleys. Slopes are less than 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about sea level to 85 feet.

In a representative profile, the surface layer i dark grayish-brown silt loam about 9 inches thick. The subsoil is mottled grayish-brown and dark-gray stratified fine sandy loam, silt loam, and fine sa to a depth of 60 inches or more.

Briscot soils are used for row crops and seeded grass pasture and for urban development.

and grass on valley floors in the vicinity of North Bend. Slopes are 0 to 3 percent. The annual precipitation is 70 to 80 inches, and the mean annual temperature is about 50° F. The frost-free season is about 150 days. Elevation ranges from 400 to 500 feet.

In a representative profile, the surface layer is very dark grayish-brown to dark grayish-brown fine sandy loam that extends to a depth of about 34 inches. The underlying layers are black gravelly sand and gravelly sandy loam that extend to a depth of 60 inches or more.

Edgewick soils are used for pasture.

Edgewick fine sandy loam (Ed).--This soil is slightly convex or level. Areas are irregular in shape and range from 5 acres to more than 300 acres in size. Slope is less than 3 percent.

Representative profile of Edgewick fine sandy loam, in pasture, 1,430 feet east and 1,000 feet south of the west quarter corner of sec. 15, T. 23 N., R. 8 E.:

Ap--0 to 9 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; slightly hard, very friable, nonsticky, nonplastic; many roots; strongly acid; abrupt, smooth boundary. 8 to 11 inches thick.

C1--9 to 34 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) fine sandy loam, grayish brown (2.5Y 5/2) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; medium acid; abrupt, smooth boundary. 24 to 30 inches thick.

IIC2--34 to 60 inches, black (5Y 2/2), stratified gravelly sand and gravelly sandy loam, grayish brown (2.5Y 5/2) dry; massive; soft, very friable, nonsticky, nonplastic; neutral.

The C horizon ranges from dark grayish brown to olive brown. The content of gravel is as much as 10 percent in places in the A horizon and the C1 horizon. The IIC horizon, at a depth below 32 to 40 inches, ranges from dark grayish brown to black and from stratified sand to fine sandy loam that has gravel in some places.

Soils included with this soil in mapping make up no more than 15 percent of the total acreage. Some areas are up to 10 percent Nooksack and Si soils; some are up to 5 percent Pilchuck soils, which occupy the natural levees along streams and the higher swells and undulations; some areas are up to 2 percent the poorly drained Puget soils; and some are 1 percent the poorly drained Seattle soils.

Permeability is moderately rapid. The effective rooting depth is restricted by the gravelly sand substratum. There is a seasonal high water table at a depth of 3 to 4 feet. Available water capacity is moderately high. Runoff is slow, and the erosion hazard is slight. The hazard of stream overflow is moderate to severe.

This soil is used for pasture. Capability unit IIIw-1; woodland group 2o1.

Everett Series

The Everett series is made up of somewhat excessively drained soils that are underlain by very gravelly sand at a depth of 18 to 36 inches. These soils formed in very gravelly glacial outwash deposits, under conifers. They are on terraces and terrace fronts and are gently undulating and moderately steep. Slopes are 0 to 30 percent. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season ranges from 150 to 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the surface layer and subsoil are black to brown, gravelly to very gravelly sandy loam about 32 inches thick. The substratum extends to a depth of 60 inches or more. It is multicolored black to gray very gravelly sand (pl. I, left).

Everett soils are used for timber and pasture and for urban development.

Everett gravelly sandy loam, 0 to 5 percent slopes (EvB).--This nearly level to very gently undulating soil is on terraces. Areas are irregular in shape and range from 5 acres to more than 200 acres in size.

Representative profile of Everett gravelly sandy loam, 0 to 5 percent slopes, in forest, 450 feet west and 250 feet north of the southeast corner of sec. 30, T. 22 N., R. - E.:

O1--1 to 3/4 inch, undecomposed roots, twigs, and moss; abundant roots. 1 to 2 inches thick.

O2--3/4 inch to 0, black (10YR 2/1), decomposed organic matter; abundant roots. 3/4 of an inch to 1 1/2 inches thick.

A1--0 to 1 1/2 inches, black (10YR 2/1) sandy loam, gray (10YR 5/1) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; abrupt, distinct boundary. 0 to 1 1/2 inches thick.

B2ir--1 1/2 to 17 inches, dark-brown (7.5YR 3/4) gravelly sandy loam, yellowish brown (10YR 5/4) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; clear, smooth boundary. 10 to 18 inches thick.

B3--17 to 32 inches, brown (10YR 4/3) very gravelly sandy loam, pale brown (10YR 6/3) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; medium acid; clear, wavy boundary. 8 to 18 inches thick.

IIC--32 to 60 inches, black and dark grayish-brown (10YR 2/1 and 4/2) very gravelly coarse sand, gray, grayish brown, and brown (10YR 5/1 and 5/3) dry; single grain; loose, nonsticky, nonplastic; few roots; medium acid.

The A horizon ranges from black to dark gray. The Bir horizon ranges from dark brown and brown to dark yellowish brown and the B3 horizon from brown to dark brown. The IIC horizon ranges from black and very dark brown to olive brown, and from very gravelly coarse sand to very gravelly loamy sand. Depth to the IIC horizon ranges from 18 to 36 inches.

Some areas are up to 5 percent included Alderwood soils, on the more rolling and undulating parts of the landscape; some are about 5 percent the deep, sandy Indianola soils; and some are up to 25 percent Neilton very gravelly loamy sands. Also included in mapping are areas where consolidated glacial till, which characteristically underlies Alderwood soils, is at a depth of 5 to 15 feet.

Permeability is rapid. The effective rooting depth is 60 inches or more. Available water capacity is low. Runoff is slow, and the erosion hazard is slight.

This soil is used for timber and pasture and for urban development. Capability unit IVs-1; woodland group 3f3.

Everett gravelly sandy loam, 5 to 15 percent slopes (EvC).--This soil is rolling. Areas are irregular in shape, have a convex surface, and range from 25 acres to more than 200 acres in size. Runoff is slow to medium, and the erosion hazard is slight to moderate.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 5 percent Alderwood soils, which overlie consolidated glacial till; some are up to 20 percent Neilton very gravelly loamy sand; and some are about 15 percent included areas of Everett soils where slopes are more gentle than 5 percent and where they are steeper than 15 percent.

This Everett soil is used for timber and pasture and for urban development. Capability unit VIs-1; woodland group 3f3.

Everett gravelly sandy loam, 15 to 30 percent slopes (EvD).--This soil occurs as long, narrow areas, mostly along drainageways or on short slopes between terrace benches. It is similar to Everett gravelly sandy loam, 0 to 5 percent slopes, but in most places is stonier and more gravelly.

Soils included with this soil in mapping make up no more than 30 percent of the total acreage. Some areas are up to 10 percent Alderwood soils, which overlie consolidated glacial till; some are up to 5 percent the deep, sandy Indianola soils; some are up to 10 percent Neilton very gravelly loamy sand; and some are about 15 percent included areas of Everett soils where slopes are less than 15 percent.

Runoff is medium to rapid, and the erosion hazard is moderate to severe.

Most of the acreage is used for timber. Capability unit VIe-1; woodland group 3f2.

Everett-Alderwood gravelly sandy loams, 6 to 15 percent slopes (EwC).--This mapping unit is about equal parts Everett and Alderwood soils. The soils are rolling. Slopes are dominantly 6 to 10 percent, but range from gentle to steep. Most areas are irregular in shape and range from 15 to 100 acres or more in size. In areas classified as Everett soils, field examination and geologic maps indicate the presence of a consolidated substratum at a depth of 7 to 20 feet. This substratum is the same material as that in the Alderwood soils.

Some areas are up to 5 percent included Norma, Seattle, and Tukwila soils, all of which are poorly drained.

Runoff is slow to medium, and the erosion hazard is slight to moderate.

Most of the acreage is used for timber. Capability unit VIs-1; woodland group 3f3.

Indianola Series

The Indianola series is made up of somewhat excessively drained soils that formed under conifers in sandy, recessional, stratified glacial drift. These undulating, rolling, and hummocky soils are on terraces. Slopes are 0 to 30 percent. The annual precipitation is 30 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to 210 days. Elevation ranges from about sea level to 1,000 feet.

In a representative profile, the upper 30 inches is brown, dark yellowish-brown, and light olive-brown loamy fine sand. This is underlain by olive sand that extends to a depth of 60 inches or more (pl. I, right).

Indianola soils are used for timber and for urban development.

Indianola loamy fine sand, 4 to 15 percent slopes (InC).--This undulating and rolling soil has convex slopes. It is near the edges of upland terraces. Areas range from 5 to more than 100 acres in size.

Representative profile of Indianola loamy fine sand, 4 to 15 percent slopes, in forest, 1,000 feet west and 900 feet south of the northeast corner of sec. 32, T. 25 N., R. 6 E.:

O1--3/4 inch to 0, leaf litter.

B21ir--0 to 6 inches, brown (10YR 4/3) loamy fine sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; many roots; slightly acid; clear, smooth boundary. 4 to 8 inches thick.

B22ir--6 to 15 inches, dark yellowish-brown (10YR 4/4) loamy fine sand, brown (10YR 5/3) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; slightly acid; clear, smooth boundary. 6 to 15 inches thick.

C1--15 to 30 inches, light olive-brown (2.5Y 5/4) loamy fine sand, yellowish brown (10YR 6/4) dry; massive; soft, very friable, nonsticky, nonplastic; common roots; slightly acid; gradual, smooth boundary. 12 to 17 inches thick.

C2--30 to 60 inches, olive (5Y 5/4) sand, light brownish gray (2.5Y 6/2) dry; single grain; loose, nonsticky, nonplastic; few roots; slightly acid. Many feet thick.

There is a thin, very dark brown A1 horizon at the surface in some places. The B horizon ranges from very dark grayish brown to brown and dark yellowish brown. The C horizon ranges from dark grayish brown to pale olive and from loamy fine sand to sand. Thin lenses of silty material are at a depth of 4 to 7 feet in some places.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 10 percent Alderwood soils, on the more rolling and undulating parts of the landscape; some are up to 8 percent the deep, gravelly Everett and Neilton soils; some are up to 15 percent Kitsap soils, which have platy lake sediments in the subsoil; and some are up to 15 percent Ragnar soils, which have a sandy substratum.

Permeability is rapid. The effective rooting depth is 60 inches or more. Available water capacity is moderate.. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for timber and for urban development. Capability unit IVs-2; woodland group 4s3.

Indianola loamy fine sand, 0 to 4 percent slopes (InA).--This soil occupies smooth terraces in long narrow tracts adjacent to streams. Areas range from about 3 to 70 acres in size.

Soils included with this soil in mapping make up no more than 20 percent of the total acreage. Some areas are up to 5 percent Alderwood soils, on the more rolling and undulating parts of the landscape; some are about 10 percent the deep, gravelly Everett and Neilton soils; some are up to 10 percent Indianola loamy fine sand that has stronger slopes; and some areas are up to 10 percent the poorly drained Norma, Shalcar, Tukwila soils.

Runoff is slow, and the erosion hazard is slight.

This soil is used for timber. Capability unit IVs-2; woodland group 4s3.

Indianola loamy fine sand, 15 to 30 percent slopes (InD).--This soil is along entrenched streams.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 10 percent Alderwood soils; some are about 5 percent the deep, gravelly Everett and Neilton soils; some are up to 15 percent Kitsap soils, which have platy, silty lake sediments in the subsoil; and some are up to 15 percent Indianola loamy fine sand that has milder slopes.

Runoff is medium, and the erosion hazard is moderate to severe.

This soil is used for timber. Capability unit VIe-1; woodland group 4s2.

Kitsap Series

The Kitsap series is made up of moderately well drained soils that formed in glacial lake deposits, under a cover of conifers and shrubs. These soils are on terraces and strongly dissected terrace fronts. They are gently undulating and rolling and moderately steep. Slopes are 2 to 70 percent. Platy, silty sediments are at a depth of 18 to 40 inches. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to more than 200 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the surface layer and subsoil are very dark brown and dark yellowish-brown silt loam that extends to a depth of about 24 inches. The substratum is olive-gray silty clay loam. It extends to a depth of 60 inches or more.

Kitsap soils are used for timber and pasture.

Kitsap silt loam, 2 to 8 percent slopes (KpB).--This undulating soil is on low terraces of the major valleys of the Area. Areas range from 5 acres to more than 600 acres in size and are nearly circular to irregular in shape. Some areas are one-eighth to a half mile wide and up to 3 or 4 miles long.

Representative profile of Kitsap silt loam, 2 to 8 percent slopes, in pasture, 820 feet west and 330 feet south of east quarter corner of sec. 28, T. 25 N., R. 7 E.:

Ap--0 to 5 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, medium, granular structure; slightly hard, very friable, nonsticky, nonplastic; many roots; medium acid; abrupt, smooth boundary.

B2--5 to 24 inches, dark yellowish-brown (10YR 3/4) silt loam, brown (10YR 5/3) dry; 2 percent iron concretions; weak, coarse, prismatic structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; slightly acid; abrupt, wavy boundary. 18 to 21 inches thick.

IIC--24 to 60 inches, olive-gray (5Y 5/2) silty clay loam, light gray (5Y 7/2) dry; many, medium and coarse, prominent mottles of dark yellowish brown and strong brown (10YR 4/4 and 7.5YR 5/8); moderate, thin and medium, platy structure; hard, firm, sticky, plastic; few roots to a depth of 36 inches, none below; strongly acid.

The A horizon ranges from very dark brown to dark brown. The B horizon ranges from dark yellowish brown to dark brown and from silt loam to silty clay loam. The platy IIC horizon ranges from grayish brown to olive gray and from silt loam to silty clay loam that has thin lenses of loamy fine sand in places. Brownish mottles are common in the upper part of the IIC horizon.

Some areas are up to 10 percent included Alderwood gravelly sandy loam; some are up to 5 percent the very deep, sandy Indianola soils; and some are up to 5 percent the poorly drained Bellingham, Tukwila, and Seattle soils.

Water flows on top of the substratum in winter. Permeability is moderate above the substratum and very slow within it. The effective rooting depth is about 36 inches. Available water capacity is moderate to moderately high. Runoff is slow to medium, and the erosion hazard is slight to moderate.

This soil is used for timber and pasture. Capability unit IIIe-1; woodland group 2d2.

dry; massive; slightly hard, very friable; nonsticky, nonplastic; few roots; neutral.

The A horizon ranges from very dark grayish brown to very dark brown. The C horizon consists of layers of silt loam, very fine sandy loam, sandy loam, loamy sand, and sand; the thickness of each layer varies. Mottles occur at a depth below 30 to 40 inches in some places.

Some areas are up to 25 or 30 percent inclusions of somewhat poorly drained Briscot, Oridia, and Woodinville soils; and some are up to 10 percent the poorly drained Puget soils. Total inclusions do not exceed 30 percent.

Permeability is moderate. The effective rooting depth is 60 inches or more. A seasonal water table is at a depth of 3 to 4 feet in places. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. The hazard of stream overflow is slight to severe, depending on the amount of flood protection provided.

This soil is used mostly for row crops. Capability unit IIw-1; woodland group 2o1.

Nooksack Series

The Nooksack series is made up of well-drained soils that formed in alluvium in river valleys, under a cover of grass, conifers, and hardwoods. Slopes are 0 to 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 190 days. Elevation ranges from about sea level to 500 feet.

In a representative profile, the soil is very dark grayish-brown, dark grayish-brown, and grayish-brown silt loam to a depth of 60 inches or more.

Nooksack soils are used for row crops and pasture and for urban development.

Nooksack silt loam (Nk).--This nearly level soil is in long, narrow areas that range from 5 to about 300 acres in size. Slopes are less than 2 percent.

Representative profile of cultivated Nooksack silt loam, 1,800 feet east and 500 feet south of the west quarter corner of sec. 4, T. 24 N., R. 7 E.:

Ap1--0 to 2 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; few, fine, faint, dark yellowish-brown (10YR 4/4) mottles; weak, thin, platy structure; slightly hard, very friable, nonsticky, nonplastic; many roots; slightly acid; abrupt, smooth boundary. 2 to 3 inches thick.

Ap2--2 to 11 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, coarse, prismatic structure; slightly hard, very friable, nonsticky, nonplastic; common roots; slightly acid; abrupt, smooth boundary. 8 to 10 inches thick.

B2--11 to 29 inches, dark grayish-brown (2.5Y 4/2) silt loam, light brownish gray (2.5Y 6/2) dry; weak, medium, prismatic structure and weak, medium, subangular blocky structure; hard, friable, slightly sticky, slightly plastic; common roots; medium acid; clear, smooth boundary. 17 to 21 inches thick.

C1--29 to 42 inches, dark grayish-brown (10YR 4/2) and grayish-brown (2.5Y 5/2) silt loam and thin lenses of very fine sandy loam, light brownish gray (2.5Y 6/2) dry; massive; sligh ly hard, very friable, nonsticky, nonplastic; common roots; slightly acid; clear, smooth boundary. 10 to 15 inches thick.

C2--42 to 60 inches, grayish-brown (2.5Y 5/3) silt loam, light brownish gray (2.5Y 6/2) dry; massive; hard, friable, sticky, plastic; common roots; medium acid.

The B and C horizons are mostly silt loam and very fine sandy loam and have lenses of silty clay loam and fine sandy loam. The C horizon is dark grayish brown, grayish brown, or dark brown.

Some areas are up to 5 percent included poorly drained Puget soils; and some are 10 to 15 percent the somewhat poorly drained Oridia and Briscot soi Also included with this soil in mapping are areas of the poorly drained Woodinville silt loam and a few areas of a Woodinville silty clay loam. Inclu soils make up no more than 15 percent of the total acreage.

Permeability is moderate. The effective rooting depth is 60 inches or more. A seasonal water table is at a depth of 3 to 4 feet in places. Available water capacity is high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a mo erate to severe hazard.

This soil is used for row crops and pasture and for urban development. Capability unit IIw-1; woo land group 2o1.

Norma Series

The Norma series is made up of poorly drained soils that formed in alluvium, under sedges, grass, conifers, and hardwoods. These soils are in basin on the glaciated uplands and in areas along the stream bottoms. Slopes are 0 to 2 percent. The annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season is 150 to 200 days. Elevation ranges from about sea level to 600 feet.

In a representative profile, the surface layer black sandy loam about 10 inches thick. The subso is dark grayish-brown and dark-gray sandy loam and extends to a depth of 60 inches or more.

Norma soils are used mainly for pasture. If drained, they are used for row crops.

Norma sandy loam (No).--This soil occurs as str 25 to 300 feet wide. Slopes are less than 2 perce Areas are level or concave and range from 1 to abo 100 acres in size.

Representative profile of Norma sandy loam, in pasture, 725 feet east and 50 feet north of the south quarter corner of sec. 31, T. 20 N., R. 7 E.:

Ap--0 to 10 inches, black (10YR 2/1) sandy loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many roots; slightly acid; abrupt, smooth boundary. 10 to 12 inches thick.

B21g--10 to 30 inches, dark grayish-brown (2.5Y 4/2) sandy loam, light brownish gray (2.5Y 6/2) dry; many, medium, prominent, yellowish-red (5YR 4/8) and brown (7.5YR 4/4) mottles, very pale brown (10YR 7/4) and reddish yellow (7.5YR 6/8) dry; thin platy structure; hard, very friable, nonsticky, nonplastic; few roots; slightly acid; clear, wavy boundary. 19 to 24 inches thick.

B22g--30 to 60 inches, dark-gray (5Y 4/1) sandy loam, light gray (5Y 7/1) dry; common, fine, prominent, strong-brown (7.5YR 5/6) and reddish-yellow (7.5YR 6/6) mottles, yellowish brown (10YR 5/8) and pale brown (2.5Y 7/4) dry; massive; slightly hard, very friable, nonsticky, nonplastic; few roots; slightly acid.

The A horizon ranges from black to very dark brown and is as much as 15 percent gravel. The B horizon commonly is sandy loam that in places is stratified with silt loam and loamy sand. It is as much as 35 percent gravel in some places. The B horizon is mottled gray, dark gray, and dark grayish brown.

Some areas are up to 5 percent included Seattle, Tukwila, and Shalcar soils; and some are up to 5 percent Alderwood and Everett soils, at the slightly higher elevations. In the area northwest of Auburn, in the Green River Valley, there are areas of Norma soils that have an organic surface layer as thick as 12 inches in some places. Also included are small areas of Norma soils that have a silt loam surface layer.

Permeability is moderately rapid. The seasonal water table is at or near the surface. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is moderately high to high. Runoff is slow, and the erosion hazard is slight. Stream overflow is a severe hazard in places.

This soil is used mostly for pasture. Drained areas are used for row crops. Capability unit IIIw-3; woodland group 3w2.

Orcas Series

The Orcas series is made up of very poorly drained organic soils that formed in sphagnum moss and small amounts of Labrador tea and cranberry plants. These soils are in basins on the undulating, rolling glaciated uplands. Slopes are 0 to 1 percent. Annual precipitation is 35 to 60 inches, and the mean annual air temperature is about 50° F. The frost-free season is 160 to 180 days. Elevation ranges from 100 to 500 feet.

In a representative profile, the surface layer is dark reddish-brown sphagnum peat about 6 inches thick. The next layer is yellowish-red sphagnum peat that extends to a depth of about 60 inches.

Orcas soils are used mostly as wildlife habitat.

Orcas peat (Or).--This level or slightly concave soil is in irregularly shaped areas that range from 2 to about 10 acres in size. Slopes are less than 1 percent.

Representative profile of Orcas peat, under wild cranberries, 600 feet north and 650 feet west of the east quarter corner of sec. 8, T. 24 N., R. 6 E.:

0i1--0 to 6 inches, dark reddish-brown (5YR 3/2) sphagnum peat, very pale brown (10YR 7/3) dry; soft, spongy; many roots; extremely acid; clear, smooth boundary. 6 to 8 inches thick.

0i2--6 to 60 inches, yellowish-red (5YR 5/6, 4/6, 4/8) sphagnum peat, very pale brown (10YR 7/4) dry; soft, spongy; few roots; extremely acid.

The 0i1 horizon ranges from dark reddish brown to reddish black. Only slight decomposition has occurred. The 0i2 horizon is uniformly sphagnum peat that ranges from dark reddish brown through yellowish red to very pale brown.

Some areas mapped are up to 20 percent included Seattle and Tukwila mucks, and some are up to 5 percent the wet Bellingham soils.

Permeability is very rapid. There is a water table at or close to the surface for several months each year. In areas where the water table is controlled, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is high. Runoff is ponded, and there is no erosion hazard.

This soil is used mostly as wildlife habitat. Capability unit VIIIw-1; no woodland classification.

Oridia Series

The Oridia series is made up of somewhat poorly drained soils that formed in alluvium in river valleys. Slopes are 0 to 2 percent. The annual precipitation is 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 200 days. Elevation ranges from about 0 to 85 feet.

In a representative profile, the surface layer is dark grayish-brown silt loam about 9 inches thick. The subsoil is grayish-brown, dark grayish-brown, and gray silt loam and silty clay loam that extends to a depth of 60 inches or more.

Oridia soils are used for row crops and pasture and for urban development.

Oridia silt loam (Os).--This gently undulating soil is in irregularly shaped areas. Slopes are less than 2 percent. Areas range from 10 to more than 200 acres in size.

Representative profile of Oridia silt loam, in pasture, 850 feet north, 620 feet east of the southwest corner of sec. 12, T. 22 N., R. 4 E.:

If drained, this soil is used for row crops. It is also used for pasture. Capability unit IIw-3; no woodland classification.

Urban Land

Urban land (Ur) is soil that has been modified by disturbance of the natural layers with additions of fill material several feet thick to accommodate large industrial and housing installations. In the Green River Valley the fill ranges from about 3 to more than 12 feet in thickness, and from gravelly sandy loam to gravelly loam in texture.

The erosion hazard is slight to moderate. No capability or woodland classification.

Woodinville Series

The Woodinville series is made up of nearly level and gently undulating, poorly drained soils that formed under grass and sedges, in alluvium, on stream bottoms. Slopes are 0 to 2 percent. The annual precipitation ranges from 35 to 55 inches, and the mean annual air temperature is about 50° F. The frost-free season is about 190 days. Elevation ranges from about sea level to about 85 feet.

In a representative profile, gray silt loam, silty clay loam, and layers of peaty muck extend to a depth of about 38 inches. This is underlain by greenish-gray silt loam that extends to a depth of 60 inches and more.

Woodinville soils are used for row crops, pasture, and urban development.

Woodinville silt loam (Wo).--This soil is in elongated and blocky shaped areas that range from 5 to nearly 300 acres in size. It is nearly level and gently undulating. Slopes are less than 2 percent.

Representative profile of Woodinville silt loam, in pasture, 1,700 feet south and 400 feet west of the north quarter corner of sec. 6, T. 25 N., R. 7 E.:

Ap1--0 to 3 inches, gray (5Y 5/1) silt loam, grayish brown (10YR 5/2) dry; common, fine, prominent, dark reddish-brown (5YR 3/4) and reddish-brown (5YR 5/4) mottles; moderate, medium, crumb structure; hard, friable, sticky, plastic; many fine roots; medium acid; clear, smooth boundary. 2 to 4 inches thick.

Ap2--3 to 8 inches, gray (5Y 5/1) silty clay loam, light brownish gray (2.5Y 6/2) dry; many, fine, prominent, dark reddish-brown (5YR 3/3 and 3/4) mottles and common, fine, prominent mottles of strong brown (7.5YR 5/6) and reddish yellow (7.5YR 6/6) dry; moderate, fine and very fine, angular blocky structure; hard, friable, sticky, plastic; common fine roots; medium acid; abrupt, wavy boundary. 4 to 6 inches thick.

B21g--8 to 38 inches, gray (5Y 5/1) silty clay loam, gray (5Y 6/1) dry; common, fine, prominent, brown (7.5YR 4/4) mottles and medium, prominent mottles of brownish yellow (10YR 6/6) dry; 25 percent of matrix is lenses of very dark brown (10YR 2/2) and dark yellowish-brown (10YR 3/4) peaty muck, brown (7.5YR 4/2) dry; massive; hard, firm, sticky, plastic; few fine roots; medium acid; clear, smooth boundary. 30 to 40 inches thick.

B22g--38 to 60 inches, greenish-gray (5BG 5/1) silt loam, gray (5Y 6/1) dry; few, fine, prominent mottles of brownish yellow (10YR 6/6) dry; massive; hard, very friable, slightly sticky, slightly plastic; strongly acid.

The A horizon ranges from dark grayish brown to gray and from silt loam to silty clay loam. The B horizon ranges from gray and grayish brown to olive gray and greenish gray and from silty clay loam to silt loam. In places there are thin lenses of very fine sandy loam and loamy fine sand. Peaty lenses are common in the B horizon. These lenses are thin, and their combined thickness, between depths of 10 and 40 inches, does not exceed 10 inches.

Soils included with this soil in mapping make up no more than 25 percent of the total acreage. Some areas are up to 15 percent Puget soils; some are up to 10 percent Snohomish soils; and some areas are up to 10 percent Oridia, Briscot, Puyallup, Newberg, and Nooksack soils.

Permeability is moderately slow. There is a seasonal high water table at or near the surface. In drained areas, the effective rooting depth is 60 inches or more. In undrained areas, rooting depth is restricted. The available water capacity is high. Runoff is slow, and the hazard of erosion is slight. Stream overflow is a severe hazard unless flood protection is provided (pl. III, top).

This soil is used for row crops, pasture, and urban development. Capability unit IIw-2; woodland group 3w2.

LOWER DUWAMISH RIVER

This drainage section includes the Duwamish River from its mouth below the Spokane Street Bridge at Elliott Bay (R.M. 0.00) in Seattle upstream to R.M. 11.0 where the Black River enters near Tukwila. In addition, it covers all independent streams entering Puget Sound from the Duwamish westerly to Alki Point at West Seattle; then southerly through Fauntleroy, Burien, Des Moines, and Redondo beaches to Dash Point, north of Tacoma.

Stream Description

The Duwamish River Waterway lies in the industrial southern portion of Seattle. The lower 5.2 miles of the river are dredged, affording navigation for ships upstream to the First Avenue South Bridge (R.M. 2.5) at high tide. Barge traffic extends to the turning basin at the head of navigation (R.M. 5.2). Water dependent activities utilize lands bordering the lower 8 miles of waterway. The mile-wide valley floor and hillsides have heavy residential development.

The width of the Duwamish varies from 500 to 1,000 feet in the lower 5.2 miles and from 150 to 200 feet upstream to R.M. 11.0. The river in this area is under tidal influence and contains definite stratified layering of salt and fresh water below the turning basin. Velocities are dissipated as the stream enters the wider section of river and currents converge with tidal pressures. Stream banks are sloped and diked to contain flows up to 11,000 cfs. Stream bank sloughing and erosion present continuous maintenance problems, and the lower navigational channel must be dredged every third year. Small areas of sparse natural brush and deciduous trees line the bank. The bottom is primarily silt and mud in the navigation channel with compacted gravel in the upper section.

Fifteen small independent streams enter Puget Sound within this section. These typical lowland drainages receive most of their flow from springs, lake outlets, rain and groundwater runoff. Miller, Bow Lake, and Des Moines creeks are the largest, each flowing down moderately steep hillside ravines before passing across gentle plateaus into Puget Sound. Miller Creek originates in Tub and Burien lakes. An impassable culvert occurs at R.M. 1.8; an impassable falls at mile 2.7. This creek has undergone extensive alteration and total deterioration from the heavy residential and commercial growth in the Burien-Riverton Heights districts. Bow Lake Creek flows from the outlet of Bow Lake (R.M. 3.45) and enters salt water at Des Moines. A sewage treatment plant is located at approximately R.M. 1.0 with a partial block to fish migration from a cement weir with a 30-inch drop, and an impassable cascade occurs at R.M. 1.5. The bottom composition is generally good in one-half of the lower mile of stream and provides suitable spawning area. Des Moines Creek is a short-run stream originating from spring and groundwater sources. It flows west 1.9 miles through a fairly steep ravine to a series of cascades at R.M. 0.75, then crosses a shallow valley and enters Puget Sound between Des Moines and Zenith. Concentrated residential development has altered habitat through diversions, channelization and encroachments. The stream is intermittent in nature and is generally dry during late summer and early fall.

Salmon Utilization

The Duwamish River Waterway is a transportation and rearing area. The lower river estuarial zone is vital to salmon as a transition area for adaptation of migrants to salinity changes. Fall chinook, coho, and chum are the principal salmon species utilizing this watershed. Coho and chum salmon are the only species that ascend Miller, Bow Lake and Des Moines creeks. Coho utilize Longfellow Creek, and coho and chum use the two unnamed tributaries in the southern portion of Poverty Bay near Redondo. Chum spawn in the lower portions of these short-run streams, while coho spawn and rear in their accessible lengths.

Limiting Factors

Water quality is the most serious limiting factor for salmon in the Duwamish waterway. The borderline dissolved oxygen level below R.M. 5.2 is very crucial in August and September, particularly for adult chinook. The saltwater wedge, created by dredging the navigation channel, varies with tidal cycles and contributes to the critical oxygen condition. Industrial wastes, domestic sewage, leachate from landfills, and storm runoff have all contributed to the water quality problems.

Low flows and limited spawning gravel are the major limiting factors in the small independent streams. Siltation and water quality are also serious problems.

Beneficial Developments

The METRO studies and waste disposal systems have benefitted the area's water quality. The Green River Hatchery produces excellent artificial runs of both chinook and coho. The Howard Hanson Dam provides flood control for the lower Green River Valley and Duwamish area.

Habitat Needs

A Shorelines Management Plan that considers protection of aquatic resources and habitat is needed to provide coordinated long-range development of this area. Rehabilitation of the small independent streams would provide excellent opportunities to local sports groups and community clubs for environmental improvement.

PHOTO 09-10. Black River flood control dam and fish passage facilities.

LOWER DUWAMISH RIVER
Duwamish River Basin — WRIA 09

Stream Number	Stream Name	Location Of Mouth	Length	Drainage Area	Salmon Use
0001	Duwamish River [1]	Sec13,T24N,R3E	93.6	—	Chin., Coho, Chum
0003	Unnamed	LB-6.5	2.0	—	Unknown
0004	Black River	RB-11.0	2.65	—	Coho
	(See Duwamish 203)				
	Duwamish R. cont. as Green River	@ mi. 11.01	—	—	
0033	Unnamed	LB-13.2	2.2	—	Unknown
	(See Duwamish 203)				
0038	Drainage Ditch	LB-17.35	~ 1.5	—	None
	(See Duwamish 203)				
0045	~~Unnamed~~ Mullen Slough	LB-21.7	4.2	—	Unknown
	(See Duwamish 203)				
0050	Drainage Ditch	RB-23.05	~ 1.15	—	Unknown
	(See Duwamish 203)				
0051	M^Hill Creek	LB-23.9	8.35	—	Coho
	(See Duwamish 203)				
0061	Unnamed	RB-28.6	1.95	—	Unknown
	(See Duwamish 203)				
0069	Unnamed	RB-30.15	1.0	—	Unknown
	(See Duwamish 203)				
	(Continued Duwamish 303)				
0359	Longfellow Creek	Sec13,T24N,R3E	1.45	—	(Coho)
0362	Unnamed	Sec12,T23N,R3E	1.9	—	Unknown
	Lake Garrett	Outlet-1.4	—	—	
	Unnamed Lake	Outlet-1.9	—	—	
0371	Miller Creek	Sec36,T23N,R3E	4.8	8.21	Coho, (Chum)
	Tub Lake	Outlet-4.2	—	—	
0377	Bow Lake Creek (Des Moines Creek)	Sec8,T22N,R4E	3.45	6.41	Coho, (Chum)
	Bow Lake	Outlet-3.45	—	—	
0380	Unnamed	Sec17,T22N,R4E	1.9	—	Coho, (Chum)
0381	Unnamed	Sec20,T22N,R4E	1.4	—	Coho, (Chum)
0385	Unnamed	Sec5,T21N,R4E	1.1	—	(Coho), (Chum)
0386	Unnamed	Sec1,T21N,R3E	1.25	—	Coho, (Chum)

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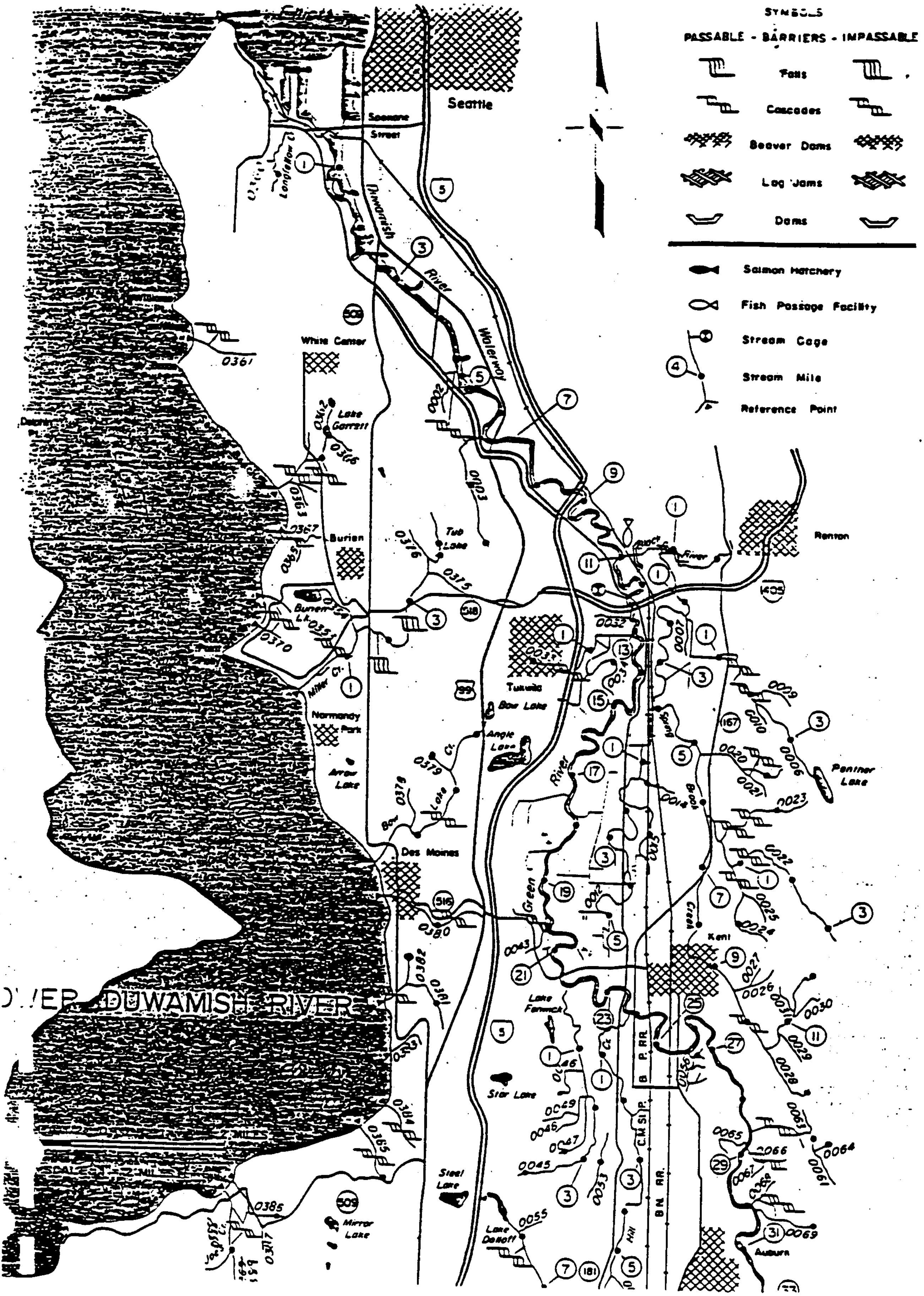
[1] *The eleven mile lower stretch of the Green River is called the Duwamish River.*


SYMBOLS
PASSABLE - BARRIERS - IMPASSABLE
Falls
Cascades
Beaver Dams
Log Jams
Dams
Salmon Hatchery
Fish Passage Facility
Stream Gage
Stream Mile
Reference Point
Seattle
Spokane Street
Longfellow Cr.
Duwamish River
Waterway
White Center
Lake Garrett
Burien
Tub Lake
Burien Lk.
Miller Cr.
Normandy Park
Arrow Lake
Tukwila
Bow Lake
Angle Lake
Des Moines
Green River
Lake Fenwick
Star Lake
Steel Lake
Lake Dolloff
Mirror Lake
Renton
Black River
Panther Lake
Springbrook Creek
Kent
Auburn
Mill Cr.
B. P. RR.
C.M.St.P.
BN RR.
LOWER DUWAMISH RIVER
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APPENDIX B:

SAMPLE DATA FORMS

DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767

WETLAND FUNCTIONAL VALUE ASSESSMENT

FUNCTIONAL VALUES	CRITERIA		
	Low Rating	Moderate Rating	High Rating
Water Quality Improvement	___ rapid flow through site	___ moderate flow through site	___ little or no flow present
	___ <50% vegetation density	___ 50-80% vegetation density	___ >80% vegetation density
	___ no proximity to pollutants	___ downstream from nonpoint pollutants	___ downstream from point discharges
Evaluation: ___	___ detains <25% overland runoff	___ detains 25-50% overland runoff	___ detains >50% overland runoff
Flood/Storm Water Control	___ size <5 acres	___ size 5-10 acres	___ size >10 acres
	___ isolated depressions	___ within flood plain	___ within flood plain
	___ <10% woody cover	___ 10-30% woody cover	___ >30% woody cover
	___ unconstrained outlet	___ located in center of watershed	___ constrained outlet
Evaluation: ___	___ located low in watershed		___ located high in watershed
Groundwater Exchange	___ size <5 acres	___ size 5-10 acres	___ size >10 acres
	___ underlain by low permeability strata	___ underlain by moderately permeable strata	___ underlain by permeable strata
	___ temporarily saturated/inundated	___ seasonally flooded systems	___ permanent inundation
Evaluation: ___	___ springs present outflow > inflow	___ outflow = inflow	___ outflow < inflow
Natural Biological Support	___ small size <5 acres	___ medium size 5-10 acres	___ large size >10 acres
	___ Ag. land or low vegetation structure	___ moderate vegetation structure	___ high vegetation structure
	___ isolated systems associated with ephermal surface water	___ associated with permanent surface water	___ associated with permanent open water
	___ one habitat type	___ two habitat types	___ three or more habitat types
	___ low plant diversity	___ moderate plant diversity	___ high plant diversity
	___ few, if any habitat features present	___ some habitat features present	___ several types of habitat features present
Evaluation: ___	___ adjacent buffers primarily disturbed	___ buffers somewhat disturbed	___ buffers generally undisturbed native vegetation

FUNCTIONAL VALUES	CRITERIA		
	Low Rating	Moderate Rating	High Rating
Hydrologic support function (Maintain hydrologic stability and integrity of system) Evaluation: ___	___ isolated marshes, bogs and potholes ___ hydrologically isolated system ___ seldom flooded	___ riverine, lakeshore wetlands ___ occasionally flooded areas	___ marine, intertidal wetlands ___ low gradient, frequently flooded ___ proximity to open water system
Erosion/Shoreline Protection Evaluation: ___	___ sparse grass/forbs or no vegetation along shore ___ little to no fetch in adjacent water body ___ wetland extends <100 yards from shore ___ undeveloped shore	___ sparse woody vegetation or dense herb vegetation ___ moderate fetch in adjacent water body ___ wetland extends 100-200 yards from shore ___ moderately developed shore	___ dense woody vegetation along shore ___ long fetch in adjacent water body ___ wetland extends >200 yards from shore ___ highly developed shore
Aquatic Study Area (Sanctuary, refuge, scientific study, protection of aquatic and terrestrial habitats) Evaluation: ___	___ small isolated wetland <5 acres ___ low educational opportunity ___ little habitat diversity ___ little (none) habitat for migratory/non-migratory species	___ medium size wetland 5-10 acres ___ some educational opportunity ___ some habitat diversity ___ some habitat for migratory and non-migratory species	___ large wetland >10 acres ___ high public educational opportunity ___ high habitat diversity ___ provides habitat for migratory and non-migratory species
Cultural Values (socio-economic) Evaluation: ___	___ lack commercial fisheries, renewable resources or agriculture ___ low aesthetic value ___ lack historic or archeological site	___ moderate aesthetic value	___ contain commercial fisheries, renewable resources or agriculture ___ high aesthetic value (visual diversity) ___ historic or archeological site
Recreational Opportunity Evaluation: ___	___ lack passive and active recreation ___ lack interconnections with open space	___ provide some opportunity for passive and active recreation ___ some interconnections with open space	___ provide good opportunities for passive and limited active recreation (birdwatching, canoeing or hunting) ___ many interconnections with open space

Overall
Evaluation: ___

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): ______________________ Date: ____________

Project/Site: ______________________________________

Applicant/Owner: ______________ Plant Community #/Name: ____________

Do normal environmental conditions exist at the plant community?
Yes ____ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ____ (If yes, explain on back)

- -

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					

Sum of Midpoints ______

Dominance Threshold Number equals 50% X Sum of Midpoints ______

- -

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Sum of Midpoints ______

Dominance Threshold Number equals 50% X Sum of Midpoints ______

- -

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Sum of Midpoints ______

Dominance Threshold Number equals 50% X Sum of Midpoints ______

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

SOILS

Series/phase: ______________________ Subgroup:△ ______________

Is the soil on the hydric soils list? Yes ____ No ____ Undetermined ________

Is the soil a Histosol? Yes ____ No ____ Histic epipedon present? Yes ____ No ____

Is the soil: Mottled? Yes ____ No ____ Gleyed? Yes ____ No ____

Matrix Color: ______________ Mottle Colors: ______________

Other hydric soil indicators: ______________________________

Is the hydric soil criterion met? Yes ____ No ____

Rationale: ______________________________________

- -

HYDROLOGY

Is the ground surface inundated? Yes ____ No ____ Surface water depth: ________

Is the soil saturated? Yes ____ No ____

Depth to free-standing water in pit/soil probe hole: ______________

Mark other field indicators of surface inundation or soil saturation below:

____ Oxidized root zones
____ Water marks
____ Drift lines
____ Water-borne sediment deposits
____ Water-stained leaves
____ Surface scoured areas
____ Wetland drainage patterns
____ Morphological plant adaptations

Additional hydrologic indicators: ______________________________

Comments: ______________________________________

Percent of dominant species that are OBL, FACW and/or FAC: ________

Is the hydrophytic vegetation criterion met? Yes ____ No ____

Is the hydric soil criterion met? Yes ____ No ____

Is the wetland hydrology criterion met? Yes ____ No ____

Is the vegetation unit or plot wetland? Yes ____ No ____

Rationale for jurisdictional decision: ______________________________

Comments (Mitigation Opportunities, Design Changes): ______________________

- -

* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

APPENDIX C:

FIELD DATA SHEETS

DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767

DES MOINES

WETLAND FUNCTIONAL VALUE ASSESSMENT

FUNCTIONAL VALUES	CRITERIA					
	Low Rating		Moderate Rating		High Rating	
Water Quality Improvement	___	rapid flow through site	X	moderate flow through site	___	little or no flow present
	___	<50% vegetation density	X	50-80% vegetation density	___	>80% vegetation density
	___	no proximity to pollutants	___	downstream from nonpoint pollutants	X	downstream from point discharges
Evaluation: M-H	___	detains <25% overland runoff	___	detains 25-50% overland runoff	X	detains >50% overland runoff
Flood/Storm Water Control	___	size <5 acres	___	size 5-10 acres	X	size >10 acres
	___	isolated depressions	___	within flood plain	X	within flood plain
	___	<10% woody cover	___	10-30% woody cover	X	>30% woody cover
	___	unconstrained outlet	___	located in center of watershed	X	constrained outlet
Evaluation: H	___	located low in watershed			X	located high in watershed
Groundwater Exchange	___	size <5 acres	___	size 5-10 acres	X	size >10 acres
	___	underlain by low permeability strata	X	underlain by moderately permeable strata	___	underlain by permeable strata
	___	temporarily saturated/inundated	___	seasonally flooded systems	X	permanent inundation
Evaluation: M-H	___	springs present outflow > inflow	X	outflow = inflow	___	outflow < inflow
Natural Biological Support	___	small size <5 acres	___	medium size 5-10 acres	X	large size >10 acres
	___	Ag. land or low vegetation structure	___	moderate vegetation structure	X	high vegetation structure
	___	isolated systems associated with ephermal surface water	___	associated with permanent surface water	X	associated with permanent open water
	___	one habitat type	___	two habitat types	X	three or more habitat types
	___	low plant diversity	X	moderate plant diversity	___	high plant diversity
	___	few, if any habitat features present	X	some habitat features present	___	several types of habitat features present
Evaluation: M-H	X	adjacent buffers primarily disturbed	___	buffers somewhat disturbed	___	buffers generally undisturbed native vegetation

FUNCTIONAL VALUES	CRITERIA		
	Low Rating	Moderate Rating	High Rating
Hydrologic support function (Maintain hydrologic stability and integrity of system) Evaluation: ___	☐ isolated marshes, bogs and potholes ☐ hydrologically isolated system ☐ seldom flooded	☒ riverine, lakeshore wetlands ☐ occasionally flooded areas	☐ marine, intertidal wetlands ☒ low gradient, frequently flooded ☐ proximity to open water system
Erosion/Shoreline Protection N/A Evaluation: ___	☐ sparse grass/forbs or no vegetation along shore ☐ little to no fetch in adjacent water body ☐ wetland extends <100 yards from shore ☐ undeveloped shore	☐ sparse woody vegetation or dense herb vegetation ☐ moderate fetch in adjacent water body ☐ wetland extends 100-200 yards from shore ☐ moderately developed shore	☐ dense woody vegetation along shore ☐ long fetch in adjacent water body ☐ wetland extends >200 yards from shore ☐ highly developed shore
Aquatic Study Area (Sanctuary, refuge, scientific study, protection of aquatic and terrestrial habitats) Evaluation: ___	☐ small isolated wetland <5 acres ☒ low educational opportunity ☐ little habitat diversity ☐ little (none) habitat for migratory/non-migratory species	☐ medium size wetland 5-10 acres ☐ some educational opportunity ☒ some habitat diversity ☒ some habitat for migratory and non-migratory species	☒ large wetland >10 acres ☐ high public educational opportunity ☐ high habitat diversity ☐ provides habitat for migratory and non-migratory species
Cultural Values (socio-economic) Evaluation: L	☒ lack commercial fisheries, renewable resources or agriculture ☒ low aesthetic value ☒ lack historic or archeological site	☐ moderate aesthetic value	☐ contain commercial fisheries, renewable resources or agriculture ☐ high aesthetic value (visual diversity) ☐ historic or archeological site
Recreational Opportunity Evaluation: L	☒ lack passive and active recreation ☐ lack interconnections with open space	☐ provide some opportunity for passive and active recreation ☒ some interconnections with open space	☐ provide good opportunities for passive and limited active recreation (birdwatching, canoeing or hunting) ☐ many interconnections with open space

Overall
Evaluation: ___

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): HANSEN, RAYBOURN Date: 5-28-98
Project/Site: DES MOINES 'REG. POND
Applicant/Owner: PORT OF SEATTLE Plant Community #/Name: WETLAND F

DP-1

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

	Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1.	POP TRICH	FAC	20	3	20.5	1	*
2.							
3.							
4.							
5.							
6.							
7.							

Sum of Midpoints 20.5
Dominance Threshold Number equals 50% X Sum of Midpoints 10.25

	Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1.	RUB. DISC.	FACU	30	4	38.0	1	*
2.	POP TRICH.	FAC	58	4	38.0	1	*
3.	ALNUS RUB	FAC	10	2	10.5		
4.							
5.							
6.							
7.							
8.							
9.							
10.							

Sum of Midpoints 86.5
Dominance Threshold Number equals 50% X Sum of Midpoints 43.25

	Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1.	PHALARIS AR.	FACW	25	3	20.5	1	*
2.	RANUNCULUS ACRIS	FACW	TR	–	–		
3.	JUNC EFF.	FACW	<5	1	3.0	2	
4.	RUMEX SP.		TR	–	–		
5.							
6.							
7.							
8.							
9.							

Sum of Midpoints 23.5
Dominance Threshold Number equals 50% X Sum of Midpoints 11.75

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

04:M13

SOILS

Series/phase: ______ Subgroup:△ ______

Is the soil on the hydric soils list? Yes ___ No ___ Undetermined ___

Is the soil a Histosol? Yes ___ No X Histic epipedon present? Yes ___ No X

Is the soil: Mottled? Yes ___ No X Gleyed? Yes ___ No X

Matrix Color: 10YR 2/1 Mottle Colors: ______

Other hydric soil indicators: ______

Is the hydric soil criterion met? Yes X No ___

Rationale: LOW CHROMA

- -

HYDROLOGY

Is the ground surface inundated? Yes ___ No X Surface water depth: ______

Is the soil saturated? Yes X No ___

Depth to free-standing water in pit/soil probe hole: 8"

Mark other field indicators of surface inundation or soil saturation below:

___ Oxidized root zones

___ Water marks

___ Drift lines

___ Water-borne sediment deposits

___ Water-stained leaves

___ Surface scoured areas

___ Wetland drainage patterns

___ Morphological plant adaptations

Additional hydrologic indicators: ______

Comments: 0-6" 10YR 2/1 SILT LOAM

6-14" 10YR 2/1 SILT LOAM

14-20 10YR 3/2 SILTY CLAY

Percent of dominant species that are OBL, FACW and/or FAC: 75%

Is the hydrophytic vegetation criterion met? Yes X No ___

Is the hydric soil criterion met? Yes X No ___

Is the wetland hydrology criterion met? Yes X No ___

Is the vegetation unit or plot wetland? Yes X No ___

Rationale for jurisdictional decision:

3 of 3 WETLAND CRITERIA MET

Comments (Mitigation Opportunities, Design Changes): ______

- -

* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): J. HANSEN, J. RAYBOURN Date: 5-28-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND A

DP-2

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. POP TRICH	FAC	60		63.0	1	*
2. ALNUS RUB	FAC	10		10.5	2	
3.						
4.						
5.						
6.						
7.						

Sum of Midpoints 73.5
Dominance Threshold Number equals 50% X Sum of Midpoints 36.75

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. RUB DISC	FACU	100		98.0	1	*
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 98.0
Dominance Threshold Number equals 50% X Sum of Midpoints 49.0

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. URTICA DIOICA	FAC+	15		10.5	1	*
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

Sum of Midpoints 10.5
Dominance Threshold Number equals 50% X Sum of Midpoints 5.25

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

D4:M13

6/1/92

SOILS

Series/phase: ______________ Subgroup:△ ______________

Is the soil on the hydric soils list? Yes ___ No ___ Undetermined ______

Is the soil a Histosol? Yes ___ No X Histic epipedon present? Yes ___ No X

Is the soil: Mottled? Yes ___ No X Gleyed? Yes ___ No X

Matrix Color: 10 YR 3/2 Mottle Colors: ______________

Other hydric soil indicators: ______________

Is the hydric soil criterion met? Yes ___ No X

Rationale: ABSENCE OF HYDRIC INDICATORS

- -

HYDROLOGY

Is the ground surface inundated? Yes ___ No X Surface water depth: ______

Is the soil saturated? Yes ___ No X

Depth to free-standing water in pit/soil probe hole: NONE PRESENT

Mark other field indicators of surface inundation or soil saturation below:

___ Oxidized root zones
___ Water marks
___ Drift lines
___ Water-borne sediment deposits
___ Water-stained leaves
___ Surface scoured areas
___ Wetland drainage patterns
___ Morphological plant adaptations

Additional hydrologic indicators: NO WETLAND HYDROLOGY

DRY FILL AT 14"

Comments: 0-14' NO HORIZONS; FILL COMPOSED OF 10 YR 3/2 SANDYLOAM WITH GRAVEL / ASPHALT

Percent of dominant species that are OBL, FACW and/or FAC: 66%

Is the hydrophytic vegetation criterion met? Yes X No ___

Is the hydric soil criterion met? Yes ___ No X

Is the wetland hydrology criterion met? Yes ___ No X

Is the vegetation unit or plot wetland? Yes ___ No X

Rationale for jurisdictional decision:

ONLY 1 OF 3 WETLAND CRITERIA MET

Comments (Mitigation Opportunities, Design Changes): ______________

- -

* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): J. HANSEN, J. RAVADUEN Date: 5-29-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND F

DP-3

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					

Sum of Midpoints ____
Dominance Threshold Number equals 50% X Sum of Midpoints ____

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. RUB DISC	FACU	80		85.5	1	*
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 85.5
Dominance Threshold Number equals 50% X Sum of Midpoints 42.75

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. ATHYRIA FELIX-F	FAC	20		20.5	2	*
2. EQUIS. ARVENSE	FAC	10		10.5	3	
3. EPILOB. WATSONII	FACW-	60		63.0	1	*
4. POLYSTICH. MUN.	FACU	TR		—		
5. URTICA DIO.	FAC+	TR		—		
6. SOLANUM DULC.	UPL	TR		—		
7.						
8.						
9.						

Sum of Midpoints 94.0
Dominance Threshold Number equals 50% X Sum of Midpoints 47.0

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

SOILS

Series/phase: ______ Subgroup:△ ______

Is the soil on the hydric soils list? [✓ Yes] No ___ Undetermined ___

Is the soil a Histosol? Yes ___ [✓ No] Histic epipedon present? Yes ___ [✓ No]

Is the soil: Mottled? Yes ___ [✓ No] Gleyed? Yes ___ [✓ No]

Matrix Color: 10 YR 2/1 Mottle Colors: ______

Other hydric soil indicators: 0-20" 10 YR 2/1 MUCK

Is the hydric soil criterion met? [✓ Yes] No ___

Rationale: LOW CHROMA

HYDROLOGY

Is the ground surface inundated? [✓ Yes] No ___ Surface water depth: 3"

Is the soil saturated? [✓ Yes] No ___

Depth to free-standing water in pit/soil probe hole: ______

Mark other field indicators of surface inundation or soil saturation below:

- ☐ Oxidized root zones
- ☐ Water marks
- ☐ Drift lines
- ☐ Water-borne sediment deposits
- ☐ Water-stained leaves
- ☐ Surface scoured areas
- ☒ Wetland drainage patterns
- ☐ Morphological plant adaptations

Additional hydrologic indicators: ______

Comments: ______

Percent of dominant species that are OBL, FACW and/or FAC: 66%

Is the hydrophytic vegetation criterion met? [✓ Yes] No ___

Is the hydric soil criterion met? [✓ Yes] No ___

Is the wetland hydrology criterion met? [✓ Yes] No ___

Is the vegetation unit or plot wetland? [✓ Yes] No ___

Rationale for jurisdictional decision:

3 OF 3 WETLAND CRITERIA MET

Comments (Mitigation Opportunities, Design Changes): ______

---

* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): J. HANSEN J. RAYBOURN Date: 5-29-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND 2

DP-4

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					

Sum of Midpoints ____
Dominance Threshold Number equals 50% X Sum of Midpoints ____

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. RUB. DISC	FACU	100		98.0	1	*
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 98.0
Dominance Threshold Number equals 50% X Sum of Midpoints 49.0

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Sum of Midpoints ____
Dominance Threshold Number equals 50% X Sum of Midpoints ____

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

D4:MI3

6/1/92

SOILS

Series/phase: ____ Subgroup:△ ____

Is the soil on the hydric soils list? Yes ____ No ____ Undetermined ____

Is the soil a Histosol? Yes ____ No X Histic epipedon present? Yes ____ No X

Is the soil: Mottled? Yes ____ No X Gleyed? Yes ____ No X

Matrix Color: 10 YR 2/2 Mottle Colors: ____

Other hydric soil indicators: ____

Is the hydric soil criterion met? Yes ____ No X

0-16" 10 YR 2/2 CLAY LOAM

Rationale: NO HYDRIC INDICATORS

- -

HYDROLOGY

Is the ground surface inundated? Yes ____ No X Surface water depth: ____

Is the soil saturated? Yes ____ No X

Depth to free-standing water in pit/soil probe hole: NONE PRESENT

Mark other field indicators of surface inundation or soil saturation below:

____ Oxidized root zones

____ Water marks

____ Drift lines

____ Water-borne sediment deposits

____ Water-stained leaves

____ Surface scoured areas

____ Wetland drainage patterns

____ Morphological plant adaptations

Additional hydrologic indicators: NONE

Comments: ____

Percent of dominant species that are OBL, FACW and/or FAC: 0

Is the hydrophytic vegetation criterion met? Yes ____ No X

Is the hydric soil criterion met? Yes ____ No X

Is the wetland hydrology criterion met? Yes ____ No X

Is the vegetation unit or plot wetland? Yes ____ No X

Rationale for jurisdictional decision:

NO WETLAND CRITERIA MET.

Comments (Mitigation Opportunities, Design Changes): ____

- -

* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): T. HANSEN, J. RAYBOURN, L. HARTEMA Date: 6-9-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND F

DP-5

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. ALNUS RUB	FAC	40		38.0	1	*
2.						
3.						
4.						
5.						
6.						
7.						

Sum of Midpoints 38.0
Dominance Threshold Number equals 50% X Sum of Midpoints 19.0

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. CORYLUS CORN.	FACU	5		3.0	4	
2. OEMLAR. CERR.	FACU	70		63.0	1	*
3. RUB. DISC	FACU	10		10.5	3	
4. CORNUS STOL.	FACW	20		20.5	2	
5. SAMBUCUS RACE	FACU	20		20.5	2	
6. RUBUS SPEC.	FAC+	5		3.0	4	
7.						
8.						
9.						
10.						

Sum of Midpoints 120.5
Dominance Threshold Number equals 50% X Sum of Midpoints 60.25

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. RANUN. ACRIS	FACW-	90		98.0	1	*
2. EQUIS. ARV.	FAC	TR		–		
3. URTICA DIOICA	FAC+	TR		–		
4. EPILOBIUM WAT	FACW-	TR		–		
5.						
6.						
7.						
8.						
9.						

Sum of Midpoints 98.0
Dominance Threshold Number equals 50% X Sum of Midpoints 49.0

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

04:M13

4/1/92

SOILS

Subgroup:△ ____

Series/phase: ____

Is the soil on the hydric soils list? Yes ____ No ____ Undetermined ____

Is the soil a Histosol? Yes X No ____ Histic epipedon present? Yes ____ No X

Is the soil: Mottled? Yes ____ No X Gleyed? Yes ____ No X

Matrix Color: 10 YR 2/1 Mottle Colors: ____

Other hydric soil indicators: ____ 0-20" 10 YR 2/1 MUCKY PEA

Is the hydric soil criterion met? Yes ____ No ____

Rationale: LOW CHROMA, ORGANIC

HYDROLOGY

Is the ground surface inundated? Yes ____ No X Surface water depth: ____

Is the soil saturated? Yes X No ____ SAT. AT 8" FROM SURFACE

Depth to free-standing water in pit/soil probe hole: ____

Mark other field indicators of surface inundation or soil saturation below:

- ____ Oxidized root zones
- ____ Water marks
- ____ Drift lines
- ____ Water-borne sediment deposits
- ____ Water-stained leaves
- ____ Surface scoured areas
- ____ Wetland drainage patterns
- ____ Morphological plant adaptations

Additional hydrologic indicators: ____

Comments: PEAT SOILS, SHRUB LAYER DOM. BY FACU SPECIES

Percent of dominant species that are OBL, FACW and/or FAC: 66%

Is the hydrophytic vegetation criterion met? Yes X No ____

Is the hydric soil criterion met? Yes X No ____

Is the wetland hydrology criterion met? Yes X No ____

Is the vegetation unit or plot wetland? Yes X No ____

Rationale for jurisdictional decision: ALL 3 CRITERIA MET

Comments (Mitigation Opportunities, Design Changes): ____

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* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): HANSEN RAYBOUEN HARTEMA Date: 6-9-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETL. A

DP-6

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. ALNUS RUB	FAC	50		38.0	1	*
2.						
3.						
4.						
5.						
6.						
7.						

Sum of Midpoints 38.0
Dominance Threshold Number equals 50% X Sum of Midpoints 19.0

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. RUB. SPEC	FAC+	80		85.5	1	*
2. CORNUS STOL.	FACW	10		10.5	3	
3. SAMBUCUS RAC	FACU	30		38.0	2	
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 134.0
Dominance Threshold Number equals 50% X Sum of Midpoints 67.0

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. MAIANTH. DILAT.	FAC	50		38.0	1	*
2. URTICA DIO.	FAC+	40		38.0	1	*
3. POLY. MUNITUM	FACU	5		3.0	2	
4. PTERID. AQUIL	FACU	5		3.0	2	
5.						
6.						
7.						
8.						
9.						

Sum of Midpoints 82.0
Dominance Threshold Number equals 50% X Sum of Midpoints 41.0

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

SOILS

Series/phase: ____ Subgroup:△ ____

Is the soil on the hydric soils list? Yes ___ No ___ Undetermined ___

Is the soil a Histosol? Yes ___ No ✓ Histic epipedon present? Yes ___ No X

Is the soil: Mottled? Yes ___ No X Gleyed? Yes ___ No ✓

Matrix Color: 10YR 3/1 DRY Mottle Colors: ____

Other hydric soil indicators: NO OTHER INDICATORS PRESENT

Is the hydric soil criterion met? Yes X No ___

Rationale: SAND LENSE BENEATH 11" DRAINS UPPER HORIZ.,

WEAK COLOR INDICATOR.

HYDROLOGY

Is the ground surface inundated? Yes ___ No ✓ Surface water depth: ____

Is the soil saturated? Yes ___ No X

Depth to free-standing water in pit/soil probe hole: NONE PRESENT TO 20"

Mark other field indicators of surface inundation or soil saturation below:

___ Oxidized root zones
___ Water marks
___ Drift lines
___ Water-borne sediment deposits
___ Water-stained leaves
___ Surface scoured areas
___ Wetland drainage patterns
___ Morphological plant adaptations

Additional hydrologic indicators: NO EVIDENCE OF ORGANIC TRANSPOR THROUGH SAND LAYER; NO WATER THOUGHT EXPECTED.

Comments: 0-6" 10 YR 2/1 (DRY), HIGH ORGANIC CONTENT
6-11" 10 YR 3/1 (DRY) SILTY CLAY
11-20" 10 YR 3/3 (DRY) SAND
SAND LAYER ACTS AS DRAIN

Percent of dominant species that are OBL, FACW and/or FAC: 100%

Is the hydrophytic vegetation criterion met? Yes X No ___

Is the hydric soil criterion met? Yes X No ___

Is the wetland hydrology criterion met? Yes ___ No X

Is the vegetation unit or plot wetland? Yes ___ No X

Rationale for jurisdictional decision: ALTHOUGH 2 OF 3 CRITERIA ME NO FIELD INDICATORS OF HYDROLOGY; VEGETATION FAC DOMINATED; WATER EXPECTED BUT NOT FOUND.

Comments (Mitigation Opportunities, Design Changes): ____

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* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): HANSEN HARTEMA RAYBOURN Date: 6-10-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND B

DP-7

Do normal environmental conditions exist at the plant community?
Yes X No ___ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ___ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]
1.					
2.					
3.					
4.					
5.					
6.					
7.					

Sum of Midpoints ___
Dominance Threshold Number equals 50% X Sum of Midpoints ___

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. SALIX SITCHEN.	FACW	15		10.5	1	*
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 10.5
Dominance Threshold Number equals 50% X Sum of Midpoints 5.25

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. JUNCUS EFF.	FACW	100		78.0	1	*
2. SCIRPUS MICRO.	OBL	40		38.0	2	*
3. CAREX STIP.	FACW+	20		20.5	3	
4. LOTUS CORNICIRATUS	FAC	20		20.5	3	
5. TYPHA LAT	OBL	5		3.0	4	
6. EPILOBIUM WAT	FACW-	TR	–	–		
7. HOLCUS LAN.	FAC	TR	–	–		
8. POA SP.	–	TR	–	–		
9.						

Sum of Midpoints 180.0
Dominance Threshold Number equals 50% X Sum of Midpoints 90.0

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

SOILS

Series/phase: ____________ Subgroup:△ ____________

Is the soil on the hydric soils list? Yes ____ No ____ Undetermined ____

Is the soil a Histosol? Yes ____ No X Histic epipedon present? Yes ____ No X

Is the soil: Mottled? Yes ____ No X Gleyed? Yes ____ No X

Matrix Color: 10 YR 2/1 Mottle Colors: ____________

Other hydric soil indicators: ____________

Is the hydric soil criterion met? Yes X No ____ 0-18" 10YR 2/1 MUCK

Rationale: LOW CHROMA

HYDROLOGY

Is the ground surface inundated? Yes ____ No X Surface water depth: ____________

Is the soil saturated? Yes X No ____ SAT. TO SURF.

Depth to free-standing water in pit/soil probe hole: 1"

Mark other field indicators of surface inundation or soil saturation below:

____ Oxidized root zones
____ Water marks
____ Drift lines
____ Water-borne sediment deposits
____ Water-stained leaves
____ Surface scoured areas
____ Wetland drainage patterns
____ Morphological plant adaptations

Additional hydrologic indicators: ____________

AREA AFFECTED BY HIGH FLOWS OF STREAM.

Comments: ____________

Percent of dominant species that are OBL, FACW and/or FAC: 100%

Is the hydrophytic vegetation criterion met? Yes X No ____

Is the hydric soil criterion met? Yes X No ____

Is the wetland hydrology criterion met? Yes X No ____

Is the vegetation unit or plot wetland? Yes X No ____

Rationale for jurisdictional decision: ____________

ALL 3 CRITERIA MET.

Comments (Mitigation Opportunities, Design Changes): ____________

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△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

DP-8

Field Investigator(s): HANSEN, HARTEMA RAYBOURN Date: 6-10-92
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND B

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover¹ Class	Midpoint¹ of Cover Class	Rank²
1.					
2.					
3.					
4.					
5.					
6.					
7.					
			Sum of Midpoints		
Dominance Threshold Number equals 50% X Sum of Midpoints					

Shrub Species	Indicator Status	Percent Areal Cover	Cover¹ Class	Midpoint¹ of Cover Class	Rank²
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
			Sum of Midpoints		
Dominance Threshold Number equals 50% X Sum of Midpoints					

GOLF COURSE FAIRWAY

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover¹ Class	Midpoint¹ of Cover Class	Rank²
1. LAWN GRASS	—	100%		98.0	1 *
2. BELLIS PERENNIS	UPL	5		3.0	2
3. TARAXACUM OFFIC.	UPL	TR		—	
4. TRIFOLIUM DUBIUM	UPL	TR		—	
5.					
6.					
7.					
8.					
9.					
			Sum of Midpoints	101.0	
Dominance Threshold Number equals 50% X Sum of Midpoints				50.5	

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

D4:M13

SOILS

Subgroup:△ ____________

Series/phase: ____________

Is the soil on the hydric soils list? Yes ____ No ____ Undetermined ____

Is the soil a Histosol? Yes ____ No X Histic epipedon present? Yes ____ No X

Is the soil: Mottled? Yes X No ____ Gleyed? Yes ____ No X.

Matrix Color: 10YR 3/3 DRY Mottle Colors: WEAK

Other hydric soil indicators: DISTURBED FILL 0-18"

Is the hydric soil criterion met? Yes ____ No X

Rationale: ABSENCE OF HYDRIC CHAR.

HYDROLOGY

Is the ground surface inundated? Yes ____ No X Surface water depth: ____________

Is the soil saturated? Yes ____ No X

Depth to free-standing water in pit/soil probe hole: NONE TO 18"

Mark other field indicators of surface inundation or soil saturation below:

- ____ Oxidized root zones
- ____ Water marks
- ____ Drift lines
- ____ Water-borne sediment deposits
- ____ Water-stained leaves
- ____ Surface scoured areas
- ____ Wetland drainage patterns
- ____ Morphological plant adaptations

Additional hydrologic indicators: NO WATER PRESENT IN WELL-DRAINED PORTION OF GOLFCOURSE FAIRWAY.

Comments: MAINTAINED FAIRWAY GRASSES COULD BE HYDROPHYTIC UNDER PERAQUIC WATER REGIME, HOWEVER, NO EVIDENCE OF HYDROLOGY, THEREFE LAWN SPECIES IDENTIFICATION NOT APPLICABLE.

Percent of dominant species that are OBL, FACW and/or FAC: N/A GOLF COURSE FAIRWAY

Is the hydrophytic vegetation criterion met? Yes ____ No ____ N/A

Is the hydric soil criterion met? Yes ____ No X

Is the wetland hydrology criterion met? Yes ____ No X

Is the vegetation unit or plot wetland? Yes ____ No X

Rationale for jurisdictional decision: VEGETATION NOT APPLICABLE; NO OTHER CRITERIA MET.

Comments (Mitigation Opportunities, Design Changes): SEVERAL FEET OF FILL OVER PEAT. SOME PEAT NOT COVERED, BUT EFFECTIVELY DRAINED WITH TILE SYSTEM.

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△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): HANSEN HARTEMA, RAYBOURN Date: 6-25-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND C

DP-9

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. POP. TRICH	FAC	80		85.5	1	*
2. ALNUS RUBRA	FAC	5		3.0	2	
3.						
4.						
5.						
6.						
7.						

Sum of Midpoints 88.5
Dominance Threshold Number equals 50% X Sum of Midpoints 44.25

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. FRAX. LATIF.	FACW	90		85.5	1	*
2. RUB. DISC.	FACU	10		10.5	2	
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 96.0
Dominance Threshold Number equals 50% X Sum of Midpoints 48.0

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. EPILOB. WAT.	FACW-	10		10.5	2	
2. FRAX. LATIF.	FACW	80		85.5	1	*
3. ATHYR. FELIX-F	FAC.	TR		—		
4. EQUIS. ARV.	FAC	TR		—		
5.						
6.						
7.						
8.						
9.						

Sum of Midpoints 96.0
Dominance Threshold Number equals 50% X Sum of Midpoints 48.0

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

D4:H13

6/1/92

SOILS

Series/phase: ______ Subgroup:△ ______

Is the soil on the hydric soils list? Yes ___ No ___ Undetermined ___

Is the soil a Histosol? Yes ___ No X Histic epipedon present? Yes ___ No X

Is the soil: Mottled? Yes ___ No X Gleyed? Yes X No ___

Matrix Color: GLEY 8/0 Mottle Colors: ______

Other hydric soil indicators: ______

Is the hydric soil criterion met? Yes ___ No ___ 0-4" 10YR 3/1, SILT LOAM

Rationale: LOW CHROMA 4-18" GLEY 8/0 SAND

HYDROLOGY

Is the ground surface inundated? Yes ___ No X Surface water depth: ______

Is the soil saturated? Yes X No ___

Depth to free-standing water in pit/soil probe hole: 2"

Mark other field indicators of surface inundation or soil saturation below:

___ Oxidized root zones

___ Water marks

___ Drift lines

___ Water-borne sediment deposits

X Water-stained leaves

___ Surface scoured areas

X Wetland drainage patterns

___ Morphological plant adaptations

Additional hydrologic indicators: WITHIN INUNDATED DITCH.

Comments: DITCH WITH CONSTRICTED OUTLET.

Percent of dominant species that are OBL, FACW and/or FAC: 100%

Is the hydrophytic vegetation criterion met? Yes X No ___

Is the hydric soil criterion met? Yes X No ___

Is the wetland hydrology criterion met? Yes X No ___

Is the vegetation unit or plot wetland? Yes X No ___

Rationale for jurisdictional decision: ______

ALL 3 WETLAND CRITERIA MET.

Comments (Mitigation Opportunities, Design Changes): ______

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* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD*

Field Investigator(s): HANSEN HARTEMA, RAYBOURN Date: 6-25-98
Project/Site: DES MOINES REG. POND
Applicant/Owner: POS Plant Community #/Name: WETLAND C

DP-10

Do normal environmental conditions exist at the plant community?
Yes X No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No X (If yes, explain on back)

VEGETATION

Tree Species (Percent Cover Option)	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. POP TRICH	FAC	100		98.0	1	*
2.						
3.						
4.						
5.						
6.						
7.						

Sum of Midpoints 98.0
Dominance Threshold Number equals 50% X Sum of Midpoints 49.0

Shrub Species	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. CYTISUS SCOP.	UPL	10		10.5	2	
2. RUB. DISC.	FACU	30		38.0	1	*
3. OEMLAR. CERAS	FACU	10		10.5	2	
4.						
5.						
6.						
7.						
8.						
9.						
10.						

Sum of Midpoints 59.0
Dominance Threshold Number equals 50% X Sum of Midpoints 29.5

Herbs and Forbs	Indicator Status	Percent Areal Cover	Cover[1] Class	Midpoint[1] of Cover Class	Rank[2]	
1. EQUIS. ARV.	FAC	50		38.0	1	*
2. RUBUS URSIN.	FACU.	TR		—	-	
3. HEDERA HELIX	UPL	TR		—		
4. POLYSTICH. MUN.	FACU	TR		—		
5.						
6.						
7.						
8.						
9.						

Sum of Midpoints 38.0
Dominance Threshold Number equals 50% X Sum of Midpoints 19.0

---

[1] Cover classes (midpoints): T < 1% (none); 1 = 1-5% (3.0); 2 = 6-15% (10.5); 3 = 16-25% (20.5); 4 = 26-50% (38.0); 5 = 51-75% (63.0); 6 = 76-95% (85.5); 7 = 96-100% (98.0).

[2] To determine the dominants, first rank the species by their midpoints. Then cumulatively sum the midpoints of the ranked species until 50% of the total for all species midpoints is immediately exceeded. All species contributing to that cumulative total (the dominance threshold number) *plus* any additional species having 20% of the total midpoint value should be considered dominants and marked with an asterisk.

D4:H13

SOILS

Series/phase: ______ Subgroup:△ ______

Is the soil on the hydric soils list? Yes ___ No ___ Undetermined ___

Is the soil a Histosol? Yes ___ No X Histic epipedon present? Yes ___ No X

Is the soil: Mottled? Yes ___ No X Gleyed? Yes ___ No X

Matrix Color: 10 YR 3/2 Mottle Colors: ROAD FILL 0-4" 10YR 3/2 GRAV. SAND

Other hydric soil indicators: NONE

Is the hydric soil criterion met? Yes ___ No X REFUSAL AT 4"

Rationale: ABSENCE OF HYDRIC CHAR.

HYDROLOGY

Is the ground surface inundated? Yes ___ No X Surface water depth: ______

Is the soil saturated? Yes ___ No X

Depth to free-standing water in pit/soil probe hole: NONE PRESENT

Mark other field indicators of surface inundation or soil saturation below:

___ Oxidized root zones

___ Water marks

___ Drift lines

___ Water-borne sediment deposits

___ Water-stained leaves

___ Surface scoured areas

___ Wetland drainage patterns

___ Morphological plant adaptations

Additional hydrologic indicators: ON SLOPE OF DITCH, NO INDICATORS OF HYDROLOGY ABOVE CLEAR ORDINARY HIGH WATER MARK.

Comments: SOIL PROBE REFUSAL AT 4" IN IMPORTED FILL FORMING DITCH SLOPE.

Percent of dominant species that are OBL, FACW and/or FAC: 66%

Is the hydrophytic vegetation criterion met? Yes X No ___

Is the hydric soil criterion met? Yes ___ No X

Is the wetland hydrology criterion met? Yes ___ No X

Is the vegetation unit or plot wetland? Yes ___ No X

Rationale for jurisdictional decision: ONLY 1 OF 3 CRITERIA MET.

Comments (Mitigation Opportunities, Design Changes): ______

---

* This data form can be used for both the Vegetation Unit Sampling Procedure and the Quadrat Transect Sampling Procedure of the Intermediate-Level Onsite Determination Method, or the Quadrat Sampling Procedure of the Comprehensive Onsite Determination Method. Indicate which method is used.

△ Classification according to "Soil Taxonomy."

APPENDIX D:

WETLAND PHOTOGRAPHS

DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767

APPENDIX E:

PLANT LIST

DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767

PLANT SPECIES LIST FOR DATA PLOTS AND STUDY SITE
DES MOINES CREEK REGIONAL DETENTION POND
KING COUNTY, WASHINGTON
CIP #1A1767

Scientific Name	**Common Name**	**Wetland Status**
Alnus rubra	red alder	FAC
Alopecurus geniculatus	water foxtail	OBL
Angelica genuflexa	kneeling angelica	FACW
Athyria felix-femina	lady fern	FAC
Bellis perennis	English daisy	UPL
Carex stipata	sawbeak sedge	FACW+
Conium maculatum	poison-hemlock	FAC+
Cornus stolonifera	red-osier dogwood	FACW
Corylus cornuta	beaked hazelnut	FACU
Cytisus scoparius	Scotch broom	UPL
Eleocharis palustris	creeping spike rush	OBL
Epilobium watsonii	Watson's willow-herb	FACW-
Equisetum arvense	field horsetail	FAC
Fraxinus latifolia	Oregon ash	FACW
Hedera helix	English ivy	UPL
Holcus lanatus	velvet grass	FAC
Iris pseudacorus	yellow flag	OBL
Juncus bolanderi	Bolander's rush	OBL
Juncus bufonius	toad rush	FACW
Juncus effusus	soft rush	FACW
Lemna sp.	duckweed	OBL
Lonicera involucrata	black twinberry	FAC+
Lotus corniculatus	birdsfoot trefoil	FAC
Lythrum salicaria	purple loosestrife	FACW+
Maianthemum dilatatum	false lily-of-the-valley	FAC
Oemleria cerasiformis	Indian plum	FACU
Phalaris arundinacea	reed canarygrass	FACW
Poa sp.	bluegrass	FAC
Polystichum munitum	Sword fern	FACU
Populus trichocarpus	black cottonwood	FAC
Pteridium aquilinum	bracken fern	FACU
Ranunculus acris	tall buttercup	FACW-
Rosa nutkana	Nootka rose	FAC
Rosa pisocarpa	clustered wild rose	FAC
Rubus discolor	Himalayan blackberry	FACU
Rubus spectabilis	Salmonberry	FAC+
Rubus ursinus	trailing blackberry	FACU
Rumex occidentalis	western dock	FACW+
Salix lasiandra	Pacific willow	FACW+

Scientific Name	**Common Name**	**Wetland Status**
Salix scouleriana	Scouler willow	FAC
Salix sitchensis	Sitka willow	FACW
Sambucus racemosa	red elderberry	FACU
Scirpus microcarpus	small-fruited bulrush	OBL
Solanum dulcamara	European bittersweet	UPL
Spiraea douglasii	Douglas spiraea	FACW
Taraxacum officinale	common dandelion	UPL
Thuja plicata	western red cedar	FAC
Trifolium dubium	least hop clover	UPL
Typha latifolia	broad-leaved cattail	OBL
Urtica dioica	stinging nettle	FAC+

OBL	Obligate. Occur almost always in wetlands, under natural conditions, > 99%.
FACW	Facultative wetland. Usually occur in wetlands, but occasionally found in non-wetlands, 67-99%.
FAC	Facultative. Equally likely to occur in wetlands and non-wetlands, 34-66%.
FACU	Facultative upland. Usually occur in non-wetlands, but sometimes found in wetlands, 1-33%.
UPL	Upland. Occur in wetlands in another region, but occur almost always, under natural conditions, in non-wetlands in this region (Region 9), <1%.
NI	No indicator. No indicator status assigned.

APPENDIX F:

WASHINGTON STATE
FUNCTIONAL ASSESSMENT RATING FORM

DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767

SITE #0 #AU= 0.0

Depressional Outflow

Summary of Function Assessments

Function	Index
Potential for Removing Sediment	0.7
Potential for Removing Nutrients	0.5
Potential for Removing Heavy Metals and Toxic Organics	0.7
Potential for Reducing Peak Flows	0.5
Potential for Reducing Decreasing Downstream Erosion	0.5
Potential for Groundwater Recharge	0.0
General Habitat Suitability	0.9
Habitat Suitability for Invertebrates	1.0
Habitat Suitability for Amphibians	0.6
Habitat Suitability for Anadromous Fish	0.9
Habitat Suitability for Resident Fish	1.0
Habitat Suitability for Birds	0.8
Habitat Suitability for Aquatic Mammals	0.6
Habitat for Native Plant Communities	0.8
Primary Production and Export	0.6

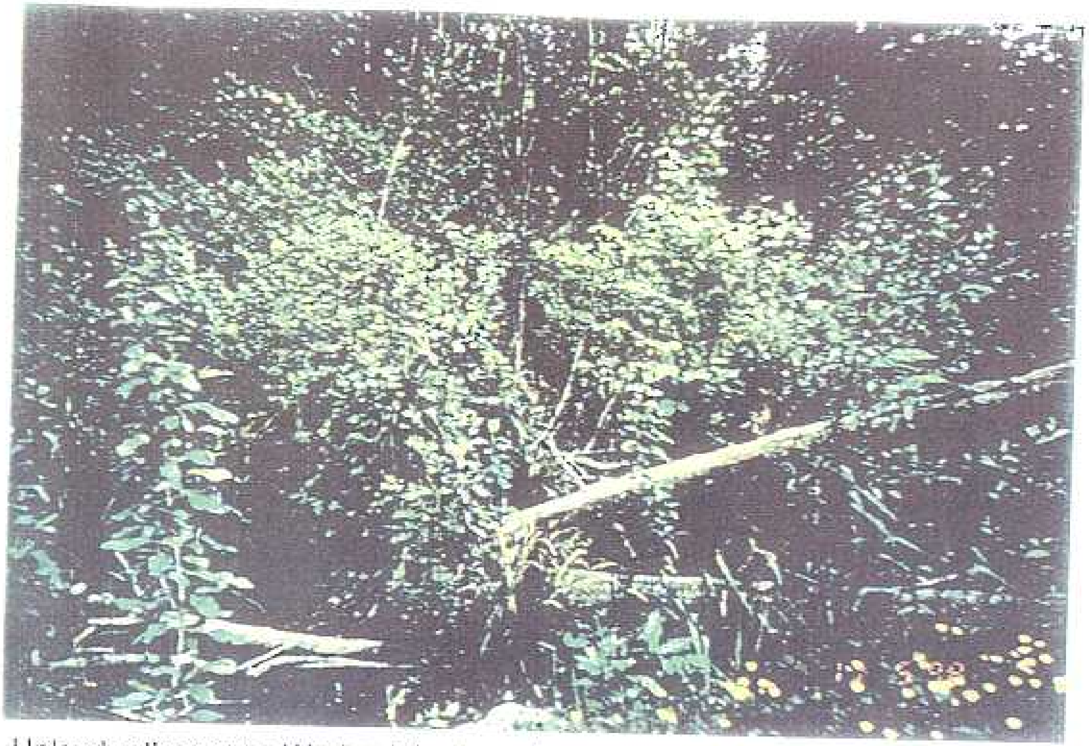
APPENDIX G:

FIELD DATA FORMS FOR THE WASHINGTON STATE WETLAND RATING SYSTEM

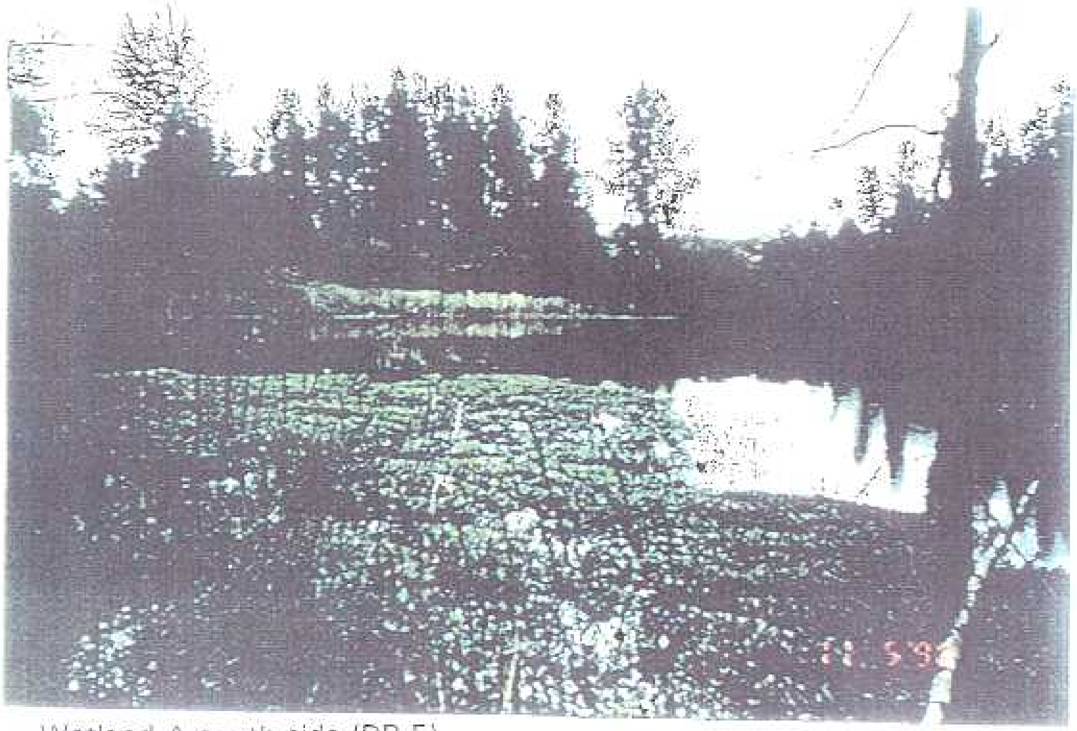
DES MOINES CREEK REGIONAL DETENTION POND

KING COUNTY, WASHINGTON

CIP #1A1767

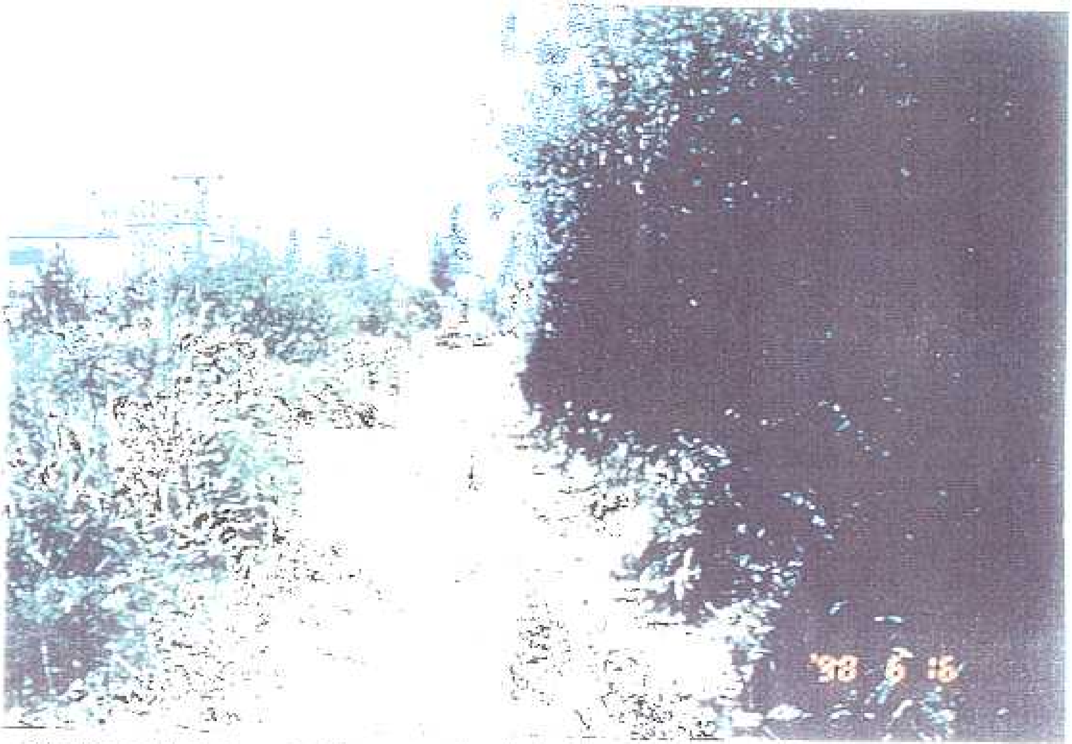


Upland adjacent to Wetland A at southwest corner (DP-4).

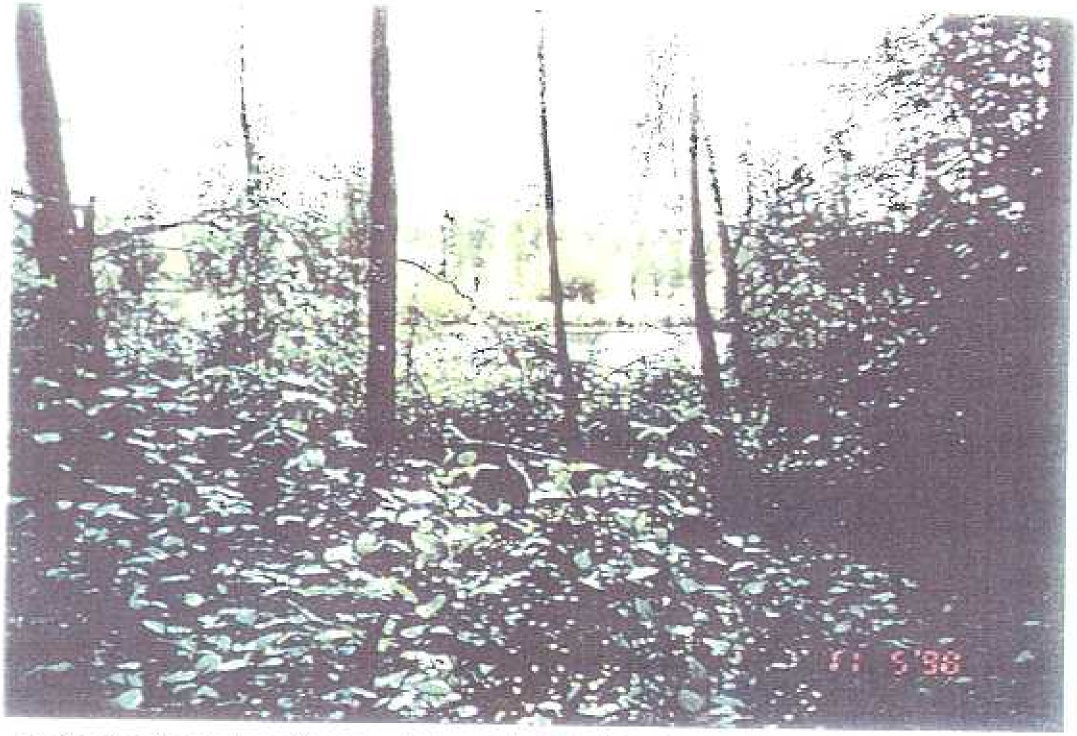


Wetland A south side (DP-5).

Upland adjacent to Wetland B (DP-8).



Wetland (right) and adjacent upland (left) near Wetland C (DP-9, DP-10).



Upland adjacent to Wetland A south side (DP-6).

Wetland B (DP-7).

Wetlands Rating Field Data Form

Background Information:

Name of Rater: JON HANSEN Affiliation: King County Date: 10-98

Name of wetland (if known): Northwest Ponds

Government Jurisdiction of wetland: City of SeaTac

Location: 1/4 Section: ____ of 1/4 S: ____ Section: 4+5 Township: 23 Range: 4

Sources of Information: (Check all sources that apply)

Site visit: ✓ USGS Topo Map: ✓ NWI map: ✓ Aerial Photo: ✓ Soils survey: ✓

Other: ___ Describe: ____

When The Field Data form is complete enter Category here: II

Q.1. High Quality Natural Wetland

Circle Answers

Answer this question if you have adequate information or experience to do so. If not find someone with the expertise to answer the questions. Then, if the answer to questions 1a, 1b and 1c are all NO, contact the Natural Heritage program of DNR.

1a. Human caused disturbances.

Is there significant evidence of human-caused changes to topography or hydrology of the wetland as indicated by any of the following conditions? Consider only changes that may have taken place in the last 5 decades. The impacts of changes done earlier have probably been stabilized and the wetland ecosystem will be close to reaching some new equilibrium that may represent a high quality wetland.

1a1. Upstream watershed > 12% impervious. [✓ Yes] go to Q.2
1a2. Wetland is ditched and water flow is not obstructed. Yes: go to Q.2
1a3. Wetland has been graded, filled, logged. Yes: go to Q.2
1a4. Water in wetland is controlled by dikes, weirs, etc. Yes: go to Q.2
1a5. Wetland is grazed. Yes: go to Q.2
1a6. Other indicators of disturbance (list below) Yes: go to Q.2
Peat excavation No: go to 1b.
Golf Course construction
Past Farming

1b Are there populations of non-native plants which are currently present, cover more than 10% of the wetland, and appear to be invading native populations? Briefly describe any non-native plant populations and Information source(s):	YES: go to Q.2 No: go to 1c.
1c. Is there evidence of human-caused disturbances which have visibly degraded water quality. Evidence of the degradation of water quality include: direct (untreated) runoff from roads or parking lots; presence, or historic evidence, of waste dumps; oily sheens; the smell of organic chemicals; or lifestock use. Briefly describe:	YES: go to Q.2 NO: Possible Cat. I contact DNR
Q.2. Irreplaceable Ecological Functions: Does the wetland:	(NO to all: go to Q.3)
⊕ have at least 1/4 acre of organic soils deeper than 16 inches and the wetland is relatively undisturbed; OR [If the answer is NO because the wetland is disturbed briefly describe: Indicators of disturbance may include: - Wetland has been graded, filled, logged; - Organic soils on the surface are dried-out for more than half of the year; - Wetland receives direct stormwater runoff from urban or agricultural areas.]; OR	YES go to 2a No based on disturbance - Stormwater input - Clearing, grading and filling in the past
⊕ have a forested class greater than 1 acre; OR	[✓ YES:] Go to 2b
⊕ have characteristics of an estuarine system; OR	YES: Go to 2c no
⊕ have eel grass, floating or non-floating kelp beds?	YES: Go to 2d no
2a. Bogs and Fens Are any of the three following conditions met for the area of organic soil?	
2a.1. Are Sphagnum mosses a common ground cover (>30%) and the cover of invasive species (see Table 3) is less than 10%?	
Is the area of sphagnum mosses and deep organic soils > 1/2 acre?	YES: Category I
Is the area of sphagnum mosses and deep organic soils 1/4-1/2 acre?	YES: Category II
	NO: Go to 2a.3
2a.2. Is there an area of organic soil which has an emergent class with at least one species from Table 2, and cover of invasive species is < 10% (see Table 3)?	
Is the area of herbaceous plants and deep organic soils > 1/2 acre?	YES: Category I
Is the area of herbaceous plants and deep organic soils 1/4-1/2 acre?	YES: Category II
	NO: Go to 2a.3

2a.3. Is the vegetation a mixture of only herbaceous plants and Sphagnum mosses with no scrub/shrub or forested classes?	
Is the area of herbaceous plants, Sphagnum, and deep organic soils > 1/2 acre?	YES: Category I
Is the area of herbaceous plants, Sphagnum, and deep organic soils 1/4-1/2 acre?	YES: Category II
	NO: Go to Q.3.
Q.2b. Mature forested wetland.	
2b.1. Does 50% of the cover of upper forest canopy consist of evergreen trees older than 80 years or deciduous trees older than 50 years? *Note:* The size of trees is often not a measure of age, and size cannot be used as a surrogate for age (see guidance).	YES: Category I [✓ NO]: Go to 2b.2 1937, 1959 aerials Show area cleared
2b.2. Does 50% of the cover of forest canopy consist of evergreen trees older than 50 years, AND is the structural diversity of the forest high as characterized by an additional layer of trees 20'-49' tall, shrubs 6' - 20', tall, and a herbaceous groundcover?	YES: Go to 2b.3 [✓ NO]: Go to Q.3
2b.3. Does < 25% of the areal cover in the herbaceous/groundcover or the shrub layer consist of invasive/exotic plant species from the list on p. 19?	YES: Category I NO: Go to Q.3
Q.2c. Estuarine wetlands.	
2c1. Is the wetland listed as National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park, or Educational, Environmental or Scientific Reserves designated under WAC 332-30-151?	YES: Category I NO: Go to 2c.2
2c.2. Is the wetland > 5 acres; . . . . *Note:* If an area contains patches of salt tolerant vegetation that are 1) less than 600 feet apart and that are separated by mudflats that go dry on a Mean Low Tide, or 2) separated by tidal channels that are less than 100 feet wide; all the vegetated areas are to be considered together in calculating the wetland area.	YES: Category I
or is the wetland 1-5 acres;	YES: Go to 2c.3
or is the wetland < 1 acre?	YES: Go to 2c.4

2c.3. Does the wetland meet at least 3 of the following 4 criteria: . . . . - minimum existing evidence of human related disturbance such as diking, ditching, filling, cultivation, grazing or the presence of non-native plant species (see guidance for definition); - surface water connection with tidal saltwater or tidal freshwater; - at least 75% of the wetland has a 100' buffer of ungrazed pasture, open water, shrub or forest; - has at least 3 of the following features: low marsh; high marsh; tidal channels; lagoon(s);woody debris; or contiguous freshwater wetland.	YES: Category I NO: Category II
2c.4. Does the wetland meet all of the four criteria under 2c3. (above)?. .	YES: Category II NO: Category III
Q.2d. Eel Grass and Kelp Beds. 2d.1. Are eel grass beds present?.	YES: Category I NO: go to 2d.2
2d.2. Are there floating or non-floating kelp bed(s) present with greater than 50% macro algal cover in the month of August or September?.	YES: Category I NO: Category II
Q.3. Category IV wetlands. 3a. Is the wetland: less than 1 acre <u>and</u>, hydrologically isolated <u>and</u>, comprised of one vegetated class that is dominated (> 80% areal cover) by one species from Table 3 (page 19) or Table 4 (page 20)	YES: Category IV [✓ NO:] go to 3b
3b. Is the wetland: less than two acres and, hydrologically isolated, with one vegetated class, and > 90% of areal cover is any combination of species from Table 3 (page 19)	YES: Category IV [✓ NO:] go to 3c
3c. Is the wetland excavated from upland <u>and</u> a pond smaller than 1 acre without a surface water connection to streams, lakes, rivers, or other wetland, and has < 0.1 acre of vegetation.	YES: Category IV [✓ NO:] go to Q.4

Q.4. Significant habitat value.

Answer all questions and enter data requested.

4a. Total wetland area

Estimate area, select from choices in the near-right column, and score in the far column:

Enter acreage of wetland here: 31 acres, and source: Survey

Circle scores that qualify

acres	points
> 200	6
40-200	5
10 - 40	[✓ 4]
5 - 10	3
1 - 5	2
0.1 - 1	1
< 0.1	0

4

4b. Wetland classes: Circle the wetland classes below that qualify:

Open Water: if the area of open water is > 1/4 acre

Aquatic Beds: if the area of aquatic beds > 1/4 acre,

Emergent: if the area of emergent class is > 1/4 acre,

Scrub-Shrub: if the area of scrub-shrub class is > 1/4 acre,

Forested: if area of forested class is > 1/4 acre,

Add the number of wetland classes, above, that qualify, and then score according to the columns at right.

e.g. If there are 4 classes (aquatic beds, open water, emergent & scrub- shrub), you would circle 8 points in the far right column.

# of classes	Points
1	0
2	3
3	6
4	[✓ 8]
5	10

8

4c. Plant species diversity.

For each wetland class (at right) that qualifies in 4b above, count the number of different plant species you can find that cover more than 5% of the ground. You do not have to name them.

Score in column at far right:

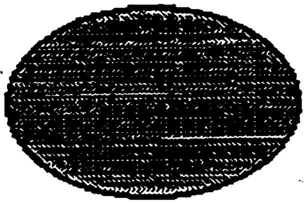
e.g. If a wetland has an aquatic bed class with 3 species, an emergent class with 4 species and a scrub-shrub class with 2 species you would circle 2, 2, and 1 in the far column.

Note: Any plant species with a cover of > 5% qualifies for points within a class, even those that are not of that class.

Class	# species in class	Points
Aquatic Bed	1	0
	2	[✓ 1]
	3	2
	> 3	3
Emergent	1	0
	2-3	1
	4-5	[✓ 2]
	> 5	3
Scrub-Shrub	1	0
	2	1
	3-4	[✓ 2]
	> 4	3
Forested	1	0
	2	1
	3-4	2
	> 4	[✓ 3]

8

4d. Structural diversity. If the wetland has a forested class, add 1 point if each of the following classes is present within the forested class and is <u>larger than 1/4 acre</u>:	
-trees > 50' tall....................	[✓ YES - 1]
-trees 20'- 49' tall....................	[✓ YES - 1]
-shrubs..........................	[✓ YES - 1]
-herbaceous ground cover..............	[✓ YES - 1]
Also add 1 point if there is any "open water" or "aquatic bed" class immediately next to the forested area (ie. there is no scrub/shrub or emergent vegetation between them). ④	YES - 1
4e. Decide from the diagrams below whether interspersion between wetland classes is high, moderate, low or none? If you think the amount of interspersion falls in between the diagrams score accordingly (i.e. a moderately high amount of insterspersion would score a 4, while a moderately low amount would score a 2) ③	High - 5 [✓ Moderate - 3] Low - 1 None - 0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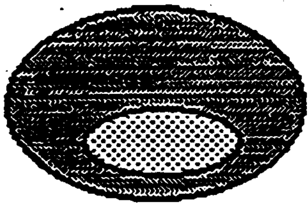
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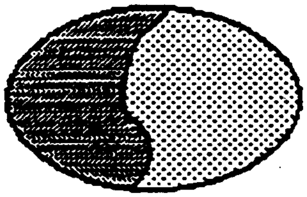
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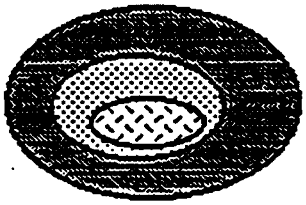
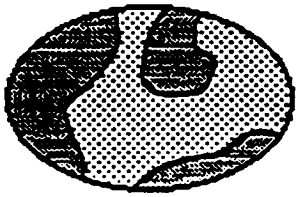

moderate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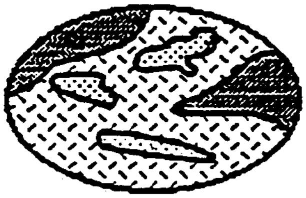
high

4f. Habitat features. Answer questions below, circle features that apply, and score to right:	
Is there evidence that the open or standing water was caused by beavers	YES = 2
Is a heron rookery located within 300'?	YES = 1
Are raptor nest/s located within 300'?	YES = 1
Are there at least 3 standing dead trees (snags) per acre greater than 10" in diameter at "breast height" (DBH)?.	YES = 1
Are there at least 3 downed logs per acre with a diameter > 6" for at least 10' in length?	YES = 1
Are there areas (vegetated or unvegetated) within the wetland that are ponded for at least 4 months out of the year, and the wetland has not qualified as having an open water class in Question 4b. ?	YES = 2

4g. Connection to streams. (Score one answer only.)	
4g.1. Does the wetland provide habitat for fish at any time of the year AND does it have a perennial surface water connection to a fish bearing stream.	[✓ YES = 6]
4g.2 Does the wetland provide fish habitat seasonally AND does it have a seasonal surface water connection to a fish bearing stream.	YES = 4
4g.3 Does the wetland function to export organic matter through a surface water connection at all times of the year to a perennial stream.	YES = 4
4g.4 Does the wetland function to export organic matter through a surface water connection to a stream on a seasonal basis? ⑥	YES = 2
4h. Buffers. Score the existing buffers on a scale of 1-5 based on the following four descriptions. If the condition of the buffers do not exactly match the description, score either a point higher or lower depending on whether the buffers are less or more degraded.	
Forest, scrub, native grassland or open water buffers are present for more than 100' around 95% of the circumference.	Score = 5
Forest, scrub, native grassland, or open water buffers wider than 100' for more than 1/2 of the wetland circumference, or a forest, scrub, grasslands, or open water buffers for more than 50' around 95% of the circumference.	Score = 3
Forest, scrub, native grassland, or open water buffers wider than 100' for more than 1/4 of the wetland circumference, or a forest, scrub, native grassland, or open water buffers wider than 50' for more than 1/2 of the wetland circumference.	[✓ Score = 2]
No roads, buildings or paved areas within 100' of the wetland for more than 95% of the wetland circumference.	Score = 2
No roads, buildings or paved areas within 25' of the wetland for more than 95% of the circumference, or No roads buildings or paved areas within 50' of the wetland for more than 1/2 of the wetland circumference.	Score = 1
Paved areas, industrial areas or residential construction (with less than 50' between houses) are less than 25 feet from the wetland for more than 95% of the circumference of the wetland. ②	Score = 0

4i. Connection to other habitat areas: Select the description which best matches the site being evaluated.	
-Is the wetland connected to, or part of, a riparian corridor at least 100' wide connecting two or more wetlands; or, is there an upland connection present >100' wide with good forest or shrub cover (>25% cover) connecting it with a Significant Habitat Area?	YES = 5
- Is the wetland connected to any other Habitat Area with either 1) a forested/shrub corridor < 100' wide, or 2) a a corridor that is > 100'wide, but has a low vegetative cover less than 6 feet in height?	YES = 3
-Is the wetland connected to, or a part of, a riparian corridor between 50 - 100' wide with scrub/shrub or forest cover connection to other wetlands?	YES = 3
-Is the wetland connected to any other Habitat Area with narrow corridor (<100') of low vegetation (< 6' in height)?	YES = 1
- Is the wetland and its buffer (if the buffer is less than 50' wide) completely isolated by development (urban, residential with a density greater than 2/acre, or industrial)?	YES = 0

Now add the scores circled (for Q.5a - Q.5i above) to get a total.

Is the Total greater than or equal to 22 points? [✓ YES = Category II] NO = Category III

Appendix B

DES MOINES CREEK REGIONAL CIP PRELIMINARY DESIGN REPORT

Appendix D

Fluvial Geomorphology Studies

Des Moines Creek

Fluvial Geomorphic Evaluation of Bed Movement

Marit Larson and Derek Booth
Center for Urban Water Resources Management
University of Washington

April 1999

INTRODUCTION AND APPROACH

This report presents a fluvial geomorphic analysis of Des Moines Creek to aid the evaluation of optimal detention and by-pass facility release rates with the overall goal of minimizing channel erosion and habitat degradation. The approach taken was to identify and characterize a reach of Des Moines Creek in which the sediment movement would be clearly affected by changes in flow. This reach was then used to predict the potential response of the channel to flow conditions corresponding to various release-rate alternatives.

Our analysis has two components. The first component is the estimation of "critical discharge," the discharge at which the bed sediment begins to move. Although the pattern of flows lower than critical may be relevant for providing a suitable environment for aquatic organisms, we have focused only on the flows above the level that cause sediment transport and resulting channel changes. The second component of the analysis is a comparison of predicted annual sediment transport rates under the different design alternatives, under the assumption that the lowest rate of transport probably would correspond to the least erosive alternative.

METHODS

Reach selection:

Des Moines Creek was divided into four reaches downstream of SW 200th Street. The uppermost reach (approximately RM 2 to RM 1.6) has a relatively low gradient (0.005) and wide floodplain valley. It is referred to as the "wetland reach." The stream then becomes steeper and moves into a narrower valley referred to as the "ravine reach." This reach begins at RM 1.6 and ends at the wastewater treatment reach (RM 0.9), with a typical channel slope of 0.03. The ravine reach can be further divided according to the predominance of clay outcrops on the channel bottom, but this distinction was not made for the purpose of this study. Next downstream is the "wastewater treatment plant reach" (WWTP), which runs from the waste water treatment plant at RM 0.9 to the culvert beneath Des Moines Highway at RM 0.4, with a typical slope of 0.01. In the last reach, called the "park reach," the stream runs downstream of this culvert through Covenant Beach Park into Puget Sound.

Study reaches were evaluated for their ability to respond to potential changes in discharge, and for the presence of habitat features or a channel form that could be negatively affected by a change in the sediment transport capacity of the flow. The wetlands reach was not identified as a reach of high concern, given the low gradient and absence of critical habitat. The Des Moines Creek Basin Plan also did not identify areas of high erosion in this reach. The Park reach was also not considered extensively for this study, because it is primarily a depositional area with the lowest slope in the system.

Transport capacity will almost certainly be greatest in the ravine reach due to the extremely constricted valley cross-section and resulting lack of a floodplain, and the high channel gradient. High transport capacity is evidenced by the absence of either gravel bars or pool-and-riffle features throughout the reach. Scour of the banks along this reach has required riprap in many locations along the right bank to protect the road. The ravine reach contains numerous locations where hillslope have failed, periodically introducing sediment into the stream for transport and subsequent downstream deposition. Frequent transport of all but the largest particles occurs, and scour down to the hard clay substratum is evident in some locations. As a result, the ravine reach will not respond strongly to changes in magnitude and frequency of discharge. Instead, the channel response is limited by the presence of clay, artificial armor on the channel banks and a course gravel pavement on the channel bed.

The WWTP reach was selected for sediment transport analysis because it is anticipated to have the greatest potential response to changes in discharge. The presence of mobile material on the channel bed also provided the best opportunity to evaluate the discharges that do mobilize the bed. Unlike the ravine reach, the WWTP reach also had several straight sections unaffected by debris or confined bends -- a simplifying condition desirable for analysis of initial motion. Finally, the WWTP reach is almost entirely "alluvial" - its bed and banks are composed of stream-transported sediment and so the available sediment transport equations should yield useful results.

Channel cross-section monitoring:

A total of 8 cross-sections were established in three groups in the WWTP reach; in addition, two cross-sections were established in the ravine reach. Rebar driven into the bank, or nails and flagging driven into a tree, were used to mark both ends of the cross-sections. A longitudinal profile of the channel bed and water surface was also surveyed at each site. These longitudinal profiles were compared to slopes throughout the entire reach, using the Sewer District Plans and Profiles completed in 1964 and 1986 that included streambed elevations. These engineering plans confirmed that the channel bed slopes measured at the cross-sections were representative of the respective channel reach.

Channel bed particle size evaluation:

Surface bed material size was evaluated at each site in the WWTP and ravine reaches by conducting a random count of at least one hundred pebbles on a bar or riffle of homogeneous substrate. At the ravine reach site, the bars and cross-sections contained atypically fine material potentially influenced by backwater from a nearby downstream debris jam. Therefore a second pebble count was conducted approximately 50 ft (15 m) upstream of the upstream cross-section.

Channel bed mobilization:

At each cross-section, 2-inch-long (5 cm) wire hooks with flagging attached were inserted into the channel bed at 1 foot (0.3 m) intervals. The movement or disappearance of these flags after major storm events indicated whether the bed material moved. The flags were installed on 5/19/98. They were counted at the end of the summer and after major rain events during the fall of 1998.

Estimate of critical discharge:

"Critical shear stress" and "critical discharge" refer to the shear stress exerted by the flow, and the magnitude of the flow, at which the median particle size of the channel bed begins to move. Understanding that the bed sediment becomes mobile over a range of flows, we assume here that the shear stresses and associated discharges that mobilize the *median*-grain size cause initiation of motion of most of the bed. This is a simplifying but almost universally applied assumption.

Measurements of the bed slope, the water surface slope, and the bed material size at Des Moines Creek were used to calculate critical shear stress and critical discharge. There is no single method of calculating critical shear stress and critical discharge appropriate for all gravel-bed streams. Differences in equations of initial motion vary depending on how initial motion is identified, for example. Furthermore, the conditions under which one critical shear stress or critical discharge equation was developed can not be exactly replicated, due to variations in bed-load transport rate, sediment supply, slope, relative roughness, and flow regime. Thus, three methods for calculating critical shear stress and critical discharge were considered here before one was chosen. These methods were used in the analysis conducted by King County on Hylebos Creek, and they are common in published studies.

Andrews Method

An equation by Andrews uses a ratio of the subsurface grain size to the surface grain size of interest to determine the dimensionless critical shear stress. Andrews method was not used in this study based on considerations raised by Buffington and Montgomery (1997). They argued that incorporating the grain sizes of the subsurface is reasonable in an expression of bedload transport, but it is less defensible in an expression for incipient motion. They suggested that scaling the critical shear stress by the subsurface medium grain size generally gives critical shear values larger than surface-based ones, because of bed surface armoring. Following this reasoning the analysis of the critical shear stress for initial movement in this report only employs surface grain sizes.

Bathurst Method

The second method we considered to predict flow conditions for the initiation of sediment movement is an equation presented by Bathurst et al. (1987):

$$q_{cr} = 0.15\, g^{0.5}\, D_{50}\, S^{-1.12}$$

The Bathurst equation expresses conditions at initial motion in terms of a unit discharge. It is based on the observation that critical conditions for sediment transport are exceeded in only part of the channel at a time (Bathurst et al. 1987). The equation was developed based on observations in steep boulder-bed channels for use in channels with high roughness (Bathurst et al. 1987), and it was employed by King County on Hylebos Creek (1996). The WWTP-reach of Des Moines Creek, however, does not have the steep slope or roughness conditions for which this equation was developed. Thus, it is not appropriate in this estimate of critical discharge.

Shields Method

Finally, the Shields method of estimating critical shear stress was considered. The Shields equation was developed in flume experiments where the bed particle sizes were nearly identical; it establishes a linear relationship between critical shear stress and particle diameter:

$$\tau_{cr} = \theta\, (\rho_s - \rho_f)\, g\, D_{50}$$

where:

τ_{cr} = critical boundary shear stress (in N/m^2)
θ = "Shields parameter" (dimensionless)
ρ_s = density of particles (2650 kg/m^3)
ρ_f = fluid density (1000 kg/m^3)
g = gravitational acceleration (9.8 m/s^2)
D_{50} = median particle size of the surface (m)

Under turbulent flow conditions typical of virtually all natural streams, Shields found that that θ becomes nearly constant with a computed mean of 0.06. Values of Shields parameter computed for the entrainment of gravels and cobbles from natural river beds, however, range from 0.02 to 0.25. A variance from flume results is generally attributed to mixed grain sizes and various roughness elements.

The Shields equation is used to calculate a critical discharge by estimating the flow depth and slope associated with the critical shear stress. Flow depth at initial motion is determined by calculating the critical shear stress (using a selected Shields parameter), setting it equal to the boundary shear stress. and then solving for h_c.

$$\tau_{cr} = \tau_{boundary} = \rho_f \, g \, S \, h_c$$

S = energy gradient
h_c = flow depth

Similarly, a total critical discharge (Q_c) was estimated using a cross-sectional area approximately associated with the calculated critical depth, and applying Mannings equation:

$$Q_c = (A \, R^{2/3} \, S^{1/2})/n$$

where:

n (Mannings roughness coefficient, given a value of 0.035 for the reaches in question)
A = cross-sectional area at h_c (hydraulic radius)

Problems in achieving reliable results using the Shields method on gravel-bedded streams are associated with the assumption of homogeneous particle sizes. On a gravel-bed river, the topographic and textural heterogeneity of the bed and the varying sizes of the surrounding particles influence the mobility of any given particle. However, the Shields method was selected for the analysis because many of the published studies offer guidance on how to minimize this problem, and because of the more severe problems with the other analyses mentioned above.

Estimate of bedload transport rate:

The bedload sediment discharge was evaluated as a function of discharge using the Bagnold sediment transport equation (Bagnold 1980). Selection of this equation was based on the evaluation of Gomez and Church (1989), who found it most accurate in systems similar to Des Moines Creek. The equation is:

$$i_b = 0.1 * ((\omega - \omega_s)/0.5)^{1.5} * (Y/0.1)^{2/3} * (d_{50}/0.0011)^{-0.5}$$

where:

i_b = submerged unit transport rate (kg/m-s)
$\omega = \tau u$ (unit stream power)
$\omega_s = 290\ d_{50}^{3/2} \log (12y/d_{50})$, the anticipated threshold of sediment motion
ω_s = threshold stream power for initiation of motion
Y = depth of flow
τ = basal shear stress of the flow
u = mean velocity of the flow

A sediment rating curve, displaying the relationship between discharge and the instantaheous sediment transport rate, was generated from this equation. Next, flow durations based on HSPF modeling conducted by King County were used to determine the cumulative average annual sediment load. To generate the sediment rating curve, depths of flow were determined for the discharges used in the HSPF modeling. This was done using HEC-RAS (1997) to model water-surface slopes at the downstream cross-sections in the WWTP reach. The fraction of time a specific range of discharges occurred (Figure 3) was then determined from the HSPF flow exceedence curve (Figures 2). Annual bedload at a given flow rate was calculated by multiplying the fraction of time a discharge occurs (Figure 3) by the instantaneous bedload transport rate (Figure 4) at that discharge and by the length of a year (3×10^7 sec). The cumulative annual bedload was determined by integrating the bedload transport per unit flow rate over the range of flows rates. The calculated bedload transport rates cannot be expected to represent accurately the actual transport rates at Des Moines Creek, however, because of the inherent approximation involved in bedload transport equations. Instead, they provide a constant means of comparing the potential effects of the flow changes on sediment transport.

RESULTS - INITIAL MOTION ANALYSIS

Cross-section monitoring:

The bankfull cross-section geometry was determined for each cross-section (Table 1). These parameters were used to compare the current channel geometry to data collected on stable channels draining watersheds of similar size, and to provide baseline data to monitor channel changes. The average channel width of Des Moines Creek near the mouth (9 m) is twice as wide as widths associated with relatively undeveloped watersheds of similar sizes (3-5 m) (Both and Jackson 1997). As of April 1999, cross-sections have not been re-surveyed.

Table 1. Cross-section Geometry

Reach		Width (m)	Avg Depth (m)	Area (m^2)
WWTP - d.s.	XS -1	8.1	0.5	4.4
	XS -2	8.2	0.4	3.5
	XS -3	10.5	0.3	3.5
	AVG	9.0	0.4	3.8
WWTP - mid	XS -1	4.5	0.6	2.7
	XS -2	7.1	0.5	3.4
	AVG	5.8	0.5	3.1
WWTP - u.s.	XS -1	5.9	0.4	2.5
	XS -2	6.4	0.4	2.7
	XS -3	7.1	0.4	3.1
	AVG	6.5	0.4	2.7
Ravine	XS -1	7.1	0.6	4.5
	XS -2	5.4	0.6	3.2
	AVG	6.3	0.6	3.8

Bed particle size:

Median particle sizes in the WWTP reach were very similar between the downstream and middle sites and slightly larger at the upstream site (Table 2). Contrary to our expectations, particle sizes were smallest at the cross-section in the ravine reach. This is probably due to the presence of a debris jam in the channel 15 m downstream that causes backwater during higher flow events, leaving fines to settle out in this reach, and rendering these results unsuitable for sediment transport calculations.

Table 2. Particle Sizes (mm)

	D16	D50	D75	D84
WWTP - d.s.	14	27	39	45
WWTP - mid	16	25	38	45
WWTP - u.s.	17	35	50	63
Ravine xs	9	15	21	28
Ravine us	14	27	40	48

Estimate of critical shear stress and critical discharge using Shields method:

The critical shear stresses and associated flow depths obtained using the Shields method are given in Table 4. Critical discharge (Table 5) was estimated using a hydraulic radius (R) set equal to the calculated critical flow depth (Table 4) and the cross-sectional area closest to this hydraulic radius. There is some variation in the results, because of the local difference in stream conditions and because a range of Shields parameters was investigated. However, all of these estimated discharges are significantly lower than the 2-year flow of 213 cfs (6.0 m^3/s) calculated from HSPF for current conditions. This indicates that the bed is mobilized at flows less than the 2-year discharge under current conditions, as is observed on gravel-bedded streams throughout temperate regions of the world

Table 4. Critical shear stress for the initiation of sediment transport.

	$\tau_c = \theta D_{50} g(\rho s-\rho)$ (N/m^2)		Critical flow depth $h_c = \tau_c / \rho g S$ (m)	
Sub-Reach	*θ = 0.06*	*θ = 0.045*	*θ = 0.06*	*θ = 0.045*
WWTP - d.s.	23.81	13.89	0.19	0.11
WWTP – mid	21.61	12.61	0.18	0.11
WWTP - u.s.	30.87	18.01	0.24	0.14
Ravine xs	13.23	7.72	0.09	0.05
Ravine us	23.81	13.89	0.15	0.09

Table 5. Critical discharge estimates at the critical flow depths from Table 3.

	$Q_c = (AR^{2/3}S^{0.5})/n$			
	$\theta = 0.06$		$\theta = 0.045$	
Site	(m3/s)	cfs	(m3/s)	Cfs
WWTP - d.s.	1.4	50	1.1	40
WWTP - mid	**2.1**	**73**	**1.7**	**60**
WWTP - u.s.	1.3	46	1.1	38
Ravine	0.5	18	0.4	12

A = cross-sectional area at R approximately equal to h_c.

Results are presented using two different Shields parameters: the value of 0.06 is taken from Shields' data on homogeneous grain sizes, whereas the value of 0.045 is based on typical values for visually determined mobility thresholds in rough, turbulent flow (Buffington and Montgomery 1998). The calculation of Q_c from the h_c made here assumes that all of the shear stress at that flow is exerted against the bed and available to mobilize material. Since τ is not partitioned in this calculation to reflect the dissipation of some of the shear stress against the banks or other obstructions, the higher Shields parameter of 0.06 may be appropriate. However, the critical shear stress calculated at the mid-WWTP reach using 0.045 best fits observations of when the bed began to move, both values are consistent with the bed tag data indicating bed movement between 35 and 88 cfs.

CONCLUSIONS

The best estimates of critical discharge at the three sites in the WWTP reach range from 46 - 73 cfs (1.3 - 2.1 m^3/s). Based on the bed tag observations, most of the bed is in motion at flows of 88 cfs (2.5 m^3/s) and virtually none at 31 cfs (m^3/sec). Observations in the field showed that the surface of the bed was on the verge of movement a discharge of 63 cfs. The analysis of sediment transport using Bagnold also suggested the threshold of motion occurs at discharges of 60 to 80 cfs (1.7 to 2.3 m^3/s) at the downstream site in the WWTP reach. Together, the above analyses suggest that a reasonable, slightly conservative value of 60 cfs should be used as the critical discharge in the WWTP reach with the likely uncertainty of +/- 10 cfs.

RESULTS - SEDIMENT TRANSPORT RATE ANALYSIS

The results of the bedload transport estimates are presented in the Figures 5 and 6. The Bagnold equation predicts the threshold of motion occurs at approximately 60 cfs (1.7 m^3/s), which is consistent with the estimate of critical discharge using the Shields method. Figure 5 (Annual bedload per discharge interval) shows that the dominant discharge, or the discharge that is cumulatively responsible for the most sediment transport, is in the range of 80 to 150 cfs (2.3 to 4.2 m^3/s). This corresponds to a HSPF-model result of 120 cfs (3.4 m3/s) for the 1.01-year discharge, and is consistent with the oft-reported dominant discharge lying between 1 and 1.5 years on many temperate rivers (Leopold, Wolman and Miller 1964).

Figure 6 shows the effects of the proposed alternatives on annual bedload transport through the downstream site at the WWTP reach. The cumulative bedload transport would be reduced from current conditions by 60% under Alternative 1 and 74% under Alternatives 2 and 3.

Table 7. Cumulative Average Annual Sediment Transport (m3)

cross-section	CURRENT (m^3)	ALT 1 (m^3)	ALT 2 (m^3)	ALT 3 (m^3)
WWTP – d.s. XS - 2	285	89	76	76
WWTP – d.s. XS - 3	261	79	68	67
Average reduction from current		69%	74%	74%

There is no direct quantitative link between the estimate of bedload transport and the magnitude of bed and bank scour. However, bedload transport is the best available surrogate for channel erosion and therefore for channel stability. The bedload transport calculations here show that Alternatives 2 and 3 are indistinguishable, that both are preferable over Alternative 1, and that all are significant improvements over current conditions.

The approach to determining a target release rate presented here is based primarily on the WWTP reach and therefore focuses on channel stability in that reach. However, managing flows to reduce the occurrence of events greater than critical for the downstream reach will also reduce transport capacity in the ravine reach. Observations indicate that the ravine reach is supply-limited, rather than transport-limited. Since most material that makes it into the channel in the ravine reach is transported downstream, an ideal objective would be to reduce the occurrence of flow events that effect significant sediment supply in this reach. However, there is no direct relationship between stream discharge and hillslope sediment supply. In the ravine reach, we are not aware of any documentation providing evidence of the range of discharges at which erosion and mass wasting processes occur. Since major mass wasting events had not been noticed in the ravine reach as of February 1999 (Frank Osen, Superintendent of Public Works and Rick Styles, Parks Department, City of Des Moines personal communication), it is possible that discharges up to 250 cfs (maximum discharge as February 1999 measured at the mouth) do not necessarily trigger severe local erosion events. Therefore, we speculate that for flows in excess of critical (Qc = 60 cfs), minimizing discharges above 250 cfs (approximately the current 5-yr discharge) may reduce sediment supply in the ravine reach, but cannot be guaranteed to do so. Alternative 1, 2, and 3 all reduce the frequency of the current 5-yr storm to between 10 and 20 years and, therefore, reduce the frequency of events which may contribute to increased sediment supply.

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ADENDUM

Construction of the access road along Des Moines Creek in the WWTP reach resulted in loss of some riparian trees and fine sediment and road gravel contribution to the stream. The potential for much more sediment deposition exists when the silt fence, which is now retaining many yards of gravel from the road embankment, fails. One of the most important sediment management measures for Des Moines Creek in the short term would be oversight of adequate erosion control measures when continued construction occurs on this road.

Figure 6. Cumulative Annual Bedload Transport (m^3) WWTP reach XS 3

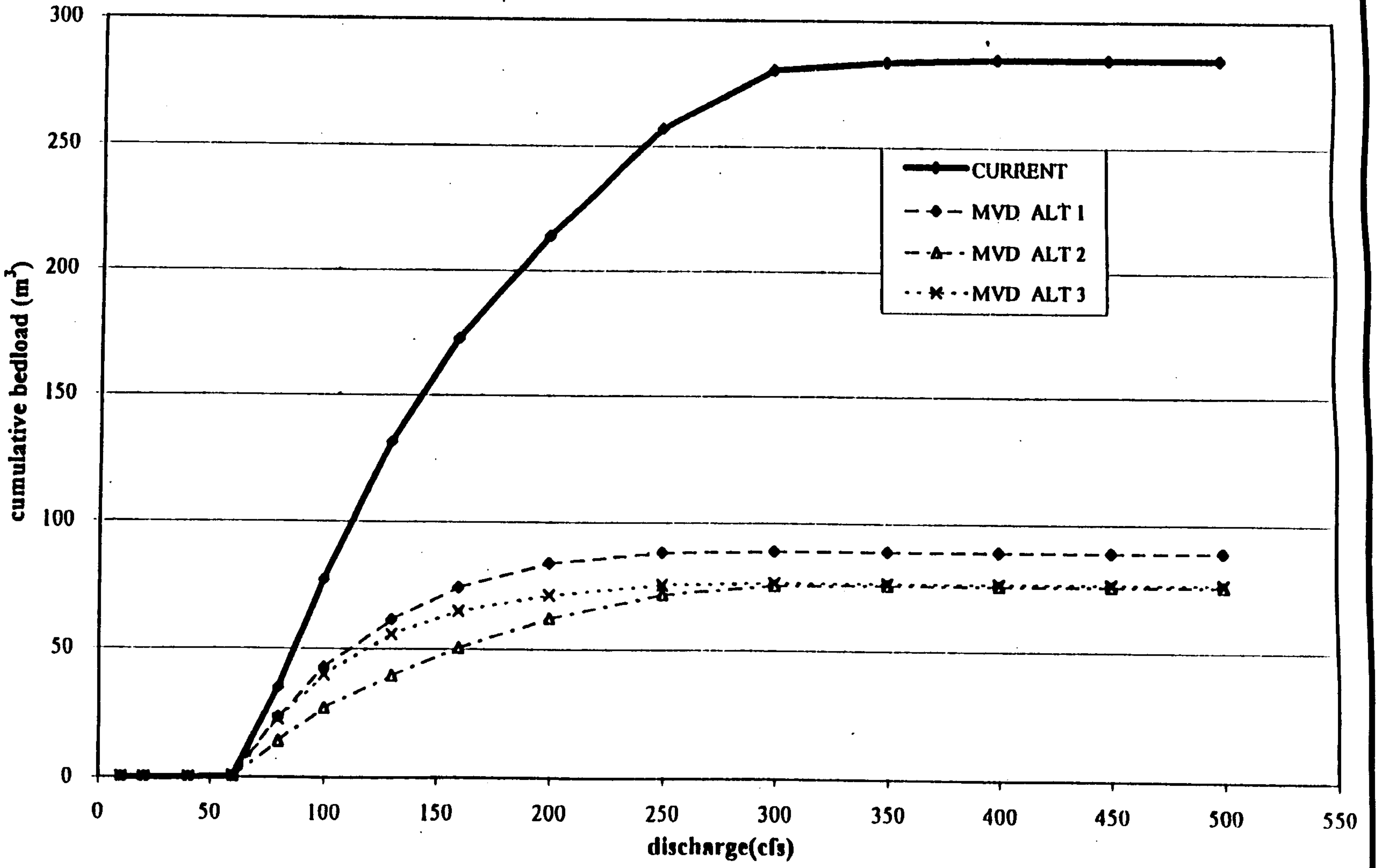


Figure 5. Instantaneous Bedload Transport by Discharge Interval (m^3/s)
WWTP reach XS 3

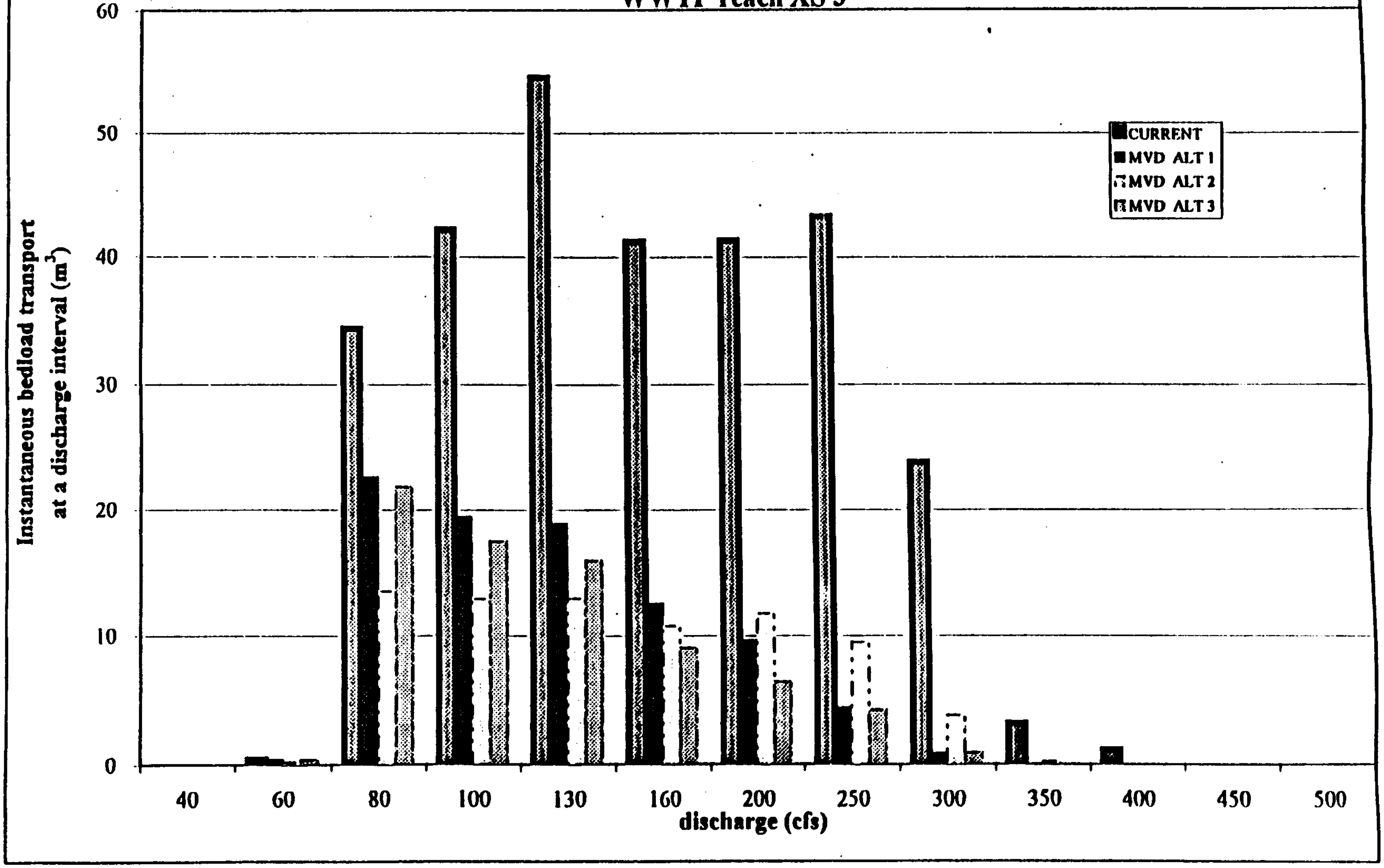


Figure 3. Duration of Discharge Interval

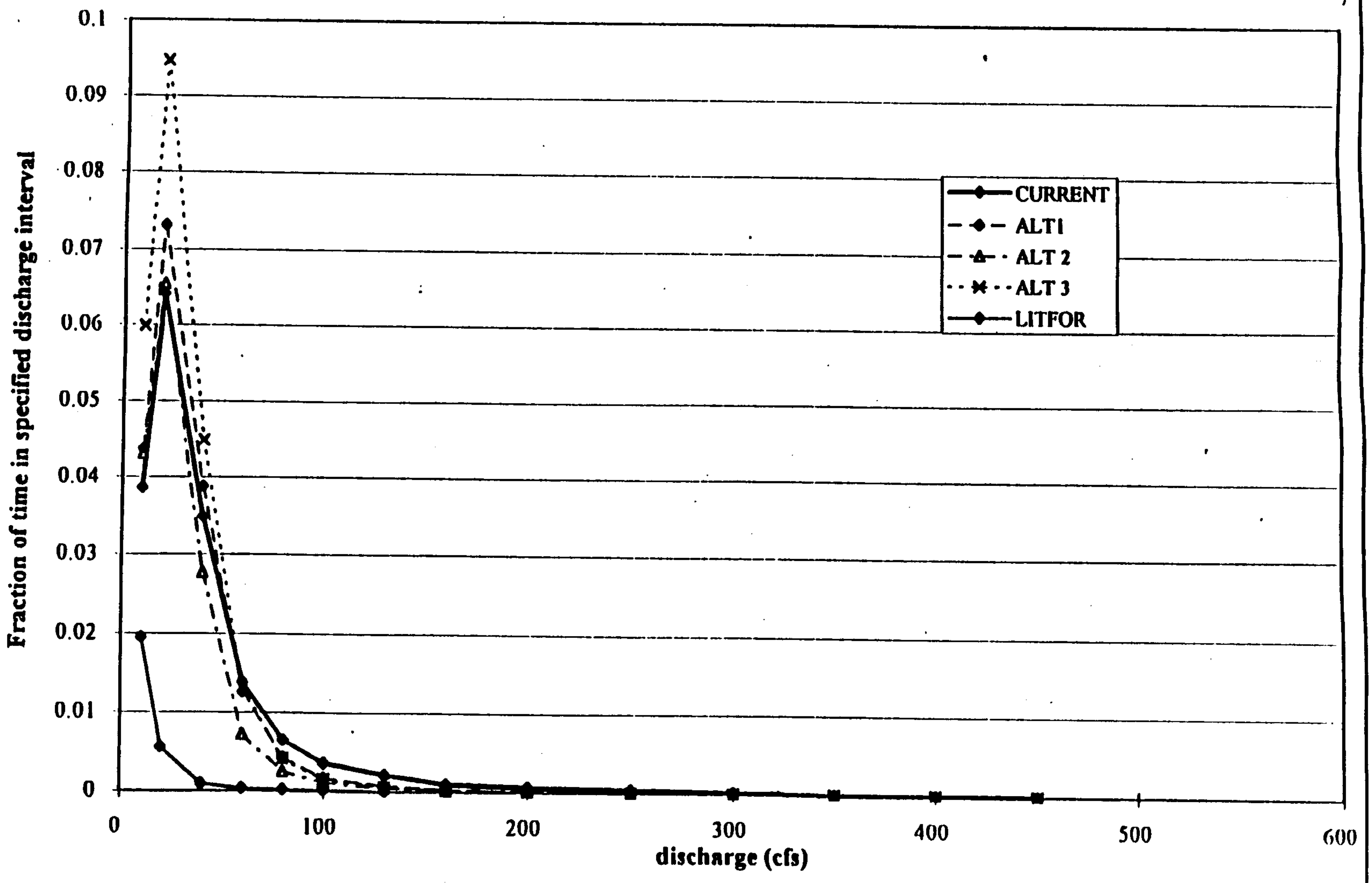


Figure 2. FLOW DURATIONS
DES MOINES CREEK NEAR MVD CULVERT

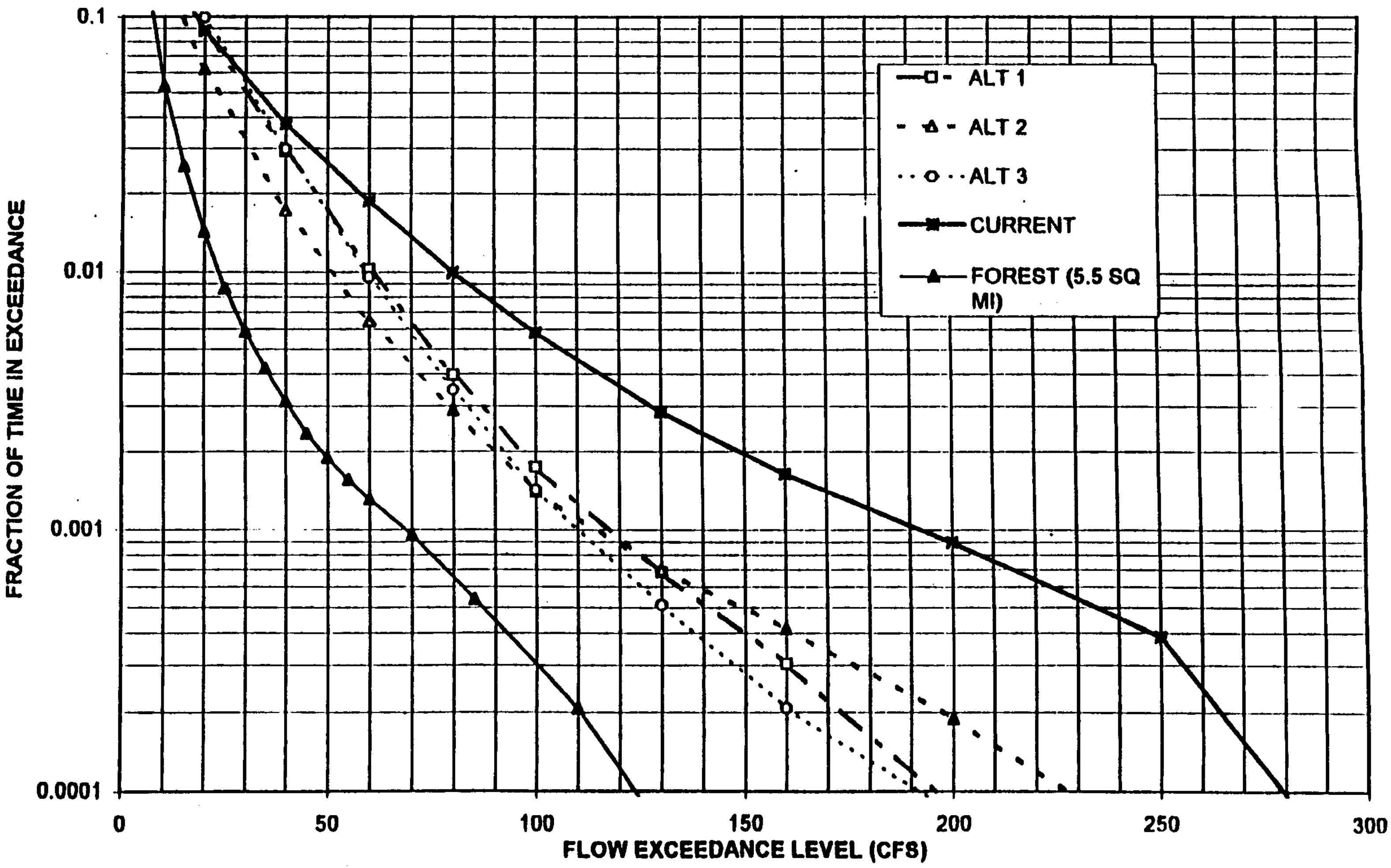


Figure 1. Fraction of bed tags mobilized after maximum observed discharge

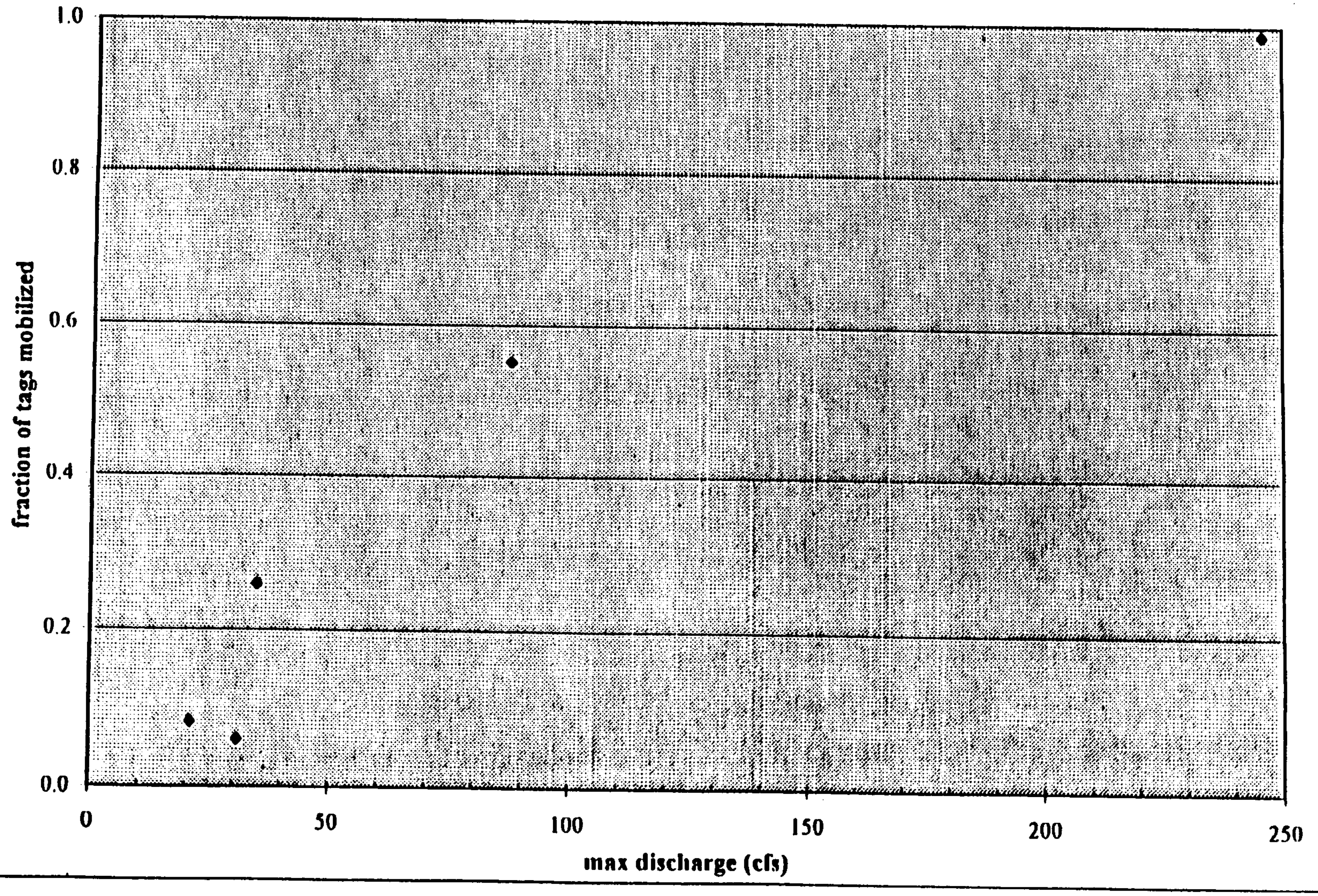
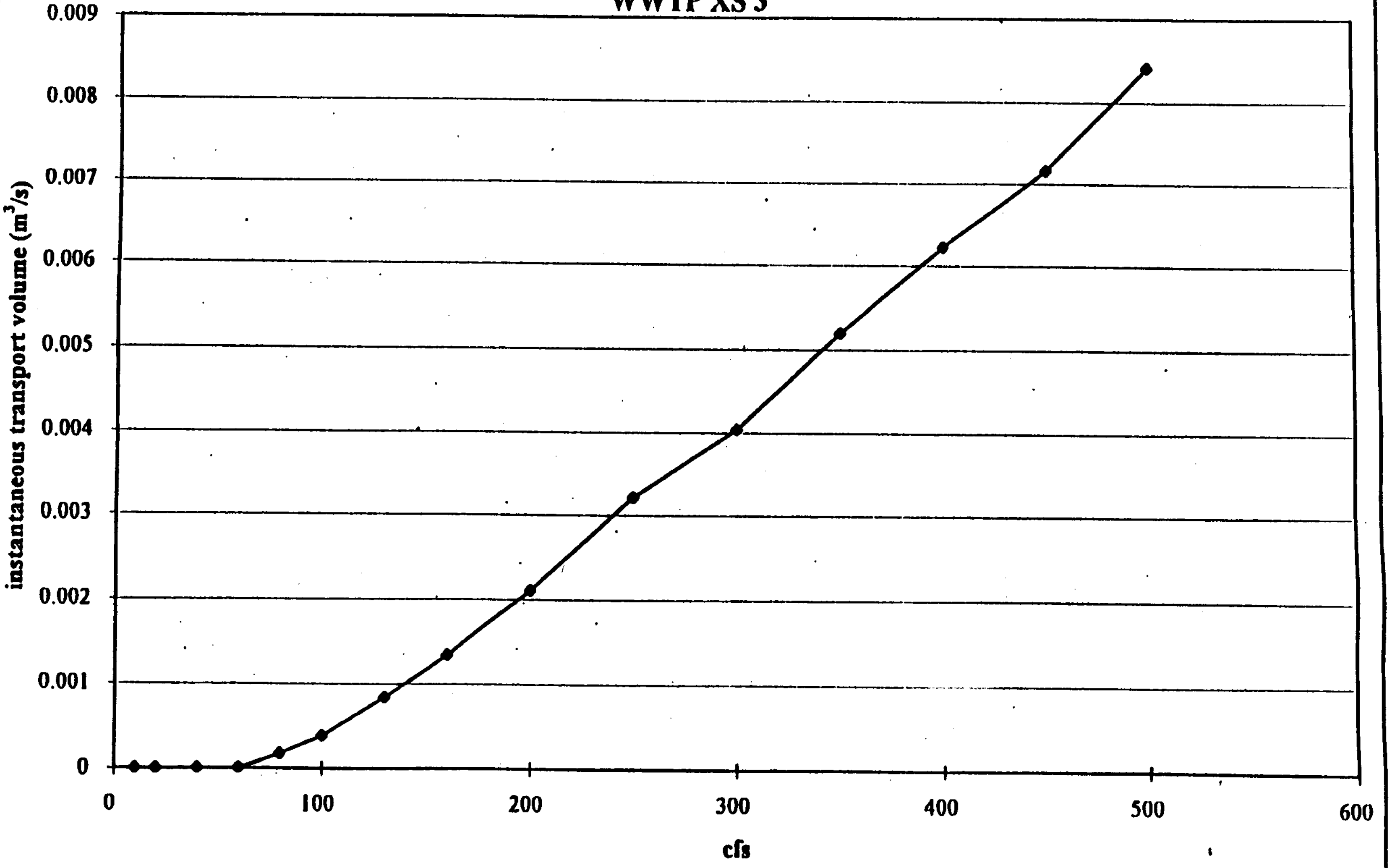


Figure 4. Instantaneous Transport Volume (m^3/s)
WWTP XS 3



Appendix E

DES MOINES CREEK REGIONAL CIP PRELIMINARY DESIGN REPORT

Appendix E

Fisheries Studies

QUALITY OF AND PROCESSES AFFECTING AQUATIC HABITAT AT DES MOINES CREEK

KING COUNTY, WASHINGTON

CIP #1A1767

Submitted To:

King County Department of Natural Resources
Surface Water Engineering and Environmental Services

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March 30, 1999

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INTRODUCTION

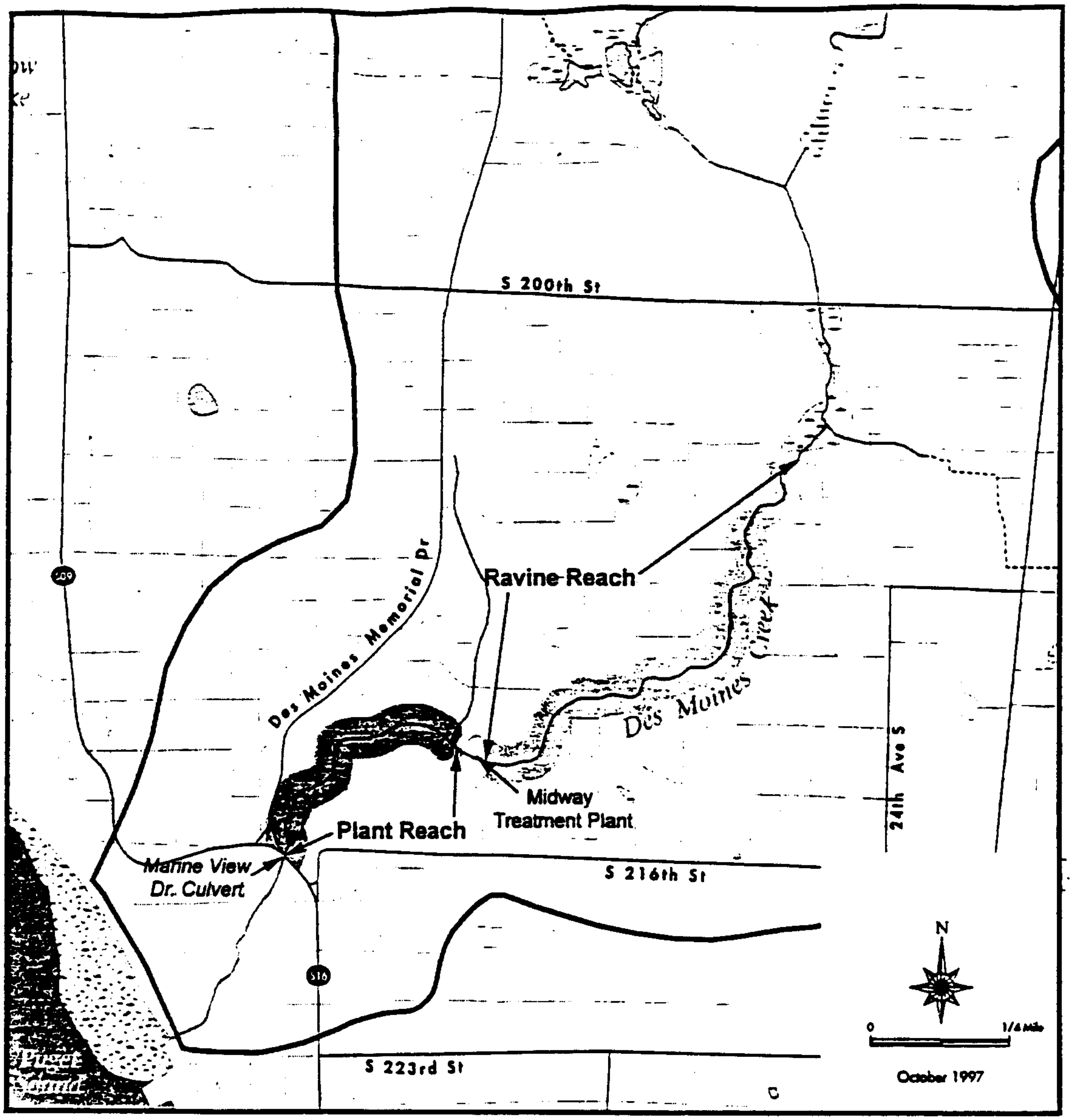
This report summarizes and aquatic habitat data collected on Des Moines Creek, in the City of Des Moines, King County, Washington during November and December, 1998 and January, 1999. This study specifically addresses those reaches between Marine View Drive on the downstream end and the top of the ravine below SE 200th Street, between River Miles 0.4 and 1.8 (see Figure 1 below). Data collected includes a longitudinal or thalweg profile, substrate characterization, large woody debris loading and flow velocity. These parameters and their methods were chosen in an effort to collect data comparable to that collected by Aquatic Resource Consultants in 1994 on the same reaches of Des Moines Creek. It was hoped that, by comparing the two data sets, trends in the streams morphological characteristics might be detected. As will be discussed later in the report, however, there were problems in directly comparing the data sets.

STREAM OVERVIEW

Des Moines Creek drains a largely urbanized basin of approximately 5.8 square miles located in the cities of SeaTac and Des Moines. This basin also contains Sea-Tac Airport and the Midway Sewage Treatment plant, which is located adjacent to the stream near the middle of the reaches studied here. The highly developed character of the drainage basin contributes to an unnaturally "flashy" flow regime in the reaches studied for this report, meaning that flow discharge rates rise and fall very quickly during storm events. Flashy flow regimes also tend to be associated with low summer base flows, as is the case in Des Moines Creek. Flashy flow regimes are frequently responsible for morphological changes in stream channels such as increased erosion and downcutting, decreases in pool habitats, and "cementation" of substrate materials. These flow regimes can also be responsible for declining fish populations, both directly by creating inhospitable flow velocities and indirectly via the morphological changes mentioned above. Other factors that may be responsible for declining fish populations, such as water quality problems, are not addressed by this report.

The reaches of Des Moines Creek studied for this report flow through Des Moines Creek Park and the Midway Sewage Treatment Plant, which lies in the middle of the park. The immediate riparian areas of these reaches are primarily forested with deciduous trees (red alder, big-leaf maple--some conifers are present, but tend to be farther upbank). However, a buried sewage pipe runs along the right bank of the stream for almost the entire length of the studied reaches. A paved pedestrian/bicycle path covers the pipe and it is protected on the stream-ward side by riprap. The placement of the sewer line and its rip rap protection within the ravine has severely constricted the stream channel, especially in the reaches upstream of the treatment plant. The resulting hardness of the right bank has forced the stream into the steep left bank, causing severe erosion, large scarps and slope failures in numerous locations.

The reach between Marine View Drive and the treatment plant, referred to hereafter as the Plant Reach, is of lower gradient (averaging 1.7%) that the reaches upstream of the



KING COUNTY DEPARTMENT OF NATURAL RESOURCES

WASTEWATER TREATMENT DIVISION

FIGURE 1
REACH MAP
DES MOINES CREEK
HABITAT AND GEOMORPHIC DATA ANALYSIS
KING COUNTY, WASHINGTON

plant (averaging 2.5%). The ravine is wider and the channel is less constricted--but certainly not unconstricted--by the sewer line. The sinuosity of the stream in this reach has allowed for complex habitat to form. Several large pools with good cover, suitable for rearing of juvenile coho and other fishes, exist in this reach (see photo #1 in Appendix A). Gravel beds that appear to be suitable for spawning are also present. Examined statically and not over time, habitat in this reach, while certainly not pristine, compares favorably with that of most streams in urban settings. Instream habitat is generally a pool-riffle sequence with several excessively long riffles, but also several extremely high-quality pools. Eroding banks and scarps, mostly in the upper portion of the reach, probably add fine sediments to the stream but excessive fine sediments do not appear to be a problem. However, there is evidence (see Larson and Booth 1999 attached as another appendix to this report and discussion below of longitudinal/thalweg profile data) that the channel bed is very mobile and that these habitat features are probably subject to drastic changes over time.

A long culvert beneath Marine View Drive at the downstream end of the reaches studied for this report appears to be at least an impediment to fish passage (photos #2 and #3, Appendix A). During many days of fieldwork in the reaches upstream of this culvert, only one fish (a decomposing coho carcass found well upstream of the culvert) was observed. During these same days, several migrating and spawning adult coho were observed downstream of the culvert.

The reach extending from the treatment plant upstream to the gradient break at the plateau south of SE 200th St., known hereafter as the Ravine Reach, contains less favorable habitat. The gradient of this reach is somewhat steeper (averaging 2.5%) and, more significantly, the channel is more constrained by both the adjacent sewer line with its riprap armoring and the natural morphology of the ravine containing it (photo #6, Appendix A). While there is a moderate amount of large woody debris in the channel vicinity, most has been swept to the channel margins and too few pieces interact sufficiently with the active channel to create complex habitat. There are three fairly large, channel-spanning accumulations of debris in this reach, along with the remnants of numerous others that have been swept to the channel margins.

Instream habitat within the Ravine Reach is mostly characterized by long riffles and step-runs punctuated by occasional scour pools. The substrate is scoured down to hardpan clay (lacustrine deposits) in numerous places (photo #7, Appendix A). There are also many eroded scarps along the left bank, opposite the sewer line; however, fine sediments seem to be more prevalent in the substrate near the top of the ravine than anywhere else. In general, habitat features are much less complex in comparison with those of the Plant Reach or less disturbed streams.

LONGITUDINAL/THALWEG PROFILE

The longitudinal profile data was collected using a hand level with 5x magnification mounted on a PVC pole at a set height (1.6 meters or 5 feet, 3 inches), sighting on a fiberglass survey rod. A hip-chain measuring device was used to measure horizontal distance. Elevation points were taken along the thalweg of the stream and recorded to the nearest tenth of a foot; efforts were made to obtain elevations at the high and low points of all morphological features along the thalweg.

The longitudinal profile begins near the top of the ravine, approximately 4,600 feet upstream of the sewage treatment plant, and ends at the culvert inlet beneath Marine View Drive, approximately 2600 feet downstream of the treatment plant. The reach through the treatment plant property itself is controlled by a series of concrete weirs and fish ladders and was not included in the longitudinal profile. Graphical plots of the longitudinal profile of the Ravine Reach, derived from two data sets (one recorded by Alan Johnson of Aquatic Resource Consultants in 1994 and another by County staff in 1998-99), are shown below in Figures 2 and 3. (The plot is split into two figures so that additional detail may be seen.) Plots of the Plant Reach are shown in Figure 4. (Note that overall elevation changes in the two data sets are different by about 5 percent and overall distances between known points were different by almost 10 percent. These differences are due to the lack of precision of the instruments used to collect the data. Data was adjusted proportionally in order to make the profiles line up by using known landmarks and stream features[1].)

To maintain consistency, Aquatic Resource Consultants ran the 1998-99 data through the same computer program that was used to analyze the 1994 data. Comparative statistics from both years for the two reaches are presented below in Table 1[2].

There are several problems with this comparison of data. First, the reach lengths are different, which is probably due to imperfect replication of the reaches surveyed (i.e. different starting/ending points, especially in the Ravine Reach), to the lack of precision of hip-chain style measuring devices, and to different styles of the data collectors. Second is a difference in resolution of the data, as might be expressed in the number of points recorded per 100 feet of distance. (Approximately 30% more points were recorded per reach during the 1998 survey than during the 1994 survey.) This could easily result in a difference in the number and sizes of pools recorded. (e.g. A higher resolution survey might record more, smaller pools that might be missed by a lower resolution survey, thereby affecting not only the number of pools recorded but also their average size, etc.) Third is the lack of figures for the 1994 survey of the Ravine Reach. None of these problems can be either fixed or assessed without access to the program used to analyze the data sets.

With the above qualifications stated, the comparison of data sets shows few definite trends in channel morphology. However, the profile shapes do show the differences

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[1] Distance figures in the 1998 data set for the Ravine Reach were increased uniformly by 5.54% and elevation figures by 5.9%. 1998 Plant Reach distance figures were increased by 8.1% and Plant Reach elevation figures were not adjusted.

[2] Data analyzed for these tables was *not* adjusted as described above.

Figure 2: 1994 and 1999 Upper Ravine Reach Profiles (Adjusted)

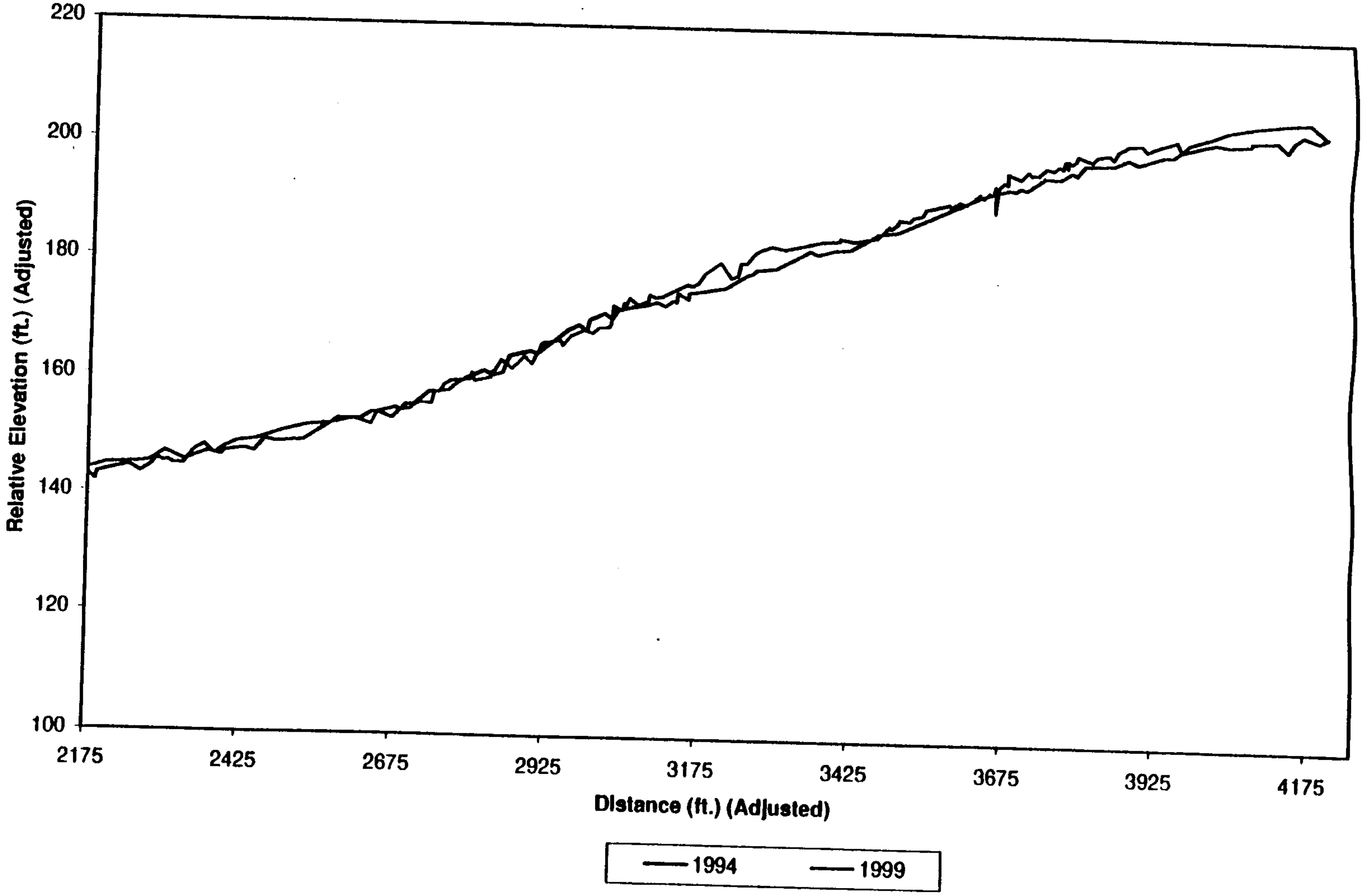
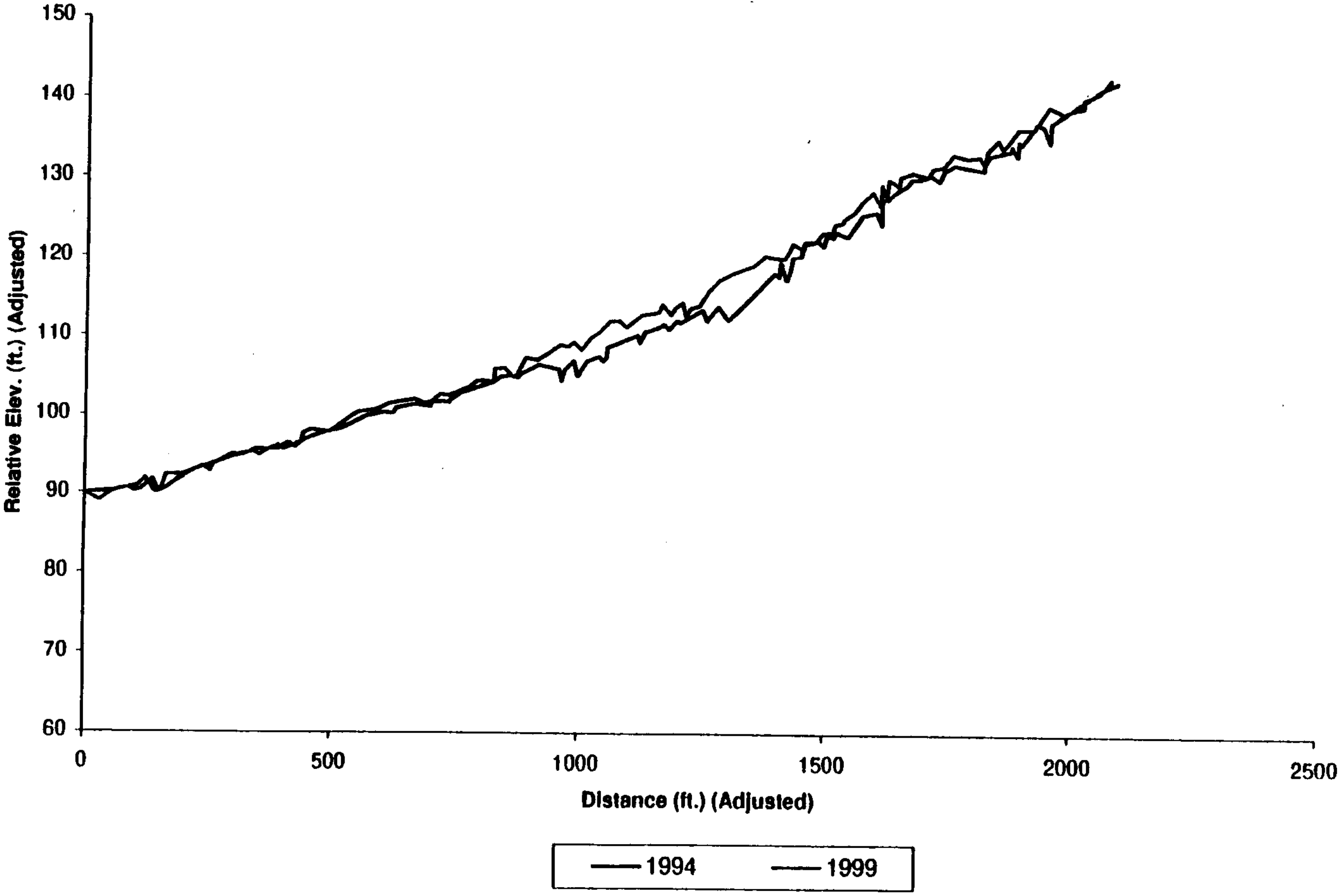


Figure 3: 1994 and 1999 Lower Ravine Reach Profiles (Adjusted)



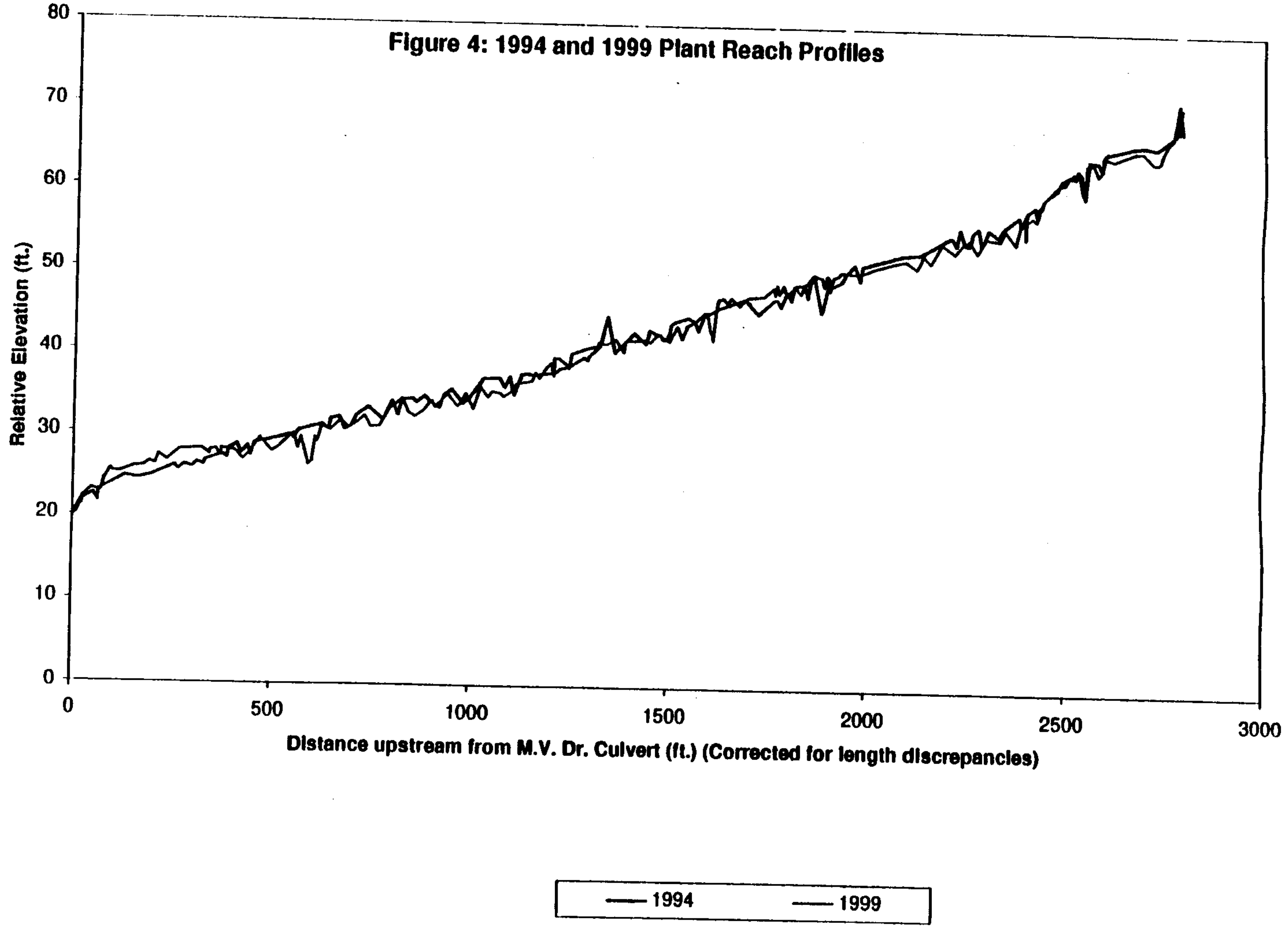


Figure 4: 1994 and 1999 Plant Reach Profiles

TABLE 1: STATISTICAL COMPARISON OF 1994 AND 1998 LONGITUDINAL PROFILE DATA

Ravine Reach

	1998					1994			
	Res. Depth	**Length of Pool**	**Calc. 2D Area SqFt**	**Bed Perim**		**Res. Depth**	**Length of Pool**	**Calc. 2D Area SqFt**	**Bed Perim**
Mean	0.8	30	14	31	Mean				
Median	0.7	27	9	28	Median	0.7			
Minimum	0.1	4	0.3	5	Minimum	0.1			
Maximum	2.4	144	86	144	Maximum	4.0			

Number of Residual Depths:	71	Number of Residual Depths:	62
Total Reach Length (feet):	4596	Total Reach Length (feet):	5330
Total Length with Residual Depth:	2145	Total Length with Residual Depth (feet):	
Percent of Reach with Residual Depth:	47	Percent of Reach with Residual Depth:	
Reach Bed Slope (percent):	2.9	Reach Bed Slope (percent):	2.6

Plant Reach

	1998					1994			
	Res. Depth	**Length of Pool**	**Calc. 2D Area SqFt**	**Bed Perim**		**Res. Depth**	**Length of Pool**	**Calc. 2D Area SqFt**	**Bed Perim**
Mean	1.2	37	24	37	Mean	1.3	29	19	30
Median	1.0	33	14	34	Median	1.2	24	11	25
Minimum	0.2	6	0.6	6	Minimum	0.2	4	0.3	4
Maximum	4.7	94	110	95	Maximum	4.4	73	95	73

Number of Residual Depths:	43	Number of Residual Depths:	48
Total Reach Length (feet):	2583	Total Reach Length (feet):	2952
Total Length with Residual Depth:	1575	Total Length with Residual Depth:	1416
Percent of Reach with Residual Depth:	61	Percent of Reach with Residual Depth:	48
Reach Bed Slope (percent):	1.7	Reach Bed Slope (percent):	1.7

between the reaches--the Ravine Reach is obviously much less complex than the Plant Reach and is lacking in large pools--and that there appear to be several large pools in the Plant Reach that didn't exist during the 1994 survey. Perhaps most importantly, the fact that the profiles of the two data sets--especially those of the Plant Reach--appear to be so different indicates that the system is dynamic and changing. This is not at all surprising given the flow regime and the frequency of large storms during the intervening years. The accompanying report by Larson and Booth (1999) indicates a high rate of bedload transport in this reach during commonly occurring discharge rates. It appears likely, therefore, that the channel bed morphology in the Plant Reach changes significantly over time, that pools are formed and filled on a relatively regular basis, and that spawning beds are disturbed frequently during the winter months.

Again, due to the lack of precision of the instruments used to collect the data, these profiles should not be used to assess channel downcutting or aggradation or the actual relative elevation of the channel features.

SUBSTRATE/BED MATERIALS

Wolman pebble counts (Wolman, 1954) were conducted on 1/6/99 at seven cross-sectional transects throughout the studied reaches. As with the longitudinal/thalweg profile, the intent of this study was to replicate as closely as possible and compare results with those of the 1994 study by Aquatic Resource Consultants. These transects were located in an effort to duplicate as closely as possible those established by Aquatic Resource Consultants in 1994. While the precise locations of those original transects are not known, every effort was made to duplicate what is known of those original transects (e.g. their relative locations within the study area and the habitat types in which they are located). However, only 5 of the transects appear to be comparable to the 1994 transects. (Data for all seven transects is included in Appendix B.)

Once the transects were established, one hundred clasts were selected at random along the transect from ordinary high water mark to ordinary high water mark, measured, and assigned to size classes. The following procedure was then applied to each transect's data set in order to obtain D_{35}, D_{50}, D_{84} and D_{100}[3] for each transect:

The percent of particles or clasts within each transect that are finer than the lower limit of each size class[4] was plotted on a graph, with the log of that lower limit on the X axis and the log of the percent figure on the Y axis. A linear regression was then established using that plot and the equation of that line determined. This equation is in the form of $y=mx+b$. D_x was then determined by the formula:

$$\log_x - b/m = \log D_x$$

Dx values for the 1994 and 1999 samples are shown below in Table 2:

TABLE 2: SUBSTRATE PARTICLE SIZE DISTRIBUTION

Transect #/ Habitat Type	D_{35} (mm)		D_{50} (mm)		D_{84}(mm)		D_{100}(mm)	
	1994	1999	1994	1999	1994	1999	1994	1999
5/Run w/ gravel bar	13	16	20	33	70	93	165	131
6/Riffle	21	9.8	36	22	88	74	205	110
8/Pool w/out LWD*	15	.03	27	.6	61	42	200	173
10/Bldr. pocket water	30	39	92	69	270	156	520	205
11/Shallow pool	14	3	19	13	57	103	220	208

*No pools completely void of LWD were found in the vicinity of the 1994 transect during the 1999 sampling. A rootwad was adjacent to the pool sampled, but did not block or significantly alter the flow patterns during normal flows.

Again, there are problems with a direct comparison of the 1994 and 1999 data sets. First and foremost among them is the fact that the transects/sampling sites are not identical. Features such as pools and riffles have highly variable characteristics within the system and even within smaller reaches of the system, so it would be unrealistic to expect two pools to have very similar

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[3] D_{35} is that particle size which is larger than 35% of the sample; D_{50} is the median particle size; D_{84} is the particle size which is larger that 84% of the sample, and D_{100} is the largest particle size in the sample, as determined by the regression curve established by the above method. These values were chosen for calculation because they were used by Aquatic Resource Consultants in their 1994 study

[4] Size classes used: 0-0.85mm (silt), 0.85mm - 2mm (sand), 2mm - 25mm, 25mm - 100mm, 100mm - 256mm, >256mm. Clasts falling into the largest size class for each transect were discarded.

substrate compositions. Second is the fact that the exact method used by Aquatic Resource Consultants to arrive at the 1994 figures is unknown. Several variables in methodologies could easily explain differences in these two data sets.

Given these qualifications, the only detectable trend is one towards an increase in fine sediments in pools (Transects 8 and 11). If this trend is real, the most likely causes are an increase in fine sediment supply due to the numerous eroding banks in the Ravine Reach and upper portion of the Plant Reach and/or and increase in erosive flow levels.

In general, substrates throughout the studied reaches appear suitable for salmonid spawning in terms of size and distribution. There is some cementation of gravels near the upper end of the Ravine Reach and exposures of hardpan clay in both reaches, but there are numerous places, especially in the Plant Reach, where substrates of suitable size and distribution for spawning exist. However, as noted above and in the study by Larson and Booth (1999), the substrate--especially in the Plant Reach--appears to be highly mobile and subject to regular scour and redistribution at commonly occurring discharge rates. It is likely, therefore, that salmonid redds, especially those created during the winter months (coho, steelhead, chum), would be subject to disturbance and consequent egg mortality.

LARGE WOODY DEBRIS (LWD)

Large woody debris was inventoried throughout the studied reaches. Each piece of LWD, defined for this study as those larger than 20cm in diameter and three meters in length, was measured (visually estimated) and categorized by type (coniferous or deciduous), position in the channel (lateral, bridge, weir, etc.), and condition (solid, moderate, rotten).

A total of 127 pieces of LWD were recorded in the Ravine Reach (an average of approximately 8.3 pieces of LWD per 100 yards of stream length). Eighty-six of those (68%) were of coniferous origin. Ninety-seven pieces of LWD were inventoried in the Plant Reach (an average of 11.3 pieces per 100 yards). Forty-eight of those (49%) are coniferous pieces.

The 1994 Aquatic Resource Consultants study reports "an average of about 7 to 10 pieces per 100 yards of stream". The 1994 study does not report data separately for the two reaches, so it is not possible to know whether the individual reaches were similarly loaded in 1998. A comparable figure for the entirety of the reaches studied in 1998 is 9.3 pieces per 100 yards of stream. It can only be assumed from this comparison that there has been little significant change in debris loading of the Ravine Reach.

While none of these debris loading statistics approach those observed in streams in mature forests (Maser *et al*, 1988, reported 18 to 45 pieces per 100 yards in such systems), they probably compare favorably with many other urbanized streams.

The 1994 Aquatic Resource Consultants report mentions that no large debris complexes were observed upstream of the treatment plant. While the definition of "large debris complex" is vague, three large spanning debris jams were inventoried in the Ravine Reach during the most recent survey. There are several other locations where what appear to be the remnants of large debris jams are evident on the channel banks. However, debris jams/complexes are certainly more numerous and complex in the Plant Reach than in the Ravine Reach.

FLOW VELOCITIES

Flow velocities within the channel were studied to assess their possible impacts upon salmonid habitation within the reaches. In Table 3 below Bell (1986) reports the following swimming speeds for salmonids, which may be related to the water velocities that constitute hospitable habitats for them:

TABLE 3: SWIMMING SPEEDS OF DES MOINES CREEK SALMONIDS (AFTER BELL, 1986)

Species	Swimming speed m/sec. (ft/sec.)		
	Cruising	*Sustained*	*Darting*
Coho salmon	0-1.04m/sec (0-3.4 ft/sec.)	1.04-3.23m/sec (3.4-10.6ft/sec)	3.23-6.55m/sec (10.6-21.5ft/sec)
Steelhead	0-1.4 (0-4.6)	1.4-4.18 (4.6-13.7)	4.18-8.08 (13.7-26.5)
Trout	0-0.61 (0-2)	0.61-1.95 (2-6.4)	1.95-4.11 (6.4-13.5)

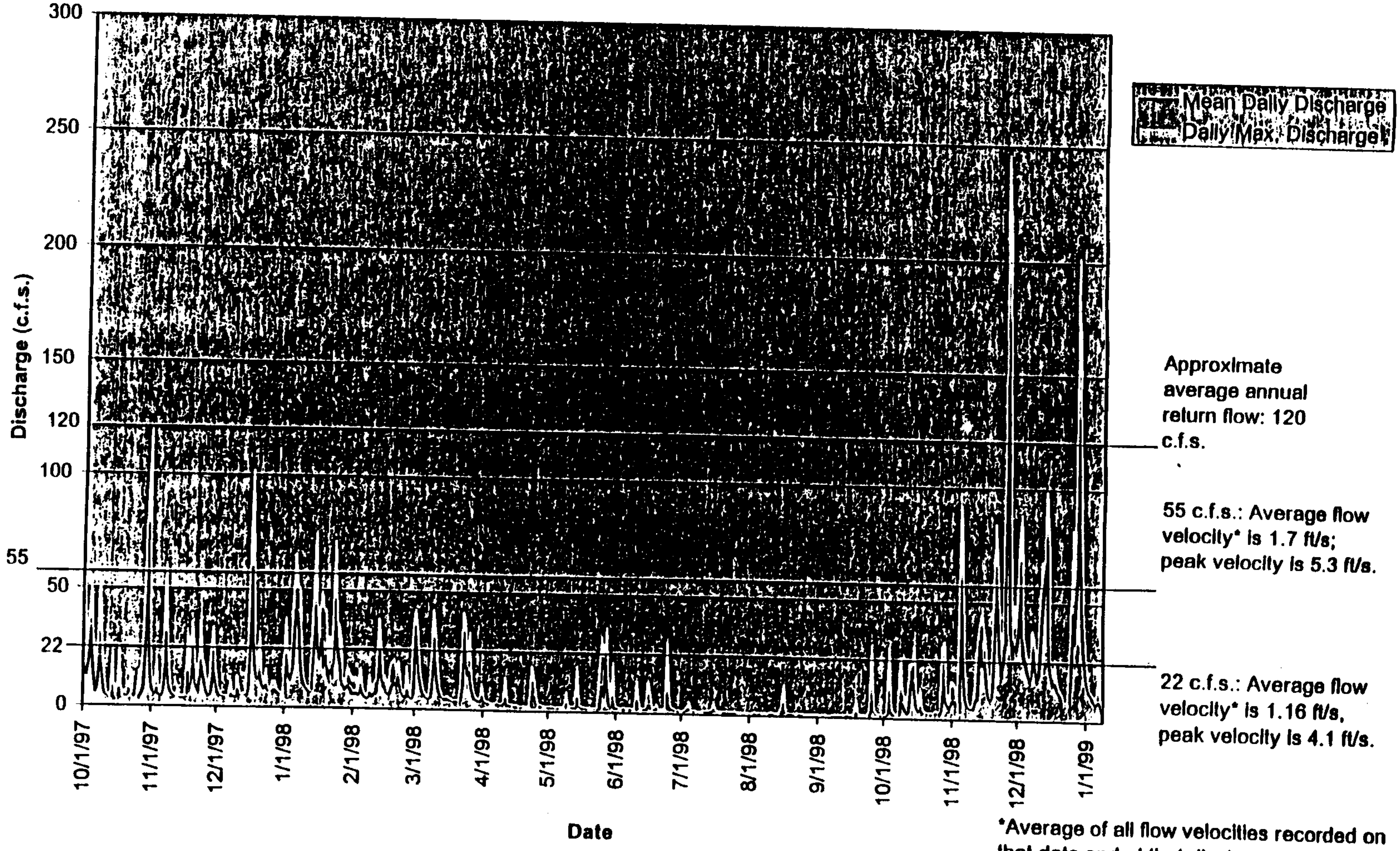
In addition, Thompson (1972) reports that adult coho and steelhead migrate upstream through water velocities up to 8 feet/second.

Based on these data, conditions inhospitable to salmonid habitation might be said to exist when a large portion of the stream flow is at velocities greater than the sustained cruising speed of the species in question. Note that these swimming speeds are for adult fish; juveniles would be less able to hold in high velocity flows. Juvenile coho, for instance, *prefer* flow velocities of less than 1 foot/second (Nickelson and Reisenbichler 1977).

Flow velocities were recorded at the same seven cross-sectional transects used to collect substrate particle distribution data. These transects are placed in a representative variety of habitats distributed throughout the two reaches. Flow velocities were recorded at five distances along each transect and at two depths at each distance (at 0.6 of the total depth and at approximately two inches off of the bottom of the channel), a total of ten measurement stations per transect. Flow velocity data was collected on January 15, 1999 at flow levels that approximate winter base flows (22 c.f.s.) and again on February 24, 1999 during a higher flow event (approximately 55 c.f.s.). (Attempts to collect flow velocity data at still higher flows proved hazardous and were abandoned.) The average annual return flow in this system has been calculated to be approximately 120 c.f.s. Figure 5 below provides some context in which to view these flows and their corresponding velocities. The complete set of flow velocity data is included in Appendix C.

Average and peak velocities for each transect, along with the habitat character present at the transect, are presented below in Table 4.

Figure 5: Discharge at Mouth of Des Moines Creek



Approximate average annual return flow: 120 c.f.s.

55 c.f.s.: Average flow velocity* is 1.7 ft/s; peak velocity is 5.3 ft/s.

22 c.f.s.: Average flow velocity* is 1.16 ft/s, peak velocity is 4.1 ft/s.

*Average of all flow velocities recorded on that date and at that discharge

TABLE 4: FLOW VELOCITIES (1/15/99 AND 2/24/99 AT 22 C.F.S AND 55 C.F.S., RESPECTIVELY)

Transect #	Habitat Type	Average Velocity		Peak Velocity (highest recorded)	
		22c.f.s.	55c.f.s.	22c.f.s.	55c.f.s.
4	Riffle	1.79 fps.	2.22 fps.	3.4 fps.	4.16 fps.
5	Run w/ gravel bar	1.61 fps.	2.33 fps.	2.6 fps.	4.4 fps.
6	Mid-channel scour pool	1.19 fps.	1.74 fps.	3.0 fps.	4.03 fps.
9	Plunge pool @ notched weir	0.75 fps.	1.19 fps.	4.1 fps.	4.17 fps.
10	Pool	0.55 fps.	1.17 fps.	0.6 fps.	3.91 fps.
11	Straight riffle	1.45 fps.	1.85 fps.	2.7 fps.	3.61 fps.
12	Step run	1.53 fps.	2.66 fps.	2.6 fps.	5.29 fps.
Bldr. Pool	Very large pool	0.46 fps.	NA	1.1 fps.	NA

Velocities at 22 c.f.s. equaled or exceeded the cruising speed of trout (2 feet/second--the slowest of the speeds Bell reports) at 19 of the 80 flow measurement stations (ten for each transect). Velocities at 55 c.f.s. exceeded 2 feet/second at 41 of 70 stations measured. No velocities were recorded at either flow rate that exceeded the sustained swimming speed of trout (6.4 feet/second). The highest velocity measured was 5.29 feet/second--still well within the sustained swimming ability of any adult salmonids presumed to be present. At each transect and at both flows sampled velocities of less than one foot/second were measured at one or more stations. Flow velocities at the margins of the channels continued to be hospitable to even juvenile salmonids at 55 c.f.s. Flow velocities do not, therefore, appear to be a problem for salmonids at the discharge rates sampled. However, flows far in excess of 55 c.f.s are common in Des Moines Creek. (See Figure 5 above: flows during the winter of 1998-99 have exceeded 200 c.f.s. on at least two occasions.)

Unfortunately, it is not possible to accurately extrapolate what flow velocities might be at 200 c.f.s. or 120 c.f.s from the two present data sets. However, it would appear unlikely that low-velocity refuge habitat would completely disappear, especially in the Plant Reach where there are large pools and accumulations of woody debris. It is more likely that high flow velocities have detrimental effects upon salmonid populations via their effects upon the channel bed and spawning gravels/redds.

CONCLUSIONS/RECOMMENDATIONS

While Des Moines Creek is certainly not comparable in habitat or other physical properties to pristine or "old growth" streams, it does appear to support--at least ephemerally--some high quality salmonid habitat. The Plant Reach contains numerous pools that would be suitable for rearing/over-wintering coho juveniles, along with many potentially excellent spawning sites. The Ravine Reach would be less suitable for such occupations, but would be suitable for cutthroat trout habitation. However, the regular occurrence of discharge rates sufficient to mobilize the substrate and the consequent significant changes in channel morphology may render such habitat less useful. Spawning sites are probably disturbed on a regular basis during the winter months and pool quality and frequency may vary season to season.

The problems affecting the Ravine Reach go beyond a mere lack of woody debris and excessively high storm flows. The constriction of the channel by the adjacent sewer line and the hardening of the right bank with rip-rap to protect the sewer line are problems that will continue to plague the stream. Traditional treatments involving the addition of large woody debris to the channel would probably not be effective here--or would be less effective--because the channel has so little room for lateral migration or scour and little storage capacity in its floodplain for high flows. High flows are instead funneled straight down the non-sinuous channel with little dispersion of energy. Wood placed in the channel would, in all likelihood, end up as has most of the wood already in the channel: swept off to the sides where it has little effect on instream habitat. This situation might be somewhat less severe if flows are reduced by upstream detention; however, it is still unlikely that woody debris treatment would have beneficial effects outweighing the effects of additional erosion on the unhardened left bank. Placement of large, rounded boulders within the channel would be more likely to have a lasting and beneficial effect without increasing erosion, especially if the goal is to improve resident trout habitat rather than coho habitat. It is unlikely that the Ravine Reach will ever contain coho habitat rivaling that of the Plant Reach.

The Plant Reach supports both the highest quality habitat and the best opportunities for habitat enhancement. While there are several pools of very high quality within the Plant Reach, these pools may be somewhat ephemeral due to substrate mobility and there are also several excessively long riffles. The sinuosity of the channel and its relative lack of constriction (compared to the Ravine Reach) would allow it to respond in a more natural and beneficial manner to woody debris treatment. However, such treatments are likely to be very limited in their benefit without reductions of regularly occurring high storm flows.

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PLANT REACH

Photo #1: Rearing/pool habitat in the Plant Reach

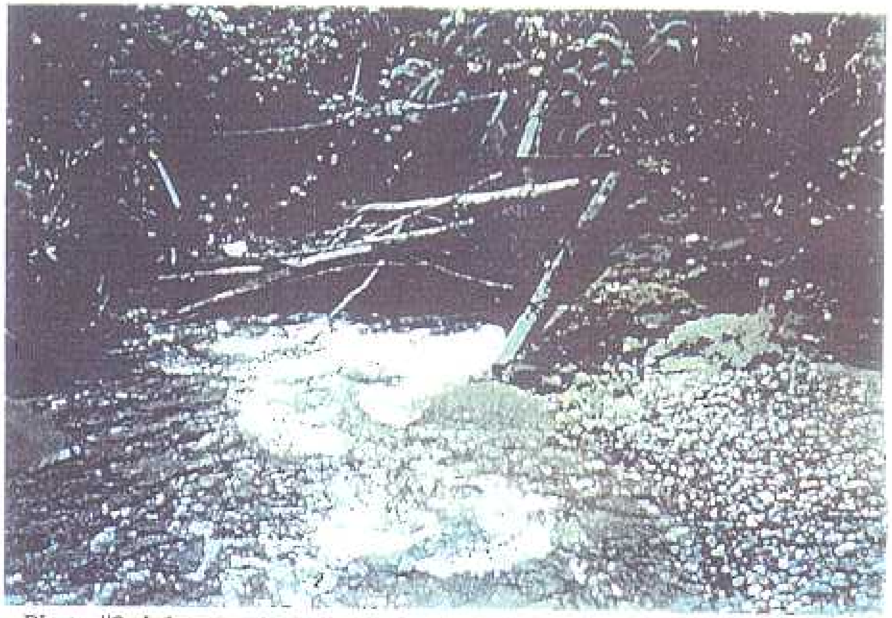

Photo #2: Inlet to culvert beneath Marine View Drive

Photo #3: Outfall of culvert beneath Marine View Drive

Photo #4: Less-constrained channel in the Plant Reach

Photo #5: Fish ladders at Midway Treatment Plant

Photo #6: Stream w/ adjacent sewer line and armoring

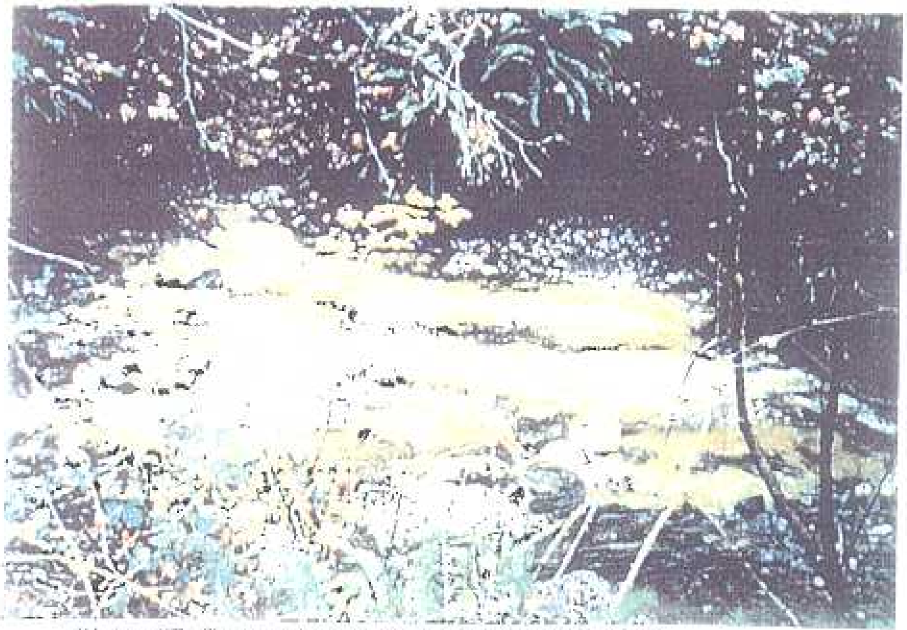

Photo #7: Exposed hardpan (lacustrine deposits).

Photo #8: Erosion along bend in Ravine Reach

APPENDIX B: SUBSTRATE DATA

Substrate Data Collected at Flow/Velocity Transects

Transect 4

					log seive size	log % finer	
256	100	D_{100}= 204					110
100	97	D_{84}= 131		100	2	2	74
25	35	D_{50}= 35		49	1.39794001	1.69019608	22
2	17	D_{35}= 14		18	0.30103	1.25527251	9.8

Transect 5

					log seive size	log % finer	
>256	100						
256	100	D_{100}= 227.0			2.40823997		131
100	95.8	D_{84}= 101.0		100	2	2	93
25	53	D_{50}= 9.0		35	1.39794001	1.54406804	33
2	38	D_{35}= 1.7		13	0.30103	1.11394335	16

Transect 6

					log seive size	log % finer	
>256							
256	100	D_{100}=	253		2.40823997		173
100	96	D_{84}=	59	100	2	2	42
25	68	D_{50}=	0.8	71	1.39794001	1.85125835	0.6
2	58	D_{35}=	0.04	60	0.30103	1.77815125	0.03

Transect 9

1000	100			3	2
256	90	D_{100}=	531	2.40823997	1.95424251
100	79	D_{84}=	234	2	1.89762709
25	55	D_{50}=	20	1.39794001	1.74036269
2	28	D_{35}=	4	0.30103	1.44715803

Transect 10

1000	100						
256	91	D_{100}=	514	100	2.40823997	2	208
100	80	D_{84}=	227	88	2	1.94448267	103
25	55	D_{50}=	20	60	1.39794001	1.77815125	13
2	28	D_{35}=	4	31	0.30103	1.49136169	3

Note: Approx. 11% solid clay not included in these figures

Transect 11

256	100	D_{100}=	238	2.40823997	2
100	79	D_{84}=	127	2	1.89762709
25	55	D_{50}=	20	1.39794001	1.74036269
2	26	D_{35}=	5.5	0.30103	1.41497335

Transect 12

1000	100				3		
256	55	D_{100}=	723	100	2.40823997	2	205
100	41	D_{84}=	533	71	2	1.85125835	156
25	16	D_{50}=	215	29	1.39794001	1.462398	69
2	3	D_{35}=	115	5	0.30103	0.69897	39

APPENDIX C: FLOW VELOCITY DATA

Flow Velocities At Des Moines Creek, 1/15/98 at 22c.f.s.

Velocities in feet/second

Transect	Habitat Type	Depth	RB-		MID Channel		LB	Average
4	Riffle	2" off bottom	0.6	2	3.4	1.4	1.5	1.79
		0.6 of total	0.6	1.9	3.4	1.3	1.8	
		Total depth=	0.4	0.5	0.4	0.3	0.7	
5	Run w/ gravel bar	2" off bottom	0.8	2.1	2.5	2.5	0.2	1.61
		0.6 of total	0.8	1.7	2.5	2.6	0.4	
		Total depth=	0.3	0.3	0.4	0.5	1.3	
6	Mid-channel Scour Pool	2" off bottom	1.9	0.8	1.5	0.2	0	1.19
		0.6 of total	1.9	2.5	3	0.1	0	
		Total depth=	0.8	1.1	1.8	2.1	0.7	
9	Plunge pool below notched weir	2" off bottom	0.5	0.2	1.5	0.3	0.1	0.75
		0.6 of total	0.5	0.1	4.1	0.1	0.1	
		Total depth=	0.6	1.4	2.2	1.9	1	
10	Pool	2" off bottom	0	0.2	0.05	2	0.3	0.55
		0.6 of total	0	0.3	0.05	2	0.6	
		Total depth=	0.6	1.9	1.8	1.4	1.1	
11	Straight riffle	2" off bottom	1.9	2.1	2.1	0.4	0.4	1.45
		0.6 of total	1.9	2	2.7	0.4	0.6	
		Total depth=	0.4	0.8	0.8	1.1	1	
12	Step Run	2" off bottom	1.2	1.4	1.4	0.2	1	1.53
		0.6 of total	1.9	1.4	1.7	2.6	2.5	
		Total depth=	0.7	0.7	0.6	1	1	
Bonus Transect in Huge Boulder scour pool		2" off bottom	0	0.2	1.1	0.3	0.4	0.46
		0.6 of total	0.3	0.2	1	0.2	0.9	
		Total depth=	2.2	4	3.8	2.6	1.7	

Flow Velocities At Des Moines Creek, 2/24/99 at 55c.f.s.

Velocities in Feet per Second

Transect	RB		MID Channel		LB	Average
4	0.62	2.14	2.32	2.73	1.92	2.22
	0.67	1.68	4.16	3.36	2.55	
	0.5	0.7	0.7	0.6	1.1	
5	2.39	3.45	3.38	0.13	0	2.33
	2.7	3.93	4.4	2.94	0	
	0.5	0.6	0.8	1.4	0.8	
6	2.33	1.78	0.72	0.17	0.95	1.74
	3.53	4.03	2.81	0.17	0.95	
	1.4	1.8	2.8	1.9	0.3	
9	0.16	0.48	2.16	2.42	0.12	1.19
	0.14	0.77	4.17	1.32	0.19	
	0.5	2	2.9	2.6	1	
10	0.04	0.5	0.89	2.45	0.64	1.17
	0.06	0.01	2.08	3.91	1.11	
	1.2	2.6	2.8	2.2	1	
11	0.97	2.63	2.32	0.88	0.53	1.85
	1.7	3.53	3.61	1.62	0.71	
	1	1.3	1.4	1.6	0.7	
12	2.95	2.24	2.71	1.75	1.89	2.66
	2.69	3.12	2.34	5.29	1.61	
	1.7	1.5	1.2	1.2	0.7	

Appendix F

DES MOINES CREEK REGIONAL CIP
PRELIMINARY DESIGN REPORT

Appendix F
Hydraulic Modeling

Open Channel Hydraulics - Existing and Proposed Channels downstream of Northwest Ponds

For the purposes of this summary, the upper channel is defined as the channel reach located between the two culverts. The lower channel is defined as the portion of the channel downstream of the 72-inch culvert. The downstream portion of the lower channel has three existing weirs. A hydraulic study of the existing and the proposed channel was conducted using of King County's Backwater Program.

The existing channel's upper reaches have an approximate carrying capacity of 20-40 cfs before spilling into the surrounding golf course area. This is equivalent to less than a 2-year storm event. The lower reaches of the channel have a carrying capacity greater than the 100-year storm event. The upper reaches of the channel experience capacity shortcomings due to negative or minimal gradients, obstructed flows due to heavy vegetation, and inadequate channel size. Two individual analyses were conducted to account for the aforementioned observations. The first analysis used the survey information and cross-sections directly without taking in to account any debris/vegetation obstructions. The channel bottom was assigned an n-value of 0.07 with the upper banks of the channel given n-values in the order of 0.05-0.03. The observed conditions were not represented by the results, especially at the lower flow levels. A second analysis attempted to account for the heavy vegetation and other channel obstructions found in the upper channel. An n-factor of 0.50 was given to the channel bottoms and a slight decrease to the channel's gradient was made to account for the backwater effect of the "debris dams" found in the channel bottom. The final outcome was more in line with the low flow observations noted by the area's hydrologists although the discrepancies were not great.

The proposed reconstruction would increase the channel capacity shortcomings of the upper channel by lowering and enlarging it. The entire channel was lowered in order to increase the channel's gradient and increase active storage in Northwest Ponds and the Approach Light cell. The upper two weirs were removed. The average channel section was lowered about 2.0 feet. To account for the lower invert elevations the channel side slopes had to be altered. The side slopes were kept at a maximum grade of 2:1. In general the proposed side slopes were cut to intersect the top of bank of the existing channel while keeping the side slope grade less than a 2:1. Portions of the extreme upper reaches of the channel were assigned side slopes of 3:1 to optimize their carrying capacity. The area surrounding the upper reaches of the channel has a gentle slope gradient. A 3:1 slope does not result in large quantities of excavation along these reaches.

The proposed redesign increased the capacity of the upper channel to approximately 100-year storm levels while maintaining the same level of protection in the lower reaches. The upper channel's capacity approaches 120 cfs, which matches a 100-year flood frequency event as determined by previous hydrologic analysis.

channel2.doc

EXISTING CHANNEL DOWNSTREAM OF NORTHWEST PONDS

(To simulate the low flow conditions, increased Manning's n to account for vegetation and debris.)

```
                KING COUNTY DEPARTMENT OF PUBLIC WORKS
                  Surface Water Management Division

                      BACKWATER ANALYSIS PROGRAM
                             Version 4.22



                      1 - INFO ON THIS PROGRAM
                      2 - BWCHAN
                      3 - BWPIPE
                      4 - BWCULV
                      5 - BWBOX
                      6 - DATA-FILE ROUTINES
                      7 - RETURN TO DOS


ENTER OPTION
2
BACKWATER COMPUTER PROGRAM FOR OPEN CHANNELS


ENTER [d:][path]filename[.ext] OF CHANNEL-DATA FILE
  CHAN1.CHA


DISPLAY CHANNEL DATA (Y or N)?
  Y

------------------------------------------------------------------------

OUTFLOW CONDITIONS AT STATION 1607.95 TAILWATER DATA:

 1) SPECIFY TYPE OF TAILWATER DATA INPUT: S - SINGLE TW-ELEV.
                                          F - TW/HW DATA FILE
  F


 2) ENTER: [d:][path]filename[.ext] OF HW/TW DATA
  RDBWW3.TW

------------------------------------------------------------------------

ENTER: QMIN, QMAX, QINCRE, PRINT-OPTION (STANDARD=1, CONDENSED=2, EXPANDED=3)
     .00   600.00    25.00   1

STATION 1607.95:    INVERT= 240.24 FT    EC=1.30    Q-RATIO= .00
```

```
CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)  N-FACTOR  *  RIGHT(FT)  STAGE(FT)  N-FACTOR
     .00        .00      .040    *      .00        .00      .040
    4.00        .00      .040    *     4.50        .00      .040
    6.93       2.97      .040    *     6.77        .98      .040
   14.16       8.24      .040    *    18.30       8.43      .040
   25.61       9.78      .040    *    35.33       8.60      .040
   40.39       9.95      .040    *    46.25       8.60      .040
  101.40      13.41      .040    *    77.18      14.47      .040
  138.48      14.57      .040    *    77.18      14.47      .040

Q(CFS)   Y1(FT)   WS ELEV. * YC-IN YN-IN _Q-TW TW-HT  N-Y1   A-Y1  WP-Y1  V-Y1
******************************************************************************
  25.00    3.07    243.31  *   .68   .82 25.00  3.07  .040  39.92  19.15   .63
  50.00    3.40    243.64  *  1.05  1.22 50.00  3.40  .040  45.82  20.34  1.09
  75.00    3.67    243.91  *  1.34  1.53 75.00  3.67  .040  50.83  21.30  1.48
 100.00    3.94    244.18  *  1.59  1.80100.00  3.94  .040  55.92  22.24  1.79
 125.00    4.23    244.47  *  1.82  2.04125.00  4.23  .040  61.65  23.26  2.03
 150.00    4.50    244.74  *  2.03  2.26150.00  4.50  .040  67.39  24.23  2.23
 175.00    4.77    245.01  *  2.22  2.47175.00  4.77  .040  73.14  25.17  2.39
 200.00    5.02    245.26  *  2.41  2.65200.00  5.02  .040  78.92  26.08  2.53
 225.00    5.28    245.52  *  2.58  2.83225.00  5.28  .040  84.74  26.97  2.66
 250.00    5.52    245.76  *  2.74  3.00250.00  5.52  .040  90.58  27.84  2.76
 275.00    5.76    246.00  *  2.90  3.16275.00  5.76  .040  96.49  28.69  2.85
 300.00    5.95    246.19  *  3.05  3.32300.00  5.95  .040 101.26  29.36  2.96
 325.00    5.95    246.19  *  3.20  3.46325.00  5.95  .040 101.26  29.36  3.21
 350.00    5.95    246.19  *  3.34  3.61350.00  5.95  .040 101.26  29.36  3.46
 375.00    5.95    246.19  *  3.47  3.74375.00  5.95  .040 101.26  29.36  3.70
 400.00    5.95    246.19  *  3.60  3.87400.00  5.95  .040 101.26  29.36  3.95
 425.00    5.95    246.19  *  3.73  4.00425.00  5.95  .040 101.26  29.36  4.20
 450.00    5.95    246.19  *  3.85  4.12450.00  5.95  .040 101.26  29.36  4.44
 475.00    5.95    246.19  *  3.97  4.24475.00  5.95  .040 101.26  29.36  4.69
 500.00    5.95    246.19  *  4.08  4.36500.00  5.95  .040 101.26  29.36  4.94
 525.00    5.95    246.19  *  4.20  4.47525.00  5.95  .040 101.26  29.36  5.18
 550.00    5.95    246.19  *  4.31  4.58550.00  5.95  .040 101.26  29.36  5.43
 575.00    5.95    246.19  *  4.41  4.68575.00  5.95  .040 101.26  29.36  5.68
 600.00    5.95    246.19  *  4.52  4.79600.00  5.95  .040 101.26  29.36  5.93


****REACH NO. 1:    LENGTH= 214.37 FT    AVG.GRADE=  1.16% ****


STATION 1393.58:    INVERT= 242.73 FT    EC=1.30    Q-RATIO=1.05

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)  N-FACTOR  *  RIGHT(FT)  STAGE(FT)  N-FACTOR
     .00        .00      .040    *      .00        .00      .040
    4.00        .00      .040    *     4.50        .00      .040
    9.03       1.20      .040    *     4.99       2.60      .040
   14.61       6.28      .040    *     9.49       3.44      .040
```

```
  25.31        9.14        .040      *      18.09        6.85        .040
  37.74        9.64        .040      *      39.95        6.85        .040
  69.66        9.89        .040      *      69.95       10.37        .040
  92.36        9.89        .040      *     101.96       13.12        .040

Q(CFS)   Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
**********************************************************************************
  12.20     .83     243.56  *   .27   .39   .43   .54  .040   8.56  12.92  1.42
  24.39    1.18     243.91  *   .42   .58   .66   .80  .040  13.08  14.79  1.86
  36.59    1.45     244.18  *   .54   .74   .85  1.01  .040  16.83  15.52  2.17
  48.78    1.70     244.43  *   .65   .87  1.01  1.19  .040  20.39  16.14  2.39
  60.98    1.96     244.69  *   .74   .99  1.15  1.34  .040  24.18  16.79  2.52
  73.17    2.21     244.94  *   .83  1.10  1.28  1.48  .040  27.90  17.42  2.62
  85.37    2.45     245.18  *   .92  1.20  1.40  1.60  .040  31.55  18.02  2.71
  97.56    2.70     245.43  *   .99  1.29  1.51  1.73  .040  35.46  19.09  2.75
 109.76    2.95     245.68  *  1.07  1.37  1.61  1.84  .040  39.71  20.82  2.76
 121.95    3.19     245.92  *  1.14  1.45  1.72  1.95  .040  44.18  22.49  2.76
 134.15    3.42     246.15  *  1.20  1.52  1.81  2.06  .040  48.80  24.08  2.75
 146.34    3.60     246.33  *  1.26  1.60  1.91  2.16  .040  52.62  24.89  2.78
 158.54    3.62     246.35  *  1.32  1.67  2.00  2.26  .040  53.05  24.98  2.99
 170.73    3.65     246.38  *  1.38  1.74  2.09  2.36  .040  53.71  25.10  3.18
 182.93    3.67     246.40  *  1.43  1.80  2.17  2.45  .040  54.14  25.19  3.38
 195.12    3.69     246.42  *  1.49  1.87  2.26  2.54  .040  54.58  25.27  3.58
 207.32    3.72     246.45  *  1.54  1.93  2.34  2.64  .040  55.24  25.40  3.75
 219.51    3.74     246.47  *  1.59  1.99  2.42  2.75  .040  55.68  25.48  3.94
 231.71    3.77     246.50  *  1.64  2.05  2.50  2.85  .040  56.34  25.61  4.11
 243.90    3.79     246.52  *  1.69  2.11  2.58  2.95  .040  56.78  25.69  4.30
 256.10    3.82     246.55  *  1.74  2.17  2.67  3.04  .040  57.45  25.82  4.46
 268.29    3.84     246.37  *  1.79  2.23  2.76  3.13  .040  57.90  25.90  4.63
 280.49    3.87     246.60  *  1.83  2.29  2.85  3.22  .040  58.58  26.03  4.79
 292.68    3.90     246.63  *  1.88  2.34  2.94  3.30  .040  59.25  26.15  4.94


****REACH NO. 2:    LENGTH= 145.79 FT    AVG.GRADE=   .83% ****


STATION 1247.79:    INVERT= 243.94 FT    EC=1.30    Q-RATIO= .00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR   *   RIGHT(FT)  STAGE(FT)   N-FACTOR
     .00        .00       .070     *       .00        .00       .070
    3.00        .00       .070     *      4.50        .00       .070
    3.60       1.03       .050     *      7.84       1.30       .050
   15.24       7.51       .050     *     25.37       8.54       .050
   27.66       8.64       .050     *     98.72       9.13       .050
   66.07       9.32       .050     *    141.65      11.40       .050
  175.22       9.34       .050     *    237.13      12.97       .050
  268.48       9.34       .050     *    247.24      13.27       .050
  302.66       9.34       .050     *    288.06      19.95       .050

 Q(CFS)   Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
**********************************************************************************
  12.20     .85     244.79  *   .46   .00   .46   .85  .064   7.51  10.83  1.62
```

```
  24.39    1.24    245.18 *   .72   .00   .72  1.24  .062  11.75  12.54  2.08
  36.59    1.55    245.49 *   .93   .00   .93  1.55  .061  15.57  14.00  2.35
  48.78    1.79    245.73 *  1.11   .00  1.11  1.79  .060  18.81  15.12  2.59
  60.98    2.01    245.95 *  1.28   .00  1.28  2.01  .060  21.99  16.15  2.77
  73.17    2.20    246.14 *  1.42   .00  1.42  2.20  .059  24.90  17.04  2.94
  85.37    2.38    246.32 *  1.56   .00  1.56  2.38  .059  27.80  17.88  3.07
  97.56    2.54    246.48 *  1.69   .00  1.69  2.54  .058  30.49  18.63  3.20
 109.76    2.69    246.63 *  1.81   .00  1.81  2.69  .058  33.11  19.33  3.32
 121.95    2.83    246.77 *  1.92   .00  1.92  2.83  .058  35.64  19.98  3.42
 134.15    2.96    246.90 *  2.03   .00  2.03  2.96  .058  38.06  20.59  3.52
 146.34    3.09    247.03 *  2.13   .00  2.13  3.09  .057  40.56  21.20  3.61
 158.54    3.21    247.15 *  2.23   .00  2.23  3.21  .057  42.93  21.76  3.69
 170.73    3.32    247.26 *  2.32   .00  2.32  3.32  .057  45.15  22.28  3.78
 182.93    3.43    247.37 *  2.41   .00  2.41  3.43  .057  47.43  22.79  3.86
 195.12    3.53    247.47 *  2.50   .00  2.50  3.53  .057  49.54  23.26  3.94
 207.32    3.63    247.57 *  2.58   .00  2.58  3.63  .057  51.69  23.73  4.01
 219.51    3.73    247.67 *  2.66   .00  2.66  3.73  .057  53.89  24.19  4.07
 231.71    3.83    247.77 *  2.74   .00  2.74  3.83  .056  56.13  24.66  4.13
 243.90    3.92    247.86 *  2.82   .00  2.82  3.92  .056  58.18  25.08  4.19
 256.10    4.01    247.95 *  2.89   .00  2.89  4.01  .056  60.26  25.50  4.25
 268.29    4.09    248.03 *  2.96   .00  2.96  4.09  .056  62.14  25.88  4.32
 280.49    4.18    248.12 *  3.03   .00  3.03  4.18  .056  64.29  26.30  4.36
 292.68    4.26    248.20 *  3.10   .00  3.10  4.26  .056  66.23  26.67  4.42


****REACH NO. 3:    LENGTH= 239.06 FT    AVG.GRADE=  -.14% ****


STATION 1008.73:    INVERT= 243.60 FT    EC=1.30    Q-RATIO= .00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

 LEFT(FT)  STAGE(FT)  N-FACTOR  *  RIGHT(FT)  STAGE(FT)  N-FACTOR
     .00       .00      .070    *      .00        .00      .070
    3.00       .00      .070    *     3.50        .00      .070
    5.74      2.10      .050    *    21.69      10.51      .050
   12.28      3.62      .050    *    69.31      12.08      .050
   20.88      8.08      .050    *   107.58      12.16      .050
  120.43      9.32      .050    *   159.83      17.78      .050
  244.25      9.32      .050    *   180.51      19.72      .050
  332.08     10.01      .050    *   180.52      19.73      .050
  418.47     12.27      .050    *   180.53      19.74      .050

Q(CFS)  Y1(FT)   WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1   V-Y1
*******************************************************************************
 12.20    2.23    245.83 *   .51   .00   .51   .00  .059  22.07  14.98    .55
 24.39    2.71    246.31 *   .78   .00   .78   .00  .058  29.32  18.06    .83
 36.59    3.04    246.64 *  1.01   .00  1.01   .00  .057  35.11  20.18   1.04
 48.78    3.34    246.94 *  1.20   .00  1.20   .00  .056  40.95  22.11   1.19
 60.98    3.58    247.18 *  1.37   .00  1.37   .00  .056  46.01  23.65   1.33
 73.17    3.79    247.39 *  1.53   .00  1.53   .00  .056  50.68  24.61   1.44
 85.37    3.98    247.58 *  1.67   .00  1.67   .00  .055  55.06  25.40   1.55
 97.56    4.16    247.76 *  1.81   .00  1.81   .00  .055  59.32  26.15   1.64
109.76    4.33    247.93 *  1.93   .00  1.93   .00  .055  63.46  26.86   1.73
```

```
121.95    4.49     248.09  *  2.05   .00  2.05   .00  .055  67.45  27.53  1.81
134.15    4.63     248.23  *  2.18   .00  2.18   .00  .055  71.01  28.12  1.89
146.34    4.77     248.37  *  2.30   .00  2.30   .00  .055  74.65  28.70  1.96
158.54    4.90     248.50  *  2.42   .00  2.42   .00  .055  78.10  29.24  2.03
170.73    5.03     248.63  *  2.53   .00  2.53   .00  .055  81.60  29.77  2.09
182.93    5.15     248.75  *  2.63   .00  2.63   .00  .055  84.89  30.28  2.15
195.12    5.27     248.87  *  2.72   .00  2.72   .00  .055  88.24  30.78  2.21
207.32    5.38     248.98  *  2.82   .00  2.82   .00  .054  91.35  31.24  2.27
219.51    5.49     249.09  *  2.90   .00  2.90   .00  .054  94.51  31.70  2.32
231.71    5.59     249.19  *  2.99   .00  2.99   .00  .054  97.41  32.12  2.38
243.90    5.69     249.29  *  3.07   .00  3.07   .00  .054 100.36  32.54  2.43
256.10    5.79     249.39  *  3.15   .00  3.15   .00  .054 103.34  32.95  2.48
268.29    5.88     249.48  *  3.22   .00  3.22   .00  .054 106.05  33.33  2.53
280.49    5.97     249.57  *  3.30   .00  3.30   .00  .054 108.79  33.70  2.58
292.68    6.06     249.66  *  3.37   .00  3.37   .00  .054 111.57  34.08  2.62

NOTE: WATER DEPTH INFORMATION FOR THIS LAST CROSS-SECTION WAS COMPUTED ASSUMING
      APPROACH VELOCITIES GREATER THAN OR EQUAL TO CROSS-SECTIONAL VELOCITIES.
      IF NOT THE CASE, WATER DEPTHS CAN BE ADJUSTED BY SPECIFYING, A - ADJUST.

SPECIFY: F - FILE, A - ADJUST, P - PRINT R/D, N - NEWJOB, S - STOP
  F

SPECIFY: H - HW/TW DATA FILE, R - ROUTING DATA FILE, E - ESCAPE, S - STOP
  H

ENTER [d:][path]filename[.ext] FOR STORAGE OF HW-DATA COMPUTED AT STA. 1008.73:
  TW1.TW

SPECIFY: H - HW/TW DATA FILE, R - ROUTING DATA FILE, E - ESCAPE, S - STOP
  S
4
BACKWATER PROGRAM FOR ROUND/ARCH CULVERTS

ENTER: NUMBER OF CULVERTS
  1

------------------------------------------------------------------------

OUTFLOW CONDITIONS PIPE NO. 1 - TAILWATER DATA:

 1) SPECIFY TYPE OF TAILWATER DATA INPUT: S - SINGLE TW-ELEV.
                                          F - TW/HW DATA FILE

  F
 2) ENTER: [d:][path]filename[.ext] OF HW/TW FILE
  TW1.TW
 2a) DISPLAY TW/HW DATA-FILE (Y or N) ?
Y

------------------------------------------------------------------------

ROUND/ARCH PIPE INPUT CODING INFORMATION:

PIPE TYPE CODING:
     1 - CONC/SMOOTH BORE (n=0.012)          5 - CMP ARCH (NEW GEOMETRY)
```

```
      2 - CORRUGATED METAL (n=0.024)            6 - CONC/SMOOTH ARCH (OLD)
      3 - HELICAL CMP (n-fac varies)            7 - CONC/SMOOTH ARCH (NEW)
      4 - CMP ARCH (OLD GEOMETRY)               8 - ROUND (user sets n-fac)

 ARCH PIPE CODING - EQUIVALENT ROUND SIZE MUST BE INPUTTED PER FOLLOWING TABLE:
   EQUIV-DIAM.   OLD-ARCH   NEW-ARCH    *    EQUIV-DIAM.   OLD-ARCH   NEW-ARCH
       15"       18"X 11"   17"X 13"    *        42"       50"X 31"   49"X 33"
       18"       22"X 13"   21"X 13"    *        48"       58"X 36"   57"X 38"
       21"       25"X 16"   24"X 18"    *        54"       65"X 40"   64"X 43"
       24"       29"X 18"   28"X 20"    *        60"       72"X 44"   71"X 47"
       30"       36"X 22"   35"X 24"    *        66"       79"X 49"   77"X 52"
       36"       43"X 27"   42"X 29"    *        72"       85"X 54"   83"X 57"

 INLET TYPE CODING:
   1 - CMP/PROJ.      4 - CP SOCKET/PROJ.     7 - CMAP/PROJ.     10 - OTHER (SEE
   2 - CMP/HDWALL     5 - CP SQ.EDGE/HDWALL   8 - CMAP/HDWALL         FHWA REPORT
   3 - CMP/MITER      6 - CP SOCKET/HDWALL    9 - CMAP/MITER          HDS NO.5)

 ENTER PIPE # 1: LENGTH(ft), DIA(in), PIPE-TYPE, OUTLET-IE, INLET-IE, INLET-TYPE
     142.00     72.00    2    243.60    244.54    1

 ------------------------------------------------------------------------------

 INFLOW CONDITIONS - OVERFLOW DATA AND UPSTREAM VELOCITY DATA:

  1) ENTER: OVERFLOW-ELEV, OVERFLOW-TYPE (NONE=0, BROAD-WEIR=1, SHARP-WEIR=2)
    252.92   1
  1a) ENTER: WEIR LENGTH(ft), HT(ft) ABOVE OVERFLOW
    110.00       .20
  2) SPECIFY TYPE OF VELOCITY DATA INPUT:  S - SINGLE VELOCITY UPSTREAM
                                           V - VARY VELOCITY ACCORDING TO V=Q/A
   V
  3) SPECIFY AN UPSTREAM CHANNEL WIDTH(ft) FOR COMPUTING A=HW*WIDTH
    34.00

 ------------------------------------------------------------------------------

 ENTER: QMIN, QMAX, QINCRE, PRINT-OPTION (STANDARD=1, CONDENSED=2, EXPANDED=3)
       .00    200.00     10.00   1


 PIPE NO. 1:  142 LF - 72"CMP  @   .66%  OUTLET: 243.60  INLET: 244.54  INTYP: 1

          TW DATA ADJUSTED BASED ON CROSS-SECTIONAL AREA
     Q-TOT(CFS)   TW(FT)   TW-ELEV(FT)   Q-ADJ(CFS)   AREA(SQ-FT)
 ********************************************************************
          .00        .00     243.60          .00          .00
        12.20       2.23     245.83        12.20         9.57
        24.39       2.71     246.31        24.39        12.40
        36.59       3.04     246.64        36.59        14.38
        48.78       3.34     246.94        48.78        16.17
        60.98       3.58     247.18        60.98        17.60
        73.17       3.79     247.39        73.17        18.82
        85.37       3.98     247.58        85.37        19.91
        97.56       4.16     247.76        97.56        20.92
```

```
     109.76        4.33      247.93       109.76       21.85
     121.95        4.49      248.09       121.95       22.69
     134.15        4.63      248.23       134.15       23.41
     146.34        4.77      248.37       146.34       24.10
     158.54        4.90      248.50       158.54       24.72
     170.73        5.03      248.63       170.73       25.31
     182.93        5.15      248.75       182.93       25.83
     195.12        5.27      248.87       195.12       26.31
     207.32        5.38      248.98       207.32       26.73
     219.51        5.49      249.09       219.51       27.12
     231.71        5.59      249.19       231.71       27.43
     243.90        5.69      249.29       243.90       27.72
     256.10        5.79      249.39       256.10       27.96
     268.29        5.88      249.48       268.29       28.14
     280.49        5.97      249.57       280.49       28.26
     292.68        6.06      249.66       292.68       28.27

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO   HWI
*******************************************************************************
  10.00    1.33    245.87  *  .024   .83   .95  1.83  1.83  1.09  1.33  1.10
  20.00    1.98    246.52  *  .024  1.18  1.33  2.54  2.54  1.72  1.98  1.59
  30.00    2.42    246.96  *  .024  1.45  1.63  2.86  2.86  2.06  2.42  1.99
  40.00    2.80    247.34  *  .024  1.68  1.89  3.12  3.12  2.35  2.80  2.34
  50.00    3.14    247.68  *  .024  1.88  2.13  3.36  3.36  2.61  3.14  2.66
  60.00    3.44    247.98  *  .024  2.07  2.34  3.56  3.56  2.83  3.44  2.96
  70.00    3.73    248.27  *  .024  2.24  2.55  3.74  3.74  3.04  3.73  3.24
  80.00    4.01    248.55  *  .024  2.40  2.75  3.90  3.90  3.23  4.01  3.52
  90.00    4.28    248.82  *  .024  2.55  2.94  4.05  4.05  3.42  4.28  3.79
 100.00    4.53    249.07  *  .024  2.70  3.13  4.19  4.19  3.60  4.53  4.05
 110.00    4.79    249.33  *  .024  2.83  3.32  4.33  4.33  3.78  4.79  4.30
 120.00    5.04    249.58  *  .024  2.97  3.50  4.46  4.46  3.96  5.04  4.56
 130.00    5.28    249.82  *  .024  3.09  3.69  4.58  4.58  4.13  5.28  4.80
 140.00    5.52    250.06  *  .024  3.21  3.88  4.70  4.70  4.30  5.52  5.05
 150.00    5.76    250.30  *  .024  3.33  4.08  4.81  4.81  4.47  5.76  5.30
 160.00    6.00    250.54  *  .024  3.45  4.28  4.92  4.92  4.64  6.00  5.54
 170.00    6.24    250.78  *  .024  3.56  4.50  5.02  5.02  4.81  6.24  5.78
 180.00    6.49    251.03  *  .024  3.67  4.74  5.12  5.12  4.99  6.49  6.03
 190.00    6.74    251.28  *  .024  3.77  5.03  5.22  5.22  5.16  6.74  6.27
 200.00    7.00    251.54  *  .024  3.87  5.49  5.31  5.31  5.34  7.00  6.51


                TOTAL "HW" VS."Q" DATA PRINT-OUT

                     Q(CFS)    HW(FT)    HW-ELEV(FT)
      ************************************************************************
                      10.00     1.33       245.87
                      20.00     1.98       246.52
                      30.00     2.42       246.96
                      40.00     2.79       247.33
                      50.00     3.14       247.68
                      60.00     3.44       247.98
                      70.00     3.73       248.27
                      80.00     4.01       248.55
                      90.00     4.28       248.82
```

```
                    100.00     4.53     249.07
                    110.00     4.79     249.33
                    120.00     5.04     249.58
                    130.00     5.28     249.82
                    140.00     5.52     250.06
                    150.00     5.76     250.30
                    160.00     6.00     250.54
                    170.00     6.24     250.78
                    180.00     6.49     251.03
                    190.00     6.74     251.28
                    200.00     7.00     251.54

SPECIFY: N - NEWJOB, F - FILE, S - STOP
F

SPECIFY [d:][path]filename[.ext] FOR STORAGE OF HW-DATA AT INLET OF CULVERT(S)
TW2.TW

SPECIFY: N - NEWJOB, F - FILE, S - STOP
S
2
BACKWATER COMPUTER PROGRAM FOR OPEN CHANNELS


ENTER [d:][path]filename[.ext] OF CHANNEL-DATA FILE
 nCHAN2.CHA


DISPLAY CHANNEL DATA (Y or N)?
 Y

------------------------------------------------------------------------

OUTFLOW CONDITIONS AT STATION  866.73 TAILWATER DATA:

 1) SPECIFY TYPE OF TAILWATER DATA INPUT: S - SINGLE TW-ELEV.
                                          F - TW/HW DATA FILE
 F


 2) ENTER: [d:][path]filename[.ext] OF HW/TW DATA
 TW2.TW

------------------------------------------------------------------------

ENTER: QMIN, QMAX, QINCRE, PRINT-OPTION (STANDARD=1, CONDENSED=2, EXPANDED=3)
     .00   200.00    10.00   1

STATION  866.73:    INVERT= 244.54 FT    EC=1.30    Q-RATIO= .00

CROSS-SECTION DATA:
 DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

 LEFT(FT)  STAGE(FT)  N-FACTOR  *  RIGHT(FT)  STAGE(FT)  N-FACTOR
    .00        .00      .300    *      .00        .00      .300
```

```
    2.50        .00        .300     *      4.00       .00       .300
    2.88       1.41        .030     *      5.49      1.53       .030
   16.35       7.53        .030     *     18.26      6.84       .030
   57.85       7.53        .030     *     50.62      7.15       .030
  112.11       7.53        .030     *     99.37      7.15       .030
  241.24       8.38        .030     *    163.43      7.15       .030
  259.13       8.47        .030     *    296.44      7.92       .030
  310.46      12.48        .030     *    348.68     10.22       .030

Q(CFS)   Y1(FT)   WS ELEV. * YC-IN YN-IN  Q-TW TW-HT  N-Y1   A-Y1  WP-Y1  V-Y1
********************************************************************************
  10.00    2.18     246.72  *   .46  2.18 10.00  1.33  .187  18.00  13.65   .56
  20.00    2.89     247.43  *   .71  2.89 20.00  1.98  .162  27.42  17.22   .73
  30.00    3.37     247.91  *   .93  3.37 30.00  2.42  .150  35.10  19.63   .85
  40.00    3.75     248.29  *  1.12  3.75 40.00  2.79  .141  41.93  21.53   .95
  50.00    4.06     248.60  *  1.29  4.06 50.00  3.14  .136  48.00  23.09  1.04
  60.00    4.33     248.87  *  1.45  4.33 60.00  3.44  .131  53.64  24.45  1.12
  70.00    4.57     249.11  *  1.62  4.57 70.00  3.73  .127  58.94  25.65  1.19
  80.00    4.79     249.33  *  1.77  4.79 80.00  4.01  .124  64.04  26.76  1.25
  90.00    4.99     249.53  *  1.92  4.99 90.00  4.28  .122  68.86  27.76  1.31
 100.00    5.17     249.71  *  2.05  5.17100.00  4.53  .119  73.36  28.67  1.36
 110.00    5.34     249.88  *  2.17  5.34110.00  4.79  .117  77.74  29.52  1.41
 120.00    5.51     250.05  *  2.28  5.51120.00  5.04  .115  82.26  30.37  1.46
 130.00    5.66     250.20  *  2.39  5.66130.00  5.28  .114  86.36  31.13  1.51
 140.00    5.80     250.34  *  2.49  5.80140.00  5.52  .112  90.27  31.83  1.55
 150.00    5.94     250.48  *  2.59  5.94150.00  5.76  .111  94.28  32.53  1.59
 160.00    6.07     250.61  *  2.68  6.07160.00  6.00  .110  98.08  33.19  1.63
 170.00    6.24     250.78  *  2.77  6.20170.00  6.24  .108 103.17  34.04  1.65
 180.00    6.49     251.03  *  2.85  6.32180.00  6.49  .106 110.90  35.30  1.62
 190.00    6.74     251.28  *  2.94  6.43190.00  6.74  .104 118.91  36.55  1.60
 200.00    7.00     251.54  *  3.01  6.54200.00  7.00  .084 128.85  54.14  1.55


****REACH NO. 1:    LENGTH= 113.42 FT    AVG.GRADE=   .34% ****


STATION  753.31:    INVERT= 244.93 FT    EC=1.30    Q-RATIO= .00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR   *   RIGHT(FT)  STAGE(FT)   N-FACTOR
     .00        .00       .300     *       .00        .00       .300
    3.50        .00       .300     *      3.00        .00       .300
    8.52       2.25       .030     *      4.40       1.92       .030
   24.97       7.84       .030     *     13.91  ~~6.77~~ 9.42   .030
   47.26       9.40       .030     *     93.89       6.77       .030
  138.94      10.78       .030     *    225.19       6.77       .030
  194.65      10.78       .030     *    329.05       9.61       .030
  264.85      15.69       .030     *    355.20       9.80       .030

 Q(CFS)   Y1(FT)   WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
********************************************************************************

  10.00    2.12     247.05  *   .45   .00   .45  1.92  .180  20.46  14.50   .49
  20.00    2.83     247.76  *   .69   .00   .69  2.61  .157  30.88  18.18   .65
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```
    30.00     3.31     248.24  *    .89   .00    .89  3.08  .145  39.32  20.73   .76
    40.00     3.69     248.62  *   1.06   .00   1.06  3.44  .137  46.81  22.75   .85
    50.00     4.01     248.94  *   1.22   .00   1.22  3.75  .131  53.66  24.45   .93
    60.00     4.28     249.21  *   1.36   .00   1.36  4.01  .127  59.83  25.88  1.00
    70.00     4.52     249.45  *   1.49   .00   1.49  4.24  .123  65.62  27.16  1.07
    80.00     4.74     249.67  *   1.61   .00   1.61  4.46  .120  71.17  28.32  1.12
    90.00     4.94     249.87  *   1.73   .00   1.73  4.65  .118  76.42  29.39  1.18
   100.00     5.12     250.05  *   1.84   .00   1.84  4.83  .116  81.32  30.34  1.23
   110.00     5.30     250.23  *   1.94   .00   1.94  4.99  .114  86.37  31.30  1.27
   120.00     5.46     250.39  *   2.05   .00   2.05  5.15  .112  91.00  32.15  1.32
   130.00     5.62     250.55  *   2.15   .00   2.15  5.30  .110  95.75  33.00  1.36
   140.00     5.76     250.69  *   2.24   .00   2.24  5.44  .109 100.01  33.74  1.40
   150.00     5.90     250.83  *   2.34   .00   2.34  5.57  .107 104.37  34.48  1.44
   160.00     6.03     250.96  *   2.43   .00   2.43  5.70  .106 108.50  35.17  1.47
   170.00     6.19     251.12  *   2.52   .00   2.52  5.82  .105 113.70  36.02  1.50
   180.00     6.40     251.33  *   2.60   .00   2.60  5.94  .103 120.72  37.14  1.49
   190.00     6.62     251.55  *   2.68   .00   2.68  6.05  .101 128.30  38.30  1.48
   200.00     6.77     251.70  *   2.76   .00   2.76  6.16  .044 133.61 250.38  1.50


****REACH NO. 2:     LENGTH= 263.93 FT     AVG.GRADE=  -.08% ****


STATION  489.38:     INVERT= 244.73 FT     EC=1.30     Q-RATIO= .00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

 LEFT(FT)  STAGE(FT)   N-FACTOR   *   RIGHT(FT)  STAGE(FT)   N-FACTOR
     .00        .00      .500     *        .00        .00      .500
    1.50        .00      .500     *       5.00        .00      .500
    2.60        .99      .300     *       8.11        .88      .300
    7.95       3.33      .050     *      14.87       2.98      .050
   24.87       5.30      .030     *      83.29       3.47      .030
   60.03       6.51      .030     *     112.76       4.24      .030
   76.36       9.50      .030     *     247.11       4.24      .030
   96.12      14.31      .030     *     336.15       7.88      .030

Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
*****************************************************************************************
   10.00     2.78     247.51  *    .44   .00    .44   .00  .276  37.33  22.08   .27
   20.00     3.45     248.18  *    .67   .00    .67   .00  .115  67.70  90.80   .30
   30.00     3.88     248.61  *    .86   .00    .86   .00  .102 111.36 113.00   .27
   40.00     4.25     248.98  *   1.02   .00   1.02   .00  .066 157.22 264.58   .25
   50.00     4.56     249.29  *   1.16   .00   1.16   .00  .065 240.40 274.85   .21
   60.00     4.83     249.56  *   1.30   .00   1.30   .00  .064 315.44 283.80   .19
   70.00     5.07     249.80  *   1.41   .00   1.41   .00  .063 384.16 291.75   .18
   80.00     5.29     250.02  *   1.53   .00   1.53   .00  .062 448.83 299.04   .18
   90.00     5.50     250.23  *   1.63   .00   1.63   .00  .061 512.47 310.08   .18
  100.00     5.68     250.41  *   1.73   .00   1.73   .00  .060 568.88 319.72   .18
  110.00     5.86     250.59  *   1.82   .00   1.82   .00  .060 627.04 329.36   .18
  120.00     6.02     250.75  *   1.91   .00   1.91   .00  .059 680.18 337.93   .18
  130.00     6.18     250.91  *   1.99   .00   1.99   .00  .058 734.70 346.50   .18
  140.00     6.33     251.06  *   2.07   .00   2.07   .00  .058 787.06 354.53   .18
  150.00     6.47     251.20  *   2.15   .00   2.15   .00  .057 837.01 362.03   .18
```

```
 160.00     6.60      251.33  *  2.22   .00  2.22   .00  .057 884.23 366.88    .18
 170.00     6.76      251.49  *  2.29   .00  2.29   .00  .057 943.08 371.68    .18
 180.00     6.94      251.67  *  2.36   .00  2.36   .00  .0561010.19 377.09    .18
 190.00     7.14      251.87  *  2.43   .00  2.43   .00  .0561085.90 383.09    .17
 200.00     7.62      252.35  *  2.49   .00  2.49   .00  .0551272.48 397.51    .16


****REACH NO. 3:    LENGTH= 224.95 FT    AVG.GRADE=   .68% ****


STATION  264.43:    INVERT= 246.25 FT    EC=1.30    Q-RATIO= .00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)    N-FACTOR    *    RIGHT(FT)  STAGE(FT)    N-FACTOR
     .00         .00       .500      *        .00        .00        .500
    3.00         .00       .500      *       4.00        .00        .500
    6.83        1.19       .300      *      14.98       3.02        .300
   14.23        4.18       .050      *      49.21       4.25        .050
   62.11        4.43       .030      *      89.19       4.63        .030
  102.52        7.06       .030      *     268.58       5.00        .030
  143.21       12.94       .030      *     307.83       5.29        .030
  143.21       12.94       .030      *     396.97       6.69        .030
  143.21       12.94       .030      *     452.20       8.85        .030

 Q(CFS)   Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
*********************************************************************************
  10.00    2.00     248.25  *   .41   .00   .41  1.89  .356  27.46  20.71   .36
  20.00    2.66     248.91  *   .63   .00   .63  2.57  .334  42.07  24.96   .48
  30.00    3.10     249.35  *   .80   .00   .80  3.06  .308  53.36  29.72   .56
  40.00    3.44     249.69  *   .94   .00   .94  3.38  .256  64.89  40.10   .62
  50.00    3.69     249.94  *  1.07   .00  1.07  3.61  .231  75.60  47.73   .66
  60.00    3.91     250.16  *  1.18   .00  1.18  3.79  .213  86.60  54.44   .69
  70.00    4.11     250.36  *  1.29   .00  1.29  3.95  .200  97.86  60.55   .72
  80.00    4.28     250.53  *  1.38   .00  1.38  4.09  .161 109.37  86.94   .73
  90.00    4.43     250.68  *  1.48   .00  1.48  4.21  .125 125.58 131.45   .72
 100.00    4.54     250.79  *  1.56   .00  1.56  4.31  .118 140.63 144.72   .71
 110.00    4.66     250.91  *  1.64   .00  1.64  4.38  .108 158.90 170.59   .69
 120.00    4.76     251.01  *  1.72   .00  1.72  4.44  .093 178.34 220.61   .67
 130.00    4.87     251.12  *  1.80   .00  1.80  4.49  .083 205.50 275.64   .63
 140.00    4.97     251.22  *  1.87   .00  1.87  4.53  .076 235.44 325.66   .59
 150.00    5.07     251.32  *  1.94   .00  1.94  4.58  .073 269.53 351.22   .56
 160.00    5.17     251.42  *  2.01   .00  2.01  4.62  .072 305.29 366.29   .52
 170.00    5.31     251.56  *  2.07   .00  2.07  4.66  .070 357.86 385.96   .48
 180.00    5.47     251.72  *  2.14   .00  2.14  4.69  .069 420.43 398.61   .43
 190.00    5.65     251.90  *  2.20   .00  2.20  4.73  .068 493.24 412.85   .39
 200.00    6.11     252.36  *  2.26   .00  2.26  4.76  .065 690.95 449.22   .29


****REACH NO. 4:    LENGTH= 164.43 FT    AVG.GRADE=   .00% ****


STATION  100.00:    INVERT= 246.25 FT    EC=1.30    Q-RATIO= .00
```

```
CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR   *   RIGHT(FT)  STAGE(FT)   N-FACTOR
     .00        .00       .500     *       .00        .00       .500
    3.50        .00       .500     *      4.00        .00       .500
   22.58        .98       .300     *      7.92       1.87       .300
   28.90       3.76       .030     *     23.81       3.95       .050
   71.36       8.16       .030     *    243.58       4.91       .030
   78.85      11.29       .030     *    381.66       5.44       .030
   78.85      11.29       .030     *    504.30       8.24       .030

 Q(CFS)   Y1(FT)   WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
************************************************************************************
  10.00    2.47     248.72  *   .35   .00   .35   .00  .304  66.22  39.27   .15
  20.00    3.18     249.43  *   .52   .00   .52   .00  .273  96.03  46.51   .21
  30.00    3.67     249.92  *   .64   .00   .64   .00  .257 119.52  51.50   .25
  40.00    4.00     250.25  *   .75   .00   .75   .00  .216 137.17  67.65   .29
  50.00    4.23     250.48  *   .84   .00   .84   .00  .149 158.77 122.54   .31
  60.00    4.41     250.66  *   .92   .00   .92   .00  .125 184.48 165.49   .33
  70.00    4.57     250.82  *   .99   .00   .99   .00  .111 213.82 203.68   .33
  80.00    4.71     250.96  *  1.05   .00  1.05   .00  .102 244.50 237.08   .33
  90.00    4.80     251.05  *  1.11   .00  1.11   .00  .097 266.70 258.56   .34
 100.00    4.86     251.11  *  1.16   .00  1.16   .00  .094 282.57 272.88   .35
 110.00    4.94     251.19  *  1.21   .00  1.21   .00  .090 305.08 292.92   .36
 120.00    5.00     251.25  *  1.27   .00  1.27   .00  .088 323.07 309.13   .37
 130.00    5.07     251.32  *  1.31   .00  1.31   .00  .085 345.28 328.05   .38
 140.00    5.13     251.38  *  1.36   .00  1.36   .00  .083 365.38 344.26   .38
 150.00    5.20     251.45  *  1.41   .00  1.41   .00  .081 390.05 363.18   .38
 160.00    5.27     251.52  *  1.46   .00  1.46   .00  .079 416.05 382.10   .38
 170.00    5.39     251.64  *  1.50   .00  1.50   .00  .075 463.70 414.53   .37
 180.00    5.53     251.78  *  1.54   .00  1.54   .00  .074 523.33 432.85   .34
 190.00    5.69     251.94  *  1.59   .00  1.59   .00  .073 593.07 441.41   .32
 200.00    6.13     252.38  *  1.63   .00  1.63   .00  .071 791.90 464.96   .25


****REACH NO. 5:    LENGTH=  74.00 FT    AVG.GRADE= -1.70% ****


STATION    26.00:    INVERT= 244.99 FT    EC=1.30    Q-RATIO= .00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR   *   RIGHT(FT)  STAGE(FT)   N-FACTOR
     .00        .00       .500     *       .00        .00       .500
    3.50        .00       .500     *      4.00        .00       .500
   22.58        .98       .300     *      7.92       1.87       .300
   28.90       3.76       .030     *     23.81       3.95       .050
   71.36       8.16       .030     *    243.58       4.91       .030
   78.85      11.29       .030     *    381.66       5.44       .030
   78.85      11.29       .030     *    504.30       8.24       .030

 Q(CFS)   Y1(FT)   WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
************************************************************************************
```

```
 10.00    3.76     248.75  *   .35   .00   .35   .00  .254 124.09  52.41    .08
 20.00    4.47     249.46  *   .52   .00   .52   .00  .119 194.76 179.81    .10
 30.00    4.96     249.95  *   .64   .00   .64   .00  .090 310.96 298.32    .10
 40.00    5.29     250.28  *   .75   .00   .75   .00  .078 423.71 387.49    .09
 50.00    5.52     250.51  *   .84   .00   .84   .00  .074 519.00 432.31    .10
 60.00    5.70     250.69  *   .92   .00   .92   .00  .073 597.45 441.94    .10
 70.00    5.86     250.85  *   .99   .00   .99   .00  .072 668.65 450.51    .10
 80.00    6.00     250.99  *  1.05   .00  1.05   .00  .072 732.06 458.00    .11
 90.00    6.08     251.07  *  1.11   .00  1.11   .00  .072 768.77 462.28    .12
100.00    6.15     251.14  *  1.16   .00  1.16   .00  .071 801.17 466.03    .12
110.00    6.22     251.21  *  1.21   .00  1.21   .00  .071 833.83 469.77    .13
120.00    6.28     251.27  *  1.27   .00  1.27   .00  .071 862.04 472.98    .14
130.00    6.35     251.34  *  1.31   .00  1.31   .00  .070 895.19 476.73    .15
140.00    6.41     251.40  *  1.36   .00  1.36   .00  .070 923.81 479.94    .15
150.00    6.48     251.47  *  1.41   .00  1.41   .00  .070 957.44 483.68    .16
160.00    6.55     251.54  *  1.46   .00  1.46   .00  .070 991.34 487.43    .16
170.00    6.67     251.66  *  1.50   .00  1.50   .00  .0691050.06 493.85    .16
180.00    6.81     251.80  *  1.54   .00  1.54   .00  .0691119.54 501.34    .16
190.00    6.96     251.95  *  1.59   .00  1.59   .00  .0681195.14 509.37    .16
200.00    7.40     252.39  *  1.63   .00  1.63   .00  .0671423.85 532.92    .14

NOTE: WATER DEPTH INFORMATION FOR THIS LAST CROSS-SECTION WAS COMPUTED ASSUMING
      APPROACH VELOCITIES GREATER THAN OR EQUAL TO CROSS-SECTIONAL VELOCITIES.
      IF NOT THE CASE, WATER DEPTHS CAN BE ADJUSTED BY SPECIFYING, A - ADJUST.

SPECIFY: F - FILE, A - ADJUST, P - PRINT R/D, N - NEWJOB, S - STOP
  F

SPECIFY: H - HW/TW DATA FILE, R - ROUTING DATA FILE, E - ESCAPE, S - STOP
  H

ENTER [d:][path]filename[.ext] FOR STORAGE OF HW-DATA COMPUTED AT STA.   26.00:
  TW3.TW

SPECIFY: H - HW/TW DATA FILE, R - ROUTING DATA FILE, E - ESCAPE, S - STOP
  S
4
BACKWATER PROGRAM FOR ROUND/ARCH CULVERTS

ENTER: NUMBER OF CULVERTS
  1

-------------------------------------------------------------------------------

OUTFLOW CONDITIONS PIPE NO. 1 - TAILWATER DATA:

 1) SPECIFY TYPE OF TAILWATER DATA INPUT: S - SINGLE TW-ELEV.
                                          F - TW/HW DATA FILE
  F
 2) ENTER: [d:][path]filename[.ext] OF HW/TW FILE
  TW3.TW
 2a) DISPLAY TW/HW DATA-FILE (Y or N) ?
 Y

-------------------------------------------------------------------------------
```

```
ROUND/ARCH PIPE INPUT CODING INFORMATION:

 PIPE TYPE CODING:
      1 - CONC/SMOOTH BORE (n=0.012)            5 - CMP ARCH (NEW GEOMETRY)
      2 - CORRUGATED METAL (n=0.024)            6 - CONC/SMOOTH ARCH (OLD)
      3 - HELICAL CMP (n-fac varies)            7 - CONC/SMOOTH ARCH (NEW)
      4 - CMP ARCH (OLD GEOMETRY)               8 - ROUND (user sets n-fac)

 ARCH PIPE CODING - EQUIVALENT ROUND SIZE MUST BE INPUTTED PER FOLLOWING TABLE:
   EQUIV-DIAM.   OLD-ARCH   NEW-ARCH    *    EQUIV-DIAM.   OLD-ARCH   NEW-ARCH
       15"       18"X 11"   17"X 13"    *        42"       50"X 31"   49"X 33"
       18"       22"X 13"   21"X 13"    *        48"       58"X 36"   57"X 38"
       21"       25"X 16"   24"X 18"    *        54"       65"X 40"   64"X 43"
       24"       29"X 18"   28"X 20"    *        60"       72"X 44"   71"X 47"
       30"       36"X 22"   35"X 24"    *        66"       79"X 49"   77"X 52"
       36"       43"X 27"   42"X 29"    *        72"       85"X 54"   83"X 57"

 INLET TYPE CODING:
   1 - CMP/PROJ.     4 - CP SOCKET/PROJ.     7 - CMAP/PROJ.     10 - OTHER (SEE
   2 - CMP/HDWALL    5 - CP SQ.EDGE/HDWALL   8 - CMAP/HDWALL         FHWA REPORT
   3 - CMP/MITER     6 - CP SOCKET/HDWALL    9 - CMAP/MITER          HDS NO.5)

 ENTER PIPE # 1: LENGTH(ft), DIA(in), PIPE-TYPE, OUTLET-IE, INLET-IE, INLET-TYPE
      26.00      48.00     2     244.99     244.91     1

 ------------------------------------------------------------------------------

 INFLOW CONDITIONS - OVERFLOW DATA AND UPSTREAM VELOCITY DATA:

  1) ENTER: OVERFLOW-ELEV, OVERFLOW-TYPE (NONE=0, BROAD-WEIR=1, SHARP-WEIR=2)
    253.00   1
  1a) ENTER: WEIR LENGTH(ft), HT(ft) ABOVE OVERFLOW
    110.00       .20
  2) SPECIFY TYPE OF VELOCITY DATA INPUT:  S - SINGLE VELOCITY UPSTREAM
                                           V - VARY VELOCITY ACCORDING TO V=Q/A
   s
  3) ENTER: VELOCITY(fps) UPSTREAM
      .00

 ------------------------------------------------------------------------------

 ENTER: QMIN, QMAX, QINCRE, PRINT-OPTION (STANDARD=1, CONDENSED=2, EXPANDED=3)
      .00    200.00      5.00    1


 PIPE NO. 1:   26 LF - 48"CMP  @  -.31%  OUTLET: 244.99  INLET: 244.91  INTYP: 1

           TW DATA ADJUSTED BASED ON CROSS-SECTIONAL AREA
    Q-TOT(CFS)   TW(FT)   TW-ELEV(FT)   Q-ADJ(CFS)   AREA(SQ-FT)
 ********************************************************************
        .00        .00      244.99          .00          .00
      10.00       3.76      248.75        10.00        12.26
      20.00       4.47      249.46        20.00        12.57
      30.00       4.96      249.95        30.00        12.57
```

```
    40.00        5.29       250.28        40.00        12.57
    50.00        5.52       250.51        50.00        12.57
    60.00        5.70       250.69        60.00        12.57
    70.00        5.86       250.85        70.00        12.57
    80.00        6.00       250.99        80.00        12.57
    90.00        6.08       251.07        90.00        12.57
   100.00        6.15       251.14       100.00        12.57
   110.00        6.22       251.21       110.00        12.57
   120.00        6.28       251.27       120.00        12.57
   130.00        6.35       251.34       130.00        12.57
   140.00        6.41       251.40       140.00        12.57
   150.00        6.48       251.47       150.00        12.57
   160.00        6.55       251.54       160.00        12.57
   170.00        6.67       251.66       170.00        12.57
   180.00        6.81       251.80       180.00        12.57
   190.00        6.96       251.95       190.00        12.57
   200.00        7.40       252.39       200.00        12.57

Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO   HWI
******************************************************************************

  5.00    1.99    246.90  *  .024   .65   .00  1.88  1.88  1.97  1.99   .89
 10.00    3.87    248.78  *  .024   .93   .00  3.76  3.76  3.85  3.87  1.29
 15.00    4.25    249.16  *  .024  1.14   .00  4.11  4.11  4.20  4.25  1.61
 20.00    4.64    249.55  *  .024  1.32   .00  4.47  4.47  4.57  4.64  1.90
 25.00    4.94    249.85  *  .024  1.48   .00  4.72  4.72  4.82  4.94  2.16
 30.00    5.25    250.16  *  .024  1.63   .00  4.96  4.96  5.08  5.25  2.42
 35.00    5.49    250.40  *  .024  1.77   .00  5.13  5.13  5.26  5.49  2.66
 40.00    5.74    250.65  *  .024  1.89   .00  5.29  5.29  5.44  5.74  2.90
 45.00    5.95    250.86  *  .024  2.01   .00  5.40  5.40  5.57  5.95  3.13
 50.00    6.18    251.09  *  .024  2.13   .00  5.52  5.52  5.71  6.18  3.36
 55.00    6.39    251.30  *  .024  2.24   .00  5.61  5.61  5.82  6.39  3.58
 60.00    6.61    251.52  *  .024  2.34   .00  5.70  5.70  5.93  6.61  3.81
 65.00    6.83    251.74  *  .024  2.44   .00  5.78  5.78  6.04  6.83  4.03
 70.00    7.07    251.98  *  .024  2.53   .00  5.86  5.86  6.15  7.07  4.25
 75.00    7.30    252.21  *  .024  2.63   .00  5.93  5.93  6.25  7.30  4.48
 80.00    7.55    252.46  *  .024  2.71   .00  6.00  6.00  6.35  7.55  4.70
 85.00    7.78    252.69  *  .024  2.80   .00  6.04  6.04  6.43  7.78  4.92
 90.00    8.02    252.93  *  .024  2.88   .00  6.08  6.08  6.51  8.02  5.08
 95.00    8.27    253.18  *  .024  2.96   .00  6.11  6.11  6.58  8.27  5.35
**************** OVERFLOW ENCOUNTERED AT  95.00 CFS DISCHARGE ****************
100.00    8.53    253.44  *  .024  3.04   .00  6.15  6.15  6.66  8.53  5.64
105.00    8.80    253.71  *  .024  3.11   .00  6.18  6.18  6.74  8.80  6.03


                    TOTAL "HW" VS."Q" DATA PRINT-OUT

                      Q(CFS)    HW(FT)    HW-ELEV(FT)
      ************************************************************
                       5.00      1.99      246.90  →  see page 17 of existing channel for details
                      10.00      3.87      248.78
                      15.00      4.25      249.16
                      20.00      4.64      249.55
                      25.00      4.94      249.85
                      30.00      5.25      250.16
```

```
                    35.00      5.49      250.40
                    40.00      5.74      250.65
                    45.00      5.95      250.86
                    50.00      6.17      251.08
                    55.00      6.39      251.30
                    60.00      6.61      251.52
                    65.00      6.83      251.74
                    70.00      7.07      251.98
                    75.00      7.30      252.21
                    80.00      7.55      252.46
                    85.00      7.78      252.69
                    90.00      8.02      252.93
                    95.00      8.27      253.18
**************** OVERFLOW ENCOUNTERED AT  95.00 CFS DISCHARGE ****************
   ******* THE FOLLOWING DATA INCLUDES CULVERT FLOW PLUS WEIR FLOW ********
                   312.08      8.53      253.44

SPECIFY: N - NEWJOB, F - FILE, S - STOP
F

SPECIFY [d:][path]filename[.ext] FOR STORAGE OF HW-DATA AT INLET OF CULVERT(S)
TW4.TW

SPECIFY: N - NEWJOB, F - FILE, S - STOP
S
7
Stop - Program terminated.
```

```
                     TOTAL "HW" VS."Q" DATA PRINT-OUT

                      Q(CFS)   HW(FT)   HW-ELEV(FT)
******************************************************************************
                        .50      .54      245.45
                       1.00      .59      245.50
                       1.50      .73      245.64
                       2.00      .90      245.81
                       2.50     1.08      245.99
                       3.00     1.25      246.16
                       3.50     1.44      246.35
                       4.00     1.62      246.53
                       4.50     1.80      246.71
                       5.00     1.99      246.90

SPECIFY: N - NEWJOB, F - FILE, S - STOP
F

SPECIFY [d:][path]filename[.ext] FOR STORAGE OF HW-DATA AT INLET OF CULVERT(S)
TW4.TW

SPECIFY: N - NEWJOB, F - FILE, S - STOP
S
7
Stop - Program terminated.
```

PROPOSED CHANNEL DOWNSTREAM OF NORTHWEST PONDS

```
                  KING COUNTY DEPARTMENT OF NATURAL RESOURCES
                     Water and Land Resources Division

                          BACKWATER ANALYSIS PROGRAM

                                Version 5.30a
    File Opened for Reading:newchal.cha

BACKWATER COMPUTER PROGRAM FOR OPEN CHANNELS
    Channel Data Filename:newchal.cha
      Tailwater Elevation:0. feet
          Discharge Range:25. to 600. Step of 25. [cfs]

STATION 2282.00:     INVERT= 237.10 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

   LEFT(FT)   STAGE(FT)    N-FACTOR    *    RIGHT(FT)   STAGE(FT)    N-FACTOR
    0.00        0.00        0.040      *      0.00        0.00        0.040
    4.00        0.00        0.040      *      4.50        0.00        0.040
   14.16        8.24        0.040      *     18.30        8.43        0.040
   25.61        9.78        0.050      *     35.33        8.60        0.050
   40.39        9.95        0.050      *     46.25        8.60        0.050
  101.40       13.41        0.050      *     77.18       14.47        0.050
  138.46       14.57        0.050      *     77.18       14.47        0.050

 Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN  Q-TW TW-HT  N-Y1   A-Y1  WP-Y1  V-Y1
*********************************************************************************
  25.00     1.16     238.26  *  0.68  1.16  0.00  0.00 0.040  11.79  12.57  2.12
  50.00     1.73     238.83  *  1.06  1.73  0.00  0.00 0.040  19.00  14.57  2.63
  75.00     2.17     239.27  *  1.36  2.17  0.00  0.00 0.040  25.20  16.11  2.98
 100.00     2.54     239.64  *  1.62  2.54  0.00  0.00 0.040  30.85  17.40  3.24
 125.00     2.86     239.96  *  1.85  2.86  0.00  0.00 0.040  36.05  18.53  3.47
 150.00     3.16     240.26  *  2.06  3.16  0.00  0.00 0.040  41.19  19.58  3.64
 175.00     3.43     240.53  *  2.26  3.43  0.00  0.00 0.040  46.04  20.52  3.80
 200.00     3.68     240.78  *  2.44  3.68  0.00  0.00 0.040  50.71  21.40  3.94
 225.00     3.91     241.01  *  2.62  3.91  0.00  0.00 0.040  55.17  22.21  4.08
 250.00     4.13     241.23  *  2.78  4.13  0.00  0.00 0.040  59.58  22.98  4.20
 275.00     4.34     241.44  *  2.94  4.34  0.00  0.00 0.040  63.92  23.72  4.30
 300.00     4.54     241.64  *  3.09  4.54  0.00  0.00 0.040  68.17  24.42  4.40
 325.00     4.73     241.83  *  3.23  4.73  0.00  0.00 0.040  72.31  25.08  4.49
 350.00     4.91     242.01  *  3.37  4.91  0.00  0.00 0.040  76.33  25.71  4.59
 375.00     5.08     242.18  *  3.50  5.08  0.00  0.00 0.040  80.21  26.31  4.68
 400.00     5.25     242.35  *  3.63  5.25  0.00  0.00 0.040  84.18  26.91  4.75
 425.00     5.41     242.51  *  3.75  5.41  0.00  0.00 0.040  87.99  27.47  4.83
 450.00     5.57     242.67  *  3.87  5.57  0.00  0.00 0.040  91.87  28.03  4.90
 475.00     5.72     242.82  *  3.99  5.72  0.00  0.00 0.040  95.57  28.55  4.97
 500.00     5.87     242.97  *  4.10  5.87  0.00  0.00 0.040  99.34  29.08  5.03
 525.00     6.01     243.11  *  4.21  6.01  0.00  0.00 0.040 102.92  29.57  5.10
 550.00     6.15     243.25  *  4.32  6.15  0.00  0.00 0.040 106.55  30.06  5.16
 575.00     6.28     243.38  *  4.43  6.28  0.00  0.00 0.040 109.98  30.52  5.23
 600.00     6.41     243.51  *  4.53  6.41  0.00  0.00 0.040 113.45  30.97  5.29

****REACH NO. 1:     LENGTH= 674.05 FT    AVG.GRADE=  0.36% ****

STATION 1607.95:     INVERT= 239.52 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

   LEFT(FT)   STAGE(FT)    N-FACTOR    *    RIGHT(FT)   STAGE(FT)    N-FACTOR
    0.00        0.00        0.040      *      0.00        0.00        0.040
    4.00        0.00        0.040      *      4.50        0.00        0.040
   25.61       10.50        0.040      *     29.00        9.32        0.050
```

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  40.39       10.67       0.050      *      60.25       9.35      0.050
 101.40       14.13       0.050      *      77.18      15.19      0.050
 138.48       15.29       0.050      *      77.18      15.19      0.050

Q(CFS)    Y1(FT)     WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
**********************************************************************************
 25.00     1.15      240.67  *  0.67  1.15  0.67  1.15 0.042  12.87  14.37  1.94
 50.00     1.70      241.22  *  1.02  1.69  1.02  1.69 0.043  21.22  17.17  2.36
 75.00     2.13      241.65  *  1.30  2.10  1.30  2.10 0.043  28.74  19.36  2.61
100.00     2.49      242.01  *  1.54  2.45  1.54  2.45 0.043  35.69  21.20  2.80
125.00     2.81      242.33  *  1.75  2.75  1.75  2.75 0.044  42.39  22.83  2.95
150.00     3.10      242.62  *  1.94  3.02  1.94  3.02 0.044  48.87  24.31  3.07
175.00     3.36      242.88  *  2.11  3.26  2.11  3.26 0.044  55.02  25.64  3.18
200.00     3.61      243.13  *  2.28  3.49  2.28  3.49 0.044  61.22  26.91  3.27
225.00     3.84      243.36  *  2.43  3.70  2.43  3.70 0.044  67.20  28.09  3.35
250.00     4.06      243.58  *  2.57  3.90  2.57  3.90 0.044  73.14  29.21  3.42
275.00     4.26      243.78  *  2.71  4.08  2.71  4.08 0.044  78.74  30.23  3.49
300.00     4.46      243.98  *  2.84  4.26  2.84  4.26 0.044  84.52  31.25  3.55
325.00     4.64      244.16  *  2.97  4.43  2.97  4.43 0.044  89.89  32.17  3.62
350.00     4.82      244.34  *  3.09  4.59  3.09  4.59 0.044  95.41  33.09  3.67
375.00     4.99      244.51  *  3.20  4.74  3.20  4.74 0.044 100.77  33.95  3.72
400.00     5.16      244.68  *  3.31  4.89  3.31  4.89 0.044 106.26  34.82  3.76
425.00     5.32      244.84  *  3.42  5.03  3.42  5.03 0.044 111.55  35.64  3.81
450.00     5.48      245.00  *  3.52  5.17  3.52  5.17 0.044 116.96  36.45  3.85
475.00     5.63      245.15  *  3.62  5.30  3.62  5.30 0.044 122.14  37.22  3.89
500.00     5.78      245.30  *  3.72  5.43  3.72  5.43 0.044 127.42  37.98  3.92
525.00     5.92      245.44  *  3.82  5.56  3.82  5.56 0.044 132.45  38.70  3.96
550.00     6.06      245.58  *  3.91  5.68  3.91  5.68 0.044 137.57  39.41  4.00
575.00     6.19      245.71  *  4.00  5.80  4.00  5.80 0.044 142.41  40.07  4.04
600.00     6.33      245.85  *  4.09  5.91  4.09  5.91 0.045 147.71  40.79  4.06

****REACH NO. 2:     LENGTH= 214.37 FT     AVG.GRADE=  0.36% ****

STATION 1393.58:     INVERT= 240.29 FT     EC=1.30     Q-RATIO=1.05

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)   STAGE(FT)    N-FACTOR     *    RIGHT(FT)   STAGE(FT)    N-FACTOR
    0.00        0.00        0.040      *       0.00        0.00        0.040
    4.00        0.00        0.040      *       4.50        0.00        0.040
   29.00       12.08        0.040      *      28.24        9.29        0.040
   37.74       12.08        0.050      *      39.95        9.29        0.050
   69.66       12.33        0.050      *      69.95       12.81        0.050
   92.36       12.33        0.050      *     101.96       15.56        0.050

Q(CFS)    Y1(FT)     WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
**********************************************************************************
 12.20     0.78      241.07  *  0.27  0.49  0.42  0.74 0.040   8.04  12.43  1.52
 24.39     1.24      241.53  *  0.42  0.73  0.66  1.10 0.040  14.10  14.75  1.73
 36.59     1.62      241.91  *  0.54  0.92  0.84  1.38 0.040  19.84  16.67  1.84
 48.78     1.96      242.25  *  0.65  1.08  1.00  1.61 0.040  25.54  18.38  1.91
 60.98     2.26      242.55  *  0.74  1.23  1.15  1.82 0.040  31.02  19.90  1.97
 73.17     2.53      242.82  *  0.83  1.35  1.28  2.00 0.040  36.31  21.26  2.02
 85.37     2.78      243.07  *  0.91  1.47  1.40  2.17 0.040  41.50  22.52  2.06
 97.56     3.02      243.31  *  0.99  1.58  1.52  2.32 0.040  46.76  23.73  2.09
109.76     3.25      243.54  *  1.06  1.69  1.62  2.47 0.040  52.05  24.89  2.11
121.95     3.46      243.75  *  1.13  1.79  1.73  2.61 0.040  57.09  25.95  2.14
134.15     3.65      243.94  *  1.20  1.88  1.82  2.74 0.040  61.83  26.91  2.17
146.34     3.85      244.14  *  1.26  1.97  1.91  2.86 0.040  67.00  27.91  2.18
158.54     4.03      244.32  *  1.32  2.05  2.00  2.98 0.040  71.81  28.82  2.21
170.73     4.20      244.49  *  1.38  2.13  2.09  3.09 0.040  76.49  29.68  2.23
182.93     4.37      244.66  *  1.44  2.21  2.17  3.20 0.040  81.31  30.54  2.25
195.12     4.53      244.82  *  1.49  2.29  2.25  3.30 0.040  85.96  31.34  2.27
207.32     4.69      244.98  *  1.55  2.36  2.33  3.40 0.040  90.73  32.15  2.28
219.51     4.85      245.14  *  1.60  2.43  2.40  3.50 0.040  95.62  32.96  2.30
231.71     5.00      245.29  *  1.65  2.50  2.47  3.59 0.040 100.31  33.71  2.31
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  243.90     5.14      245.43  *  1.70  2.57  2.55  3.69 0.040 104.79  34.42  2.33
  256.10     5.28      245.57  *  1.75  2.63  2.61  3.77 0.040 109.35  35.13  2.34
  268.29     5.42      245.71  *  1.80  2.69  2.68  3.86 0.040 114.00  35.83  2.35
  280.49     5.55      245.84  *  1.84  2.76  2.75  3.95 0.040 118.41  36.49  2.37
  292.68     5.69      245.98  *  1.89  2.82  2.81  4.03 0.040 123.24  37.19  2.37

****REACH NO. 3:     LENGTH= 145.79 FT     AVG.GRADE=  0.36% ****

STATION 1247.79:     INVERT= 240.82 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR    *   RIGHT(FT)  STAGE(FT)   N-FACTOR
    0.00       0.00       0.040     *      0.00       0.00       0.040
    3.00       0.00       0.040     *      4.50       0.00       0.040
    3.60       1.03       0.040     *      7.84       1.30       0.040
   27.66      11.76       0.050     *     33.00      11.73       0.050
   66.07      12.44       0.050     *     98.72      12.25       0.050

 Q(CFS)    Y1(FT)     WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1    A-Y1   WP-Y1   V-Y1
*******************************************************************************
  12.20     0.82       241.64  *  0.46  0.81  0.46  0.82 0.040    7.21  10.71  1.69
  24.39     1.23       242.05  *  0.72  1.23  0.72  1.23 0.040   11.64  12.57  2.09
  36.59     1.57       242.39  *  0.93  1.56  0.93  1.57 0.041   15.90  14.31  2.30
  48.78     1.85       242.67  *  1.11  1.85  1.11  1.85 0.042   19.80  15.73  2.46
  60.98     2.10       242.92  *  1.28  2.09  1.28  2.10 0.043   23.60  16.99  2.58
  73.17     2.32       243.14  *  1.43  2.31  1.43  2.32 0.043   27.18  18.11  2.69
  85.37     2.54       243.36  *  1.56  2.51  1.56  2.52 0.044   30.99  19.22  2.75
  97.56     2.76       243.58  *  1.69  2.69  1.69  2.70 0.044   35.02  20.34  2.79
 109.76     2.97       243.79  *  1.81  2.86  1.81  2.87 0.044   39.08  21.40  2.81
 121.95     3.17       243.99  *  1.92  3.02  1.92  3.03 0.045   43.14  22.41  2.83
 134.15     3.35       244.17  *  2.03  3.17  2.03  3.18 0.045   46.95  23.33  2.86
 146.34     3.54       244.36  *  2.13  3.31  2.13  3.32 0.045   51.13  24.29  2.86
 158.54     3.71       244.53  *  2.22  3.44  2.22  3.46 0.045   55.02  25.15  2.88
 170.73     3.87       244.69  *  2.32  3.57  2.32  3.58 0.045   58.80  25.96  2.90
 182.93     4.03       244.85  *  2.40  3.70  2.40  3.71 0.046   62.70  26.77  2.92
 195.12     4.19       245.01  *  2.49  3.82  2.49  3.83 0.046   66.72  27.58  2.92
 207.32     4.34       245.16  *  2.57  3.93  2.57  3.94 0.046   70.60  28.34  2.94
 219.51     4.49       245.31  *  2.65  4.04  2.65  4.05 0.046   74.58  29.10  2.94
 231.71     4.64       245.46  *  2.73  4.15  2.73  4.16 0.046   78.67  29.86  2.95
 243.90     4.77       245.59  *  2.80  4.25  2.80  4.26 0.046   82.29  30.52  2.96
 256.10     4.91       245.73  *  2.88  4.35  2.88  4.36 0.046   86.29  31.23  2.97
 268.29     5.05       245.87  *  2.95  4.45  2.95  4.46 0.046   90.37  31.94  2.97
 280.49     5.17       245.99  *  3.02  4.54  3.02  4.56 0.046   93.95  32.55  2.99
 292.68     5.31       246.13  *  3.09  4.64  3.09  4.65 0.046   98.20  33.26  2.98

****REACH NO. 4:     LENGTH= 239.06 FT     AVG.GRADE=  0.37% ****

STATION 1008.73:     INVERT= 241.70 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR    *   RIGHT(FT)  STAGE(FT)   N-FACTOR
    0.00       0.00       0.040     *      0.00       0.00       0.040
    3.00       0.00       0.040     *      3.50       0.00       0.040
   12.28       5.52       0.050     *     28.32      12.41       0.050
   20.88       9.98       0.050     *     69.31      13.98       0.050
  120.43      11.22       0.050     *    159.83      14.06       0.050

 Q(CFS)    Y1(FT)     WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1    A-Y1   WP-Y1   V-Y1
*******************************************************************************
  12.20     0.91       242.61  *  0.50  0.00  0.50  0.91 0.044    7.44  10.31  1.64
  24.39     1.36       243.06  *  0.77  0.00  0.77  1.36 0.045   12.24  12.20  1.99
  36.59     1.70       243.40  *  0.99  0.00  0.99  1.70 0.045   16.37  13.63  2.24
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                                                                       20.22   14.84   2.41
  48.78      1.99       243.69  *  1.18  0.00  1.18   1.99 0.046      23.80   15.89   2.56
  60.98      2.24       243.94  *  1.34  0.00  1.34   2.24 0.046      27.28   16.85   2.68
  73.17      2.47       244.17  *  1.49  0.00  1.49   2.47 0.046      30.64   17.73   2.79
  85.37      2.68       244.38  *  1.63  0.00  1.63   2.68 0.046      33.82   18.53   2.89
  97.56      2.87       244.57  *  1.76  0.00  1.76   2.87 0.047      36.95   19.29   2.97
 109.76      3.05       244.75  *  1.88  0.00  1.88   3.05 0.047      40.01   20.00   3.05
 121.95      3.22       244.92  *  2.00  0.00  2.00   3.22 0.047      43.00   20.67   3.12
 134.15      3.38       245.08  *  2.11  0.00  2.11   3.38 0.047      45.88   21.30   3.19
 146.34      3.53       245.23  *  2.21  0.00  2.21   3.53 0.047      48.85   21.93   3.25
 158.54      3.68       245.38  *  2.31  0.00  2.31   3.68 0.047      51.48   22.47   3.32
 170.73      3.81       245.51  *  2.41  0.00  2.41   3.81 0.047      54.39   23.06   3.36
 182.93      3.95       245.65  *  2.50  0.00  2.50   3.95 0.047      56.94   23.56   3.43
 195.12      4.07       245.77  *  2.59  0.00  2.59   4.07 0.047      59.77   24.11   3.47
 207.32      4.20       245.90  *  2.68  0.00  2.68   4.20 0.047      62.21   24.57   3.53
 219.51      4.31       246.01  *  2.76  0.00  2.76   4.31 0.047      64.92   25.07   3.57
 231.71      4.43       246.13  *  2.84  0.00  2.84   4.43 0.048      67.45   25.53   3.62
 243.90      4.54       246.24  *  2.92  0.00  2.92   4.54 0.048      70.02   25.99   3.66
 256.10      4.65       246.35  *  3.00  0.00  3.00   4.65 0.048      72.88   26.50   3.68
 268.29      4.77       246.47  *  3.07  0.00  3.07   4.75 0.048      75.55   26.96   3.71
 280.49      4.88       246.58  *  3.15  0.00  3.15   4.86 0.048      78.51   27.46   3.73
 292.68      5.00       246.70  *  3.22  0.00  3.22   4.96 0.048

Save results to HW/TW file:twla.tw
Save results to Routing file:test.RS1
    File Opened for Reading:twla.tw

HW/TW Data File:twla.tw
 Stage(ft)  Discharge(cfs)
     0.0         0.00
     0.9        12.20
     1.4        24.39
     1.7        36.59
     2.0        48.78
     2.2        60.98
     2.5        73.17
     2.7        85.37
     2.9        97.56
     3.0       109.76
     3.2       121.95
     3.4       134.15
     3.5       146.34
     3.7       158.54
     3.8       170.73
     4.0       182.93
     4.1       195.12
     4.2       207.32
     4.3       219.51
     4.4       231.71
     4.5       243.90
     4.7       256.10
     4.8       268.29
     4.9       280.49
     5.0       292.68
 Zero Stage Elevation:241.7 feet

 BACKWATER PROGRAM FOR ROUND/ARCH CULVERTS
 Tailwater from HW/TW File:twla.tw
            Discharge Range:10. to 200. Step of 10. [cfs]
        Overflow Elevation:250.05  feet
        Broad Crested Weir: Length:110. feet, Height:0.2 feet
            Channel Width:34. feet


 CULV NO. 1:  142 LF - 72"CMP  @  0.25%  OUTLET: 241.70  INLET: 242.05  INTYP: 1

           TW DATA ADJUSTED BASED ON CROSS-SECTIONAL AREA
     Q-TOT(CFS)    TW(FT)    TW-ELEV(FT)    Q-ADJ(CFS)    AREA(SQ-FT)
 ****************************************************************
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```
     0.00          0.00        241.70          0.00           0.00
    12.20          0.91        242.61         12.20           2.70
    24.39          1.36        243.06         24.39           4.81
    36.59          1.70        243.40         36.59           6.59
    48.78          1.99        243.69         48.78           8.19
    60.98          2.24        243.94         60.98           9.63
    73.17          2.47        244.17         73.17          10.97
    85.37          2.68        244.38         85.37          12.22
    97.56          2.87        244.57         97.56          13.36
   109.76          3.05        244.75        109.76          14.44
   121.95          3.22        244.92        121.95          15.46
   134.15          3.38        245.08        134.15          16.41
   146.34          3.53        245.23        146.34          17.30
   158.54          3.68        245.38        158.54          18.18
   170.73          3.81        245.51        170.73          18.94
   182.93          3.95        245.65        182.93          19.74
   195.12          4.07        245.77        195.12          20.42
   207.32          4.20        245.90        207.32          21.14
   219.51          4.31        246.01        219.51          21.74
   231.71          4.43        246.13        231.71          22.38
   243.90          4.54        246.24        243.90          22.95
   256.10          4.65        246.35        256.10          23.51
   268.29          4.77        246.47        268.29          24.10
   280.49          4.88        246.58        280.49          24.63
   292.68          5.00        246.70        292.68          25.18

Q(CFS)   HW(FT)    HW ELEV. * N-FAC  DC    DN    TW    DO    DE    HWO   HWI
*****************************************************************************
  10.00    1.39    243.44  * 0.024  0.83  1.21  0.75  0.83  1.21  1.39  1.11
  20.00    1.98    244.03  * 0.024  1.18  1.71  1.20  1.20  1.71  1.98  1.61
  30.00    2.45    244.50  * 0.024  1.45  2.11  1.52  1.52  2.11  2.45  2.00
  40.00    2.85    244.90  * 0.024  1.68  2.46  1.78  1.78  2.46  2.85  2.35
  50.00    3.20    245.25  * 0.024  1.88  2.79  2.02  2.02  2.73  3.20  2.67
  60.00    3.51    245.56  * 0.024  2.07  3.10  2.22  2.22  2.97  3.51  2.97
  70.00    3.80    245.85  * 0.024  2.24  3.41  2.41  2.41  3.19  3.80  3.26
  80.00    4.09    246.14  * 0.024  2.40  3.71  2.59  2.59  3.41  4.09  3.53
  90.00    4.36    246.41  * 0.024  2.55  4.03  2.75  2.75  3.61  4.36  3.80
 100.00    4.63    246.68  * 0.024  2.70  4.37  2.91  2.91  3.82  4.63  4.06
 110.00    4.89    246.94  * 0.024  2.83  4.75  3.05  3.05  4.01  4.89  4.32
 120.00    5.14    247.19  * 0.024  2.97  5.28  3.19  3.19  4.20  5.14  4.57
 130.00    5.40    247.45  * 0.024  3.09  6.00  3.33  3.33  4.39  5.40  4.82
 140.00    5.65    247.70  * 0.024  3.21  6.00  3.45  3.45  4.58  5.65  5.06
 150.00    5.90    247.95  * 0.024  3.33  6.00  3.58  3.58  4.76  5.90  5.31
 160.00    6.15    248.20  * 0.024  3.45  6.00  3.70  3.70  4.94  6.15  5.55
 170.00    6.41    248.46  * 0.024  3.56  6.00  3.80  3.80  5.13  6.41  5.80
 180.00    6.66    248.71  * 0.024  3.67  6.00  3.92  3.92  5.31  6.66  6.04
 190.00    6.93    248.98  * 0.024  3.77  6.00  4.02  4.02  5.49  6.93  6.28
 200.00    7.21    249.26  * 0.024  3.87  6.00  4.12  4.12  5.68  7.21  6.52


                 TOTAL "HW" VS."Q" DATA PRINT-OUT

                   Q(CFS)    HW(FT)    HW-ELEV(FT)
  ************************************************************************
                    10.00     1.39      243.44
                    20.00     1.98      244.03
                    30.00     2.44      244.49
                    40.00     2.85      244.90
                    50.00     3.20      245.25
                    60.00     3.51      245.56
                    70.00     3.80      245.85
                    80.00     4.09      246.14
                    90.00     4.36      246.41
                   100.00     4.63      246.68
                   110.00     4.89      246.94
                   120.00     5.14      247.19
                   130.00     5.40      247.45
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                          140.00      5.65      247.70
                          150.00      5.90      247.95
                          160.00      6.15      248.20
                          170.00      6.41      248.46
                          180.00      6.66      248.71
                          190.00      6.93      248.98
                          200.00      7.21      249.26

Save results to HW/TW file:tw2a.tw
    File Opened for Reading:newchan2.cha
    File Opened for Reading:tw2a.tw

HW/TW Data File:tw2a.tw
 Stage(ft)  Discharge(cfs)
   0.0          0.00
   1.4         10.00
   2.0         20.00
   2.4         30.00
   2.8         40.00
   3.2         50.00
   3.5         60.00
   3.8         70.00
   4.1         80.00
   4.4         90.00
   4.6        100.00
   4.9        110.00
   5.1        120.00
   5.4        130.00
   5.7        140.00
   5.9        150.00
   6.2        160.00
   6.4        170.00
   6.7        180.00
   6.9        190.00
   7.2        200.00
 Zero Stage Elevation:242.05 feet

 BACKWATER COMPUTER PROGRAM FOR OPEN CHANNELS
     Channel Data Filename:newchan2.cha
 Tailwater from HW/TW File:tw2a.tw
          Discharge Range:10. to 200. Step of 10. [cfs]

 STATION  866.73:    INVERT= 242.05 FT    EC=1.30    Q-RATIO=0.00

 CROSS-SECTION DATA:
   DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

   LEFT(FT)  STAGE(FT)   N-FACTOR   *   RIGHT(FT)  STAGE(FT)   N-FACTOR
     0.00      0.00       0.040     *     0.00       0.00       0.040
     2.50      0.00       0.040     *     4.00       0.00       0.040
    15.00      6.25       0.040     *    18.25       7.10       0.040
    30.51     10.25       0.030     *    50.62       9.69       0.030

  Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN  Q-TW TW-HT  N-Y1   A-Y1  WP-Y1  V-Y1
********************************************************************************
   10.00     1.39     243.44  *  0.44  0.89 10.00  1.39 0.040  12.91  12.73  0.77
   20.00     1.98     244.03  *  0.68  1.30 20.00  1.98 0.040  20.72  15.37  0.97
   30.00     2.44     244.49  *  0.87  1.62 30.00  2.44 0.040  27.79  17.43  1.08
   40.00     2.85     244.90  *  1.04  1.89 40.00  2.85 0.040  34.80  19.26  1.15
   50.00     3.20     245.25  *  1.18  2.12 50.00  3.20 0.040  41.32  20.83  1.21
   60.00     3.51     245.56  *  1.32  2.33 60.00  3.51 0.040  47.50  22.22  1.26
   70.00     3.80     245.85  *  1.44  2.52 70.00  3.80 0.040  53.63  23.52  1.31
   80.00     4.09     246.14  *  1.55  2.69 80.00  4.09 0.040  60.10  24.82  1.33
   90.00     4.36     246.41  *  1.66  2.85 90.00  4.36 0.040  66.43  26.03  1.35
  100.00     4.63     246.68  *  1.76  3.01100.00  4.63 0.040  73.04  27.24  1.37
  110.00     4.89     246.94  *  1.86  3.15110.00  4.89 0.040  79.69  28.40  1.38
  120.00     5.14     247.19  *  1.95  3.29120.00  5.14 0.040  86.34  29.52  1.39
  130.00     5.40     247.45  *  2.04  3.42130.00  5.40 0.040  93.52  30.68  1.39
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 140.00    5.65      247.70  *  2.13  3.55140.00  5.65 0.040 100.68  31.80  1.39
 150.00    5.90      247.95  *  2.21  3.67150.00  5.90 0.040 108.09  32.92  1.39
 160.00    6.15      248.20  *  2.29  3.78160.00  6.15 0.040 115.75  34.04  1.38
 170.00    6.41      248.46  *  2.37  3.89170.00  6.41 0.040 124.01  35.49  1.37
 180.00    6.66      248.71  *  2.44  4.00180.00  6.66 0.040 132.32  37.05  1.36
 190.00    6.93      248.98  *  2.51  4.10190.00  6.93 0.039 141.70  38.74  1.34
 200.00    7.21      249.26  *  2.58  4.21200.00  7.21 0.039 151.94  41.62  1.32

****REACH NO. 1:     LENGTH= 113.42 FT    AVG.GRADE=  0.22% ****

STATION  753.31:     INVERT= 242.30 FT    EC=1.30    Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR    *   RIGHT(FT)   STAGE(FT)   N-FACTOR
    0.00      0.00       0.040      *     0.00        0.00       0.040
    2.50      0.00       0.040      *     3.00        0.00       0.040
    8.52      3.95       0.040      *    27.01        8.47       0.040
   24.97      9.54       0.030      *    60.00        8.50       0.030

 Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1    A-Y1  WP-Y1  V-Y1
************************************************************************************
  10.00     1.21      243.51  *  0.48  0.96  0.48  0.95 0.040    9.85  11.34  1.02
  20.00     1.80      244.10  *  0.74  1.39  0.74  1.39 0.040   16.96  14.19  1.18
  30.00     2.25      244.55  *  0.94  1.71  0.94  1.71 0.040   23.41  16.36  1.28
  40.00     2.66      244.96  *  1.11  1.98  1.11  1.98 0.040   30.05  18.34  1.33
  50.00     3.01      245.31  *  1.26  2.22  1.26  2.22 0.040   36.30  20.03  1.38
  60.00     3.31      245.61  *  1.40  2.43  1.40  2.42 0.040   42.08  21.48  1.43
  70.00     3.60      245.90  *  1.52  2.62  1.52  2.61 0.040   48.04  22.88  1.46
  80.00     3.89      246.19  *  1.64  2.79  1.64  2.79 0.040   54.37  24.28  1.47
  90.00     4.16      246.46  *  1.75  2.95  1.75  2.95 0.040   60.63  25.86  1.48
 100.00     4.43      246.73  *  1.85  3.11  1.85  3.10 0.039   67.30  27.51  1.49
 110.00     4.68      246.98  *  1.95  3.25  1.95  3.25 0.039   73.85  29.04  1.49
 120.00     4.93      247.23  *  2.05  3.39  2.05  3.38 0.039   80.77  30.57  1.49
 130.00     5.19      247.49  *  2.14  3.52  2.14  3.51 0.039   88.34  32.16  1.47
 140.00     5.44      247.74  *  2.22  3.64  2.22  3.64 0.039   95.99  33.68  1.46
 150.00     5.69      247.99  *  2.30  3.76  2.30  3.76 0.039  104.00  35.21  1.44
 160.00     5.93      248.23  *  2.38  3.87  2.38  3.87 0.038  112.04  36.68  1.43
 170.00     6.19      248.49  *  2.46  3.98  2.46  3.98 0.038  121.11  38.27  1.40
 180.00     6.44      248.74  *  2.54  4.09  2.54  4.09 0.038  130.21  39.80  1.38
 190.00     6.71      249.01  *  2.61  4.19  2.61  4.19 0.038  140.44  41.45  1.35
 200.00     6.99      249.29  *  2.68  4.29  2.68  4.29 0.038  151.49  43.16  1.32

****REACH NO. 2:     LENGTH= 263.93 FT    AVG.GRADE=  0.22% ****

STATION  489.38:     INVERT= 242.88 FT    EC=1.30    Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)  STAGE(FT)   N-FACTOR    *   RIGHT(FT)   STAGE(FT)   N-FACTOR
    0.00      0.00       0.040      *     0.00        0.00       0.040
    1.50      0.00       0.040      *     5.00        0.00       0.040
    7.95      5.18       0.040      *    14.87        4.83       0.040
   24.87      7.15       0.030      *    43.35        5.38       0.030

 Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1    A-Y1  WP-Y1  V-Y1
************************************************************************************
  10.00     0.97      243.85  *  0.45  0.91  0.45  0.90 0.040    7.85  10.26  1.27
  20.00     1.50      244.38  *  0.69  1.34  0.69  1.33 0.040   13.45  12.31  1.49
  30.00     1.92      244.80  *  0.88  1.67  0.88  1.67 0.040   18.54  13.93  1.62
  40.00     2.30      245.18  *  1.05  1.95  1.05  1.95 0.040   23.65  15.41  1.69
  50.00     2.64      245.52  *  1.21  2.20  1.21  2.20 0.040   28.62  16.72  1.75
  60.00     2.93      245.81  *  1.35  2.42  1.35  2.42 0.040   33.16  17.85  1.81
  70.00     3.20      246.08  *  1.47  2.63  1.47  2.62 0.040   37.64  18.89  1.86
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  80.00      3.48      246.36  *  1.59  2.81  1.59  2.81 0.040  42.53   19.97  1.88
  90.00      3.74      246.62  *  1.71  2.99  1.71  2.98 0.040  47.31   20.98  1.90
 100.00      4.00      246.88  *  1.81  3.15  1.81  3.15 0.040  52.31   21.99  1.91
 110.00      4.24      247.12  *  1.92  3.31  1.92  3.30 0.040  57.12   22.92  1.93
 120.00      4.48      247.36  *  2.01  3.46  2.01  3.45 0.040  62.12   23.85  1.93
 130.00      4.73      247.61  *  2.11  3.60  2.11  3.59 0.040  67.53   24.81  1.92
 140.00      4.99      247.87  *  2.20  3.73  2.20  3.72 0.038  74.02   33.75  1.89
 150.00      5.25      248.13  *  2.28  3.86  2.28  3.85 0.036  83.85   48.12  1.79
*************** OVERFLOW ENCOUNTERED AT 160.00 CFS DISCHARGE ***************
 160.00      5.48      248.36  *  2.37  3.99  2.37  3.98 0.035  95.58   56.94  1.67
 170.00      5.72      248.60  *  2.45  4.11  2.45  4.10 0.035 108.76   59.26  1.56
 180.00      5.96      248.84  *  2.53  4.22  2.53  4.21 0.034 122.43   61.57  1.47
 190.00      6.21      249.09  *  2.60  4.33  2.60  4.32 0.034 137.20   63.98  1.38
 200.00      6.48      249.36  *  2.68  4.44  2.68  4.43 0.034 153.75   66.59  1.30

****REACH NO. 3:      LENGTH= 224.95 FT     AVG.GRADE=   0.22% ****

STATION  264.43:      INVERT= 243.37 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)   STAGE(FT)    N-FACTOR     *    RIGHT(FT)   STAGE(FT)    N-FACTOR
    0.00        0.00        0.040      *       0.00        0.00        0.040
    3.00        0.00        0.040      *       4.00        0.00        0.040
   14.23        5.24        0.040      *      14.98        4.08        0.040
   34.23        5.31        0.030      *      49.21        5.31        0.030

 Q(CFS)     Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1    A-Y1   WP-Y1  V-Y1
*********************************************************************************
  10.00      0.88      244.25  *  0.42  0.84  0.42  0.84 0.040   8.03   11.61  1.25
  20.00      1.35      244.72  *  0.64  1.23  0.64  1.23 0.040  13.86   14.07  1.44
  30.00      1.74      245.11  *  0.82  1.53  0.82  1.53 0.040  19.50   16.11  1.54
  40.00      2.08      245.45  *  0.98  1.78  0.98  1.78 0.040  25.02   17.89  1.60
  50.00      2.40      245.77  *  1.12  2.00  1.12  2.00 0.040  30.72   19.57  1.63
  60.00      2.68      246.05  *  1.24  2.19  1.24  2.19 0.040  36.12   21.03  1.66
  70.00      2.94      246.31  *  1.36  2.37  1.36  2.37 0.040  41.47   22.39  1.69
  80.00      3.21      246.58  *  1.47  2.53  1.47  2.54 0.040  47.38   23.81  1.69
  90.00      3.46      246.83  *  1.57  2.68  1.57  2.69 0.040  53.16   25.12  1.69
 100.00      3.70      247.07  *  1.66  2.83  1.66  2.83 0.040  58.99   26.37  1.70
 110.00      3.94      247.31  *  1.75  2.96  1.75  2.97 0.040  65.10   27.63  1.69
 120.00      4.17      247.54  *  1.84  3.09  1.84  3.09 0.039  71.32   31.08  1.68
 130.00      4.42      247.79  *  1.92  3.21  1.92  3.22 0.038  79.62   38.63  1.63
 140.00      4.69      248.06  *  2.00  3.33  2.00  3.33 0.037  90.68   46.79  1.54
 150.00      4.94      248.31  *  2.08  3.44  2.08  3.44 0.036 102.86   54.35  1.46
 160.00      5.15      248.52  *  2.15  3.55  2.15  3.55 0.035 114.55   60.69  1.40
*************** OVERFLOW ENCOUNTERED AT 170.00 CFS DISCHARGE ***************
 170.00      5.37      248.74  *  2.23  3.65  2.23  3.66 0.034 130.04   85.48  1.31
 180.00      5.58      248.95  *  2.30  3.75  2.30  3.76 0.034 147.57   85.90  1.22
 190.00      5.81      249.18  *  2.36  3.85  2.36  3.85 0.034 166.76   86.36  1.14
 200.00      6.06      249.43  *  2.43  3.94  2.43  3.95 0.034 187.62   86.86  1.07

****REACH NO. 4:      LENGTH= 164.43 FT     AVG.GRADE=   0.22% ****

STATION  100.00:      INVERT= 243.73 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)   STAGE(FT)    N-FACTOR     *    RIGHT(FT)   STAGE(FT)    N-FACTOR
    0.00        0.00        0.040      *       0.00        0.00        0.040
    3.50        0.00        0.040      *       4.00        0.00        0.040
    7.00        1.16        0.040      *       7.92        2.64        0.040
   22.58        1.75        0.030      *      23.81        4.72        0.030
   28.90        4.53        0.030      *      25.00        4.75        0.030
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 Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
**********************************************************************************
  10.00     0.84     244.57  *  0.40  0.81  0.40  0.82 0.040   7.89  11.67  1.27
  20.00     1.28     245.01  *  0.62  1.21  0.62  1.23 0.038  13.46  16.65  1.49
  30.00     1.63     245.36  *  0.80  1.52  0.80  1.54 0.035  20.79  26.53  1.44
  40.00     1.93     245.66  *  0.95  1.72  0.95  1.73 0.035  29.40  30.68  1.36
  50.00     2.21     245.94  *  1.09  1.84  1.09  1.86 0.035  37.91  31.88  1.32
  60.00     2.48     246.21  *  1.26  1.95  1.26  1.97 0.035  46.39  33.03  1.29
  70.00     2.72     246.45  *  1.41  2.06  1.41  2.07 0.035  54.18  34.53  1.29
  80.00     2.98     246.71  *  1.52  2.15  1.52  2.17 0.034  63.18  37.18  1.27
  90.00     3.22     246.95  *  1.61  2.24  1.61  2.26 0.034  72.08  39.62  1.25
 100.00     3.46     247.19  *  1.69  2.33  1.69  2.35 0.034  81.55  42.07  1.23
 110.00     3.69     247.42  *  1.76  2.41  1.76  2.44 0.034  91.16  44.41  1.21
 120.00     3.92     247.65  *  1.81  2.50  1.81  2.52 0.034 101.30  46.76  1.18
 130.00     4.16     247.89  *  1.86  2.57  1.86  2.60 0.033 112.43  49.20  1.16
 140.00 .   4.42     248.15  *  1.91  2.65  1.91  2.68 0.033 125.14  51.85  1.12
*************** OVERFLOW ENCOUNTERED AT 150.00 CFS DISCHARGE ***************
 150.00     4.66     248.39  *  1.96  2.73  1.96  2.75 0.033 137.45  54.10  1.09
 160.00     4.86     248.59  *  2.00  2.80  2.00  2.83 0.033 148.13  56.06  1.08
 170.00     5.08     248.81  *  2.05  2.87  2.05  2.90 0.033 159.99  56.50  1.06
 180.00     5.27     249.00  *  2.09  2.94  2.09  2.97 0.033 170.23  56.88  1.06
 190.00     5.49     249.22  *  2.14  3.01  2.14  3.04 0.033 182.08  57.32  1.04
 200.00     5.73     249.46  *  2.18  3.08  2.18  3.11 0.033 195.02  57.80  1.03


****REACH NO. 5:     LENGTH=  74.00 FT     AVG.GRADE=  0.23% ****

STATION    26.00:    INVERT= 243.90 FT     EC=1.30     Q-RATIO=0.00

CROSS-SECTION DATA:
  DIST/STAGE IS MEASURED FROM INVERT; N-FAC IS MEASURED BETWEEN STAGES

  LEFT(FT)   STAGE(FT)    N-FACTOR     *    RIGHT(FT)   STAGE(FT)    N-FACTOR
    0.00       0.00        0.040       *       0.00        0.00        0.040
    3.50       0.00        0.040       *       4.00        0.00        0.040
    4.50       1.16        0.040       *       7.92        2.64        0.040
   22.58       1.75        0.030       *      23.81        4.72        0.030
   28.90       4.53        0.030       *      25.00        4.75        0.030

 Q(CFS)    Y1(FT)    WS ELEV. * YC-IN YN-IN YC-OT YN-OT  N-Y1   A-Y1  WP-Y1  V-Y1
**********************************************************************************
  10.00     0.84     244.74  *  0.41  0.00  0.41  0.84 0.040   7.13  10.11  1.40
  20.00     1.34     245.24  *  0.64  0.00  0.64  1.34 0.037  12.64  16.95  1.58
  30.00     1.63     245.53  *  0.83  0.00  0.83  1.63 0.035  18.63  26.36  1.61
  40.00     1.86     245.76  *  1.00  0.00  1.00  1.80 0.034  25.13  30.72  1.59
  50.00     2.11     246.01  *  1.15  0.00  1.15  1.91 0.034  32.65  31.79  1.53
  60.00     2.36     246.26  *  1.42  0.00  1.42  2.02 0.034  40.40  32.86  1.49
  70.00     2.59     246.49  *  1.54  0.00  1.54  2.12 0.034  47.74  33.84  1.47
  80.00     2.84     246.74  *  1.64  0.00  1.64  2.22 0.034  56.06  36.10  1.43
  90.00     3.08     246.98  *  1.72  0.00  1.72  2.31 0.034  64.63  38.54  1.39
 100.00     3.32     247.22  *  1.79  0.00  1.79  2.39 0.034  73.77  40.99  1.36
 110.00     3.54     247.44  *  1.84  0.00  1.84  2.48 0.033  82.65  43.23  1.33
 120.00     3.77     247.67  *  1.89  0.00  1.89  2.56 0.033  92.44  45.57  1.30
 130.00     4.01     247.91  *  1.94  0.00  1.94  2.63 0.033 103.22  48.02  1.26
 140.00     4.27     248.17  *  1.99  0.00  1.99  2.71 0.033 115.54  50.66  1.21
 150.00     4.50     248.40  *  2.03  0.00  2.03  2.79 0.033 127.00  53.01  1.18
*************** OVERFLOW ENCOUNTERED AT 160.00 CFS DISCHARGE ***************
 160.00     4.70     248.60  *  2.08  0.00  2.08  2.86 0.033 137.36  54.79  1.16
 170.00     4.92     248.82  *  2.12  0.00  2.12  2.93 0.033 149.17  56.53  1.14
 180.00     5.11     249.01  *  2.17  0.00  2.17  3.00 0.033 159.41  56.91  1.13
 190.00     5.33     249.23  *  2.21  0.00  2.21  3.07 0.033 171.27  57.35  1.11
 200.00     5.57     249.47  *  2.25  0.00  2.25  3.13 0.033 184.21  57.83  1.09

Save results to HW/TW file:tw3a.tw
Save results to Routing file:tw3a.RS1
    File Opened for Reading:tw3a.tw

HW/TW Data File:tw3a.tw
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Stage(ft)  Discharge(cfs)
   0.0          0.00
   0.8         10.00
   1.3         20.00
   1.6         30.00
   1.9         40.00
   2.1         50.00
   2.4         60.00
   2.6         70.00
   2.8         80.00
   3.1         90.00
   3.3        100.00
   3.5        110.00
   3.8        120.00
   4.0        130.00
   4.3        140.00
   4.5        150.00
   4.7        160.00
   4.9        170.00
   5.1        180.00
   5.3        190.00
   5.6        200.00
Zero Stage Elevation:243.9 feet

BACKWATER PROGRAM FOR ROUND/ARCH CULVERTS
Tailwater from HW/TW File:tw3a.tw
          Discharge Range:10. to 200. Step of 5. [cfs]
         Overflow Elevation:253.  feet
         Broad Crested Weir: Length:110. feet, Height:0.2 feet
              Channel Width:75. feet

CULV NO. 1:   26 LF - 48"CMP  @  0.38%  OUTLET: 243.90  INLET: 244.00  INTYP: 1

              TW DATA ADJUSTED BASED ON CROSS-SECTIONAL AREA
     Q-TOT(CFS)     TW(FT)    TW-ELEV(FT)    Q-ADJ(CFS)    AREA(SQ-FT)
*******************************************************************
        0.00          0.00      243.90          0.00          0.00
       10.00          0.84      244.74         10.00          1.92
       20.00          1.34      245.24         20.00          3.69
       30.00          1.63      245.53         30.00          4.81
       40.00          1.86      245.76         40.00          5.72
       50.00          2.11      246.01         50.00          6.72
       60.00          2.36      246.26         60.00          7.72
       70.00          2.59      246.49         70.00          8.61
       80.00          2.84      246.74         80.00          9.54
       90.00          3.08      246.98         90.00         10.38
      100.00          3.32      247.22        100.00         11.15
      110.00          3.54      247.44        110.00         11.76
      120.00          3.77      247.67        120.00         12.28
      130.00          4.01      247.91        130.00         12.57
      140.00          4.27      248.17        140.00         12.57
      150.00          4.50      248.40        150.00         12.57
      160.00          4.70      248.60        160.00         12.57
      170.00          4.92      248.82        170.00         12.57
      180.00          5.11      249.01        180.00         12.57
      190.00          5.33      249.23        190.00         12.57
      200.00          5.57      249.47        200.00         12.57

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO   HWI
***************************************************************************
  10.00     1.49     245.49  * 0.024  0.93  1.24  0.84  0.93  1.20  1.49  1.27
  15.00     1.84     245.84  * 0.024  1.14  1.54  1.09  1.14  1.44  1.84  1.60
  20.00     2.14     246.14  * 0.024  1.32  1.80  1.34  1.34  1.65  2.14  1.88
  25.00     2.42     246.42  * 0.024  1.48  2.05  1.49  1.49  1.84  2.42  2.15
  30.00     2.68     246.68  * 0.024  1.63  2.29  1.63  1.63  2.02  2.68  2.40
  35.00     2.92     246.92  * 0.024  1.77  2.53  1.75  1.77  2.18  2.92  2.65
  40.00     3.15     247.15  * 0.024  1.89  2.78  1.86  1.89  2.34  3.15  2.88
```

```
  45.00    3.37    247.37  * 0.024  2.01  3.06  1.98  2.01  2.48   3.37   3.11
  50.00    3.59    247.59  * 0.024  2.13  3.43  2.11  2.13  2.62   3.59   3.34
  55.00    3.80    247.80  * 0.024  2.24  4.00  2.23  2.24  2.76   3.80   3.57
  60.00    4.01    248.01  * 0.024  2.34  4.00  2.36  2.36  2.89   4.01   3.79
  65.00    4.22    248.22  * 0.024  2.44  4.00  2.47  2.47  3.01   4.22   4.02
  70.00    4.43    248.43  * 0.024  2.53  4.00  2.59  2.59  3.13   4.43   4.24
  75.00    4.64    248.64  * 0.024  2.63  4.00  2.71  2.71  3.25   4.64   4.46
  80.00    4.85    248.85  * 0.024  2.71  4.00  2.84  2.84  3.37   4.85   4.69
  85.00    5.07    249.07  * 0.024  2.80  4.00  2.96  2.96  3.49   5.07   4.91
  90.00    5.29    249.29  * 0.024  2.88  4.00  3.08  3.08  3.61   5.29   5.06
  95.00    5.52    249.52  * 0.024  2.96  4.00  3.20  3.20  3.73   5.52   5.34
 100.00    5.77    249.77  * 0.024  3.04  4.00  3.32  3.32  3.86   5.77   5.62
 105.00    6.07    250.07  * 0.024  3.11  4.00  3.43  3.43  4.01   6.07   6.01
 110.00    6.39    250.39  * 0.024  3.18  4.00  3.54  3.54  4.11   6.37   6.39
 115.00    6.78    250.78  * 0.024  3.24  4.00  3.65  3.65  4.21   6.68   6.78
 120.00    7.19    251.19  * 0.024  3.30  4.00  3.77  3.77  4.32   7.01   7.19
 125.00    7.62    251.62  * 0.024  3.36  4.00  3.89  3.89  4.45   7.37   7.62
 130.00    8.07    252.07  * 0.024  3.42  4.00  4.01  4.01  4.64   7.80   8.07
 135.00    8.53    252.53  * 0.024  3.47  4.00  4.14  4.14  4.82   8.23   8.53
 140.00    9.01    253.01  * 0.024  3.52  4.00  4.27  4.27  5.01   8.68   9.01
*************** OVERFLOW ENCOUNTERED AT 140.00 CFS DISCHARGE ***************
 145.00    9.51    253.51  * 0.024  3.56  4.00  4.39  4.39  5.19   9.12   9.51


                    TOTAL "HW" VS."Q" DATA PRINT-OUT

                     Q(CFS)    HW(FT)    HW-ELEV(FT)
**********************************************************************
                      10.00      1.49     245.49
                      15.00      1.84     245.84
                      20.00      2.14     246.14
                      25.00      2.42     246.42
                      30.00      2.68     246.68
                      35.00      2.92     246.92
                      40.00      3.15     247.15
                      45.00      3.37     247.37
                      50.00      3.59     247.59
                      55.00      3.80     247.80
                      60.00      4.01     248.01
                      65.00      4.22     248.22
                      70.00      4.43     248.43
                      75.00      4.64     248.64
                      80.00      4.85     248.85
                      85.00      5.07     249.07
                      90.00      5.29     249.29
                      95.00      5.52     249.52
                     100.00      5.77     249.77
                     105.00      6.07     250.07
                     110.00      6.39     250.39
                     115.00      6.78     250.78
                     120.00      7.19     251.19
                     125.00      7.62     251.62
                     130.00      8.07     252.07
                     135.00      8.53     252.53
                     140.00      9.02     253.02
*************** OVERFLOW ENCOUNTERED AT 140.00 CFS DISCHARGE ****************
********** THE FOLLOWING DATA INCLUDES CULVERT FLOW PLUS WEIR FLOW **********
                     145.00      9.09     253.09
                     150.00      9.12     253.12
                     155.00      9.15     253.15
                     160.00      9.17     253.17
                     165.00      9.18     253.18
                     170.00      9.20     253.20
                     175.00      9.21     253.21
                     180.00      9.22     253.22
                     185.00      9.23     253.23
                     190.00      9.24     253.24
```

```
                    195.00      9.25       253.25
                    200.00      9.26       253.26

Save results to HW/TW file:tw4a.tw
Exit KCBW Program

                 KING COUNTY DEPARTMENT OF NATURAL RESOURCES
                     Water and Land Resources Division

                        BACKWATER ANALYSIS PROGRAM

                              Version 5.30a
```

Tyee Diversion

This study investigates several alternatives that will divert some of the storm water flowing into Tyee Pond to one of the proposed ponds behind either Berm A at Northwest Ponds or Berm B at the Approach Light Road.

Given:

- 100 year flow into Tyee Pond = 158 cfs
- Maximum flow through 48-inch diversion pipe to stream = 30 cfs
- Modeled 100-year flow for the airport drainage pipe that will be connected to the diversion pipe is 16 cfs
- Slope ~ 1%
- n = 0.012
- Spacing between Catch Basins = 200 feet (approximately)
- Control Structure at Tyee Pond = 120-inch (10-feet) with debris cage. Overflow into diversion pipeline at elevation = 273.5'

Alternative 1

- Northwest pond water surface elevation range = 244 - 253
- Pipeline Length ~ 1,420 feet
- Pipe Size = 72" (6-feet)

The analysis indicates that some of the catch basins near the pond will need to have solid covers because the maximum predicted water surface elevation in the pond would be several feet higher than the rim elevation. This will allow the system to work with high head and not overflow into the golf course during these large, infrequent events. In addition, this would allow the catch basin rims to be set as close to the existing ground elevation as possible, not up higher because of the high head.

The analysis also indicates that several hundred feel of the pipeline will be above grade. This will occur in the lower reaches near the gravel roadway. As long as the alignment of the pipeline parallels the roadway the impact to the golf course should be minimal. Additional refinement of the design may reduce the size of the pipeline and / or the depth.

This design also anticipates intercepting the storm drainage flow from the upper airport runways. This would involve replacing the existing catch basin for the drainage system and diverting the flow into the north pond area.

Alternative 3

- Berm B water surface elevation range = 242 - 255
- Run ~ 530 feet
- Pipe Size = 48" (4-feet)

This analysis deals with a much shorter pipeline than the first. However, the impacts to the golf course are much greater. This design will require the berm to be raised over two feet to accommodate the exposed pipeline. In addition the pipeline is several feet above the ground for several hundred feet near the berm which will have a significant impact the golf cart paths in this area. Additional refinement of the design may reduce the size of the pipeline and / or the depth.

This design also anticipates intercepting the storm drainage flow from the upper airport runways. This would involve replacing the existing catch basin for the drainage system and diverting the flow into the pond area. The existing storm catch basin that the new pipeline will connect to has not been physically located in the field. In addition, the invert elevation is needed. It is anticipated that this information will be obtained in the near future.

Some grading may be necessary at the pipe outlet to convey the flows to the stream.

TYEE DIVERSION PIPE – ALTERNATIVES 1 and 2

72" smooth pipe

```
                         KING COUNTY DEPARTMENT OF PUBLIC WORKS
                           Surface Water Management Division

                               BACKWATER ANALYSIS PROGRAM
                                     Version 4.22




                              1 - INFO ON THIS PROGRAM
                              2 - BWCHAN
                              3 - BWPIPE
                              4 - BWCULV
                              5 - BWBOX
                              6 - DATA-FILE ROUTINES
                              7 - RETURN TO DOS


ENTER OPTION
3
BACKWATER COMPUTER PROGRAM FOR PIPES


SPECIFY TYPE OF PIPE-DATA INPUT: K - KEYBOARD
                                 F - FILE
  F
ENTER [d:][path]filename[.ext] OF PIPE-DATA FILE
  A:72CPA.DAT

--------------------------------------------------------------------------------

OUTFLOW CONDITIONS PIPE NO. 1 - TAILWATER DATA:

 1) SPECIFY TYPE OF TAILWATER DATA INPUT: S - SINGLE TW-ELEV.
                                          F - TW/HW DATA FILE
  S
 2) ENTER: TW-ELEV
   253.00

--------------------------------------------------------------------------------

INFLOW CONDITIONS PIPE NO. 7 - OVERFLOW DATA AND UPSTREAM VELOCITY DATA:

1) ENTER: OVERFLOW-ELEV, OVERFLOW-TYPE (NONE=0, BROAD-WEIR=1, SHARP-WEIR=2)
  273.50   0
2) SPECIFY TYPE OF VELOCITY DATA INPUT:  S - SINGLE VELOCITY UPSTREAM
                                         V - VARY VELOCITY ACCORDING TO V=Q/A
 S
3) ENTER: VELOCITY(fps) UPSTREAM
     .00
```

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--------------------------------------------------------------------------------

ENTER: QMIN, QMAX, QINCRE, PRINT-OPTION (STANDARD=1, CONDENSED=2, EXPANDED=3)
      .00     150.00      10.00   1

PIPE NO. 1:   180 LF - 72"CP    @  1.28%  OUTLET: 244.34  INLET: 246.64  INTYP: 5
JUNC NO. 1:   OVERFLOW-EL: 254.50  BEND: 90 DEG    DIA/WIDTH: 8.0  Q-RATIO:  .00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO    HWI
*************************************************************************************
  10.00    6.37    253.01  *  .012    .83    .58   8.66   8.66   6.37   6.37   1.07
  20.00    6.38    253.02  *  .012   1.18    .81   8.66   8.66   6.36   6.38   1.55
  30.00    6.40    253.04  *  .012   1.45    .98   8.66   8.66   6.37   6.40   1.93
  40.00    6.43    253.07  *  .012   1.68   1.13   8.66   8.66   6.37   6.43   2.26
  50.00    6.47    253.11  *  .012   1.88   1.26   8.66   8.66   6.38   6.47   2.56
  60.00    6.52    253.16  *  .012   2.07   1.38   8.66   8.66   6.39   6.52   2.85
  70.00    6.58    253.22  *  .012   2.24   1.49   8.66   8.66   6.40   6.58   3.11
  80.00    6.64    253.28  *  .012   2.40   1.60   8.66   8.66   6.41   6.64   3.37
  90.00    6.72    253.36  *  .012   2.55   1.70   8.66   8.66   6.43   6.72   3.62
 100.00    6.80    253.44  *  .012   2.70   1.79   8.66   8.66   6.45   6.80   3.87
 110.00    6.89    253.53  *  .012   2.83   1.88   8.66   8.66   6.46   6.89   4.11
 120.00    6.99    253.63  *  .012   2.97   1.97   8.66   8.66   6.48   6.99   4.35
 130.00    7.10    253.74  *  .012   3.09   2.05   8.66   8.66   6.50   7.10   4.58
 140.00    7.22    253.86  *  .012   3.21   2.13   8.66   8.66   6.53   7.22   4.82
 150.00    7.35    253.99  *  .012   3.33   2.21   8.66   8.66   6.55   7.35   5.05

PIPE NO. 2:   210 LF - 72"CP    @  1.00%  OUTLET: 246.64  INLET: 248.74  INTYP: 5
JUNC NO. 2:   OVERFLOW-EL: 255.50  BEND: 90 DEG    DIA/WIDTH: 8.0  Q-RATIO:  .00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO    HWI
*************************************************************************************
  10.00    4.29    253.03  *  .012    .83    .62   6.37   6.37   4.28   4.29   1.08
  20.00    4.30    253.04  *  .012   1.18    .86   6.38   6.38   4.28   4.30   1.56
  30.00    4.35    253.09  *  .012   1.45   1.04   6.40   6.40   4.30   4.35   1.94
  40.00    4.42    253.16  *  .012   1.68   1.20   6.43   6.43   4.33   4.42   2.27
  50.00    4.51    253.25  *  .012   1.88   1.34   6.47   6.47   4.37   4.51   2.57
  60.00    4.61    253.35  *  .012   2.07   1.47   6.52   6.52   4.42   4.61   2.85
  70.00    4.73    253.47  *  .012   2.24   1.59   6.58   6.58   4.48   4.73   3.12
  80.00    4.87    253.61  *  .012   2.40   1.70   6.64   6.64   4.55   4.87   3.38
  90.00    5.03    253.77  *  .012   2.55   1.81   6.72   6.72   4.63   5.03   3.63
 100.00    5.20    253.94  *  .012   2.70   1.91   6.80   6.80   4.73   5.20   3.88
 110.00    5.39    254.13  *  .012   2.83   2.01   6.89   6.89   4.84   5.39   4.12
 120.00    5.59    254.33  *  .012   2.97   2.10   6.99   6.99   4.96   5.59   4.36
 130.00    5.81    254.55  *  .012   3.09   2.19   7.10   7.10   5.10   5.81   4.59
 140.00    6.04    254.78  *  .012   3.21   2.28   7.22   7.22   5.25   6.04   4.83
 150.00    6.29    255.03  *  .012   3.33   2.37   7.35   7.35   5.42   6.29   5.06

PIPE NO. 3:   220 LF - 72"CP    @  1.00%  OUTLET: 248.74  INLET: 250.94  INTYP: 5
JUNC NO. 3:   OVERFLOW-EL: 258.00  BEND:  0 DEG    DIA/WIDTH: 8.0  Q-RATIO:  .00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO    HWI
*************************************************************************************
  10.00    2.11    253.05  *  .012    .83    .62   4.29   4.29   2.08   2.11   1.08
```

```
   20.00     2.19      253.13  *  .012  1.18   .86  4.30  4.30  2.07   2.19   1.55
   30.00     2.34      253.28  *  .012  1.45  1.04  4.35  4.35  2.08   2.34   1.92
   40.00     2.54      253.48  *  .012  1.68  1.20  4.42  4.42  2.08   2.54   2.23
   50.00     2.80      253.74  *  .012  1.88  1.34  4.51  4.51  2.08   2.80   2.51
   60.00     3.12      254.06  *  .012  2.07  1.47  4.61  4.61  2.08   3.12   2.76
   70.00     3.00      253.94  *  .012  2.24  1.59  4.73  4.73  2.24  *****   3.00
   80.00     3.22      254.16  *  .012  2.40  1.70  4.87  4.87  2.40  *****   3.22
   90.00     3.43      254.37  *  .012  2.55  1.81  5.03  5.03  2.55  *****   3.43
  100.00     3.62      254.56  *  .012  2.70  1.91  5.20  5.20  2.70  *****   3.62
  110.00     3.81      254.75  *  .012  2.83  2.01  5.39  5.39  2.83  *****   3.81
  120.00     3.99      254.93  *  .012  2.97  2.10  5.59  5.59  2.97  *****   3.99
  130.00     4.16      255.10  *  .012  3.09  2.19  5.81  5.81  3.09  *****   4.16
  140.00     4.33      255.27  *  .012  3.21  2.28  6.04  6.04  3.21  *****   4.33
  150.00     4.87      255.81  *  .012  3.33  2.37  6.29  6.29  3.94   4.87   4.49

PIPE NO. 4:  200 LF - 72"CP   @  1.00%  OUTLET: 250.94  INLET: 252.94  INTYP: 5
JUNC NO. 4:  OVERFLOW-EL: 262.00  BEND:  0 DEG    DIA/WIDTH: 8.0  Q-RATIO:  .00

 Q(CFS)   HW(FT)   HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  10.00     1.08      254.02  *  .012   .83   .62  2.11  2.11   .83  *****   1.08
  20.00     1.55      254.49  *  .012  1.18   .86  2.19  2.19  1.18  *****   1.55
  30.00     1.92      254.86  *  .012  1.45  1.04  2.34  2.34  1.45  *****   1.92
  40.00     2.23      255.17  *  .012  1.68  1.20  2.54  2.54  1.68  *****   2.23
  50.00     2.51      255.45  *  .012  1.88  1.34  2.80  2.80  1.88  *****   2.51
  60.00     2.76      255.70  *  .012  2.07  1.47  3.12  3.12  2.07  *****   2.76
  70.00     3.00      255.94  *  .012  2.24  1.59  3.00  3.00  2.24  *****   3.00
  80.00     3.22      256.16  *  .012  2.40  1.70  3.22  3.22  2.40  *****   3.22
  90.00     3.43      256.37  *  .012  2.55  1.81  3.43  3.43  2.55  *****   3.43
 100.00     3.62      256.56  *  .012  2.70  1.91  3.62  3.62  2.70  *****   3.62
 110.00     3.81      256.75  *  .012  2.83  2.01  3.81  3.81  2.83  *****   3.81
 120.00     3.99      256.93  *  .012  2.97  2.10  3.99  3.99  2.97  *****   3.99
 130.00     4.16      257.10  *  .012  3.09  2.19  4.16  4.16  3.09  *****   4.16
 140.00     4.33      257.27  *  .012  3.21  2.28  4.33  4.33  3.21  *****   4.33
 150.00     4.49      257.43  *  .012  3.33  2.37  4.87  4.87  3.33  *****   4.49

PIPE NO. 5:  210 LF - 72"CP   @  1.00%  OUTLET: 252.94  INLET: 255.04  INTYP: 5
JUNC NO. 5:  OVERFLOW-EL: 263.12  BEND: 45 DEG    DIA/WIDTH: 8.0  Q-RATIO:  .15

 Q(CFS)   HW(FT)   HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  10.00     1.08      256.12  *  .012   .83   .62  1.08  1.08   .83  *****   1.08
  20.00     1.55      256.59  *  .012  1.18   .86  1.55  1.55  1.18  *****   1.55
  30.00     1.93      256.97  *  .012  1.45  1.04  1.92  1.92  1.45  *****   1.93
  40.00     2.25      257.29  *  .012  1.68  1.20  2.23  2.23  1.68  *****   2.25
  50.00     2.54      257.58  *  .012  1.88  1.34  2.51  2.51  1.88  *****   2.54
  60.00     2.81      257.85  *  .012  2.07  1.47  2.76  2.76  2.07  *****   2.81
  70.00     3.06      258.10  *  .012  2.24  1.59  3.00  3.00  2.24  *****   3.06
  80.00     3.29      258.33  *  .012  2.40  1.70  3.22  3.22  2.40  *****   3.29
  90.00     3.52      258.56  *  .012  2.55  1.81  3.43  3.43  2.55  *****   3.52
 100.00     3.74      258.78  *  .012  2.70  1.91  3.62  3.62  2.70  *****   3.74
 110.00     3.95      258.99  *  .012  2.83  2.01  3.81  3.81  2.83  *****   3.95
 120.00     4.16      259.20  *  .012  2.97  2.10  3.99  3.99  2.97  *****   4.16
 130.00     4.36      259.40  *  .012  3.09  2.19  4.16  4.16  3.09  *****   4.36
 140.00     4.56      259.60  *  .012  3.21  2.28  4.33  4.33  3.21  *****   4.55
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```
 150.00     4.76      259.80  *  .012  3.33  2.37  4.49  4.49  3.33  *****   4.76

PIPE NO. 6:  196 LF - 72"CP    @  1.00%  OUTLET: 255.04  INLET: 257.00  INTYP: 5
JUNC NO. 6:  OVERFLOW-EL: 270.00  BEND:   0 DEG    DIA/WIDTH: 8.0  Q-RATIO:   .00

 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO     HWI
*********************************************************************************
   8.70     1.00      258.00  *  .012   .77   .58  1.08  1.08   .77  *****   1.00
  17.39     1.44      258.44  *  .012  1.10   .80  1.55  1.55  1.10  *****   1.44
  26.09     1.78      258.78  *  .012  1.35   .98  1.93  1.93  1.35  *****   1.78
  34.78     2.07      259.07  *  .012  1.56  1.12  2.25  2.25  1.56  *****   2.07
  43.48     2.33      259.33  *  .012  1.75  1.25  2.54  2.54  1.75  *****   2.33
  52.17     2.57      259.57  *  .012  1.92  1.37  2.81  2.81  1.92  *****   2.57
  60.87     2.78      259.79  *  .012  2.08  1.48  3.06  3.06  2.08  *****   2.78
  69.57     2.99      259.99  *  .012  2.23  1.58  3.29  3.29  2.23  *****   2.99
  78.26     3.18      260.18  *  .012  2.37  1.68  3.52  3.52  2.37  *****   3.18
  86.96     3.36      260.36  *  .012  2.51  1.77  3.74  3.74  2.51  *****   3.36
  95.65     3.54      260.54  *  .012  2.63  1.86  3.95  3.95  2.63  *****   3.54
 104.35     3.71      260.71  *  .012  2.76  1.95  4.16  4.16  2.76  *****   3.71
 113.04     3.87      260.87  *  .012  2.87  2.03  4.36  4.36  2.87  *****   3.87
 121.74     4.02      261.02  *  .012  2.99  2.12  4.56  4.56  2.99  *****   4.02
 130.43     4.17      261.17  *  .012  3.10  2.19  4.76  4.76  3.10  *****   4.17

PIPE NO. 7:  180 LF - 72"CP    @  1.00%  OUTLET: 257.00  INLET: 258.80  INTYP: 5

 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO     HWI
*********************************************************************************
   8.70     1.00      259.80  *  .012   .77   .58  1.00  1.00   .77  *****   1.00
  17.39     1.45      260.25  *  .012  1.10   .80  1.44  1.44  1.10  *****   1.45
  26.09     1.79      260.59  *  .012  1.35   .98  1.78  1.78  1.35  *****   1.79
  34.78     2.10      260.90  *  .012  1.56  1.12  2.07  2.07  1.56  *****   2.10
  43.48     2.37      261.17  *  .012  1.75  1.25  2.33  2.33  1.75  *****   2.37
  52.17     2.62      261.42  *  .012  1.92  1.37  2.57  2.57  1.92  *****   2.62
  60.87     2.86      261.66  *  .012  2.08  1.48  2.78  2.78  2.08  *****   2.86
  69.57     3.08      261.88  *  .012  2.23  1.58  2.99  2.99  2.23  *****   3.08
  78.26     3.30      262.10  *  .012  2.37  1.68  3.18  3.18  2.37  *****   3.30
  86.96     3.51      262.31  *  .012  2.51  1.77  3.36  3.36  2.51  *****   3.51
  95.65     3.71      262.51  *  .012  2.63  1.86  3.54  3.54  2.63  *****   3.71
 104.35     3.91      262.71  *  .012  2.76  1.95  3.71  3.71  2.76  *****   3.91
 113.04     4.11      262.91  *  .012  2.87  2.03  3.87  3.87  2.87  *****   4.11
 121.74     4.30      263.10  *  .012  2.99  2.12  4.02  4.02  2.99  *****   4.30
 130.43     4.50      263.30  *  .012  3.10  2.19  4.17  4.17  3.10  *****   4.50

SPECIFY: R - REVISE, N - NEWJOB, F - FILE, S - STOP
  S
7
Stop - Program terminated.
```

```
          -1
  3
F
A:72CPA.DAT
S
    253.00
    273.50   0
S
       .00
       .00    150.00      10.00    1
S
 7
```

```
7
 180.00     72.00     1   244.34    246.64      5
 254.50     90.00     8.00       .00
 210.00     72.00     1   246.64    248.74      5
 255.50     90.00     8.00       .00
 220.00     72.00     1   248.74    250.94      5
 258.00       .00     8.00       .00
 200.00     72.00     1   250.94    252.94      5
 262.00       .00     8.00       .00
 210.00     72.00     1   252.94    255.04      5
 263.12     45.00     8.00       .15
 196.00     72.00     1   255.04    257.00      5
 270.00       .00     8.00       .00
 180.00     72.00     1   257.00    258.80      5
```

TYEE DIVERSION PIPE – ALTERNATIVE 3
48" smooth pipe

```
                    KING COUNTY DEPARTMENT OF PUBLIC WORKS
                      Surface Water Management Division

                          BACKWATER ANALYSIS PROGRAM
                                Version 4.22



                        1 - INFO ON THIS PROGRAM
                        2 - BWCHAN
                        3 - BWPIPE
                        4 - BWCULV
                        5 - BWBOX
                        6 - DATA-FILE ROUTINES
                        7 - RETURN TO DOS


ENTER OPTION
3
BACKWATER COMPUTER PROGRAM FOR PIPES


SPECIFY TYPE OF PIPE-DATA INPUT: K - KEYBOARD
                                 F - FILE
 F
ENTER [d:][path]filename[.ext] OF PIPE-DATA FILE
 A:48CP3.DAT
--------------------------------------------------------------------------------
OUTFLOW CONDITIONS PIPE NO. 1 - TAILWATER DATA:

 1) SPECIFY TYPE OF TAILWATER DATA INPUT: S - SINGLE TW-ELEV.
                                          F - TW/HW DATA FILE
 S
 2) ENTER: TW-ELEV
  253.00
--------------------------------------------------------------------------------
INFLOW CONDITIONS PIPE NO. 3 - OVERFLOW DATA AND UPSTREAM VELOCITY DATA:

 1) ENTER: OVERFLOW-ELEV, OVERFLOW-TYPE (NONE=0, BROAD-WEIR=1, SHARP-WEIR=2)
   273.50   0
 2) SPECIFY TYPE OF VELOCITY DATA INPUT:  S - SINGLE VELOCITY UPSTREAM
                                          V - VARY VELOCITY ACCORDING TO V=Q/A
 S
 3) ENTER: VELOCITY(fps) UPSTREAM
     .00
```

```
-----------------------------------------------------------------------------------------

ENTER: QMIN, QMAX, QINCRE, PRINT-OPTION (STANDARD=1, CONDENSED=2, EXPANDED=3)
      .00    150.00      10.00   1

PIPE NO. 1:  160 LF - 48"CP   @  1.00%  OUTLET: 250.00  INLET: 251.60  INTYP: 5
JUNC NO. 1:  OVERFLOW-EL: 258.00  BEND:  0 DEG    DIA/WIDTH: 4.5  Q-RATIO:  .15

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE    HWO    HWI
*****************************************************************************************
  10.00     1.52      253.12  *  .012    .93    .69  3.00   3.00   1.37   1.52   1.23
  20.00     1.77      253.37  *  .012   1.32    .97  3.00   3.00   1.32  *****   1.77
  30.00     2.21      253.81  *  .012   1.63   1.20  3.00   3.00   1.63  *****   2.21
  40.00     2.60      254.20  *  .012   1.89   1.39  3.00   3.00   1.89  *****   2.60
  50.00     2.94      254.54  *  .012   2.13   1.56  3.00   3.00   2.13  *****   2.94
  60.00     3.27      254.87  *  .012   2.34   1.73  3.00   3.00   2.34  *****   3.27
  70.00     3.58      255.18  *  .012   2.53   1.89  3.00   3.00   2.53  *****   3.58
  80.00     3.89      255.49  *  .012   2.71   2.04  3.00   3.00   2.71  *****   3.89
  90.00     4.18      255.78  *  .012   2.88   2.19  3.00   3.00   2.88  *****   4.18
 100.00     4.51      256.11  *  .012   3.04   2.34  3.00   3.00   3.04  *****   4.51
 110.00     4.93      256.53  *  .012   3.18   2.49  3.00   3.00   3.18  *****   4.93
 120.00     5.36      256.96  *  .012   3.30   2.64  3.00   3.00   3.30  *****   5.36
 130.00     5.83      257.43  *  .012   3.42   2.80  3.00   3.00   3.42  *****   5.83
 140.00     6.34      257.94  *  .012   3.52   2.97  3.00   3.00   3.52  *****   6.34
 150.00     6.40      258.49  *  .012   3.60   3.16  3.00   3.16   3.60  *****   6.89

PIPE NO. 2:  190 LF - 48"CP   @  2.74%  OUTLET: 251.60  INLET: 256.80  INTYP: 5
JUNC NO. 2:  OVERFLOW-EL: 264.00  BEND:  0 DEG    DIA/WIDTH: 4.5  Q-RATIO:  .00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE    HWO    HWI
*****************************************************************************************
   8.70     1.10      257.90  *  .012    .86    .51  1.52   1.52    .86  *****   1.10
  17.39     1.60      258.40  *  .012   1.23    .71  1.77   1.77   1.23  *****   1.60
  26.09     1.99      258.79  *  .012   1.52    .86  2.21   2.21   1.52  *****   1.99
  34.78     2.33      259.13  *  .012   1.76   1.00  2.60   2.60   1.76  *****   2.33
  43.48     2.62      259.42  *  .012   1.98   1.12  2.94   2.94   1.98  *****   2.62
  52.17     2.89      259.69  *  .012   2.17   1.23  3.27   3.27   2.17  *****   2.89
  60.87     3.15      259.95  *  .012   2.36   1.33  3.58   3.58   2.36  *****   3.15
  69.57     3.38      260.18  *  .012   2.53   1.43  3.89   3.89   2.53  *****   3.38
  78.26     3.60      260.40  *  .012   2.68   1.52  4.18   4.18   2.68  *****   3.60
  86.96     3.82      260.62  *  .012   2.83   1.61  4.51   4.51   2.83  *****   3.82
  95.65     4.03      260.83  *  .012   2.97   1.69  4.93   4.93   2.97  *****   4.03
 104.35     4.32      261.12  *  .012   3.10   1.78  5.36   5.36   3.10  *****   4.32
 113.04     4.61      261.41  *  .012   3.22   1.86  5.83   5.83   3.22  *****   4.61
 121.74     4.93      261.73  *  .012   3.32   1.94  6.34   6.34   3.32  *****   4.93
 130.43     5.27      262.07  *  .012   3.42   2.02  6.40   6.40   3.42  *****   5.27

PIPE NO. 3:  200 LF - 48"CP   @  1.00%  OUTLET: 256.80  INLET: 258.80  INTYP: 5

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE    HWO    HWI
*****************************************************************************************
   8.70     1.14      259.94  *  .012    .86    .65  1.10   1.10    .86  *****   1.14
  17.39     1.67      260.47  *  .012   1.23    .91  1.60   1.60   1.23  *****   1.67
```

```
   26.09     2.09     260.89  *  .012  1.52  1.11  1.99  1.99  1.52  *****   2.09
   34.78     2.48     261.28  *  .012  1.76  1.29  2.33  2.33  1.76  *****   2.48
   43.48     2.84     261.64  *  .012  1.98  1.45  2.62  2.62  1.98  *****   2.84
   52.17     3.19     261.99  *  .012  2.17  1.60  2.89  2.89  2.17  *****   3.19
   60.87     3.54     262.34  *  .012  2.36  1.74  3.15  3.15  2.36  *****   3.54
   69.57     3.88     262.68  *  .012  2.53  1.88  3.38  3.38  2.53  *****   3.88
   78.26     4.23     263.03  *  .012  2.68  2.01  3.60  3.60  2.68  *****   4.23
   86.96     4.58     263.38  *  .012  2.83  2.14  3.82  3.82  2.83  *****   4.58
   95.65     4.95     263.75  *  .012  2.97  2.27  4.03  4.03  2.97  *****   4.95
  104.35     5.40     264.20  *  .012  3.10  2.40  4.32  4.32  3.10  *****   5.40
  113.04     5.88     264.68  *  .012  3.22  2.53  4.61  4.61  3.32   5.72   5.88
  121.74     6.40     265.20  *  .012  3.32  2.67  4.93  4.93  4.16   6.35   6.40
  130.43     7.19     265.99  *  .012  3.42  2.81  5.27  5.27  4.68   7.19   6.95

SPECIFY: R - REVISE, N - NEWJOB, F - FILE, S - STOP
  S
7
Stop - Program terminated.
```

```
           -1
  3
F
A:48CP3.DAT
S
    253.00
    273.50    0
S
       .00
       .00    150.00      10.00    1
S
  7
```

```
3
 160.00     48.00      1   250.00   251.60     5
 258.00       .00      4.50       .15
 190.00     48.00      1   251.60   256.80     5
 264.00       .00      4.50       .00
 200.00     48.00      1   256.80   258.80     5
```

Hydraulic modeling of bypass pipeline from MH 348 near treatment plant upstream to Northwest Ponds (Alternative 1).

Includes results for both "Bypass Downstream of S. 200th" and "Alternative 1 - Bypass from Northwest Ponds"

```
BACKWATER COMPUTER PROGRAM FOR PIPES
     Pipe data from file:nwbyps4.bwp
     Tailwater Elevation:107.67 feet (This assumes the downstream manhole #348 is full
     to the rim. This is conservative, but only affects the results through pipe 4. To be consistent
     with the datum difference found in the golf course survey, 3.67 feet was added to all
     elevations taken from sewer district plans.)
          Discharge Range:14. to 28. Step of 2. [cfs]
       Overflow Elevation:253.  feet
       Broad Crested Weir: Length:110. feet, Height:0.1 feet
        Upstream Velocity:0.1 feet/sec


PIPE NO. 1:    90 LF - 24"CP   @  1.00%  OUTLET: 100.29  INLET: 101.19  INTYP: 5
JUNC NO. 1:  OVERFLOW-EL: 109.17  BEND:   9 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
********************************************************************************
  14.00     6.95      108.14  * 0.012  1.35   1.09   7.38   7.38   6.78   6.95   1.84
  16.00     7.08      108.27  * 0.012  1.45   1.18   7.38   7.38   6.86   7.08   1.98
  18.00     7.24      108.43  * 0.012  1.53   1.28   7.38   7.38   6.97   7.24   2.15
  20.00     7.42      108.61  * 0.012  1.61   1.38   7.38   7.38   7.08   7.42   2.34
  22.00     7.62      108.81  * 0.012  1.68   1.49   7.38   7.38   7.21   7.62   2.56
  24.00     7.84      109.03  * 0.012  1.74   1.61   7.38   7.38   7.34   7.84   2.79
  26.00     7.98      109.27  * 0.012  1.79   1.79   7.38   7.38   7.49   8.08   3.04
**************** OVERFLOW ENCOUNTERED AT  26.00 CFS DISCHARGE ****************


PIPE NO. 2:  154 LF - 24"CP   @  1.01%  OUTLET: 101.19  INLET: 102.74  INTYP: 5
JUNC NO. 2:  OVERFLOW-EL: 112.67  BEND: 60 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
********************************************************************************
  14.00     6.26      109.00  * 0.012  1.35   1.09   6.95   6.95   5.91   6.26   2.02
  16.00     6.65      109.39  * 0.012  1.45   1.18   7.08   7.08   6.19   6.65   2.21
  18.00     7.10      109.84  * 0.012  1.53   1.28   7.24   7.24   6.53   7.10   2.45
  20.00     7.61      110.35  * 0.012  1.61   1.37   7.42   7.42   6.90   7.61   2.71
  22.00     8.17      110.91  * 0.012  1.68   1.48   7.62   7.62   7.31   8.17   3.00
  24.00     8.79      111.53  * 0.012  1.74   1.60   7.84   7.84   7.77   8.79   3.32
  26.00     9.37      112.11  * 0.012  1.79   1.78   7.98   7.98   8.16   9.37   3.66
  28.00     9.93      112.80  * 0.012  1.83   2.00   8.20   8.20   8.66  10.06   4.03

PIPE NO. 3:  427 LF - 24"CP   @  1.00%  OUTLET: 102.74  INLET: 107.01  INTYP: 5
JUNC NO. 3:  OVERFLOW-EL: 117.17  BEND: 32 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
********************************************************************************
  14.00     3.62      110.63  * 0.012  1.35   1.09   6.26   6.26   3.39   3.62   1.90
  16.00     4.49      111.50  * 0.012  1.45   1.18   6.65   6.65   4.20   4.49   2.05
```

```
  18.00      5.51       112.52   * 0.012   1.53   1.28   7.10   7.10   5.14    5.51    2.24
  20.00      6.65       113.66   * 0.012   1.61   1.38   7.61   7.61   6.19    6.65    2.46
  22.00      7.90       114.91   * 0.012   1.68   1.49   8.17   8.17   7.35    7.90    2.70
  24.00      9.28       116.29   * 0.012   1.74   1.61   8.79   8.79   8.62    9.28    2.96
  26.00     10.16       117.69   * 0.012   1.79   1.79   9.37   9.37   9.90   10.68    3.24
**************** OVERFLOW ENCOUNTERED AT  26.00 CFS DISCHARGE *****************


PIPE NO. 4:  328 LF - 24"CP    @  3.46%  OUTLET: 107.01  INLET: 118.37  INTYP: 5
JUNC NO. 4:  OVERFLOW-EL: 129.17  BEND: 41 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
*******************************************************************************
  14.00      1.90       120.27   * 0.012   1.35   0.77   3.62   3.62   1.35   *****   1.90
  16.00      2.07       120.44   * 0.012   1.45   0.82   4.49   4.49   1.45   *****   2.07
  18.00      2.27       120.64   * 0.012   1.53   0.88   5.51   5.51   1.53   *****   2.27
  20.00      2.50       120.87   * 0.012   1.61   0.93   6.65   6.65   1.61   *****   2.50
  22.00      2.75       121.12   * 0.012   1.68   0.98   7.90   7.90   1.68   *****   2.75
  24.00      3.02       121.39   * 0.012   1.74   1.04   9.28   9.28   1.74   *****   3.02
  26.00      3.39       121.76   * 0.012   1.79   1.09  10.16  10.16   2.50    3.39   3.32
  28.00      4.34       122.71   * 0.012   1.83   1.14  10.38  10.38   3.31    4.34   3.64


PIPE NO. 5:  173 LF - 24"CP    @  2.37%  OUTLET: 118.37  INLET: 122.47  INTYP: 5
JUNC NO. 5:  OVERFLOW-EL: 134.47  BEND: 24 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
*******************************************************************************
  14.00      1.86       124.33   * 0.012   1.35   0.85   1.90   1.90   1.35   *****   1.86
  16.00      2.01       124.48   * 0.012   1.45   0.91   2.07   2.07   1.45   *****   2.01
  18.00      2.19       124.66   * 0.012   1.53   0.98   2.27   2.27   1.53   *****   2.19
  20.00      2.39       124.86   * 0.012   1.61   1.04   2.50   2.50   1.61   *****   2.39
  22.00      2.62       125.09   * 0.012   1.68   1.10   2.75   2.75   1.68   *****   2.62
  24.00      2.87       125.34   * 0.012   1.74   1.16   3.02   3.02   1.74   *****   2.87
  26.00      3.14       125.61   * 0.012   1.79   1.23   3.39   3.39   1.79   *****   3.14
  28.00      3.43       125.90   * 0.012   1.83   1.29   4.34   4.34   2.50    3.30   3.43


PIPE NO. 6:  191 LF - 24"CP    @  6.23%  OUTLET: 122.47  INLET: 134.37  INTYP: 5
JUNC NO. 6:  OVERFLOW-EL: 141.87  BEND: 39 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
*******************************************************************************
  14.00      1.87       136.24   * 0.012   1.35   0.66   1.86   1.86   1.35   *****   1.87
  16.00      2.03       136.40   * 0.012   1.45   0.70   2.01   2.01   1.45   *****   2.03
  18.00      2.23       136.60   * 0.012   1.53   0.75   2.19   2.19   1.53   *****   2.23
  20.00      2.46       136.83   * 0.012   1.61   0.79   2.39   2.39   1.61   *****   2.46
  22.00      2.70       137.07   * 0.012   1.68   0.83   2.62   2.62   1.68   *****   2.70
  24.00      2.97       137.34   * 0.012   1.74   0.88   2.87   2.87   1.74   *****   2.97
  26.00      3.27       137.64   * 0.012   1.79   0.92   3.14   3.14   1.79   *****   3.27
  28.00      3.59       137.96   * 0.012   1.83   0.95   3.43   3.43   1.83   *****   3.59


PIPE NO. 7:  210 LF - 24"CP    @  1.57%  OUTLET: 134.37  INLET: 137.67  INTYP: 5
JUNC NO. 7:  OVERFLOW-EL: 149.17  BEND: 62 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
```

```
******************************************************************************
  14.00     2.03      139.70   * 0.012  1.35  0.95  1.87  1.87  1.35  *****   2.03
  16.00     2.22      139.89   * 0.012  1.45  1.03  2.03  2.03  1.45  *****   2.22
  18.00     2.46      140.13   * 0.012  1.53  1.11  2.23  2.23  1.53  *****   2.46
  20.00     2.73      140.40   * 0.012  1.61  1.18  2.46  2.46  1.61  *****   2.73
  22.00     3.03      140.70   * 0.012  1.68  1.26  2.70  2.70  1.68  *****   3.03
  24.00     3.35      141.02   * 0.012  1.74  1.34  2.97  2.97  1.74  *****   3.35
  26.00     3.70      141.37   * 0.012  1.79  1.42  3.27  3.27  2.34   3.59   3.70
  28.00     4.47      142.14   * 0.012  1.83  1.50  3.59  3.59  3.03   4.47   4.08

PIPE NO. 8:   70 LF - 24"CP   @  2.34%  OUTLET: 137.67  INLET: 139.31  INTYP: 5
JUNC NO. 8:  OVERFLOW-EL: 153.67  BEND: 46 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00     1.94      141.25   * 0.012  1.35  0.85  2.03  2.03  1.35  *****   1.94
  16.00     2.11      141.42   * 0.012  1.45  0.92  2.22  2.22  1.45  *****   2.11
  18.00     2.32      141.63   * 0.012  1.53  0.98  2.46  2.46  1.53  *****   2.32
  20.00     2.55      141.86   * 0.012  1.61  1.04  2.73  2.73  1.61  *****   2.55
  22.00     2.81      142.12   * 0.012  1.68  1.11  3.03  3.03  1.68  *****   2.81
  24.00     3.21      142.52   * 0.012  1.74  1.17  3.35  3.35  2.39   3.21   3.10
  26.00     3.81      143.12   * 0.012  1.79  1.23  3.70  3.70  2.85   3.81   3.41
  28.00     4.86      144.17   * 0.012  1.83  1.29  4.47  4.47  3.75   4.86   3.74

PIPE NO. 9:   57 LF - 24"CP   @  2.30%  OUTLET: 139.31  INLET: 140.62  INTYP: 5
JUNC NO. 9:  OVERFLOW-EL: 155.37  BEND: 33 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00     1.89      142.51   * 0.012  1.35  0.86  1.94  1.94  1.35  *****   1.89
  16.00     2.04      142.66   * 0.012  1.45  0.92  2.11  2.11  1.45  *****   2.04
  18.00     2.24      142.86   * 0.012  1.53  0.99  2.32  2.32  1.53  *****   2.24
  20.00     2.45      143.07   * 0.012  1.61  1.05  2.55  2.55  1.61  *****   2.45
  22.00     2.69      143.31   * 0.012  1.68  1.11  2.81  2.81  1.68  *****   2.69
  24.00     3.12      143.74   * 0.012  1.74  1.17  3.21  3.21  2.45   3.12   2.95
  26.00     3.93      144.55   * 0.012  1.79  1.24  3.81  3.81  3.14   3.93   3.24
  28.00     5.22      145.84   * 0.012  1.83  1.30  4.86  4.86  4.30   5.22   3.54

PIPE NO.10:   98 LF - 24"CP   @  2.60%  OUTLET: 140.62  INLET: 143.17  INTYP: 5
JUNC NO.10:  OVERFLOW-EL: 154.47  BEND: 53 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00     1.97      145.14   * 0.012  1.35  0.83  1.89  1.89  1.35  *****   1.97
  16.00     2.15      145.32   * 0.012  1.45  0.89  2.04  2.04  1.45  *****   2.15
  18.00     2.37      145.54   * 0.012  1.53  0.95  2.24  2.24  1.53  *****   2.37
  20.00     2.62      145.79   * 0.012  1.61  1.01  2.45  2.45  1.61  *****   2.62
  22.00     2.89      146.06   * 0.012  1.68  1.07  2.69  2.69  1.68  *****   2.89
  24.00     3.19      146.36   * 0.012  1.74  1.13  3.12  3.12  1.74  *****   3.19
  26.00     3.57      146.74   * 0.012  1.79  1.19  3.93  3.93  2.49   3.57   3.52
  28.00     5.19      148.36   * 0.012  1.83  1.25  5.22  5.22  3.95   5.19   3.87

PIPE NO.11:  284 LF - 24"CP   @  3.27%  OUTLET: 143.17  INLET: 152.47  INTYP: 5
```

```
JUNC NO.11:   OVERFLOW-EL: 163.87  BEND: 45 DEG     DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO     HWI
******************************************************************************************
  14.00     1.92      154.39  * 0.012  1.35   0.78   1.97   1.97   1.35   *****   1.92
  16.00     2.09      154.56  * 0.012  1.45   0.84   2.15   2.15   1.45   *****   2.09
  18.00     2.30      154.77  * 0.012  1.53   0.89   2.37   2.37   1.53   *****   2.30
  20.00     2.54      155.01  * 0.012  1.61   0.95   2.62   2.62   1.61   *****   2.54
  22.00     2.79      155.26  * 0.012  1.68   1.00   2.89   2.89   1.68   *****   2.79
  24.00     3.08      155.55  * 0.012  1.74   1.05   3.19   3.19   1.74   *****   3.08
  26.00     3.38      155.85  * 0.012  1.79   1.11   3.57   3.57   1.79   *****   3.38
  28.00     3.72      156.19  * 0.012  1.83   1.16   5.19   5.19   1.83   *****   3.72

PIPE NO.12:    95 LF - 24"CP   @  3.26%  OUTLET: 152.47  INLET: 155.57  INTYP: 5
JUNC NO.12:   OVERFLOW-EL: 162.60  BEND: 26 DEG     DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO     HWI
******************************************************************************************
  14.00     1.85      157.42  * 0.012  1.35   0.78   1.92   1.92   1.35   *****   1.85
  16.00     2.01      157.58  * 0.012  1.45   0.84   2.09   2.09   1.45   *****   2.01
  18.00     2.19      157.76  * 0.012  1.53   0.89   2.30   2.30   1.53   *****   2.19
  20.00     2.40      157.97  * 0.012  1.61   0.95   2.54   2.54   1.61   *****   2.40
  22.00     2.63      158.20  * 0.012  1.68   1.00   2.79   2.79   1.68   *****   2.63
  24.00     2.88      158.45  * 0.012  1.74   1.05   3.08   3.08   1.74   *****   2.88
  26.00     3.15      158.72  * 0.012  1.79   1.11   3.38   3.38   1.79   *****   3.15
  28.00     3.44      159.01  * 0.012  1.83   1.16   3.72   3.72   1.83   *****   3.44

PIPE NO.13:  326 LF - 24"CP   @  2.83%  OUTLET: 155.57  INLET: 164.80  INTYP: 5
JUNC NO.13:  OVERFLOW-EL: 180.17  BEND: 39 DEG     DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO     HWI
******************************************************************************************
  14.00     1.90      166.70  * 0.012  1.35   0.81   1.85   1.85   1.35   *****   1.90
  16.00     2.07      166.87  * 0.012  1.45   0.87   2.01   2.01   1.45   *****   2.07
  18.00     2.27      167.07  * 0.012  1.53   0.93   2.19   2.19   1.53   *****   2.27
  20.00     2.49      167.29  * 0.012  1.61   0.99   2.40   2.40   1.61   *****   2.49
  22.00     2.74      167.54  * 0.012  1.68   1.04   2.63   2.63   1.68   *****   2.74
  24.00     3.01      167.81  * 0.012  1.74   1.10   2.88   2.88   1.74   *****   3.01
  26.00     3.30      168.10  * 0.012  1.79   1.16   3.15   3.15   1.79   *****   3.30
  28.00     3.62      168.42  * 0.012  1.83   1.21   3.44   3.44   1.83   *****   3.62

PIPE NO.14:  224 LF - 24"CP   @  4.63%  OUTLET: 164.80  INLET: 175.18  INTYP: 5
JUNC NO.14:  OVERFLOW-EL: 188.17  BEND: 41 DEG     DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO     HWI
******************************************************************************************
  14.00     1.89      177.07  * 0.012  1.35   0.71   1.90   1.90   1.35   *****   1.89
  16.00     2.06      177.24  * 0.012  1.45   0.76   2.07   2.07   1.45   *****   2.06
  18.00     2.26      177.44  * 0.012  1.53   0.81   2.27   2.27   1.53   *****   2.26
  20.00     2.49      177.67  * 0.012  1.61   0.86   2.49   2.49   1.61   *****   2.49
  22.00     2.74      177.92  * 0.012  1.68   0.91   2.74   2.74   1.68   *****   2.74
  24.00     3.01      178.19  * 0.012  1.74   0.95   3.01   3.01   1.74   *****   3.01
  26.00     3.31      178.49  * 0.012  1.79   1.00   3.30   3.30   1.79   *****   3.31
  28.00     3.63      178.81  * 0.012  1.83   1.04   3.62   3.62   1.83   *****   3.63
```

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PIPE NO.15:  235 LF - 24"CP   @  3.00%  OUTLET: 175.18  INLET: 182.24  INTYP: 5
JUNC NO.15:  OVERFLOW-EL: 193.67  BEND: 17 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00    1.83      184.07  * 0.012  1.35  0.80  1.89  1.89  1.35  *****   1.83
  16.00    1.98      184.22  * 0.012  1.45  0.86  2.06  2.06  1.45  *****   1.98
  18.00    2.15      184.39  * 0.012  1.53  0.91  2.26  2.26  1.53  *****   2.15
  20.00    2.35      184.59  * 0.012  1.61  0.97  2.49  2.49  1.61  *****   2.35
  22.00    2.57      184.81  * 0.012  1.68  1.03  2.74  2.74  1.68  *****   2.57
  24.00    2.81      185.05  * 0.012  1.74  1.08  3.01  3.01  1.74  *****   2.81
  26.00    3.07      185.31  * 0.012  1.79  1.14  3.31  3.31  1.79  *****   3.07
  28.00    3.35      185.59  * 0.012  1.83  1.19  3.63  3.63  1.83  *****   3.35

PIPE NO.16:   94 LF - 24"CP   @  3.00%  OUTLET: 182.24  INLET: 185.06  INTYP: 5
JUNC NO.16:  OVERFLOW-EL: 198.20  BEND: 16 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00    1.83      186.89  * 0.012  1.35  0.80  1.83  1.83  1.35  *****   1.83
  16.00    1.97      187.03  * 0.012  1.45  0.86  1.98  1.98  1.45  *****   1.97
  18.00    2.15      187.21  * 0.012  1.53  0.91  2.15  2.15  1.53  *****   2.15
  20.00    2.35      187.41  * 0.012  1.61  0.97  2.35  2.35  1.61  *****   2.35
  22.00    2.56      187.62  * 0.012  1.68  1.03  2.57  2.57  1.68  *****   2.56
  24.00    2.80      187.86  * 0.012  1.74  1.08  2.81  2.81  1.74  *****   2.80
  26.00    3.06      188.12  * 0.012  1.79  1.14  3.07  3.07  1.79  *****   3.06
  28.00    3.34      188.40  * 0.012  1.83  1.19  3.35  3.35  1.83  *****   3.34

PIPE NO.17:  170 LF - 24"CP   @  3.01%  OUTLET: 185.06  INLET: 190.17  INTYP: 5
JUNC NO.17:  OVERFLOW-EL: 203.67  BEND: 55 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00    1.97      192.14  * 0.012  1.35  0.80  1.83  1.83  1.35  *****   1.97
  16.00    2.16      192.33  * 0.012  1.45  0.86  1.97  1.97  1.45  *****   2.16
  18.00    2.38      192.55  * 0.012  1.53  0.91  2.15  2.15  1.53  *****   2.38
  20.00    2.64      192.81  * 0.012  1.61  0.97  2.35  2.35  1.61  *****   2.64
  22.00    2.91      193.08  * 0.012  1.68  1.03  2.56  2.56  1.68  *****   2.91
  24.00    3.22      193.39  * 0.012  1.74  1.08  2.80  2.80  1.74  *****   3.22
  26.00    3.55      193.72  * 0.012  1.79  1.14  3.06  3.06  1.79  *****   3.55
  28.00    3.91      194.08  * 0.012  1.83  1.19  3.34  3.34  1.83  *****   3.91

PIPE NO.18:   27 LF - 24"CP   @  4.93%  OUTLET: 190.17  INLET: 191.50  INTYP: 5
JUNC NO.18:  OVERFLOW-EL: 205.60  BEND: 29 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
******************************************************************************
  14.00    1.85      193.35  * 0.012  1.35  0.70  1.97  1.97  1.35  *****   1.85
  16.00    2.00      193.50  * 0.012  1.45  0.75  2.16  2.16  1.45  *****   2.00
  18.00    2.19      193.69  * 0.012  1.53  0.80  2.38  2.38  1.53  *****   2.19
  20.00    2.40      193.90  * 0.012  1.61  0.84  2.64  2.64  1.61  *****   2.40
  22.00    2.63      194.13  * 0.012  1.68  0.89  2.91  2.91  1.68  *****   2.63
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  24.00      2.89      194.39   * 0.012  1.74  0.93  3.22  3.22  2.15   2.78   2.89
  26.00      3.27      194.77   * 0.012  1.79  0.98  3.55  3.55  2.53   3.27   3.16
  28.00      3.80      195.30   * 0.012  1.83  1.02  3.91  3.91  2.93   3.80   3.46

PIPE NO.19:    73 LF - 24"CP    @  4.24%  OUTLET: 191.50  INLET: 194.62  INTYP: 5
JUNC NO.19:  OVERFLOW-EL: 207.17  BEND: 69 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00      2.04      196.66   * 0.012  1.35  0.73  1.85  1.85  1.35  *****   2.04
  16.00      2.26      196.88   * 0.012  1.45  0.78  2.00  2.00  1.45  *****   2.26
  18.00      2.51      197.13   * 0.012  1.53  0.83  2.19  2.19  1.53  *****   2.51
  20.00      2.80      197.42   * 0.012  1.61  0.88  2.40  2.40  1.61  *****   2.80
  22.00      3.11      197.73   * 0.012  1.68  0.93  2.63  2.63  1.68  *****   3.11
  24.00      3.46      198.08   * 0.012  1.74  0.98  2.89  2.89  1.74  *****   3.46
  26.00      3.83      198.45   * 0.012  1.79  1.02  3.27  3.27  1.79  *****   3.83
  28.00      4.24      198.86   * 0.012  1.83  1.07  3.80  3.80  1.83  *****   4.24

PIPE NO.20:  163 LF - 24"CP    @  4.70%  OUTLET: 194.62  INLET: 202.28  INTYP: 5
JUNC NO.20:  OVERFLOW-EL: 214.20  BEND: 53 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00      1.95      204.23   * 0.012  1.35  0.71  2.04  2.04  1.35  *****   1.95
  16.00      2.13      204.41   * 0.012  1.45  0.76  2.26  2.26  1.45  *****   2.13
  18.00      2.35      204.63   * 0.012  1.53  0.81  2.51  2.51  1.53  *****   2.35
  20.00      2.60      204.88   * 0.012  1.61  0.86  2.80  2.80  1.61  *****   2.60
  22.00      2.87      205.15   * 0.012  1.68  0.90  3.11  3.11  1.68  *****   2.87
  24.00      3.17      205.45   * 0.012  1.74  0.95  3.46  3.46  1.74  *****   3.17
  26.00      3.50      205.78   * 0.012  1.79  0.99  3.83  3.83  1.79  *****   3.50
  28.00      3.85      206.13   * 0.012  1.83  1.04  4.24  4.24  1.83  *****   3.85

PIPE NO.21:    62 LF - 24"CP    @  4.63%  OUTLET: 202.28  INLET: 205.15  INTYP: 5
JUNC NO.21:  OVERFLOW-EL: 215.70  BEND: 83 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00      2.14      207.29   * 0.012  1.35  0.71  1.95  1.95  1.35  *****   2.14
  16.00      2.38      207.53   * 0.012  1.45  0.76  2.13  2.13  1.45  *****   2.38
  18.00      2.67      207.82   * 0.012  1.53  0.81  2.35  2.35  1.53  *****   2.67
  20.00      3.00      208.15   * 0.012  1.61  0.86  2.60  2.60  1.61  *****   3.00
  22.00      3.36      208.51   * 0.012  1.68  0.91  2.87  2.87  1.68  *****   3.36
  24.00      3.75      208.90   * 0.012  1.74  0.95  3.17  3.17  1.74  *****   3.75
  26.00      4.17      209.32   * 0.012  1.79  1.00  3.50  3.50  1.79  *****   4.17
  28.00      4.63      209.78   * 0.012  1.83  1.04  3.85  3.85  1.83  *****   4.63

PIPE NO.22:  110 LF - 24"CP    @  0.95%  OUTLET: 205.15  INLET: 206.20  INTYP: 5
JUNC NO.22:  OVERFLOW-EL: 223.67  BEND: 49 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00      1.96      208.16   * 0.012  1.35  1.10  2.14  2.14  1.35  *****   1.96
  16.00      2.22      208.42   * 0.012  1.45  1.20  2.38  2.38  1.71   2.22   2.14
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 18.00    2.70     208.90  * 0.012  1.53  1.30  2.67  2.67  2.22   2.70   2.35
 20.00    3.28     209.48  * 0.012  1.61  1.40  3.00  3.00  2.68   3.28   2.59
 22.00    3.91     210.11  * 0.012  1.68  1.51  3.36  3.36  3.19   3.91   2.86
 24.00    4.61     210.81  * 0.012  1.74  1.65  3.75  3.75  3.75   4.61   3.15
 26.00    5.37     211.57  * 0.012  1.79  2.00  4.17  4.17  4.36   5.37   3.47
 28.00    6.19     212.39  * 0.012  1.83  2.00  4.63  4.63  5.02   6.19   3.81

PIPE NO.23:  127 LF - 24"CP   @  0.91%  OUTLET: 206.20  INLET: 207.35  INTYP: 5
JUNC NO.23:  OVERFLOW-EL: 225.47  BEND: 44 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
 14.00    1.94     209.29  * 0.012  1.35  1.12  1.96  1.96  1.35  *****   1.94
 16.00    2.11     209.46  * 0.012  1.45  1.22  2.22  2.22  1.45  *****   2.11
 18.00    2.69     210.04  * 0.012  1.53  1.32  2.70  2.70  2.24   2.69   2.32
 20.00    3.52     210.87  * 0.012  1.61  1.43  3.28  3.28  2.97   3.52   2.55
 22.00    4.46     211.81  * 0.012  1.68  1.55  3.91  3.91  3.79   4.46   2.81
 24.00    5.47     212.82  * 0.012  1.74  1.70  4.61  4.61  4.68   5.47   3.09
 26.00    6.58     213.93  * 0.012  1.79  2.00  5.37  5.37  5.65   6.58   3.39
 28.00    7.78     215.13  * 0.012  1.83  2.00  6.19  6.19  6.70   7.78   3.72

PIPE NO.24:  117 LF - 24"CP   @  0.91%  OUTLET: 207.35  INLET: 208.42  INTYP: 5
JUNC NO.24:  OVERFLOW-EL: 228.47  BEND: 22 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
 14.00    1.87     210.29  * 0.012  1.35  1.12  1.94  1.94  1.35  *****   1.87
 16.00    2.01     210.43  * 0.012  1.45  1.22  2.11  2.11  1.45  *****   2.01
 18.00    2.57     210.99  * 0.012  1.53  1.32  2.69  2.69  2.25   2.57   2.19
 20.00    3.63     212.05  * 0.012  1.61  1.43  3.52  3.52  3.23   3.63   2.40
 22.00    4.81     213.23  * 0.012  1.68  1.54  4.46  4.46  4.33   4.81   2.62
 24.00    6.10     214.52  * 0.012  1.74  1.69  5.47  5.47  5.53   6.10   2.86
 26.00    7.50     215.92  * 0.012  1.79  2.00  6.58  6.58  6.83   7.50   3.13
 28.00    9.01     217.43  * 0.012  1.83  2.00  7.78  7.78  8.24   9.01   3.42

PIPE NO.25:  138 LF - 24"CP   @  0.88%  OUTLET: 208.42  INLET: 209.63  INTYP: 5
JUNC NO.25:  OVERFLOW-EL: 231.67  BEND: 54 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
 14.00    1.99     211.62  * 0.012  1.35  1.13  1.87  1.87  1.35  *****   1.99
 16.00    2.17     211.80  * 0.012  1.45  1.23  2.01  2.01  1.45  *****   2.17
 18.00    2.63     212.26  * 0.012  1.53  1.34  2.57  2.57  2.11   2.63   2.40
 20.00    3.99     213.62  * 0.012  1.61  1.45  3.63  3.63  3.34   3.99   2.65
 22.00    5.49     215.12  * 0.012  1.68  1.57  4.81  4.81  4.71   5.49   2.92
 24.00    7.14     216.77  * 0.012  1.74  1.74  6.10  6.10  6.21   7.14   3.23
 26.00    8.94     218.57  * 0.012  1.79  2.00  7.50  7.50  7.84   8.94   3.55
 28.00   10.87     220.50  * 0.012  1.83  2.00  9.01  9.01  9.61  10.87   3.91

PIPE NO.26:  118 LF - 24"CP   @  0.89%  OUTLET: 209.63  INLET: 210.68  INTYP: 5
JUNC NO.26:  OVERFLOW-EL: 231.20  BEND: 20 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)   HW(FT)   HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
```

```
********************************************************************************
  14.00     1.86      212.54  * 0.012  1.35   1.13   1.99   1.99   1.35   *****   1.86
  16.00     2.00      212.68  * 0.012  1.45   1.23   2.17   2.17   1.45   *****   2.00
  18.00     2.54      213.22  * 0.012  1.53   1.33   2.63   2.63   2.23    2.54   2.18
  20.00     4.11      214.79  * 0.012  1.61   1.44   3.99   3.99   3.72    4.11   2.38
  22.00     5.86      216.54  * 0.012  1.68   1.56   5.49   5.49   5.40    5.86   2.60
  24.00     7.78      218.46  * 0.012  1.74   1.72   7.14   7.14   7.23    7.78   2.85
  26.00     9.87      220.55  * 0.012  1.79   2.00   8.94   8.94   9.22    9.87   3.11
  28.00    12.12      222.80  * 0.012  1.83   2.00  10.87  10.87  11.37   12.12   3.39


PIPE NO.27:  224 LF - 24"CP   @  0.92%  OUTLET: 210.68  INLET: 212.73  INTYP: 5
JUNC NO.27:  OVERFLOW-EL: 231.20  BEND: 12 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
********************************************************************************
  14.00     1.84      214.57  * 0.012  1.35   1.12   1.86   1.86   1.35   *****   1.84
  16.00     1.99      214.72  * 0.012  1.45   1.22   2.00   2.00   1.45   *****   1.99
  18.00     2.18      214.91  * 0.012  1.53   1.32   2.54   2.54   1.55    2.18   2.16
  20.00     3.90      216.63  * 0.012  1.61   1.43   4.11   4.11   3.55    3.90   2.35
  22.00     6.04      218.77  * 0.012  1.68   1.54   5.86   5.86   5.62    6.04   2.5
  24.00     8.39      221.12  * 0.012  1.74   1.69   7.78   7.78   7.88    8.39   2.80
  26.00    10.94      223.67  * 0.012  1.79   2.00   9.87   9.87  10.34   10.94   3.06
  28.00    13.69      226.42  * 0.012  1.83   2.00  12.12  12.12  12.99   13.69   3.33


PIPE NO.28:  302 LF - 24"CP   @  0.91%  OUTLET: 212.73  INLET: 215.49  INTYP: 5
JUNC NO.28:  OVERFLOW-EL: 231.17  BEND: 20 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00
```

Junction 28 is Manhole 367

```
 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
********************************************************************************
  14.00     1.86      217.35  * 0.012  1.35   1.12   1.84   1.84   1.35   *****   1.86
  16.00     2.00      217.49  * 0.012  1.45   1.22   1.99   1.99   1.45   *****   2.00
  18.00     2.18      217.67  * 0.012  1.53   1.32   2.18   2.18   1.53   *****   2.18
  20.00     3.54      219.03  * 0.012  1.61   1.43   3.90   3.90   3.16    3.54   2.38
  22.00     6.18      221.67  * 0.012  1.68   1.54   6.04   6.04   5.72    6.18   2.60
  24.00     9.08      224.57  * 0.012  1.74   1.69   8.39   8.39   8.52    9.08   2.85
  26.00    12.22      227.71  * 0.012  1.79   2.00  10.94  10.94  11.57   12.22   3.11
  28.00    15.62      231.11  * 0.012  1.83   2.00  13.69  13.69  14.87   15.62   3.39
```

This is downstream end of "Bypass downstream of S. 200th" section

```
PIPE NO.29:  185 LF - 24"CP   @  1.57%  OUTLET: 215.49  INLET: 218.40  INTYP: 5
JUNC NO.29:  OVERFLOW-EL: 226.87  BEND: 50 DEG    DIA/WIDTH: 4.5  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
********************************************************************************
  14.00     2.06      220.46  * 0.012  1.35   0.95   1.86   1.86   1.35   *****   2.06
  16.00     2.27      220.67  * 0.012  1.45   1.03   2.00   2.00   1.45   *****   2.27
  18.00     2.52      220.92  * 0.012  1.53   1.10   2.18   2.18   1.53   *****   2.52
  20.00     2.80      221.20  * 0.012  1.61   1.18   3.54   3.54   1.70    2.71   2.80
  22.00     5.75      224.15  * 0.012  1.68   1.26   6.18   6.18   4.77    5.75   3.11
  24.00     8.47      227.50  * 0.012  1.74   1.33   9.08   9.08   7.94    9.10   3.45
**************** OVERFLOW ENCOUNTERED AT  24.00 CFS DISCHARGE ****************
```

```
PIPE NO.30:  290 LF - 30"CP   @  0.44%  OUTLET: 218.40  INLET: 219.69  INTYP: 5
JUNC NO.30:  OVERFLOW-EL: 230.67  BEND:  4 DEG    DIA/WIDTH: 4.5  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.71     221.40  * 0.012  1.26  1.21  2.06  2.06  1.26  *****   1.71
  16.00     1.83     221.52  * 0.012  1.36  1.31  2.27  2.27  1.36  *****   1.83
  18.00     2.09     221.78  * 0.012  1.44  1.41  2.52  2.52  1.65   2.09   1.95
  20.00     2.29     221.98  * 0.012  1.52  1.51  2.80  2.80  2.02   2.29   2.06
  22.00     5.34     225.03  * 0.012  1.60  1.61  5.75  5.75  5.17   5.34   2.17
  24.00     8.22     227.91  * 0.012  1.67  1.71  8.47  8.47  8.03   8.22   2.28
  26.00     8.63     228.32  * 0.012  1.74  1.82  8.69  8.69  8.40   8.63   2.38
  28.00     8.96     228.65  * 0.012  1.81  1.94  8.83  8.83  8.69   8.96   2.47

PIPE NO.31:  335 LF - 30"CP   @  0.44%  OUTLET: 219.69  INLET: 221.16  INTYP: 5
JUNC NO.31:  OVERFLOW-EL: 233.67  BEND: 29 DEG    DIA/WIDTH: 4.5  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.73     222.89  * 0.012  1.26  1.22  1.71  1.71  1.26  *****   1.73
  16.00     1.86     223.02  * 0.012  1.36  1.32  1.83  1.83  1.36  *****   1.86
  18.00     1.99     223.15  * 0.012  1.44  1.42  2.09  2.09  1.44  *****   1.99
  20.00     2.27     223.43  * 0.012  1.52  1.52  2.29  2.29  1.52   2.27   2.11
  22.00     4.91     226.07  * 0.012  1.60  1.62  5.34  5.34  4.69   4.91   2.23
  24.00     7.99     229.15  * 0.012  1.67  1.72  8.22  8.22  7.73   7.99   2.34
  26.00     8.61     229.77  * 0.012  1.74  1.83  8.63  8.63  8.31   8.61   2.45
  28.00     9.17     230.33  * 0.012  1.81  1.95  8.96  8.96  8.82   9.17   2.56

PIPE NO.32:  235 LF - 30"CP   @  0.44%  OUTLET: 221.16  INLET: 222.20  INTYP: 5
JUNC NO.32:  OVERFLOW-EL: 239.67  BEND: 67 DEG    DIA/WIDTH: 5.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.80     224.00  * 0.012  1.26  1.22  1.73  1.73  1.26  *****   1.80
  16.00     1.96     224.16  * 0.012  1.36  1.32  1.86  1.86  1.36  *****   1.96
  18.00     2.11     224.31  * 0.012  1.44  1.41  1.99  1.99  1.44  *****   2.11
  20.00     2.39     224.59  * 0.012  1.52  1.51  2.27  2.27  1.60   2.39   2.26
  22.00     4.85     227.05  * 0.012  1.60  1.61  4.91  4.91  4.45   4.85   2.41
  24.00     8.11     230.31  * 0.012  1.67  1.71  7.99  7.99  7.64   8.11   2.55
  26.00     8.93     231.13  * 0.012  1.74  1.82  8.61  8.61  8.38   8.93   2.70
  28.00     9.71     231.91  * 0.012  1.81  1.94  9.17  9.17  9.06   9.71   2.85

PIPE NO.33:  275 LF - 30"CP   @  0.44%  OUTLET: 222.20  INLET: 223.41  INTYP: 5
JUNC NO.33:  OVERFLOW-EL: 234.67  BEND: 86 DEG    DIA/WIDTH: 5.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.86     225.27  * 0.012  1.26  1.22  1.80  1.80  1.26  *****   1.86
  16.00     2.03     225.44  * 0.012  1.36  1.32  1.96  1.96  1.36  *****   2.03
  18.00     2.20     225.61  * 0.012  1.44  1.42  2.11  2.11  1.44  *****   2.20
  20.00     2.50     225.91  * 0.012  1.52  1.51  2.39  2.39  1.63   2.50   2.37
  22.00     4.86     228.27  * 0.012  1.60  1.61  4.85  4.85  4.32   4.86   2.54
  24.00     8.34     231.75  * 0.012  1.67  1.72  8.11  8.11  7.70   8.34   2.72
  26.00     9.41     232.82  * 0.012  1.74  1.83  8.93  8.93  8.66   9.41   2.90
```

```
  28.00    10.46      233.87  * 0.012  1.81  1.95  9.71  9.71  9.59  10.46    3.08
```

```
PIPE NO.34:   200 LF - 30"CP   @  0.13%  OUTLET: 223.41  INLET: 223.67  INTYP: 5
JUNC NO.34:   OVERFLOW-EL: 238.17  BEND:   3 DEG     DIA/WIDTH: 6.0  Q-RATIO: 0.00
```

Junction 34 is Manhole 371

```
 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.85      225.52  * 0.012  1.26  1.81  1.86  1.86  1.85   1.85   1.53
  16.00     2.03      225.70  * 0.012  1.36  2.05  2.03  2.03  2.03   1.97   1.61
  18.00     2.23      225.90  * 0.012  1.44  2.50  2.20  2.20  2.23   2.09   1.66
  20.00     2.65      226.32  * 0.012  1.52  2.50  2.50  2.50  2.65   2.43   1.71
  22.00     5.09      228.76  * 0.012  1.60  2.50  4.86  4.86  5.09   4.82   1.74
  24.00     8.67      232.34  * 0.012  1.67  2.50  8.34  8.34  8.67   8.34   1.76
  26.00     9.84      233.51  * 0.012  1.74  2.50  9.41  9.41  9.84   9.46   1.77
  28.00    11.00      234.67  * 0.012  1.81  2.50 10.46 10.46 11.00  10.56   1.77
```

This is upstream end of "Bypass downstream of S. 200th" section

```
PIPE NO.35:   324 LF - 24"CP   @  1.85%  OUTLET: 223.67  INLET: 229.67  INTYP: 5
JUNC NO.35:   OVERFLOW-EL: 244.17  BEND:   7 DEG     DIA/WIDTH: 6.0  Q-RATIO: 0.00
```

Junction 35 is Manhole 372

```
 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.83      231.50  * 0.012  1.35  0.91  1.85  1.85  1.35  *****   1.83
  16.00     1.97      231.64  * 0.012  1.45  0.98  2.03  2.03  1.45  *****   1.97
  18.00     2.14      231.81  * 0.012  1.53  1.05  2.23  2.23  1.53  *****   2.14
  20.00     2.33      232.00  * 0.012  1.61  1.12  2.65  2.65  1.61  *****   2.33
  22.00     2.54      232.21  * 0.012  1.68  1.19  5.09  5.09  1.68  *****   2.54
  24.00     6.27      235.94  * 0.012  1.74  1.26  8.67  8.67  5.78   6.27   2.77
  26.00     8.06      237.73  * 0.012  1.79  1.33  9.84  9.84  7.49   8.06   3.03
  28.00     9.89      239.56  * 0.012  1.83  1.41 11.00 11.00  9.23   9.89   3.30
```

```
PIPE NO.36:   400 LF - 24"CP   @  1.56%  OUTLET: 229.67  INLET: 235.90  INTYP: 5
JUNC NO.36:   OVERFLOW-EL: 245.00  BEND: 26 DEG      DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 36 is new manhole at south end of golf course

```
 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     1.87      237.77  * 0.012  1.35  0.95  1.83  1.83  1.35  *****   1.87
  16.00     2.02      237.92  * 0.012  1.45  1.03  1.97  1.97  1.45  *****   2.02
  18.00     2.21      238.11  * 0.012  1.53  1.11  2.14  2.14  1.53  *****   2.21
  20.00     2.41      238.31  * 0.012  1.61  1.18  2.33  2.33  1.61  *****   2.41
  22.00     2.64      238.54  * 0.012  1.68  1.26  2.54  2.54  1.68  *****   2.64
  24.00     4.49      240.39  * 0.012  1.74  1.34  6.27  6.27  3.88   4.49   2.89
  26.00     7.05      242.95  * 0.012  1.79  1.42  8.06  8.06  6.33   7.05   3.17
  28.00     9.10      245.61  * 0.012  1.83  1.51  9.89  9.89  8.89   9.71   3.46
```

Below this point are the new pipes on the golf course

```
PIPE NO.37:    30 LF - 24"CP   @  0.83%  OUTLET: 236.00  INLET: 236.25  INTYP: 5
JUNC NO.37:   OVERFLOW-EL: 246.00  BEND: 40 DEG      DIA/WIDTH: 4.0  Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00     2.01      238.26  * 0.012  1.35  1.15  1.77  1.77  1.50   2.01   1.92
```

```
    16.00       2.17        238.42   * 0.012   1.45   1.26   1.92   1.92   1.72    2.17    2.09
    18.00       2.44        238.69   * 0.012   1.53   1.36   2.11   2.11   2.02    2.44    2.29
    20.00       2.78        239.03   * 0.012   1.61   1.48   2.31   2.31   2.26    2.78    2.52
    22.00       3.16        239.41   * 0.012   1.68   1.61   2.54   2.54   2.54    3.16    2.76
    24.00       5.17        241.42   * 0.012   1.74   1.84   4.39   4.39   4.43    5.17    3.04
    26.00       7.91        244.16   * 0.012   1.79   2.00   6.95   6.95   7.04    7.91    3.33
    28.00       9.75        246.40   * 0.012   1.83   2.00   9.00   9.00   9.14   10.15    3.65

PIPE NO.38:  320 LF - 24"CP   @  0.84%  OUTLET: 236.25  INLET: 238.95  INTYP: 5
JUNC NO.38:  OVERFLOW-EL: 250.00  BEND:  0 DEG     DIA/WIDTH: 4.0  Q-RATIO: 0.00

  Q(CFS)    HW(FT)     HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
*******************************************************************************************
   14.00      1.83      240.78   * 0.012   1.35   1.15   2.01   2.01   1.35   *****    1.83
   16.00      1.97      240.92   * 0.012   1.45   1.25   2.17   2.17   1.45   *****    1.97
   18.00      2.14      241.09   * 0.012   1.53   1.36   2.44   2.44   1.53   *****    2.14
   20.00      2.55      241.50   * 0.012   1.61   1.47   2.78   2.78   2.22    2.55    2.33
   22.00      3.44      242.39   * 0.012   1.68   1.60   3.16   3.16   3.04    3.44    2.54
   24.00      6.01      244.96   * 0.012   1.74   1.81   5.17   5.17   5.54    6.01    2.77
   26.00      9.36      248.31   * 0.012   1.79   2.00   7.91   7.91   8.81    9.36    3.01
   28.00     11.05      250.82   * 0.012   1.83   2.00   9.75   9.75  11.23   11.87    3.28

PIPE NO.39:  320 LF - 24"CP   @  0.84%  OUTLET: 238.95  INLET: 241.65  INTYP: 5
JUNC NO.39:  OVERFLOW-EL: 252.00  BEND: 30 DEG     DIA/WIDTH: 4.5  Q-RATIO: 0.00

  Q(CFS)    HW(FT)     HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
*******************************************************************************************
   14.00      2.03      243.68   * 0.012   1.35   1.15   1.83   1.83   1.35   *****    2.03
   16.00      2.23      243.88   * 0.012   1.45   1.25   1.97   1.97   1.45   *****    2.23
   18.00      2.47      244.12   * 0.012   1.53   1.36   2.14   2.14   1.53   *****    2.47
   20.00      2.74      244.39   * 0.012   1.61   1.47   2.55   2.55   1.78    2.65    2.74
   22.00      4.22      245.87   * 0.012   1.68   1.60   3.44   3.44   3.32    4.22    3.04
   24.00      7.45      249.10   * 0.012   1.74   1.81   6.01   6.01   6.38    7.45    3.36
   26.00     10.35      253.17   * 0.012   1.79   2.00   9.36   9.36  10.27   11.52    3.71
**************** OVERFLOW ENCOUNTERED AT   26.00 CFS DISCHARGE ****************

PIPE NO.40:  256 LF - 30"CP   @  0.19%  OUTLET: 241.65  INLET: 242.13  INTYP: 5
JUNC NO.40:  OVERFLOW-EL: 252.00  BEND:  0 DEG     DIA/WIDTH: 4.5  Q-RATIO: 0.00

  Q(CFS)    HW(FT)     HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO     HWI
*******************************************************************************************
   14.00      2.00      244.13   * 0.012   1.26   1.59   2.03   2.03   1.81    2.00    1.71
   16.00      2.20      244.33   * 0.012   1.36   1.75   2.23   2.23   2.04    2.20    1.83
   18.00      2.48      244.61   * 0.012   1.44   1.92   2.47   2.47   2.36    2.48    1.95
   20.00      2.91      245.04   * 0.012   1.52   2.16   2.74   2.74   2.78    2.91    2.06
   22.00      4.53      246.66   * 0.012   1.60   2.50   4.22   4.22   4.36    4.53    2.17
   24.00      7.91      250.04   * 0.012   1.67   2.50   7.45   7.45   7.71    7.91    2.28
   26.00      9.87      253.10   * 0.012   1.74   2.50  10.35  10.35  10.75   10.97    2.38
**************** OVERFLOW ENCOUNTERED AT   26.00 CFS DISCHARGE ****************

PIPE NO.41:  230 LF - 30"CP   @  0.19%  OUTLET: 242.13  INLET: 242.56  INTYP: 5
JUNC NO.41:  OVERFLOW-EL: 255.00  BEND:  0 DEG     DIA/WIDTH: 4.5  Q-RATIO: 0.00
```

```
 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC      DN      TW      DO      DE      HWO      HWI
*****************************************************************************************
  14.00     2.00      244.56  * 0.012   1.26    1.59    2.00    2.00    1.81    2.00     1.71
  16.00     2.20      244.76  * 0.012   1.36    1.75    2.20    2.20    2.03    2.20     1.83
  18.00     2.51      245.07  * 0.012   1.44    1.93    2.48    2.48    2.39    2.51     1.95
  20.00     3.08      245.64  * 0.012   1.52    2.16    2.91    2.91    2.95    3.08     2.06
  22.00     4.82      247.38  * 0.012   1.60    2.50    4.53    4.53    4.66    4.82     2.17
  24.00     8.34      250.90  * 0.012   1.67    2.50    7.91    7.91    8.15    8.34     2.28
  26.00    10.45      253.01  * 0.012   1.74    2.50    9.87    9.87   10.23   10.45     2.38
  28.00    10.84      253.40  * 0.012   1.81    2.50   10.09   10.09   10.58   10.84     2.47

PIPE NO.42:   250 LF - 30"CP    @  0.19%  OUTLET: 242.56   INLET: 243.03   INTYP: 5
JUNC NO.42:   OVERFLOW-EL: 252.00   BEND: 17 DEG       DIA/WIDTH: 4.5   Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC      DN      TW      DO      DE      HWO      HWI
*****************************************************************************************
  14.00     2.00      245.03  * 0.012   1.26    1.59    2.00    2.00    1.79    2.00     1.72
  16.00     2.19      245.22  * 0.012   1.36    1.74    2.20    2.20    2.01    2.19     1.85
  18.00     2.55      245.58  * 0.012   1.44    1.92    2.51    2.51    2.42    2.55     1.97
  20.00     3.27      246.30  * 0.012   1.52    2.15    3.08    3.08    3.12    3.27     2.09
  22.00     5.15      248.18  * 0.012   1.60    2.50    4.82    4.82    4.97    5.15     2.19
  24.00     8.82      251.85  * 0.012   1.67    2.50    8.34    8.34    8.60    8.82     2.30
  26.00     8.97      254.13  * 0.012   1.74    2.50   10.45   10.45   10.84   11.10     2.41
**************** OVERFLOW ENCOUNTERED AT   26.00 CFS DISCHARGE *****************

PIPE NO.43:   258 LF - 30"CP    @  0.19%  OUTLET: 243.03   INLET: 243.51   INTYP: 5
JUNC NO.43:   OVERFLOW-EL: 250.00   BEND:  0 DEG       DIA/WIDTH: 4.5   Q-RATIO: 0.00

 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC      DN      TW      DO      DE      HWO      HWI
*****************************************************************************************
  14.00     1.99      245.50  * 0.012   1.26    1.59    2.00    2.00    1.79    1.99     1.71
  16.00     2.18      245.69  * 0.012   1.36    1.75    2.19    2.19    2.01    2.18     1.83
  18.00     2.59      246.10  * 0.012   1.44    1.93    2.55    2.55    2.48    2.59     1.95
  20.00     3.45      246.96  * 0.012   1.52    2.17    3.27    3.27    3.32    3.45     2.06
  22.00     5.47      248.98  * 0.012   1.60    2.50    5.15    5.15    5.30    5.47     2.17
  24.00     6.49      252.80  * 0.012   1.67    2.50    8.82    8.82    9.09    9.29     2.28
**************** OVERFLOW ENCOUNTERED AT   24.00 CFS DISCHARGE *****************

PIPE NO.44:   262 LF - 30"CP    @  0.19%  OUTLET: 243.51   INLET: 244.00   INTYP: 5
```

These results are at the bypass pipeline inlet at Northwest Ponds

```
 Q(CFS)    HW(FT)    HW ELEV. * N-FAC    DC      DN      TW      DO      DE      HWO      HWI
*****************************************************************************************
  14.00     2.10      246.10  * 0.012   1.26    1.59    1.99    1.99    1.77    2.10     1.83
  16.00     2.34      246.34  * 0.012   1.36    1.75    2.18    2.18    2.00    2.34     2.00
  18.00     2.84      246.84  * 0.012   1.44    1.92    2.59    2.59    2.53    2.84     2.16
  20.00     3.88      247.88  * 0.012   1.52    2.16    3.45    3.45    3.49    3.88     2.32
  22.00     6.09      250.09  * 0.012   1.60    2.50    5.47    5.47    5.62    6.09     2.48
  24.00     7.32      251.32  * 0.012   1.67    2.50    6.49    6.49    6.76    7.32     2.64
  26.00     7.77      251.77  * 0.012   1.74    2.50    6.71    6.71    7.12    7.77     2.80
  28.00     8.15      252.15  * 0.012   1.81    2.50    6.85    6.85    7.40    8.15     2.97
```

Hydraulic modeling of bypass pipeline
"Alternative 2 - Bypass from Tyee Pond"

```
BACKWATER COMPUTER PROGRAM FOR PIPES
     Pipe data from file:tyeebyp4.bwp

          Discharge Range:14. to 28. Step of 2. [cfs]
       Overflow Elevation:276.  Feet (At Tyee Pond)
       Broad Crested Weir: Length:50. feet, Height:0.1 feet
        Upstream Velocity:0.1 feet/sec
```

Results for Pipes 1-34 were not included, because they are identical to the model included for Alternative 1.

```
PIPE NO.35:  324 LF - 24"CP   @  1.85%  OUTLET: 223.67  INLET: 229.67  INTYP: 5
JUNC NO.35:  OVERFLOW-EL: 244.17  BEND:  7 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00
```

Junction 35 is MH 372 on the south side of S. 200th St

```
 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
*********************************************************************************
  14.00     1.83      231.50   * 0.012  1.35   0.91   1.85   1.85   1.35   *****   1.83
  16.00     1.97      231.64   * 0.012  1.45   0.98   2.03   2.03   1.45   *****   1.97
  18.00     2.14      231.81   * 0.012  1.53   1.05   2.23   2.23   1.53   *****   2.14
  20.00     2.33      232.00   * 0.012  1.61   1.12   2.65   2.65   1.61   *****   2.33
  22.00     2.54      232.21   * 0.012  1.68   1.19   5.09   5.09   1.68   *****   2.54
  24.00     6.27      235.94   * 0.012  1.74   1.26   8.67   8.67   5.78    6.27   2.77
  26.00     8.06      237.73   * 0.012  1.79   1.33   9.84   9.84   7.49    8.06   3.03
  28.00     9.89      239.56   * 0.012  1.83   1.41  11.00  11.00   9.23    9.89   3.30
```

```
PIPE NO.36:  400 LF - 24"CP   @  1.56%  OUTLET: 229.67  INLET: 235.90  INTYP: 5
JUNC NO.36:  OVERFLOW-EL: 244.00  BEND: 49 DEG    DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 36 is new manhole at the south end of the golf course (CB6)

```
 Q(CFS)    HW(FT)    HW ELEV.  * N-FAC    DC     DN     TW     DO     DE     HWO    HWI
*********************************************************************************
  14.00     2.06      237.96   * 0.012  1.35   0.95   1.83   1.83   1.35   *****   2.06
  16.00     2.27      238.17   * 0.012  1.45   1.03   1.97   1.97   1.45   *****   2.27
  18.00     2.52      238.42   * 0.012  1.53   1.11   2.14   2.14   1.53   *****   2.52
  20.00     2.79      238.69   * 0.012  1.61   1.18   2.33   2.33   1.61   *****   2.79
  22.00     3.10      239.00   * 0.012  1.68   1.26   2.54   2.54   1.68   *****   3.10
  24.00     5.04      240.94   * 0.012  1.74   1.34   6.27   6.27   3.88    5.04   3.44
  26.00     7.69      243.59   * 0.012  1.79   1.42   8.06   8.06   6.33    7.69   3.81
  28.00     8.10      246.36   * 0.012  1.83   1.51   9.89   9.89   8.89   10.46   4.21
```

```
PIPE NO.37:    50 LF - 30"CP   @  0.30%  OUTLET: 236.00  INLET: 236.15  INTYP: 5
JUNC NO.37:  OVERFLOW-EL: 244.00  BEND: 45 DEG    DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 37 is CB5

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC   DC     DN     TW     DO     DE     HWO    HWI
***********************************************************************************
  14.00     2.07       238.22   * 0.012  1.26   1.36   1.96   1.96   1.85   2.07   1.75
  16.00     2.28       238.43   * 0.012  1.36   1.48   2.17   2.17   2.06   2.28   1.89
  18.00     2.54       238.69   * 0.012  1.44   1.60   2.42   2.42   2.33   2.54   2.03
  20.00     2.88       239.03   * 0.012  1.52   1.73   2.69   2.69   2.65   2.88   2.16
  22.00     3.25       239.40   * 0.012  1.60   1.87   3.00   3.00   2.98   3.25   2.29
  24.00     5.26       241.41   * 0.012  1.67   2.02   4.94   4.94   4.93   5.26   2.41
  26.00     7.85       244.15   * 0.012  1.74   2.27   7.59   7.59   7.61   8.00   2.54
**************** OVERFLOW ENCOUNTERED AT  26.00 CFS DISCHARGE *****************
```

```
PIPE NO.38:  225 LF - 30"CP   @  0.30%  OUTLET: 236.15  INLET: 236.82  INTYP: 5
JUNC NO.38:  OVERFLOW-EL: 247.00  BEND: 10 DEG    DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 38 is CB4

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC   DC     DN     TW     DO     DE     HWO    HWI
***********************************************************************************
  14.00     1.90       238.72   * 0.012  1.26   1.37   2.07   2.07   1.61   1.90   1.71
  16.00     2.08       238.90   * 0.012  1.36   1.49   2.28   2.28   1.84   2.08   1.84
  18.00     2.35       239.17   * 0.012  1.44   1.61   2.54   2.54   2.19   2.35   1.96
  20.00     2.81       239.63   * 0.012  1.52   1.74   2.88   2.88   2.67   2.81   2.07
  22.00     3.31       240.13   * 0.012  1.60   1.87   3.25   3.25   3.14   3.31   2.18
  24.00     5.45       242.27   * 0.012  1.67   2.03   5.26   5.26   5.25   5.45   2.29
  26.00     8.19       245.01   * 0.012  1.74   2.30   7.85   7.85   7.95   8.19   2.39
  28.00     8.58       245.40   * 0.012  1.81   2.50   8.07   8.07   8.30   8.58   2.49
```

```
PIPE NO.39:  300 LF - 30"CP   @  0.30%  OUTLET: 236.82  INLET: 237.72  INTYP: 5
JUNC NO.39:  OVERFLOW-EL: 250.00  BEND:  0 DEG    DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 39 is CB3

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC   DC     DN     TW     DO     DE     HWO    HWI
***********************************************************************************
  14.00     1.85       239.57   * 0.012  1.26   1.36   1.90   1.90   1.40   1.85   1.71
  16.00     1.98       239.70   * 0.012  1.36   1.48   2.08   2.08   1.58   1.98   1.83
  18.00     2.15       239.87   * 0.012  1.44   1.60   2.35   2.35   1.87   2.15   1.95
  20.00     2.65       240.37   * 0.012  1.52   1.73   2.81   2.81   2.52   2.65   2.06
  22.00     3.30       241.02   * 0.012  1.60   1.87   3.31   3.31   3.14   3.30   2.17
  24.00     5.62       243.34   * 0.012  1.67   2.02   5.45   5.45   5.43   5.62   2.27
  26.00     8.54       246.26   * 0.012  1.74   2.27   8.19   8.19   8.32   8.54   2.37
  28.00     9.13       246.85   * 0.012  1.81   2.50   8.58   8.58   8.87   9.13   2.47
```

```
PIPE NO.40:  200 LF - 30"CP   @  0.30%  OUTLET: 237.72  INLET: 238.32  INTYP: 5
JUNC NO.40:  OVERFLOW-EL: 250.00  BEND: 41 DEG    DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 40 is CB2

```
 Q(CFS)   HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00    1.77     240.09   * 0.012  1.26  1.36  1.85  1.85  1.47   1.77   1.63
  16.00    1.88     240.20   * 0.012  1.36  1.48  1.98  1.98  1.63   1.88   1.73
  18.00    2.00     240.32   * 0.012  1.44  1.60  2.15  2.15  1.83   2.00   1.82
  20.00    2.44     240.76   * 0.012  1.52  1.73  2.65  2.65  2.44   2.41   1.90
  22.00    3.20     241.52   * 0.012  1.60  1.87  3.30  3.30  3.20   3.16   1.97
  24.00    5.60     243.92   * 0.012  1.67  2.02  5.62  5.62  5.60   5.56   2.03
  26.00    8.63     246.95   * 0.012  1.74  2.27  8.54  8.54  8.63   8.57   2.09
  28.00    9.32     247.64   * 0.012  1.81  2.50  9.13  9.13  9.32   9.26   2.14
```

```
PIPE NO.41:  100 LF - 24"CP   @  0.30%  OUTLET: 238.32  INLET: 238.62  INTYP: 5
JUNC NO.41:  OVERFLOW-EL: 252.00  BEND:  6 DEG    DIA/WIDTH: 8.0  Q-RATIO: 0.00
```

Junction 41 is the 96" structure near the creek

```
 Q(CFS)   HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00    2.29     240.91   * 0.012  1.35  1.73  1.77  1.77  1.77   2.29   2.14
  16.00    2.58     241.20   * 0.012  1.45  2.00  1.88  1.88  1.98   2.58   2.36
  18.00    3.00     241.62   * 0.012  1.53  2.00  2.00  2.00  2.24   3.00   2.64
  20.00    3.74     242.36   * 0.012  1.61  2.00  2.44  2.44  2.81   3.74   2.94
  22.00    4.84     243.46   * 0.012  1.68  2.00  3.20  3.20  3.71   4.84   3.28
  24.00    7.61     246.23   * 0.012  1.74  2.00  5.60  5.60  6.26   7.61   3.65
  26.00   11.04     249.66   * 0.012  1.79  2.00  8.63  8.63  9.45  11.04   4.05
  28.00   12.17     250.79   * 0.012  1.83  2.00  9.32  9.32 10.33  12.17   4.48
```

```
PIPE NO.42:  460 LF - 72"CP   @  3.40%  OUTLET: 243.18  INLET: 258.80  INTYP: 5
```

(The size of the pipe leaving Tyee Pond needs to be checked. Survey shows it is 72". But it doesn't affect the sizing of the downstream pipes. It does affect the headwater results below.)

```
 Q(CFS)   HW(FT)    HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*******************************************************************************
  14.00    1.22     260.02   * 0.012  0.98  0.54  0.00  0.54  0.98  *****   1.22
  16.00    1.31     260.11   * 0.012  1.05  0.58  0.00  0.58  1.05  *****   1.31
  18.00    1.40     260.20   * 0.012  1.12  0.61  0.00  0.61  1.12  *****   1.40
  20.00    1.49     260.29   * 0.012  1.18  0.64  0.00  0.64  1.18  *****   1.49
  22.00    1.57     260.37   * 0.012  1.24  0.67  0.28  0.67  1.24  *****   1.57
  24.00    1.64     260.44   * 0.012  1.29  0.70  3.05  3.05  1.29  *****   1.64
  26.00    1.72     260.52   * 0.012  1.35  0.73  6.48  6.48  1.35  *****   1.72
  28.00    1.79     260.59   * 0.012  1.40  0.75  7.61  7.61  1.40  *****   1.79
```

Hydraulic modeling of bypass pipeline
"Alternative 3 - Bypass from Approach Light Road"

```
BACKWATER COMPUTER PROGRAM FOR PIPES
     Pipe data from file:approach.bwp

          Discharge Range:14. to 28. Step of 2. [cfs]
       Overflow Elevation:255.  Feet (Berm B at Approach Light Road)
       Broad Crested Weir: Length:110. feet, Height:0.1 feet
        Upstream Velocity:0.1 feet/sec
```

Results for Pipes 1-34 were not included, because they are identical to the model included for Alternative 1.

```
PIPE NO.35:   324 LF - 24"CP   @  1.85%  OUTLET: 223.67  INLET: 229.67  INTYP: 5
JUNC NO.35:   OVERFLOW-EL: 244.17  BEND:  7 DEG    DIA/WIDTH: 6.0  Q-RATIO: 0.00
```

Junction 35 is MH 372 on the south side of S. 200th St

```
 Q(CFS)   HW(FT)    HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO     HWI
**************************************************************************************
  14.00    1.83     231.50   * 0.012  1.35   0.91   1.85   1.85   1.35   *****   1.83
  16.00    1.97     231.64   * 0.012  1.45   0.98   2.03   2.03   1.45   *****   1.97
  18.00    2.14     231.81   * 0.012  1.53   1.05   2.23   2.23   1.53   *****   2.14
  20.00    2.33     232.00   * 0.012  1.61   1.12   2.65   2.65   1.61   *****   2.33
  22.00    2.54     232.21   * 0.012  1.68   1.19   5.09   5.09   1.68   *****   2.54
  24.00    6.27     235.94   * 0.012  1.74   1.26   8.67   8.67   5.78    6.27   2.77
  26.00    8.06     237.73   * 0.012  1.79   1.33   9.84   9.84   7.49    8.06   3.03
  28.00    9.89     239.56   * 0.012  1.83   1.41  11.00  11.00   9.23    9.89   3.30
```

```
PIPE NO.36:   400 LF - 24"CP   @  1.56%  OUTLET: 229.67  INLET: 235.90  INTYP: 5
JUNC NO.36:   OVERFLOW-EL: 244.00  BEND: 26 DEG    DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 36 is new manhole at the south end of the golf course (CB5)

```
 Q(CFS)   HW(FT)    HW ELEV. * N-FAC   DC     DN     TW     DO     DE     HWO     HWI
**************************************************************************************
  14.00    1.87     237.77   * 0.012  1.35   0.95   1.83   1.83   1.35   *****   1.87
  16.00    2.02     237.92   * 0.012  1.45   1.03   1.97   1.97   1.45   *****   2.02
  18.00    2.21     238.11   * 0.012  1.53   1.11   2.14   2.14   1.53   *****   2.21
  20.00    2.41     238.31   * 0.012  1.61   1.18   2.33   2.33   1.61   *****   2.41
  22.00    2.64     238.54   * 0.012  1.68   1.26   2.54   2.54   1.68   *****   2.64
  24.00    4.49     240.39   * 0.012  1.74   1.34   6.27   6.27   3.88    4.49   2.89
  26.00    7.05     242.95   * 0.012  1.79   1.42   8.06   8.06   6.33    7.05   3.17
  28.00    8.10     245.61   * 0.012  1.83   1.51   9.89   9.89   8.89    9.71   3.46
```

```
PIPE NO.37:    30 LF - 24"CP   @  0.60%  OUTLET: 236.00  INLET: 236.18  INTYP: 5
JUNC NO.37:  OVERFLOW-EL: 244.00  BEND: 40 DEG      DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 37 is CB4

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC    DC      DN      TW      DO      DE     HWO     HWI
**********************************************************************************************
  14.00     2.03       238.21   * 0.012   1.35    1.28    1.77    1.77    1.64    2.03    1.93
  16.00     2.21       238.39   * 0.012   1.45    1.41    1.92    1.92    1.83    2.21    2.09
  18.00     2.51       238.69   * 0.012   1.53    1.56    2.11    2.11    2.09    2.51    2.29
  20.00     2.85       239.03   * 0.012   1.61    1.76    2.31    2.31    2.33    2.85    2.52
  22.00     3.23       239.41   * 0.012   1.68    2.00    2.54    2.54    2.61    3.23    2.77
  24.00     5.24       241.42   * 0.012   1.74    2.00    4.39    4.39    4.50    5.24    3.04
  26.00     7.82       244.16   * 0.012   1.79    2.00    6.95    6.95    7.11    7.98    3.34
**************** OVERFLOW ENCOUNTERED AT  26.00 CFS DISCHARGE *****************
```

```
PIPE NO.38:  320 LF - 24"CP   @  0.59%  OUTLET: 236.18  INLET: 238.08  INTYP: 5
JUNC NO.38:  OVERFLOW-EL: 250.00  BEND:  0 DEG      DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 38 is CB3

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC    DC      DN      TW      DO      DE     HWO     HWI
**********************************************************************************************
  14.00     1.83       239.91   * 0.012   1.35    1.29    2.03    2.03    1.35   *****    1.83
  16.00     2.03       240.11   * 0.012   1.45    1.42    2.21    2.21    1.58    2.03    1.97
  18.00     2.61       240.69   * 0.012   1.53    1.57    2.51    2.51    2.34    2.61    2.14
  20.00     3.41       241.49   * 0.012   1.61    1.78    2.85    2.85    3.08    3.41    2.33
  22.00     4.31       242.39   * 0.012   1.68    2.00    3.23    3.23    3.91    4.31    2.54
  24.00     6.88       244.96   * 0.012   1.74    2.00    5.24    5.24    6.41    6.88    2.77
  26.00    10.08       248.16   * 0.012   1.79    2.00    7.82    7.82    9.52   10.08    3.02
  28.00    10.96       249.04   * 0.012   1.83    2.00    8.04    8.04   10.32   10.96    3.29
```

```
PIPE NO.39:  320 LF - 24"CP   @  0.59%  OUTLET: 238.08  INLET: 239.97  INTYP: 5
JUNC NO.39:  OVERFLOW-EL: 252.00  BEND:  4 DEG      DIA/WIDTH: 4.0  Q-RATIO: 0.00
```

Junction 39 is CB2

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC    DC      DN      TW      DO      DE     HWO     HWI
**********************************************************************************************
  14.00     1.84       241.81   * 0.012   1.35    1.29    1.83    1.83    1.35   *****    1.84
  16.00     1.98       241.95   * 0.012   1.45    1.42    2.03    2.03    1.45   *****    1.98
  18.00     2.72       242.69   * 0.012   1.53    1.57    2.61    2.61    2.45    2.72    2.15
  20.00     3.99       243.96   * 0.012   1.61    1.79    3.41    3.41    3.65    3.99    2.34
  22.00     5.40       245.37   * 0.012   1.68    2.00    4.31    4.31    4.99    5.40    2.55
  24.00     8.54       248.51   * 0.012   1.74    2.00    6.88    6.88    8.06    8.54    2.78
  26.00    12.03       252.32   * 0.012   1.79    2.00   10.08   10.08   11.79   12.35    3.03
**************** OVERFLOW ENCOUNTERED AT  26.00 CFS DISCHARGE *****************
```

```
PIPE NO.40:  246 LF - 24"CP   @  0.59%  OUTLET: 239.97  INLET: 241.42  INTYP: 5
JUNC NO.40:  OVERFLOW-EL: 252.50  BEND: 43 DEG    DIA/WIDTH: 4.5  Q-RATIO: 0.00
```

Junction 40 is CB1

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*********************************************************************************
  14.00     2.06      243.48  * 0.012  1.35  1.29  1.84  1.84  1.35  *****   2.06
  16.00     2.26      243.68  * 0.012  1.45  1.42  1.98  1.98  1.45  *****   2.26
  18.00     3.23      244.65  * 0.012  1.53  1.57  2.72  2.72  2.60   3.23   2.51
  20.00     4.96      246.38  * 0.012  1.61  1.79  3.99  3.99  4.17   4.96   2.78
  22.00     6.88      248.30  * 0.012  1.68  2.00  5.40  5.40  5.93   6.88   3.09
  24.00    10.58      252.00  * 0.012  1.74  2.00  8.54  8.54  9.45  10.58   3.42
  26.00    11.08      256.09  * 0.012  1.79  2.00 12.03 12.03 13.35  14.67   3.78
**************** OVERFLOW ENCOUNTERED AT  26.00 CFS DISCHARGE *****************
```

```
PIPE NO.41:  222 LF - 30"CP   @  0.26%  OUTLET: 241.42  INLET: 242.00  INTYP: 5
```

These results are at the bypass pipeline inlet at Northwest Ponds

```
 Q(CFS)    HW(FT)     HW ELEV.  * N-FAC   DC    DN    TW    DO    DE    HWO    HWI
*********************************************************************************
  14.00     2.05      244.05  * 0.012  1.26  1.42  2.06  2.06  1.68   2.05   1.83
  16.00     2.28      244.28  * 0.012  1.36  1.55  2.26  2.26  1.92   2.28   2.00
  18.00     3.33      245.33  * 0.012  1.44  1.68  3.23  3.23  3.02   3.33   2.16
  20.00     5.21      247.21  * 0.012  1.52  1.83  4.96  4.96  4.83   5.21   2.32
  22.00     7.31      249.31  * 0.012  1.60  1.99  6.88  6.88  6.84   7.31   2.48
  24.00    11.20      253.20  * 0.012  1.67  2.21 10.58 10.58 10.64  11.20   2.64
  26.00    11.91      253.91  * 0.012  1.74  2.50 11.08 11.08 11.26  11.91   2.80
  28.00    12.36      254.36  * 0.012  1.81  2.50 11.30 11.30 11.61  12.36   2.97
```

Appendix G

DES MOINES CREEK REGIONAL CIP
PRELIMINARY DESIGN REPORT

Appendix G
Geotechnical Studies

King County Wastewater Treatment Division

Geotechnical Report of Preliminary Investigations - Des Moines Regional Detention Facility

January 4, 1999

Our File: K46.1

SITKA CORP.

SITKA CORP

January 4, 1999

Our File: K46.1

Mr. Don Althauser, P.E.
King County Wastewater Treatment Division
Department of Natural Resources
700 Fifth Avenue, Suite 2200
Seattle, WA 98104

Re: Geotechnical Report of Preliminary Investigations - Des Moines Regional Detention Facility

Dear Mr. Althauser:

We are pleased to submit 7 copies of our report entitled Geotechnical Report of Preliminary Investigations - Des Moines Regional Detention Facility, dated January 4, 1999.

Please contact us if we can serve you further.

Sincerely,
SITKA CORP

Reid Carscadden

Reid Carscadden, P.E.
Project Engineer

REID M. CARSCADDEN
EXPIRES 4/14/99

Enclosure: Geotechnical Report of Preliminary Investigations - Des Moines Regional Detention Facility, dated January 4, 1999.

9436 NE 129th Place
Kirkland, WA, USA 98034
Tel (425) 820-7791
Fax (425) 823-5476

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1. INTRODUCTION

This report presents the findings of a geotechnical investigation carried out in support of the Des Moines Regional Retention/Detention Facility project. The purpose of the investigation was to conduct a preliminary assessment of the foundation conditions at proposed locations for two stormwater retention/detention berms.

The investigation was carried out under the direction of Don Althauser of the King County Wastewater Treatment Division. Sitka Corp was retained to provide geotechnical consultation for the investigation, as outlined in King County's Request for Services, dated September 29, 1998. These services included guidance to King County in setting out the investigation plan and interpretation of the results.

2. PROJECT AND SITE DESCRIPTION

The site is located between Sea-Tac's runway 34R and South 200th Street. The proposed detention area lies within the boundaries of the Tyee Golf Course (see Figure 1).

The project involves construction of two earth berms for the purpose of temporary stormwater retention/detention within the west fork of the Des Moines Creek drainage basin. The berms will be constructed to a maximum height of approximately 6 feet and will extend 700 to 900 feet across the valley bottom.

The western berm will be constructed near the outlet of the Northwest Ponds, located to the northeast of S. 196th Street. Two alternative sites have been identified for this berm (Berms 1 and 2). The east berm will be constructed along Approach Light Road (Berm 3).

The site topography is relatively level across the valley bottom at an elevation of approximately 250 feet, and slopes up gently to the north and more steeply to the south at the abutments. There is little forested area in the vicinity of the berms and vegetation is comprised mostly of the grass-covered fairways of the Tyee Golf Course.

3. GEOTECHNICAL INVESTIGATIONS

3.1 Existing Information

Existing data were reviewed from prior subsurface investigations conducted in the vicinity of the project area. The findings from these investigations provide some insight into the geologic/geotechnical conditions surrounding the site area, but include limited information in the immediate vicinity of the proposed berms. A listing of the data sources reviewed, along with other pertinent project information, is provided in the References section of this report.

3.2 1998 Detention Facility Explorations

This preliminary investigation focused on characterizing the surficial foundation conditions along the proposed berm alignments. Several test holes were advanced at each berm site (see Figure 1). The explorations included 12 shallow borings, 2 hand dug test holes, and 2 peat probes. The fieldwork was carried out on October 26-27, 1998 by the King County Materials Laboratory, in coordination with Sitka Corp. The data from their investigation was issued on December 9, 1998 and is included in Appendix 1 to this report.

The borings were completed to a maximum depth of 15 feet, using a 12-inch diameter open flight power auger (borings B1 through B12). Bulk samples were taken from the auger flights at approximately 3-foot intervals for classification and laboratory testing. In addition, 2 hand auger test holes (HA-1 and HA-2) and 2 peat probes (P-1 and P-2) were completed. Laboratory testing included natural moisture content, grain size, and Atterberg limit analyses. Boring logs were prepared for each test hole and are included in Appendix 1.

3.3 Subsurface Conditions

The subsurface conditions for the west berm sites (Berms 1 and 2) are similar, consisting of fill overlying a thick peat deposit and deeper granular deposits. Fill is also present along the east berm alignment (Berm 3), but is underlain by a thick clay deposit, rather than peat. The limited information from this investigation, along with other studies in the area, suggests that dense granular outwash and till deposits are present beneath the peat and clay deposits. Additional details of the subsurface conditions are provided in the following paragraphs.

Berm 1

Along the Berm 1 alignment, the surficial fill thickness ranges from about 3 feet in the center of the basin, to 6.5 to 8.5 feet at the north and south abutments, respectively. The fill is loose to medium dense. At the south end of the alignment, the fill consists of silty sand/sandy silt and sand with silt (B3, HA-1). Toward the north end of the alignment the fill includes zones of silty gravel, silty sand with gravel, and sand with silt and gravel (B2, B1). Relatively clean sand and gravel zones were also encountered in the fill at test holes HA-2 and B1, respectively.

A thick peat deposit is present beneath the fill along the entire Berm 1 alignment. The thickness of the peat deposit is greatest at the south end of the alignment (B3, P1, HA-1, HA-2), where a maximum thickness of 13.5 feet was recorded. Due to limitations on the drilling depth, the bottom of the peat zone was not proven at these test holes. Thus, the total thickness of the peat zone is not known. At the north end of Berm 1, the peat tapers to a thickness of about 1.5 feet (B2 and B1) and is underlain by a thin clay deposit. Beneath the clay, granular deposits are present, consisting of loose to medium dense sand with varying amounts of gravel and silt, and stiff clay/sand mixtures.

Groundwater was encountered in 3 of the Berm 1 test holes (HA-1, HA-2, and B2), at depths ranging from 1.5 to 5 feet below the ground surface (elevations 248.0 to 248.5 feet).

Berm 2

Along Berm 2, the fill thickness ranges from about 1.5 feet in the center of the basin, and 8.5 to 9.0 feet at the south and north abutments, respectively. The fill is loose to medium dense and generally consists of silty sand, sandy silt, and sand with silt (B3, B4, B5, B6, B7, B8). At the north end of the alignment, cleaner sand and gravel zones are present (B7, B8).

Similar to Berm 1, a thick peat deposit is present beneath the fill. The thickness of the peat is greatest at the south end of the alignment (B3, P2, and B4), where a maximum thickness of 14 feet was recorded. Due to limitations on the drilling depth, the bottom of the peat zone was not proven at these test holes. In the central and northern sections of Berm 1, the peat tapers to a thickness ranging from about 6 to 8 feet (B5, B6, B7). Peat was not encountered in the northern most test hole (B8).

At test holes B5, B6, and B7, the peat is underlain by granular deposits of loose to medium dense sitly sand, and relatively clean sand/gravel mixtures. A soft to stiff clay layer was encountered beneath the granular deposits at test holes B5 (LL-29, PI=8) and B7 (LL=33, PI=12).

Groundwater was encountered in 3 of the Berm 2 test holes (B5, B6, and B8), at depths ranging from 3.0 to 8.0 feet below the ground surface (elevations 245.5 to 248.0).

<u>Berm 3</u>

Surficial fill materials are also present along the Berm 3 alignment, ranging in thickness from about 1.0 foot in the center of the basin, to 4.0 feet at the south abutment (B11) and 6.5 feet at the north abutment (B9). The fill gradation varies from sandy silt to relatively clean sand/gravel mixtures. The fill is generally soft/loose to stiff/medium dense.

The fill at Berm 3 is underlain by a relatively thick soft to medium stiff low plastic clay deposit (LL = 23 to 48; PI = 5 to 26). The upper portion of the clay deposit has some sand and/or occasional sand lenses (B9, B10, B12). The clay deposit ranges in thickness from 4.5 feet at the south abutment (B12), to more than 14 feet in the central basin and at the north abutment (B9, B10). Due to limitations on the drilling depth, the bottom of the clay zone was not proven in these later test holes. At the south end of the alignment, test holes B11 and B12, a granular deposit of medium dense sand with silt/clay was encountered beneath the clay unit.

Groundwater was encountered in 2 of the Berm 3 test holes (B9 and B12), at a depths of 10.5 and 7.0 below the ground surface, respectively (elevations 246.0 241.5 feet).

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the preliminary investigations conducted for this study along with information from the other investigations in the area, it appears that the subsurface conditions are suitable for construction of the proposed retention/detention berms, provided that the following factors are considered in preparation of the berm designs.

4.1 Foundation Preparation and Slope Stability

The structural stability of the berms and associated appurtenant structures will depend on the strength of the foundation soils, the fill materials that are used, and any foundation improvement measures taken.

As discussed in Section 4.3, the strength of the foundation soils will need to be determined during the design phase of the project, by means of further explorations, laboratory testing and/or engineering analyses.

Given the presence of the thick peat deposits at the west berm sites, there would be little benefit to removing the overlying fill materials for the purpose of improving the subgrade conditions. However, in some locations, the existing fill may need to be replaced to limited depths to improve the permeability characteristics of the foundation. For the east berm, it may be practicable to remove the existing fill and construct the berm over the underlying clay layer and less permeable natural deposits at the north abutment.

Geosynthetic reinforcement materials (geotextile or geogrid) may also be incorporated over soft subgrade areas at both berm sites to improve the foundation conditions. The central sections of the berm alignments, where the fill thickness is the least, may benefit most from the use of geosynthetics. The type and strength of geosynthetics required will depend on the gradation and strength of the subgrade soil and anticipated loading.

The foundation preparation requirements for the appurtenant structures (low level outlet pipes, manholes, vaults, spillway, etc.) will also depend on the strength of the subgrade soil and estimated loading. Where structures must be placed over relatively loose or soft subgrade soils, the required foundation support may be provided by sub-excavation and replacement with compacted granular soils, a reinforced concrete foundation, and/or driven timber or steel piles.

Once the appropriate subgrade preparation measures have been selected, the geometry of the berms can be determined. The embankments will need to be designed in accordance with the Washington State Department of Ecology, Dam Safety Section's "Dam Safety Guidelines", and must include provisions to ensure adequate upstream and downstream slope stability, seepage control, filter compatibility, erosion control, emergency flow control, and freeboard.

4.2 Settlement

The peat deposit at the west berm location will be susceptible to settlement during and after construction, although some consolidation has likely occurred already under the present fill loading. The clay deposit at the east berm may also be susceptible to settlement, though to a lesser extent. The amount of settlement will need to be estimated as part of the design phase for the berms.

Provisions must be included in the designs to ensure that the minimum dam crest elevations are maintained under maximum anticipated settlements, and that differential settlements do not impact the integrity or performance of the embankment or appurtenant structures.

In addition, the designs should address possible construction induced pore pressures and associated impacts on slope stability. This condition can be addressed by controlling the rate of construction to keep excess pore water pressures at an acceptable level, along with drainage features to accommodate possible upward drainage of groundwater.

4.3 Seepage

The existing fill materials at both of the berm sites include zones of relatively clean (free draining) soils which will be susceptible to seepage under relatively low head conditions. In addition, seepage may also occur through the peat zone beneath the west berm. Since the impoundments are designed to provide stormwater detention/retention, they can accommodate some seepage provided that the integrity of the structures is maintained. The allowable seepage rate will need to be determined as part of the design for the berms. As previously noted, certain subgrade preparation measures can be taken to reduce seepage, along with appropriate selection of embankment fill materials.

4.4 Further Investigations

The test holes completed for this study were limited in both aerial and vertical extent. In addition, sampling and laboratory testing was conducted only for the purpose of classifying the soils and providing a preliminary assessment of the site stratigraphy.

Additional subsurface investigations and laboratory testing will likely be necessary to complete the berm designs in order to: 1) delineate the gradation, strength, and permeability characteristics of the existing fill materials at both berm locations, 2) determine the depth, strength, and settlement characteristics of the peat at the west berm location, 3) determine the depth, strength, and consolidation characteristics of the soft clay zone at the east berm location, and 4) determine the geotechnical design parameters of the embankment fill materials.

The above information may be obtained by a variety of field exploration methods, including test pits, borings, standard penetration tests (SPTs), cone penetration tests (CPTs), and vane shear tests. Laboratory testing to determine necessary geotechnical design parameters may include natural moisture content, grain size distribution, bulk density, Atterberg limits, moisture/density relationship, direct shear, triaxial shear, and consolidation analyses. The specific requirements for any future investigations and testing will depend on the engineering approach taken by the design engineer.

5. CLOSING

The objectives of this preliminary subsurface investigation have been achieved. Sufficient geotechnical data was collected to assess the suitability of the proposed detention/retention berms. As discussed herein, the proposed berm sites appear to be suitable, provided that appropriate design measures are taken to meet the project objectives.

REFERENCES

Reports:

Hong West Associates, September 18, 1998. *SeaTac Lagoon 3 Preliminary Lab Results.*

Parametrix, Inc., August 18, 1998. *Des Moines Creek Flow Augmentation Plan.*

Hong West Associates, June 28, 1998. *Seattle-Tacoma International Airport Comprehensive Storm Drainage System Plan.*

King County, November 1997. *Des Moines Creek Basin Plan*

HDR Engineering, Inc., February 1997. *Sea-Tac International Airport Storm Drainage System Comprehensive Plan.*

Derek Booth, March 25, 1996. *Geology and Geomorphology of the Des Moines Creek Basin.*

GeoEngineers, March 20, 1996. *Groundwater and Excavation Evaluation, Proposed Sewer Line Relocation, Sea-Tac 34R South Safety Area Expansion.*

Dames and Moore, March 1992. *South Aviation Support Area DEIS, Technical Appendix - Earth.*

Associated Earth Sciences, December 3, 1987. *Subsurface Exploration and Geotechnical Engineering Report, Des Moines Creek Regional Pond.*

Dames and Moore, 1960. *Report of Soils Investigation, Proposed Main Runway Extension.*

Other Information:

- Aerial photographs of site area: 1959, 1970, 1985, and 1992
- Site Maps: King County, July 1998. Des Moines Regional R/D Facility Base Map; Nies Mapping Group, Inc., May 6, 1994 Photogrammetric Topography Map

APPENDIX 1
TEST HOLE LOGS AND LABORATORY TEST RESULTS

K46.1

King County
Department of Transportation
Engineering Services Section
Materials Laboratory
155 Monroe Avenue NE, Bldg. D
Renton, WA 98056-4199

RECEIVED
DEC 11 1998

December 9, 1998

TO: Don Althauser, Senior Engineer, Water and Land Resources Division

VIA: Alan D. Corwin, Materials Engineer, Materials Laboratory,
Project Support Services

FM: Douglas Walters, Engineer, Materials Laboratory,
Project Support Services

RE: Des Moines Regional Detention Pond

As requested, we have completed geotechnical drilling at the Des Moines Regional Detention Facility Project. The purpose of the drilling operation was to log the subsurface conditions at the project site. In addition, representative soil samples were collected and returned to our laboratory for identification and testing. The boring logs (plates A-1 through A-14) and associated laboratory test results are enclosed for your review.

Subsurface conditions were explored by drilling twelve (12) borings within the project limits using a truck mounted MP-225 Open Flight Auger. Borings were advanced to a maximum depth of fifteen (15) feet below the ground surface. In addition, two (2) hand auger holes and two (2) peat probes were performed in areas not accessible to the drill truck. Approximate boring and peat probe locations are indicated on the enclosed site plan, Figure 1, "Boring Locations".

Two peat probes were performed in the general area between Hand Auger 1 (HA-1) and Boring 3 (B-3). Peat Probe 1 (P-1) was advanced to a maximum nineteen (19) feet below ground level, the total length of the rod. P-2 was advanced seventeen (17) feet below ground level before refusal on what may have been woody debris.

We trust this memorandum responds adequately to your request. If you have questions, or if you require further clarification, please call me at 296-7708.

cc: Thomas Harper, P.E., Sitka Corp

KEY TO SYMBOLS

Symbol	Description
Strata symbols	
⬚	Topsoil
▥	Silty sand
⁘	Poorly graded gravel
■	Peat
▨	Low plasticity clay
░	Poorly graded sand
⁘	Silty gravel
▥	Poorly graded sand with silt
▨	Well graded sand with clay
▦	Well graded sand with silt
▨	Clayey sand
≋	Low plasticity organic silts

Symbol	Description
▥	Elastic silt
▥	Silt
▧	Silty low plasticity clay
▨	Poorly graded sand with clay
⁙	Crushed surfacing
Misc. Symbols	
①➡	The boring caved
▽	Water table during drilling
↑	End of Boring
Soil Samplers	
☒	Bulk sample taken from 12 in. auger
◩	Bulk/Grab sample

KEY TO SYMBOLS

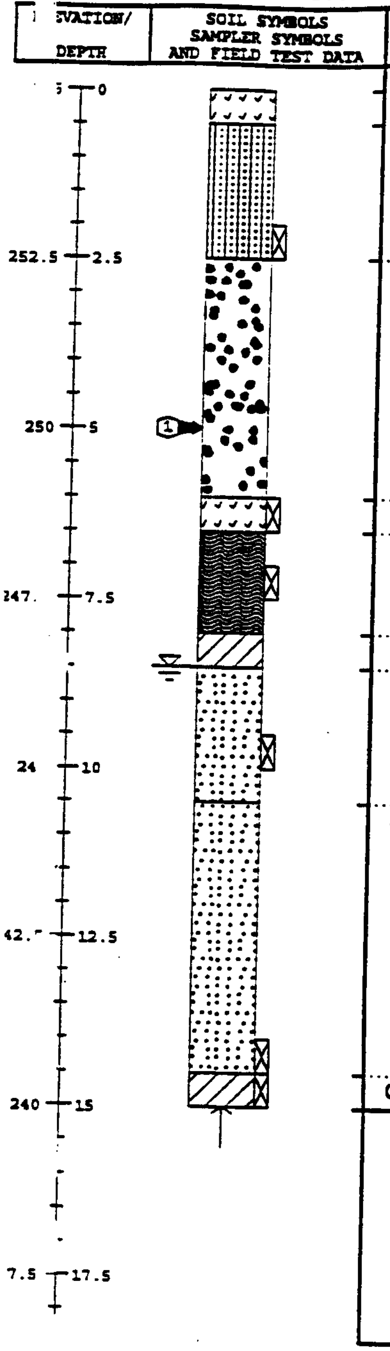
Notes:

1. Exploratory borings were drilled on 10/26/98 using a 12-inch diameter open flight power auger. Exploratory test holes were excavated on 10/27/98 using hand augers.
2. Surface elevations for boring logs were interpolated from the King County Department of Natural Resources "Tyee Creek-Seatac/Des Moines" topography map.
3. These logs are subject to the limitations, conclusions, and recommendations in this report.

LOG OF BORING
BORING 1

PROJECT: **Des Moines R/D**
ORING LOCATION **Tyee Golf Course, Berm 1**
'LL METHOD: **MP-225 Open Power Auger**
.ILLER: **King County Materials Laboratory**
EPTH TO - Water: **8.5'** Caving: **5.0'**

DATE: **10/26/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/26/98**



USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
SM	Brown silty sand with gravel, moist, loose to medium dense. (fill)	6.2		
GP	Gray poorly graded gravel with sand, wet, loose. (fill)			
	Black topsoil with peat, wet, very soft.	89.3		
PT	Dark brown peat, wet, very soft.	354.2		
CL	Gray clay, trace organics, soft, wet.			
SP	Gray poorly graded sand with gravel, wet, loose.	8.4	0.9	
SP	Gray poorly graded sand with gravel, wet, loose to medium dense.	13.2		
CL	Gray clay with sand and gravel, wet, stiff.	22.4		LL=22 PI=8

ring was advanced in berm 1. Groundwater was encountered at
eet.

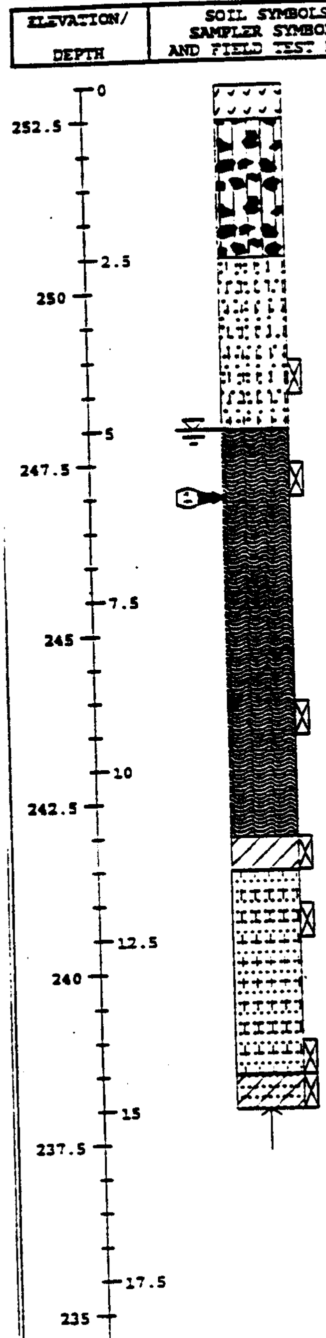
PLATE NUMBER A-1

KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 2

PROJECT: Des Moines R/D
BORING LOCATION Tyee Golf Course, Berm 1
DRILL METHOD: MP-225 Open Power Auger
DRILLER: King County Materials Laboratory
DEPTH TO - Water: 5.0' Caving: 6.0'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98



USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
GM	Brown silty gravel, moist, loose to medium dense. (fill)			
SP-SM	Gray poorly graded sand with silt and gravel, wet, loose to medium dense. (fill)	9.0	10.5	
PT	Brown peat, wet, very soft.	191.7 520.9 68.1		LL=29 PI=8
CL	Gray clay, trace organics, wet, soft.			
SW-SM	Gray well-graded sand with silt and gravel, wet, loose to medium dense.	18.1 13.7	10.3	
SC	Gray clayey sand with gravel, wet, stiff.	18.6	47.2	LL=26 PI=11

The boring was advanced in berm 1. Groundwater was encountered at -5.0 feet.

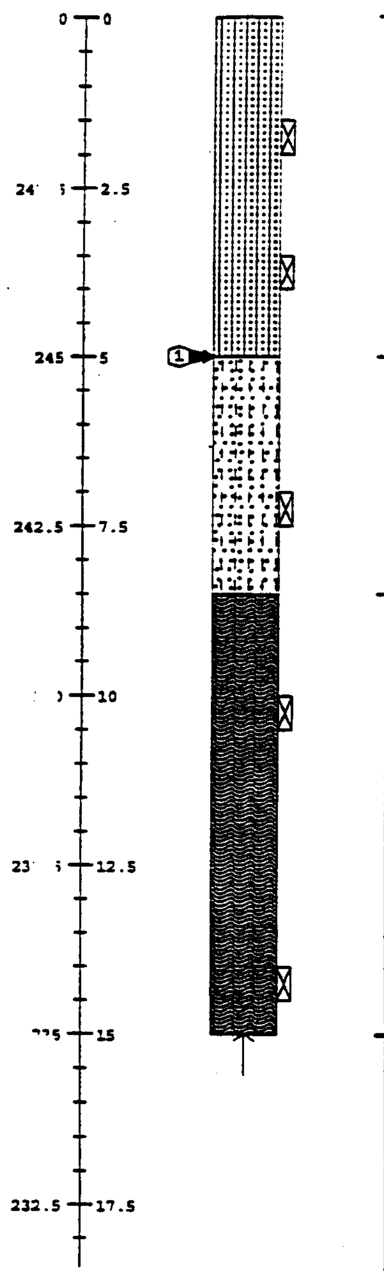
PLATE NUMBER A-2

KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 3

ROJECT: **Des Moines R/D**
RING LOCATION **Tyee Golf Course, Berm 2**
LL METHOD: **MP-225 Open Power Auger**
RILLER: **King County Materials Laboratory**
EPTH TO - Water: Caving: 5.0'

DATE: **10/26/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/26/98**



ELEVATION/ DEPTH	SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA	USCS	Description	Moist (%)	-200 (%)	Remarks
		SM	Brown to gray silty sand with gravel, trace organics, moist, loose to medium dense. (fill)	17.2	24.8	
				11.3	22.8	
		SP-SM	Gray poorly graded sand with silt, wet, loose. (fill?)	20.9	8.7	
		PT	Dark brown peat, wet, very soft.	132.4		
				493.8		

oring was advanced in berm 2. The groundwater table could not b determined during drilling. Severe caving of the borehole o urred at -5.0 feet.

PLATE NUMBER **A-3**

KING COUNTY MATERIALS LABORATORY

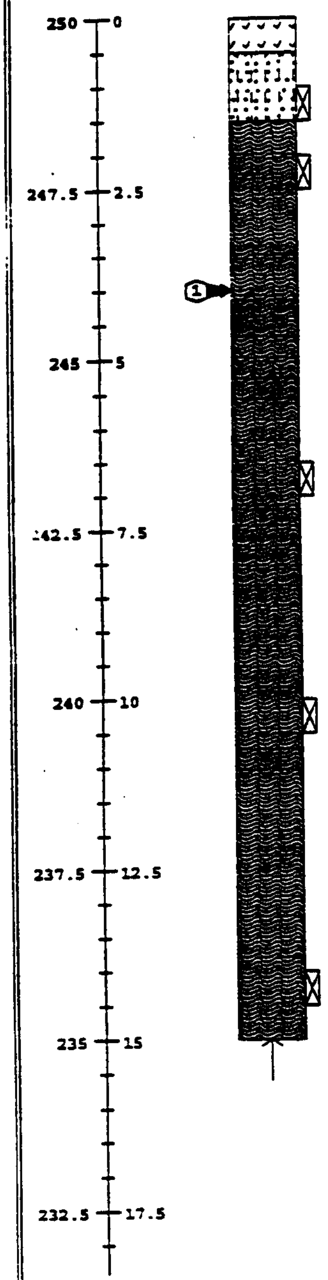
LOG OF BORING

BORING 4

PROJECT: Des Moines R/D
BORING LOCATION Tyee Golf Course, Berm 2
DRILL METHOD: MP-225 Open Power Auger
DRILLER: King County Materials Laboratory
DEPTH TO - Water: Caving: 4.0'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98

ELEVATION/ DEPTH | SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
SP-SM	Gray poorly graded sand with silt, iron stained, wet, loose to medium dense.	19.1	9.4	
PT	Brown to dark brown peat, wet, very soft.	168.7		
		502.1		
		627.4		
		551.6		

The boring was advanced in berm 2. The groundwater table could not be determined during drilling. Severe caving of the borehole occurred at -4.0 feet.

PLATE NUMBER A-4

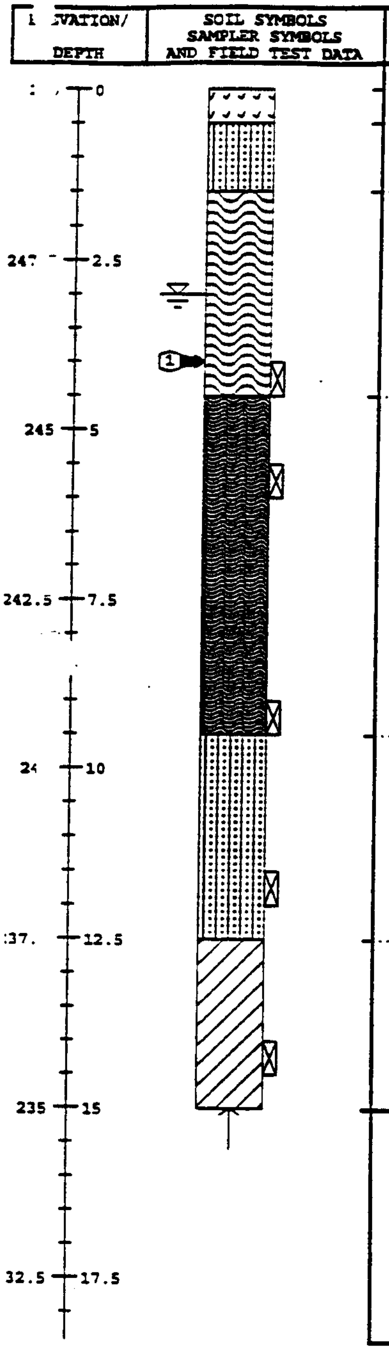
KING COUNTY MATERIALS LABORATORY

LOG OF BORING

BORING 5

ROJECT: Des Moines R/D
RING LOCATION Tyee Golf Course, Berm 2
L METHOD: MP-225 Open Power Auger
LLER: King County Materials Laboratory
EPTH TO - Water: 3.0' Caving: 4.0'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98



USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
SM	Brown to gray silty sand, moist, loose to medium dense. (fill)			
OL	Brown organic silt intermixed with peat, wet, soft.	237.3		
PT	Brown to dark brown peat, wet, very soft.	463.1 703.1		
SM	Gray silty sand intermixed with brown organics, wet, loose.	153.9	28.6	
CL	Gray clay, wet, soft.	38.5		LL=29 PI=8

ring was advanced in berm 2. Groundwater was encountered
3. eet.

PLATE NUMBER A-5

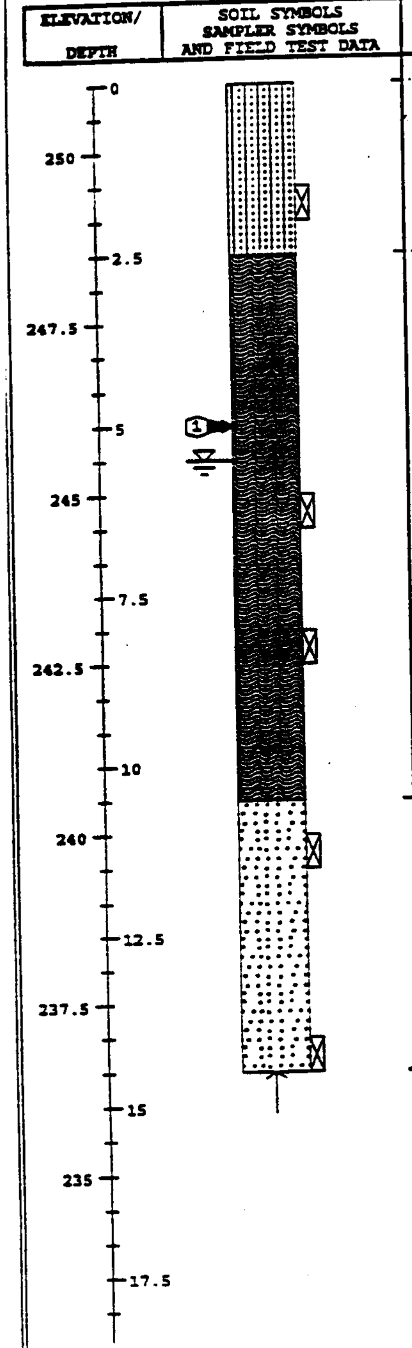
KING COUNTY MATERIALS LABORATORY

LOG OF BORING

BORING 6

PROJECT: Des Moines R/D
BORING LOCATION Tyee Golf Course, Berm 2
DRILL METHOD: MP-225 Open Power Auger
DRILLER: King County Materials Laboratory
DEPTH TO - Water: 5.5' Caving: 5.0'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98



USCS	Description	Moist (%)	-200 (%)	Remarks
SM	Gray to brown silty sand with gravel, moist, loose to medium dense. (fill)	9.8	11.9	
PT	Brown to dark brown peat, wet, very soft.	285.9 480.7		
SP	Gray poorly graded sand with gravel, wet, loose to medium dense.	17.2 24.5	3.0	

The boring was advanced in berm 2. Groundwater was encountered at -5.5 feet.

PLATE NUMBER A-6

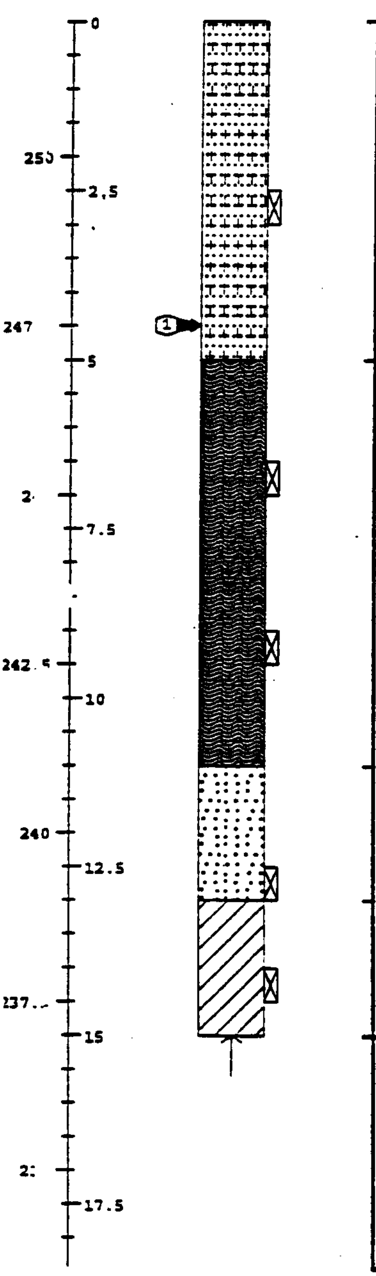
KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 7

PROJECT: Des Moines R/D
)RING LOCATION Tyee Golf Course, Berm 2
'LL METHOD: MP-225 Open Power Auger
.LLER: King County Materials Laboratory
:PTH TO - Water: Caving: 4.5'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98

VATION/ DEPTH | SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
SW-SM	Gray well-graded sand with silt and gravel, loose, medium dense. (fill)	7.2	8.4	
PT	Brown to dark brown peat, wet, very soft.	267.2 494.8		
SP	Gray poorly graded sand with gravel, wet, loose to medium dense.	17.6		
CL	Gray clay, wet, stiff.	30.5		LL=33 PI=12

oring was advanced in berm 2. Water seepage was noted at -13.0 fee The groundwater table, however, could not be determined due o e caving of the borehole at -4.5 feet.

PLATE NUMBER A-7

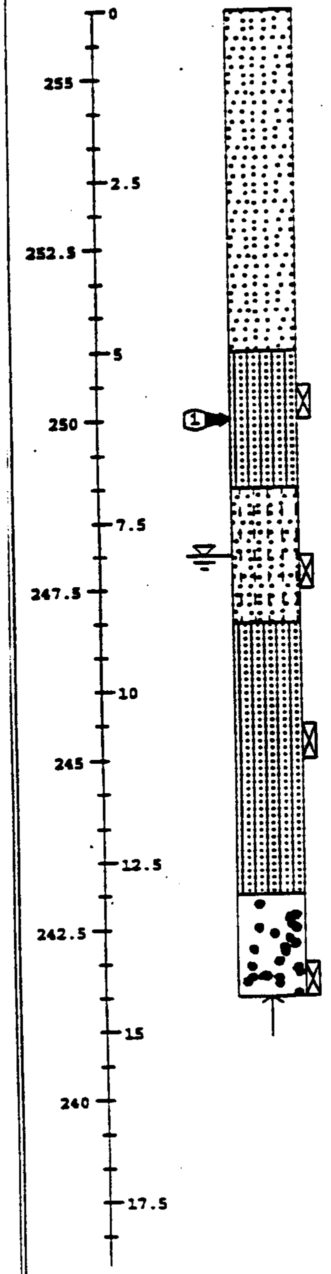
KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 8

PROJECT: Des Moines R/D
BORING LOCATION Tyee Golf Course, Berm 2
DRILL METHOD: MP-225 Open Power Auger
DRILLER: King County Materials Laboratory
DEPTH TO - Water: 8.0' Caving: 6.0'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98

ELEVATION/ DEPTH — SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
SP	Gray poorly graded sand with gravel, moist, loose to medium dense. (fill?)			
SM	Dark grayish brown silty sand with gravel, wet, loose.	18.8	12.6	
SP-SM	Dark gray poorly graded sand with silt and gravel, wet, loose to medium dense.	12.1	6.3	
SM	Gray silty sand with gravel, trace organics, wet, loose to medium dense.	23.7	33.0	
GP	Gray poorly graded gravel with sand, wet, loose to medium dense.	9.3	3.7	

The boring was advanced in berm 2. Groundwater was encountered during drilling at -8.0 feet.

PLATE NUMBER A-8

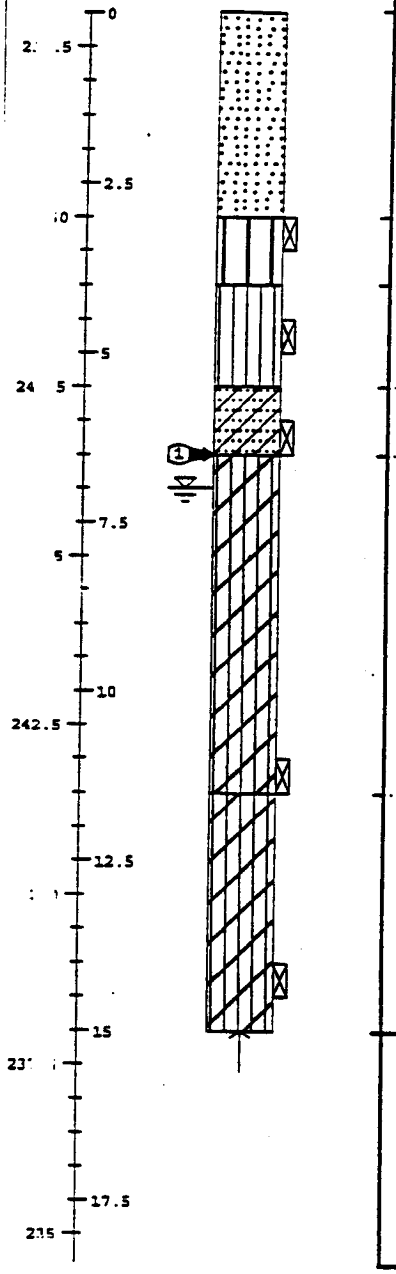
KING COUNTY MATERIALS LABORATORY

LOG OF BORING
BORING 9

PROJECT: **Des Moines R/D**
ORING LOCATION **Tyee Golf Course, Berm 3**
LL METHOD: **MP-225 Open Power Auger**
LLER: **King County Materials Laboratory**
EPTH TO - Water: **7.0'** Caving: **6.5'**

DATE: **10/26/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/26/98**

EVATION/ DEPTH | SOIL SYMBOLS SAMPLER SYMBOLS AND FIELD TEST DATA



USCS	Description	Moist (%)	-200 (%)	Remarks
SP	Gray poorly graded sand with gravel, moist, loose to medium dense. (fill)			
MH	Brown sandy elastic silt, trace organics, moist to wet, medium stiff.	69.0		LL=65 10
ML	Brownish gray sandy silt, mottled with iron stains, moist to wet, soft to medium stiff.	41.1		LL=28 PI=5
SC	Gray silty sand, wet, loose to medium dense.	28.4	47.0	
CL-ML	Gray silty clay with intermittent clay and sand lenses, wet, soft to medium stiff.	26.1		LL=25 PI=7
CL-ML	Gray silty clay, wet, medium stiff to stiff.	18.9		

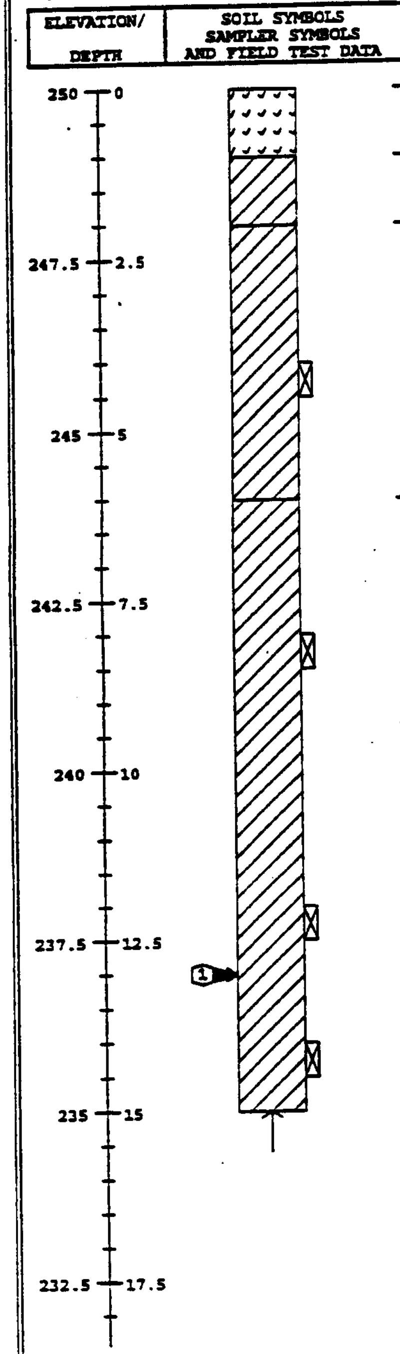
oring was advanced in berm 3. Groundwater was encountered du ng drilling at -6.5 feet.

PLATE NUMBER **A-9**

LOG OF BORING
BORING 10

PROJECT: **Des Moines R/D**
BORING LOCATION **Tyee Golf Course, Berm 3**
DRILL METHOD: **MP-225 Open Power Auger**
DRILLER: **King County Materials Laboratory**
DEPTH TO - Water: Caving: **13.0'**

DATE: **10/26/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/26/98**



USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
CL	Gray clay with sand, moist, medium stiff to stiff.			
CL	Gray clay with sand, trace organics, iron-stained, wet, soft to medium stiff.			
		26.5		
CL	Gray clay, wet, medium stiff to stiff.			Increasing stiffness with depth.
		37.5		
		36.2		LL=28 PI=8
		24.6	90.9	

The boring was advanced in berm 3. No groundwater was encountered during drilling.

PLATE NUMBER **A-10**

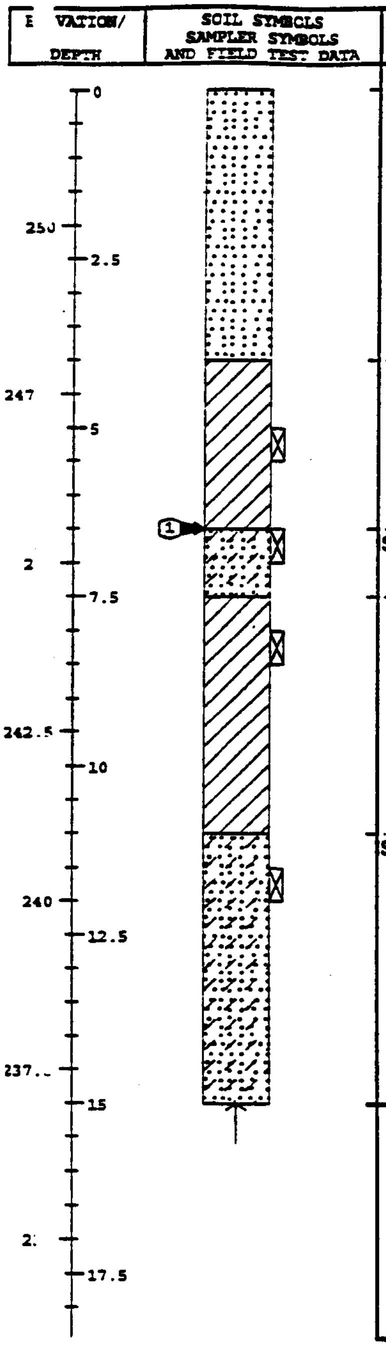
KING COUNTY MATERIALS LABORATORY

LOG OF BORING

BORING 11

PROJECT: **Des Moines R/D**
BORING LOCATION **Tyee Golf Course, Berm 3**
LL METHOD: **MP-225 Open Power Auger**
DRILLER: **King County Materials Laboratory**
DEPTH TO - Water: Caving: **6.5'**

DATE: **10/26/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/26/98**



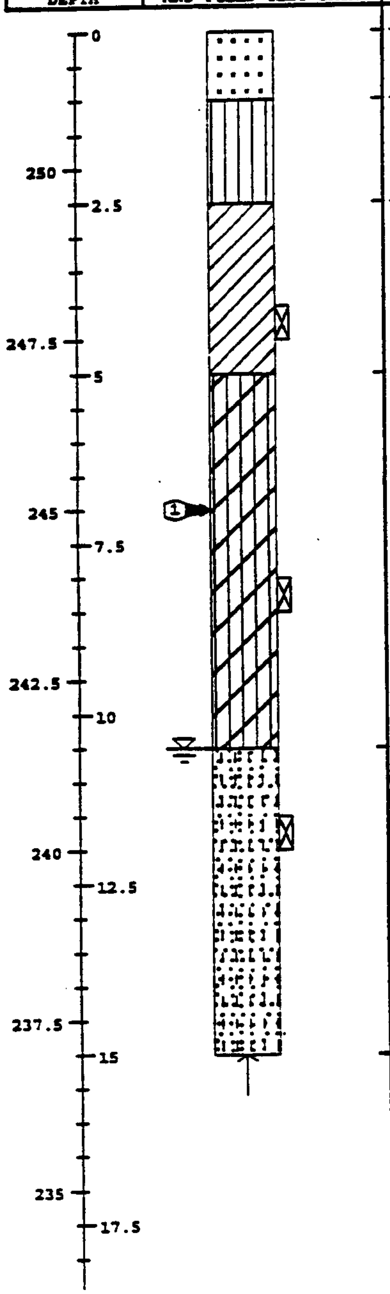
USCS	Description	Moist (%)	-200 (%)	Remarks
SP	Gray poorly graded sand, moist, medium dense. (fill)			
CL	Gray clay, trace organics, wet, soft.	38.2		LL=48 PI=26
SP-SC	Brownish gray poorly graded sand with clay, wet, loose.	21.7	11.1	
CL	Gray clay, wet, soft.	37.9		
SP-SC	Gray poorly graded sand with clay, wet, medium dense.	25.0	8.9	

Boring was advanced in berm 3. No groundwater was encountered during drilling.

LOG OF BORING
BORING 12

PROJECT: Des Moines R/D
BORING LOCATION Tyee Golf Course, Berm 3
DRILL METHOD: MP-225 Open Power Auger
DRILLER: King County Materials Laboratory
DEPTH TO - Water: 10.5' Caving: 7.0'

DATE: 10/26/98
START: N/A
FINISH: N/A
LOGGER: DW
DATE CHECKED: 10/26/98



USCS	Description	Moist (%)	-200 (%)	Remarks
	Crushed surfacing.			
ML	Brown sandy silt, moist, stiff.			
CL	Brown to gray clay with sand, iron-stained, moist, medium stiff.	29.0		LL=39 PI=23
CL-ML	Gray silty clay, wet, soft.	26.9		LL=23 PI=5
SP-SM	Gray poorly graded sand with silt, wet, medium dense.	24.4	6.3	

The boring was advanced in berm 3. Groundwater was encountered -10.5 feet.

PLATE NUMBER A-12

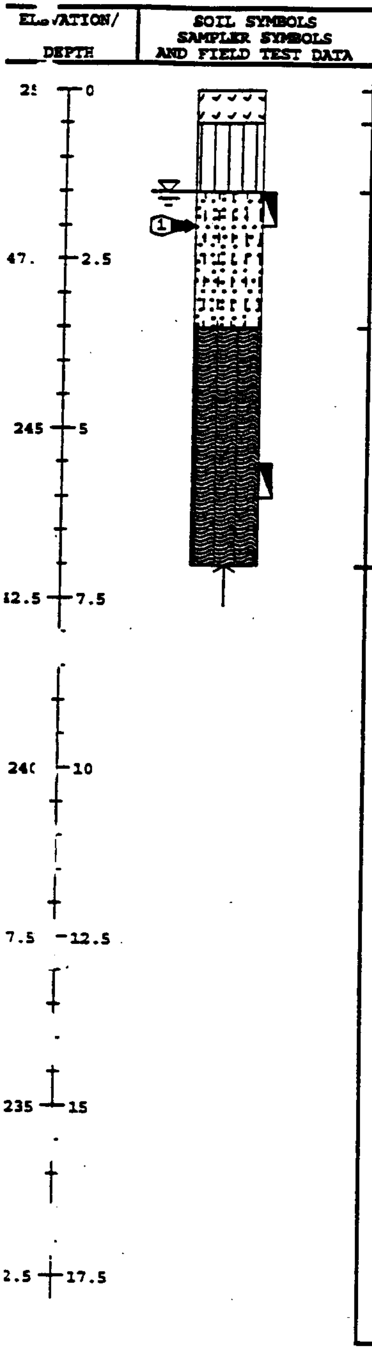
KING COUNTY MATERIALS LABORATORY

LOG OF HAND HOLE

HAND HOLE 1

P‾OJECT: **Des Moines R/D**
ND HOLE LOCATION: **Tyee Golf Course**
:AVATION METHOD: **Hand dug test holes.**
E×CAVATOR: **King County Materials Laboratory**
D PTH TO - Water: **1.5'** Caving: **2.0'**

DATE: **10/27/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/27/98**



USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
ML	Brown sandy silt, wet, soft to medium dense. (fill)			
SP-SM	Gray poorly graded sand with silt, wet, loose. (fill?)	21.3	7.5	
PT	Brown peat, wet, very soft.	252.5		

ı. ɔring was advanced in berm one of the Tyee Golf Course.
roı dwater was encountered at -1.5 feet. The borehole was
rm ated at -7.0 feet due to severe caving at -2.0 feet.

PLATE NUMBER **A-13**

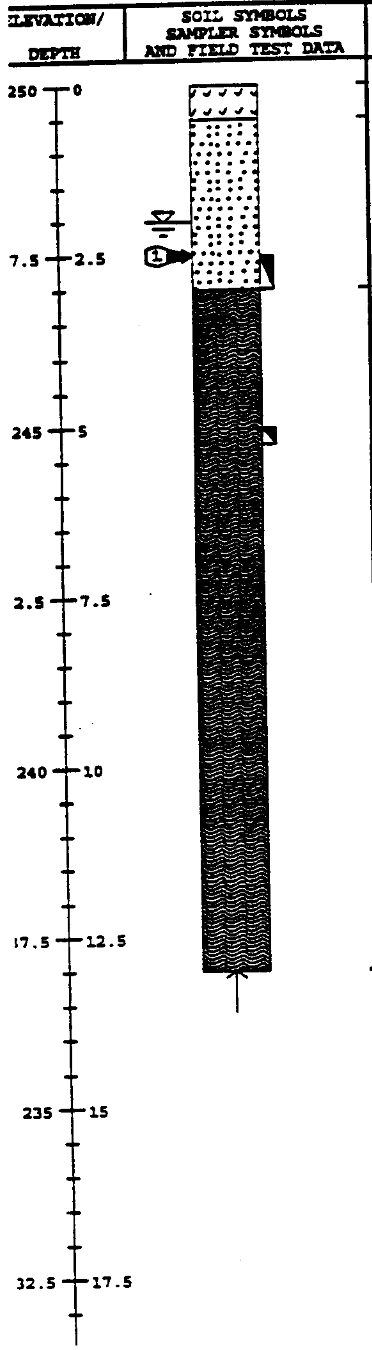
KING COUNTY MATERIALS LABORATORY

LOG OF HAND HOLE

HAND HOLE 2

PROJECT: **Des Moines R/D**
HAND HOLE LOCATION: **Tyee Golf Course**
EXCAVATION METHOD: **Hand dug test holes.**
EXCAVATOR: **King County Materials Laboratory**
DEPTH TO - Water: **2.0'** Caving: **2.5'**

DATE: **10/27/98**
START: **N/A**
FINISH: **N/A**
LOGGER: **DW**
DATE CHECKED: **10/27/98**

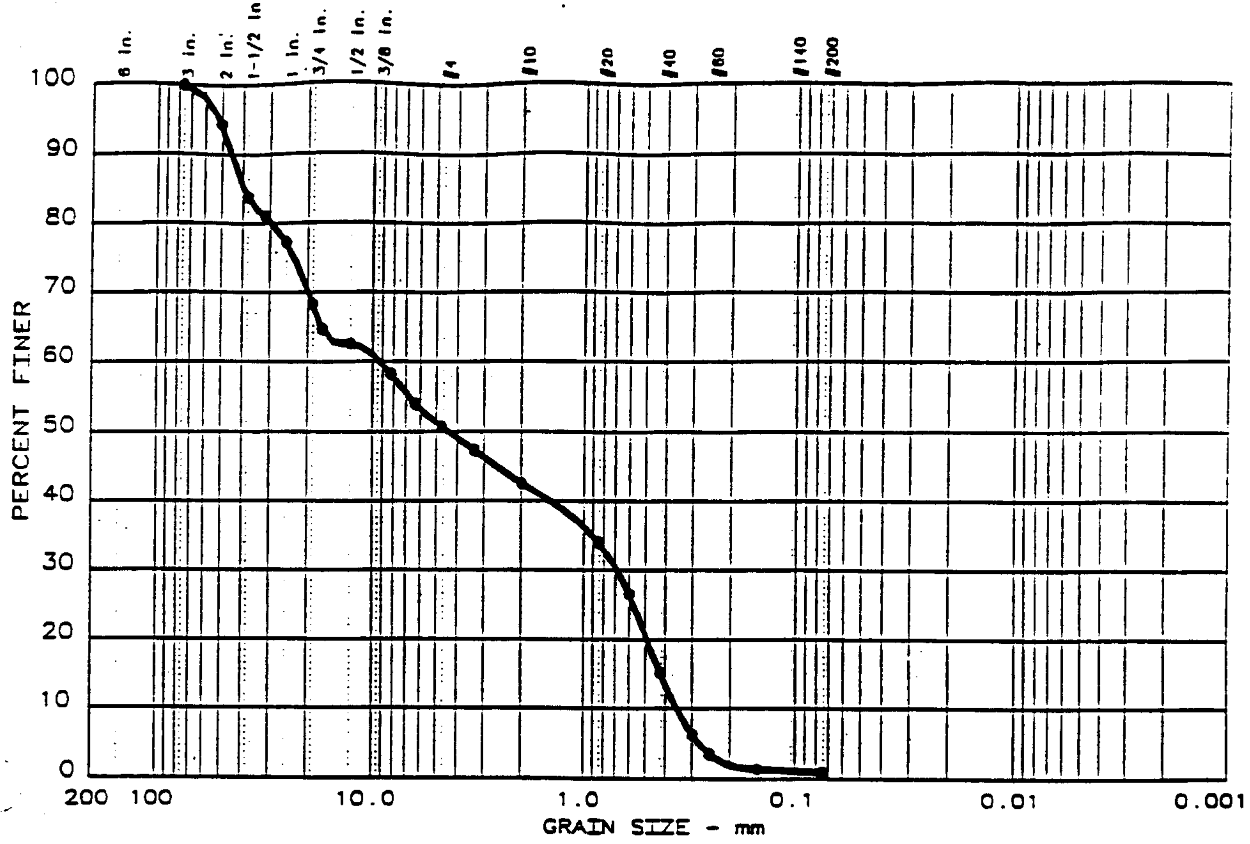


USCS	Description	Moist (%)	-200 (%)	Remarks
	Sod, topsoil.			
SP	Gray poorly graded sand, wet, loose. (fill?)	25.4		
PT	Brown peat, wet, very soft.	153.7		
				Hand probed to -13.0 feet.

The boring was advanced in berm one of the Tyee Golf Course.
Groundwater was encountered at -2.0 feet.

PLATE NUMBER **A-14**

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
18	0.0	49.3	49.8	0.9	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		39.7	9.20	4.41	0.682	0.421	0.354	0.14	26.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Gravel	SP	

Project No.: 1A1767
roject: Tyee Golf Course
● Location: B-1: 9.5' to 10.0'

te: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

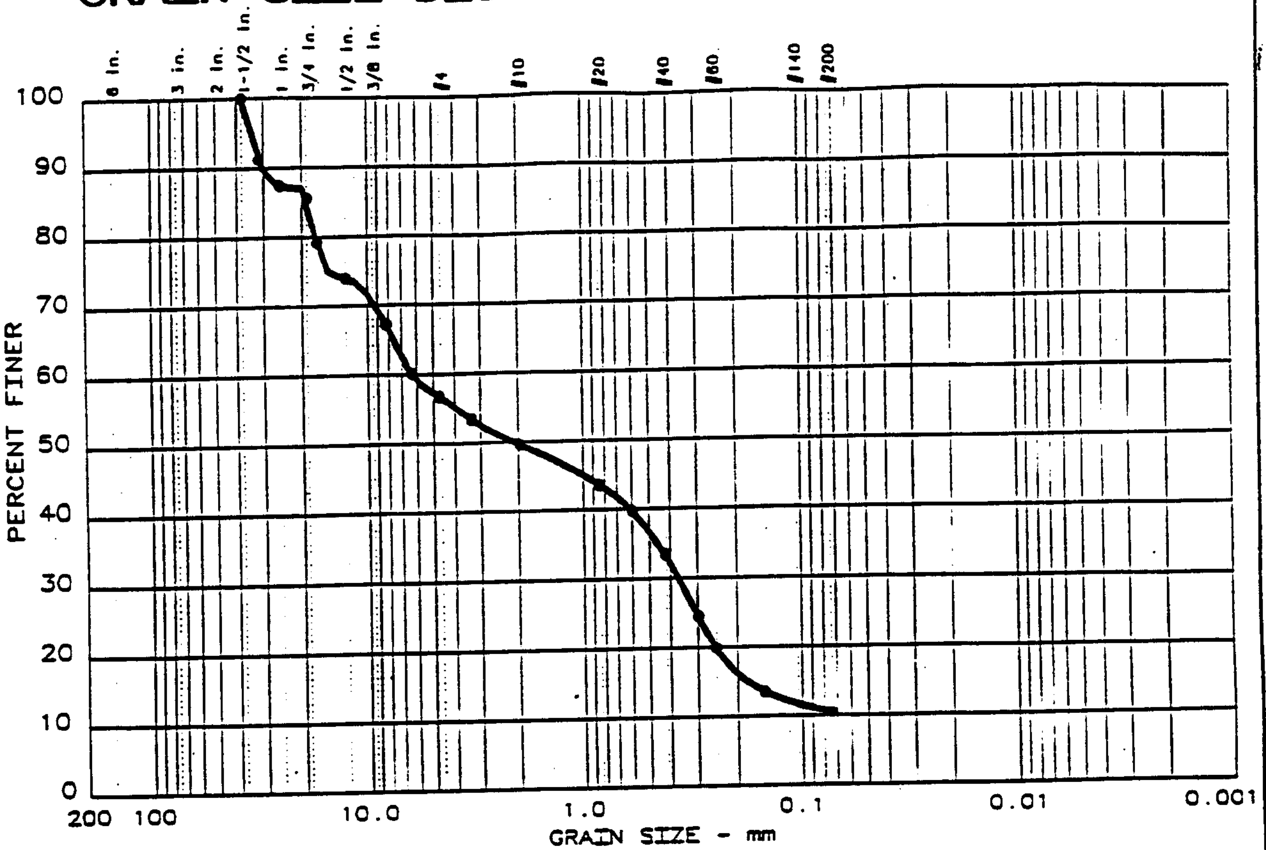
Remarks:

K98-1535

Moisture: 8.4%

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	15	0.0	43.2	45.3	10.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			18.8	6.24	2.11	0.367	0.180	~0.075	0.29	83.2

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt and Gravel	SP-SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-2 : 4.0' to 4.5'

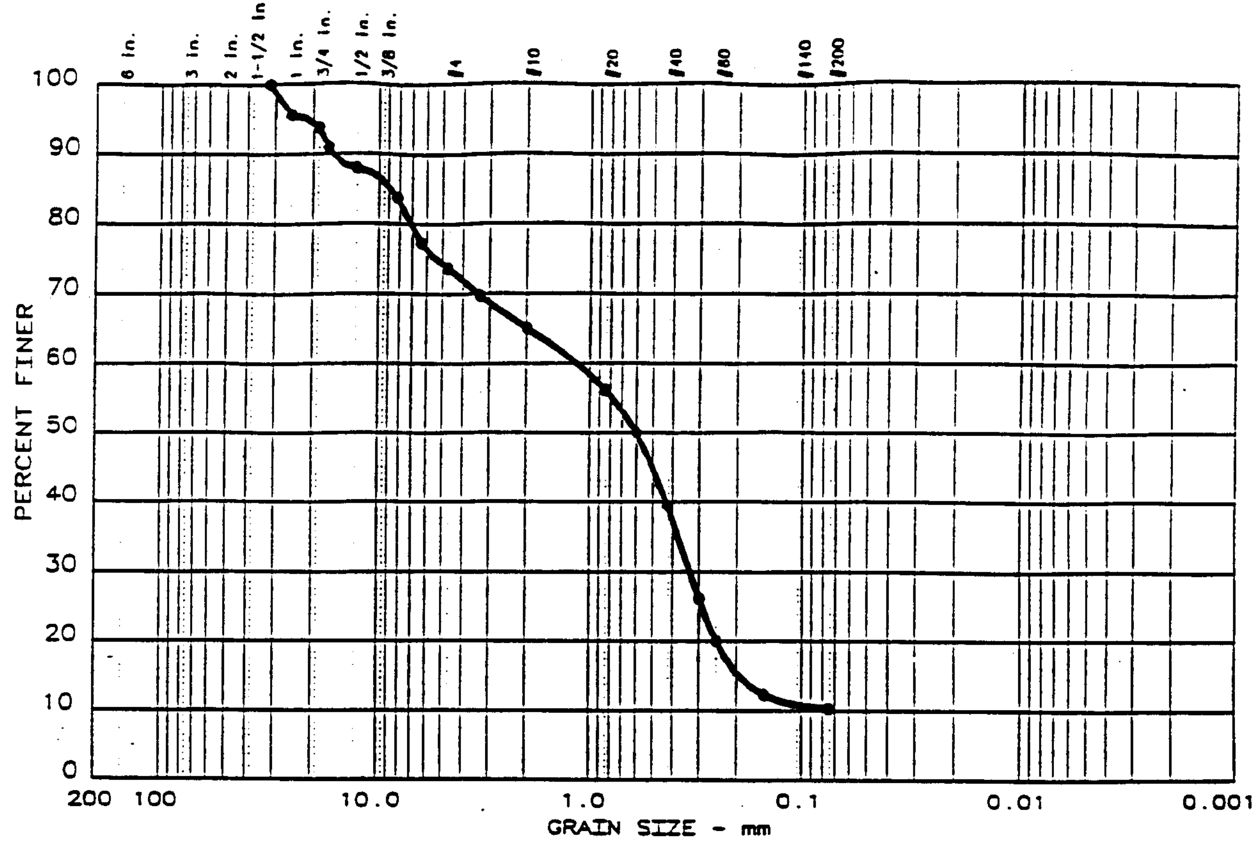
Date: 10/28/98

Remarks:
K98-1525
Moisture: 9.0%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
16	0.0	26.3	63.3	10.4	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		8.81	1.16	0.603	0.331	0.195	~0.073	~1.29	~159

MATERIAL DESCRIPTION	USCS	AASHTO
● Well-Graded Sand with Silt and Gravel	SW-SM	

Project No.: 1A1767
roject: Tyee Golf Course
● Location: B-2 : 12.0' to 12.5'

te: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

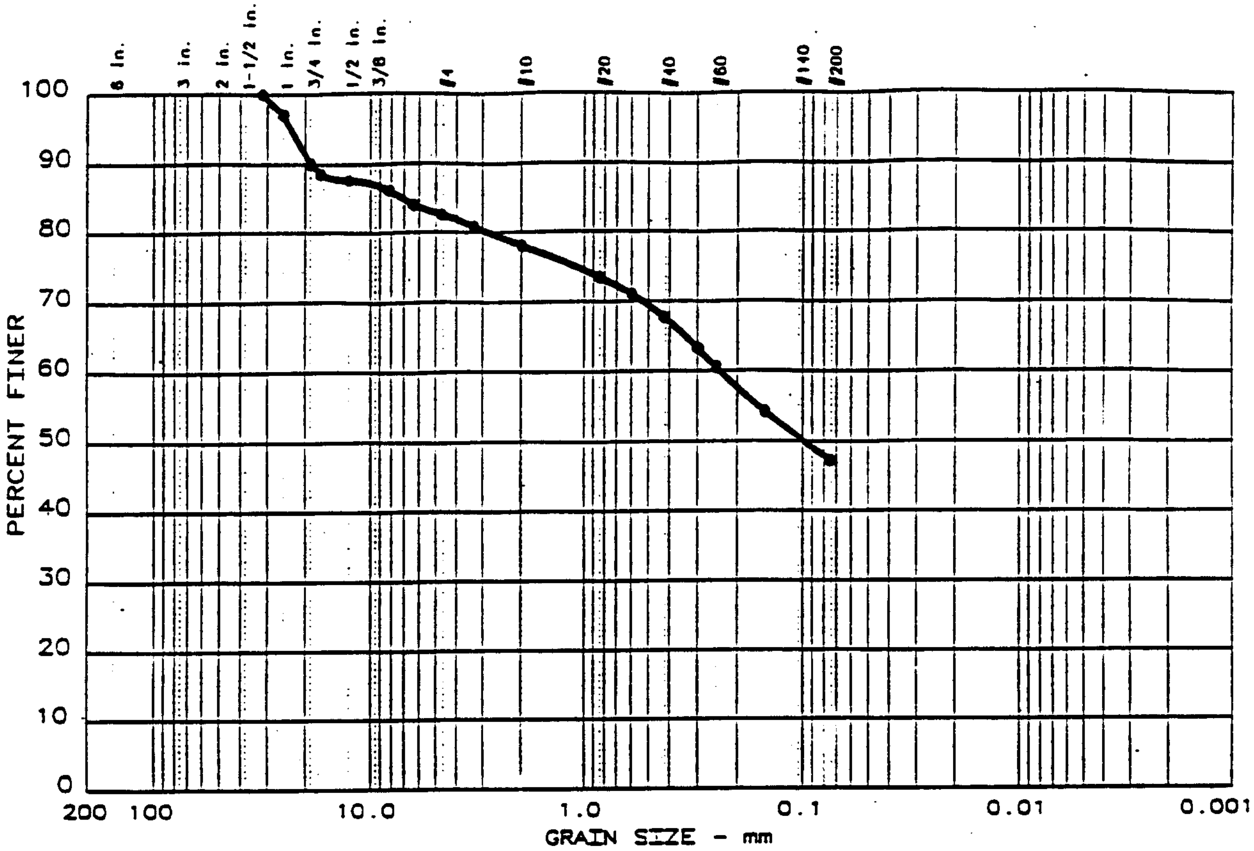
Remarks:

K98-1529

Moisture: 18.1%

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	17	0.0	17.5	35.3	47.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	26	11	7.16	0.240	0.0989					

MATERIAL DESCRIPTION	USCS	AASHTO
● Sandy Lean Clay with Gravel	CL	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-2: 14.5' to 15.0'

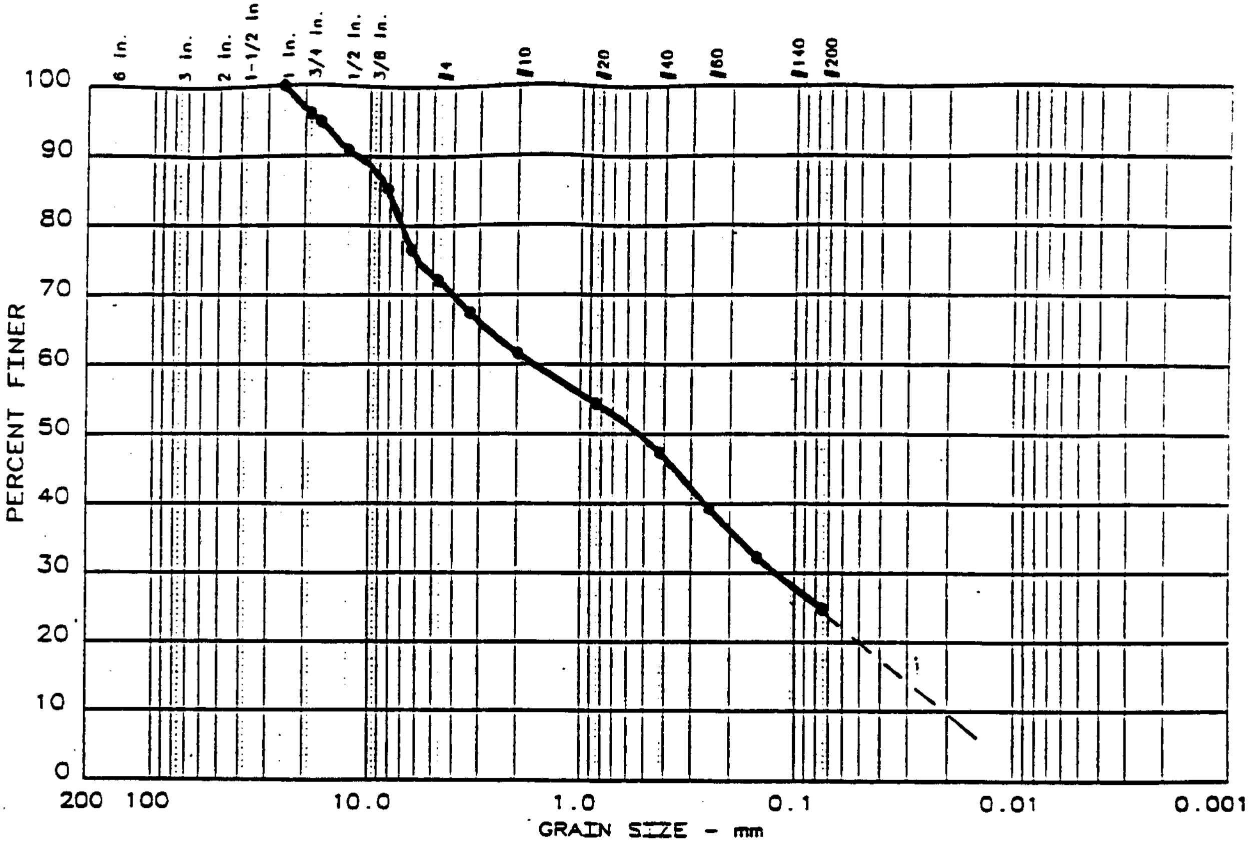
Date: 10/28/98

Remarks:
K98-1531
Moisture: 18.6%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
3	0.0	27.9	47.3	24.8	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		8.13	1.66	0.531	0.123	~0.035	~.022	~0.43	~75.5

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Sand with Gravel	SM	

Project No.: 1A1767
roject: Tyee Golf Course
● Location: B-3 : 1.5' to 2.0'

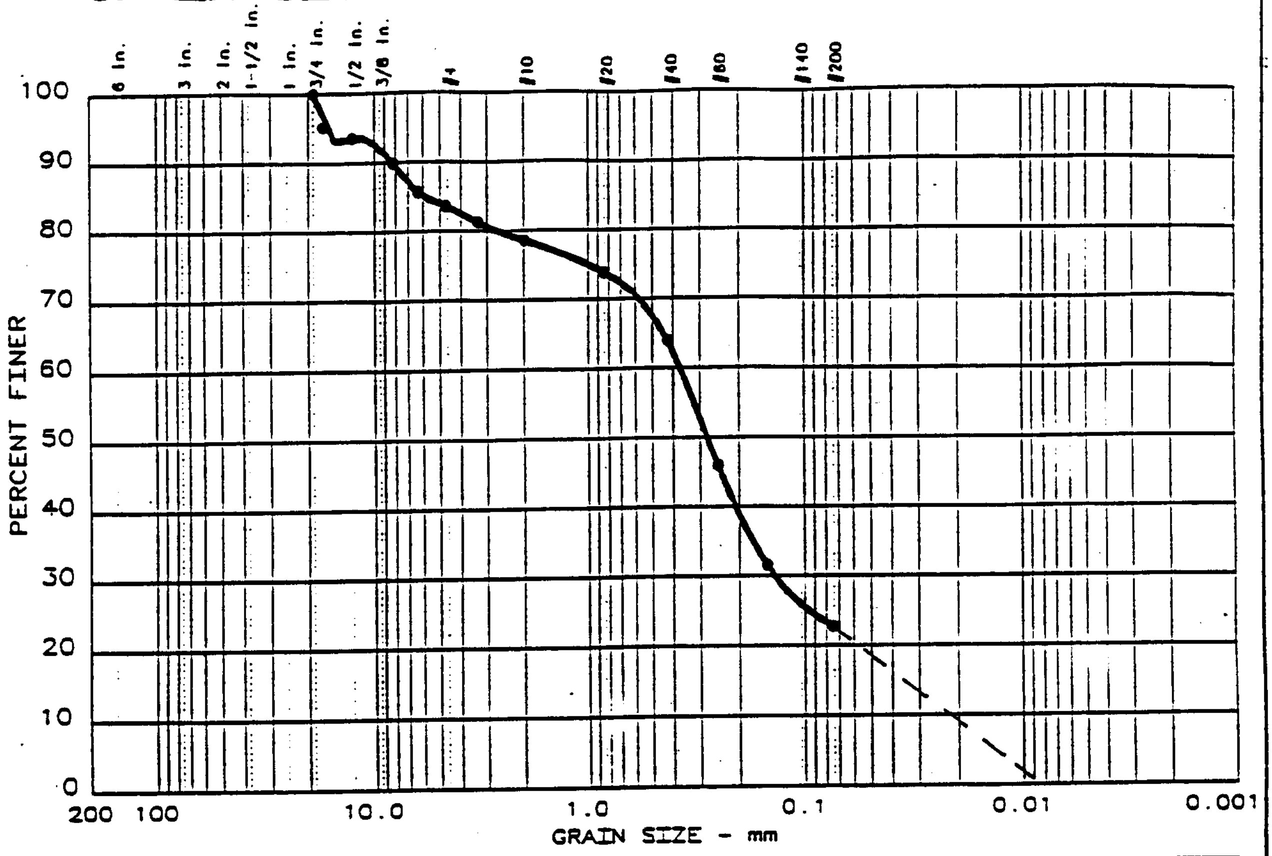
te: 10/28/98

Remarks:
K98-1496
Moisture: 17.2%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	16.4	60.8	22.8	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			5.96	0.372	0.279	0.138	~0.036	~0.021	~2.44	~17.7

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Sand with Gravel	SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-3: 3.5' to 4.0'

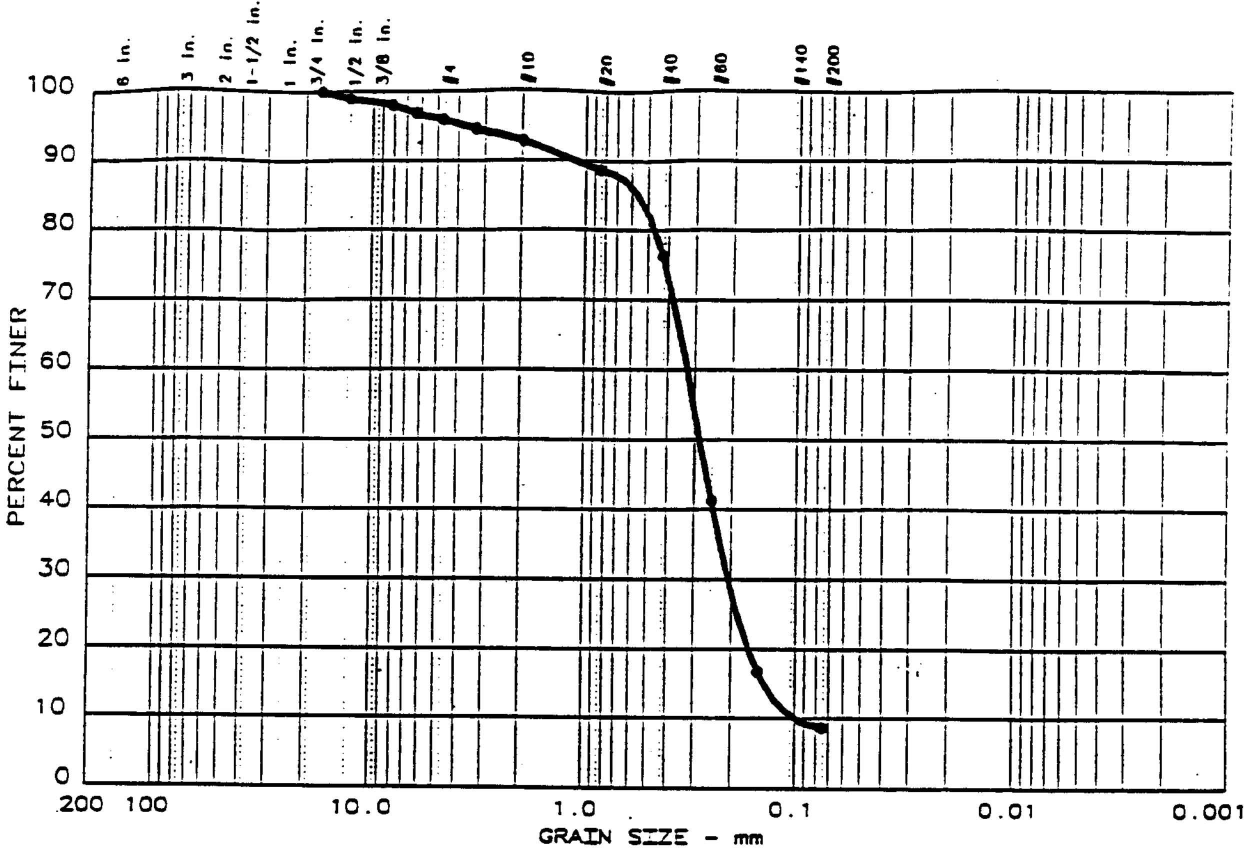
Date: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Remarks:
K98-1497
Moisture: 11.3%

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
5	0.0	4.2	87.1	8.7	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		0.550	0.326	0.284	0.207	0.140	0.0991	1.33	3.3

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt	SP-SM	

Project No.: 1A1767
roject: Tyee Golf Course
● Location: B-3 : 7.0' to 7.5'

.te: 10/28/98

Remarks:

K98-1498

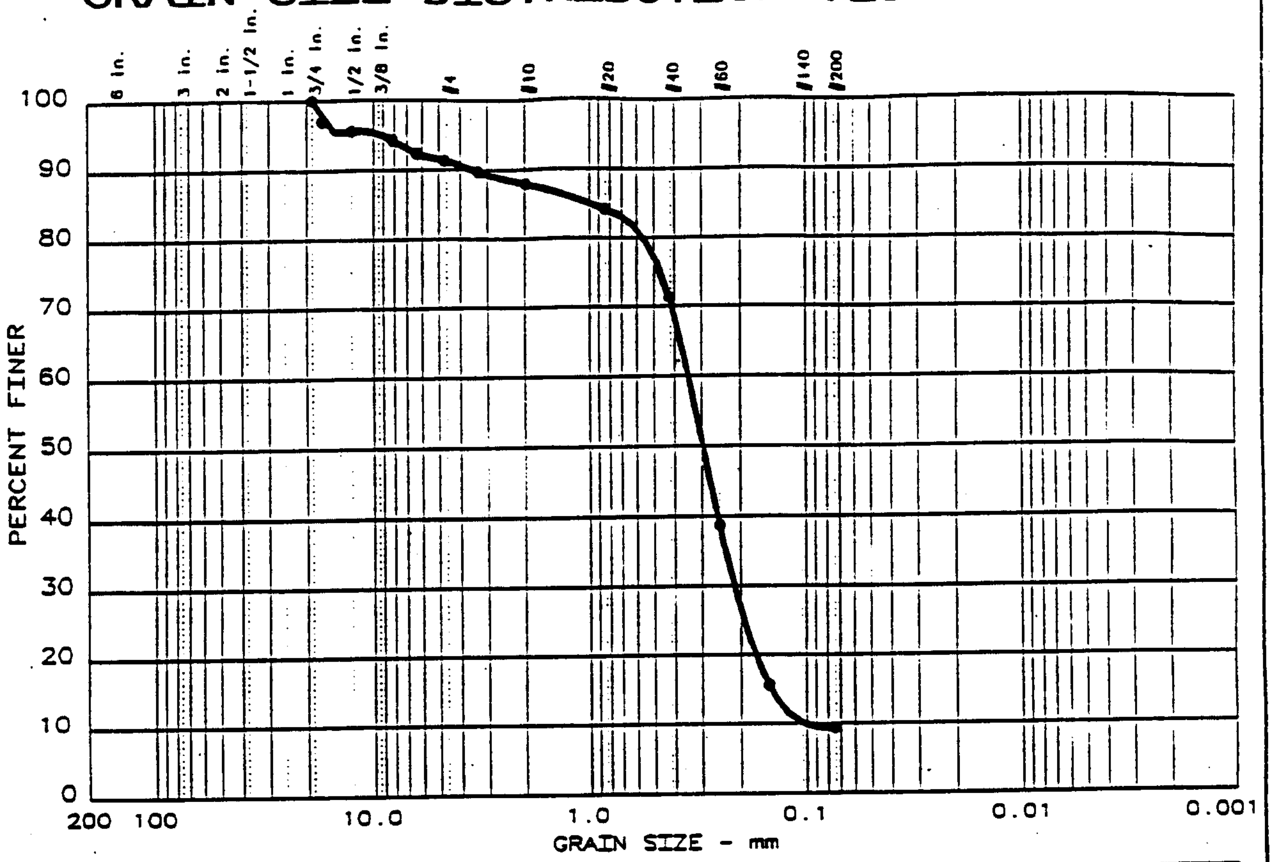
Moisture: 20.9%

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	6	0.0	8.7	81.9	9.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.00	0.346	0.297	0.214	0.146	0.102	1.30	3.4

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt	SP-SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-4: 1.0' to 1.5'

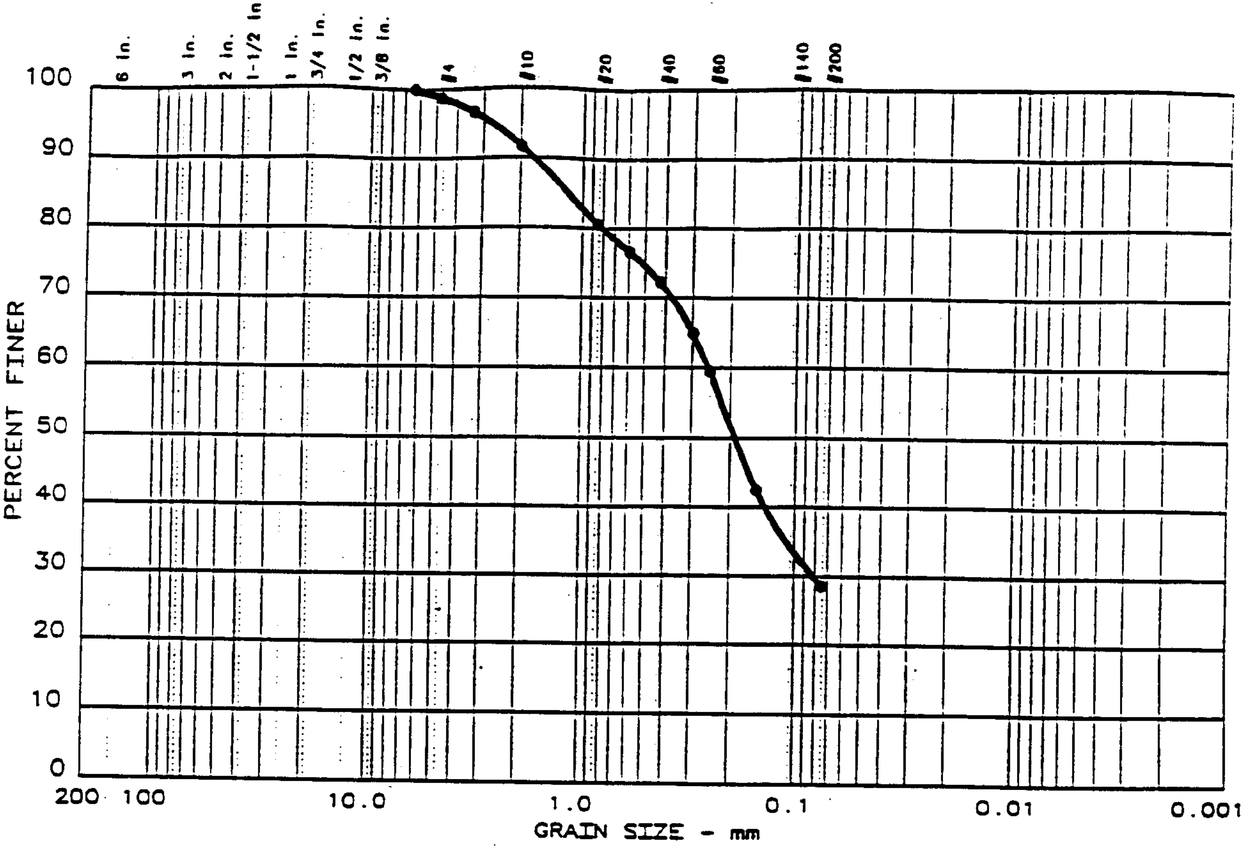
Date: 10/28/98

Remarks:
K98-1501
Moisture: 19.1%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
7	0.0	1.2	70.2	28.6	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		1.17	0.254	0.188	0.0813				

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Sand w/Organics	SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-5: 11.5' to 12.0'

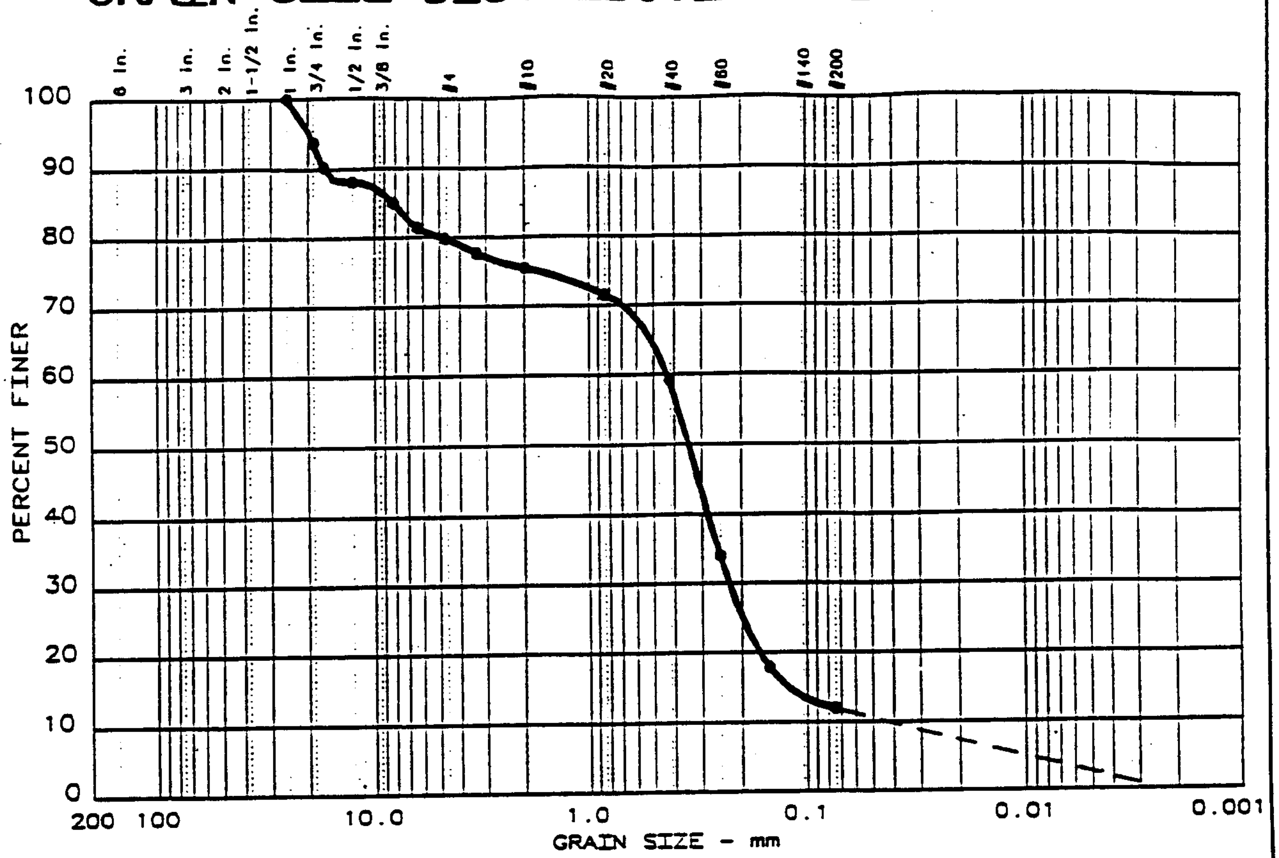
te: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Remarks:
K98-1509
Moisture: 153.9%

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	8	0.0	20.2	67.9	11.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			8.22	0.432	0.346	0.228	0.124	~0.042	~2.87	~10.3

MATERIAL DESCRIPTION	USCS	AASHTO
● Well-Graded Sand with Silt and Gravel	SW-SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-6 : 1.5' to 2.0'

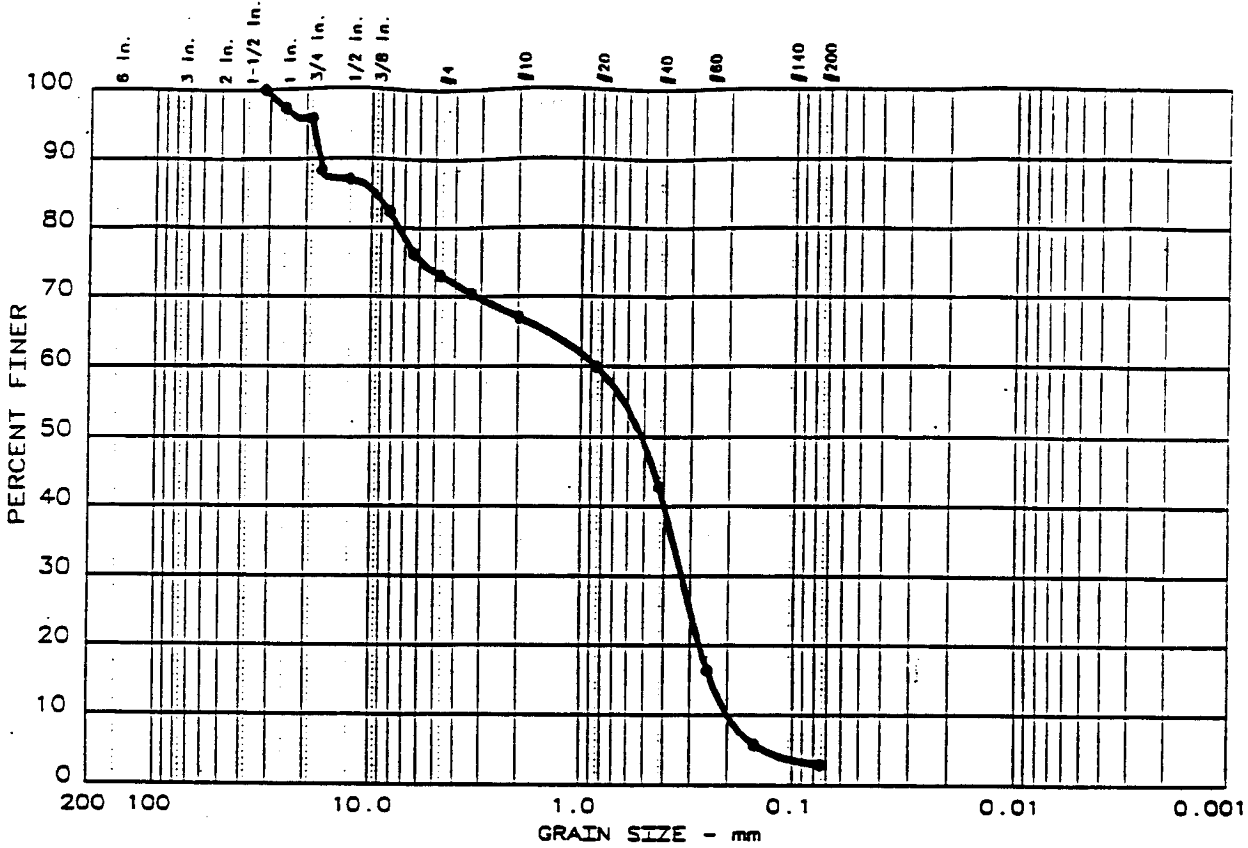
Date: 10/28/98

Remarks:
K98-1511
Moisture: 9.8%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
9	0.0	26.9	70.1	3.0	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		9.55	0.851	0.516	0.331	0.240	0.201	0.64	4.2

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Gravel	SP	

Project No.: 1A1767
F oject: Tyee Golf Course
● Location: B-6: 11.0' to 11.5'

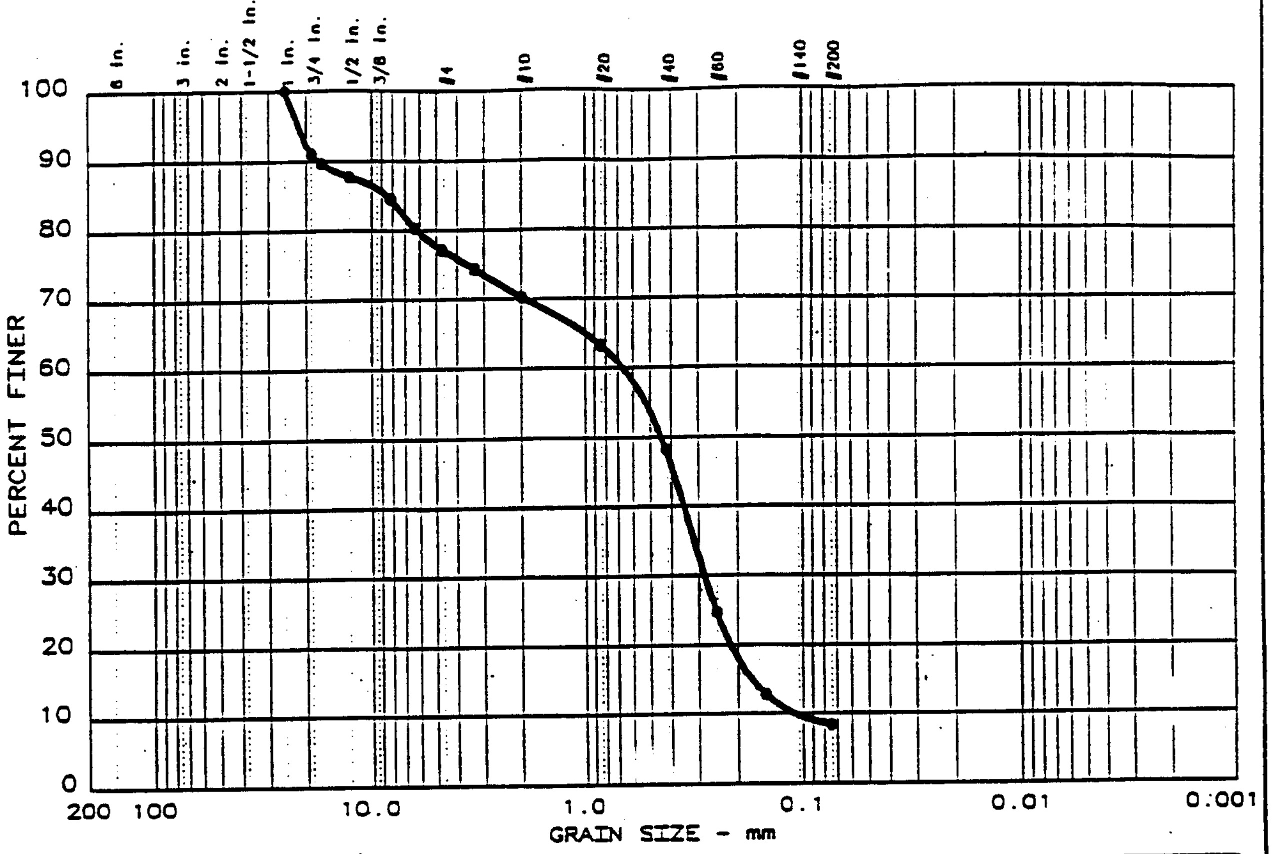
te: 10/28/98

Remarks:
K98-1514
Moisture: 17.2%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	10	0.0	22.9	68.8	8.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			8.51	0.661	0.446	0.283	0.173	0.110	1.10	6.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Well-Graded Sand with Silt and Gravel	SW-SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-7: 2.5' to 3.0'

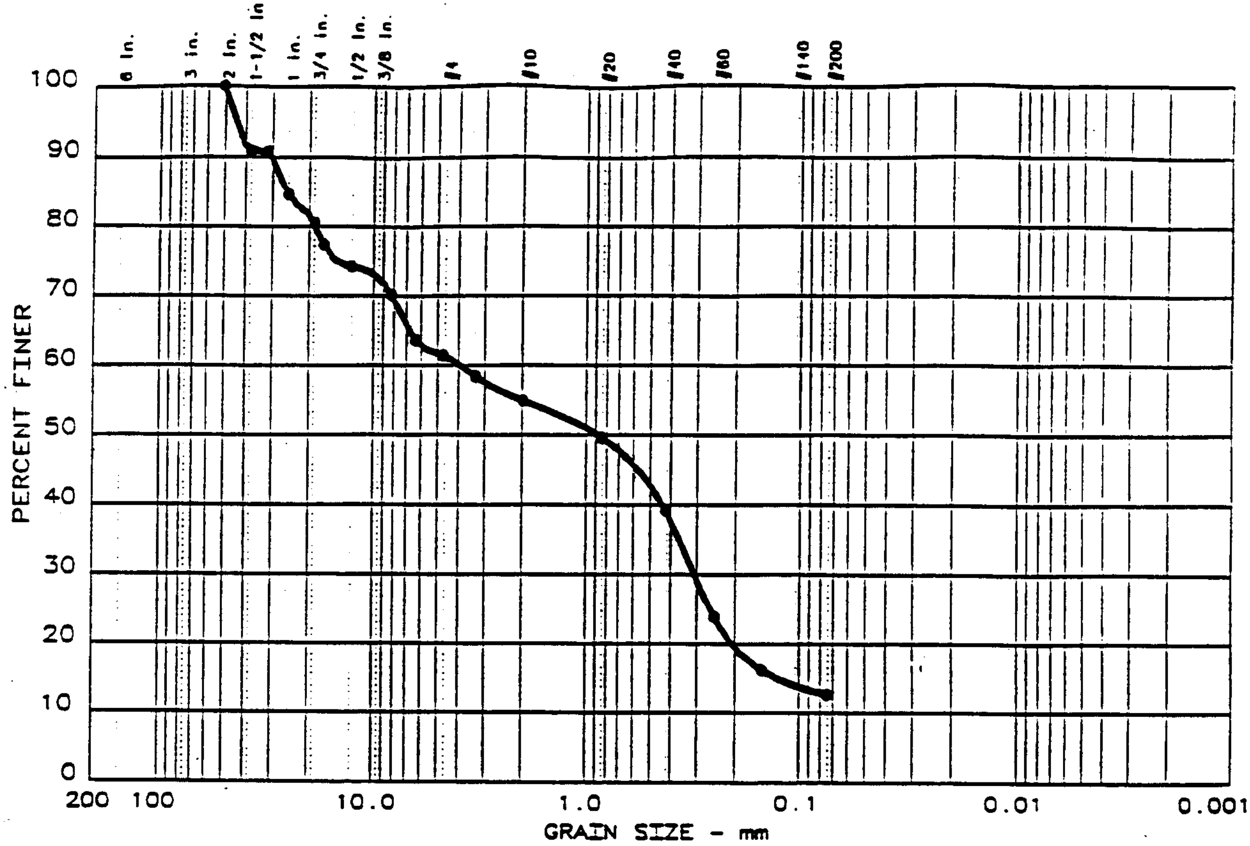
Date: 10/28/98

Remarks:
K98-1516
Moisture: 7.2%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
11	0.0	38.6	48.8	12.6	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		25.7	3.93	0.880	0.311	0.128			

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Sand with Gravel	SM	

Project No.: 1A1767
roject: Tyee Golf Course
● Location: B-8 : 5.5' to 6.0'

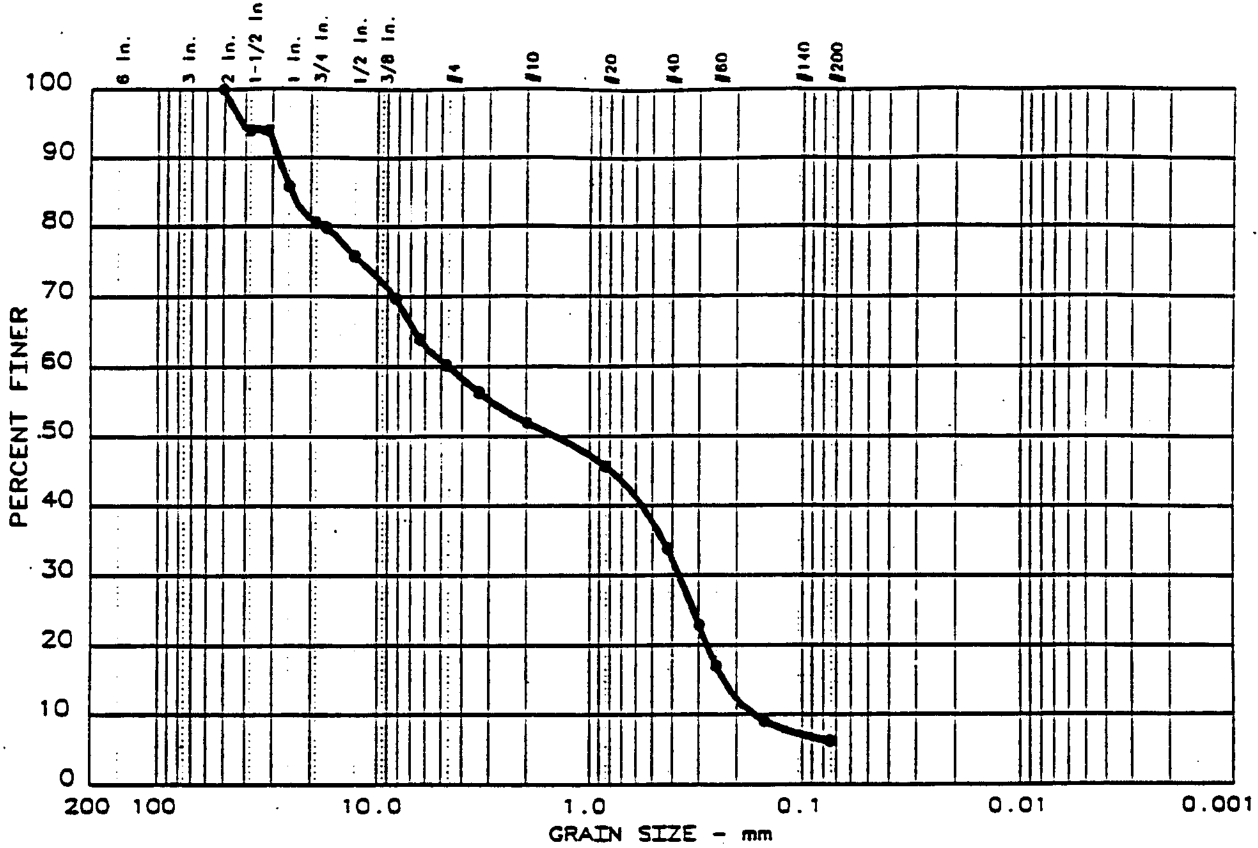
:e: 10/28/98

Remarks:
K98-1521
Moisture: 18.8%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	12	0.0	39.8	54.0	6.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			24.7	4.61	1.47	0.373	0.230	0.165	0.18	28.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt and Gravel	SP-SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-8: 8.0' to 8.5'

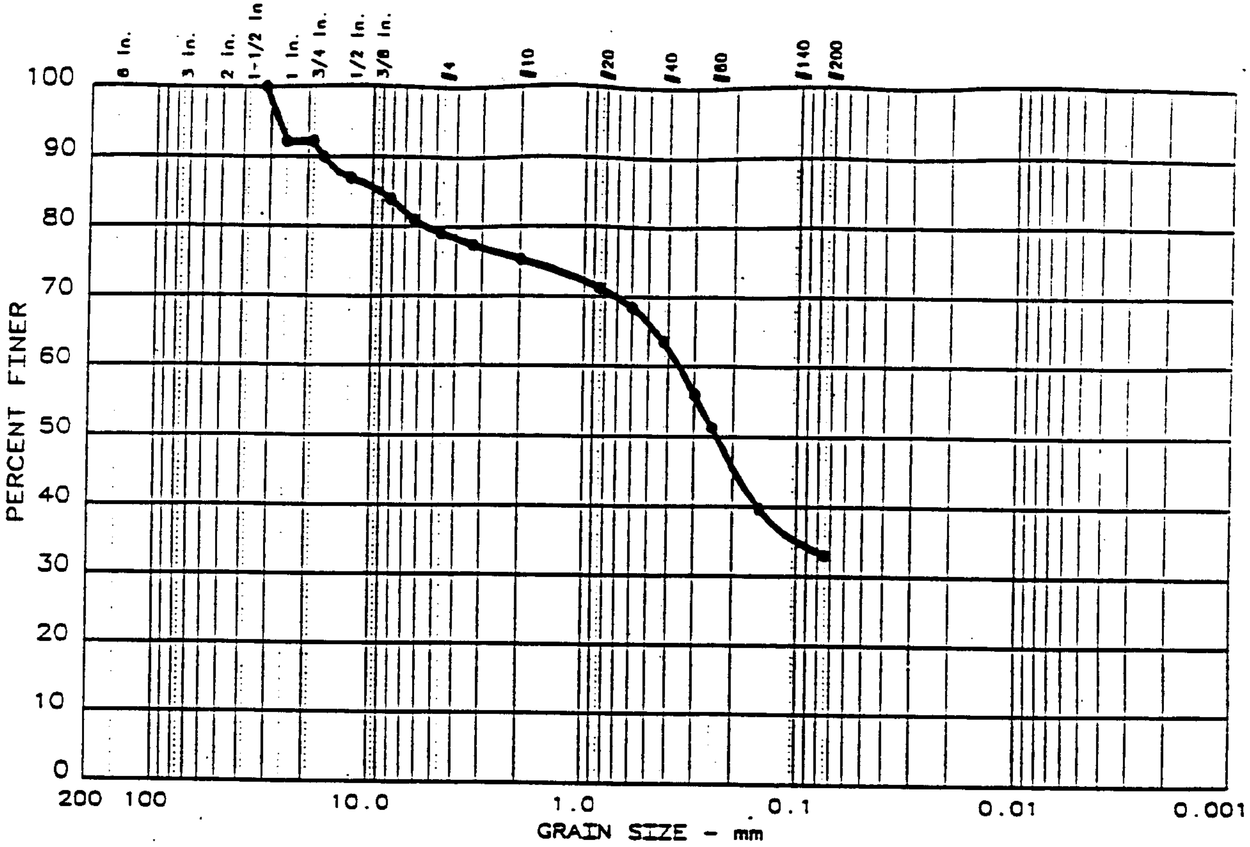
Date: 10/28/98

Remarks:
K98-1522
Moisture: 12.1%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	13	0.0	20.9	46.1	33.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			9.23	0.355	0.237					

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Sand with Gravel	SM	

Project No.: 1A1767

Project: Tyee Golf Course

● Location: B-8: 10.5' to 11.0'

te: 10/28/98

Remarks:

K98-1523

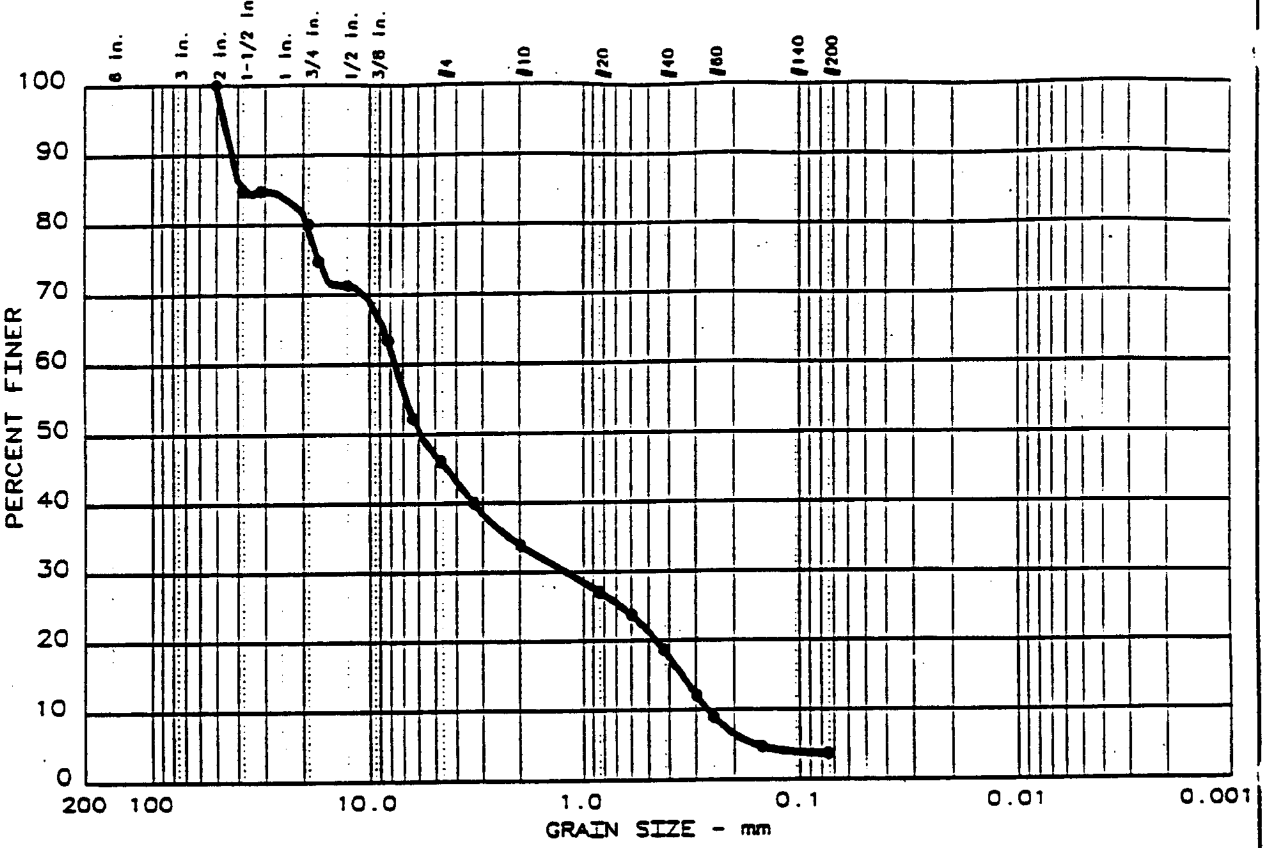
Moisture: 23.7%

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	14	0.0	53.9	42.4	3.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			38.0	7.64	5.86	1.22	0.349	0.265	0.74	28.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Gravel with Sand	GP	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-8 : 14.0' to 14.5'

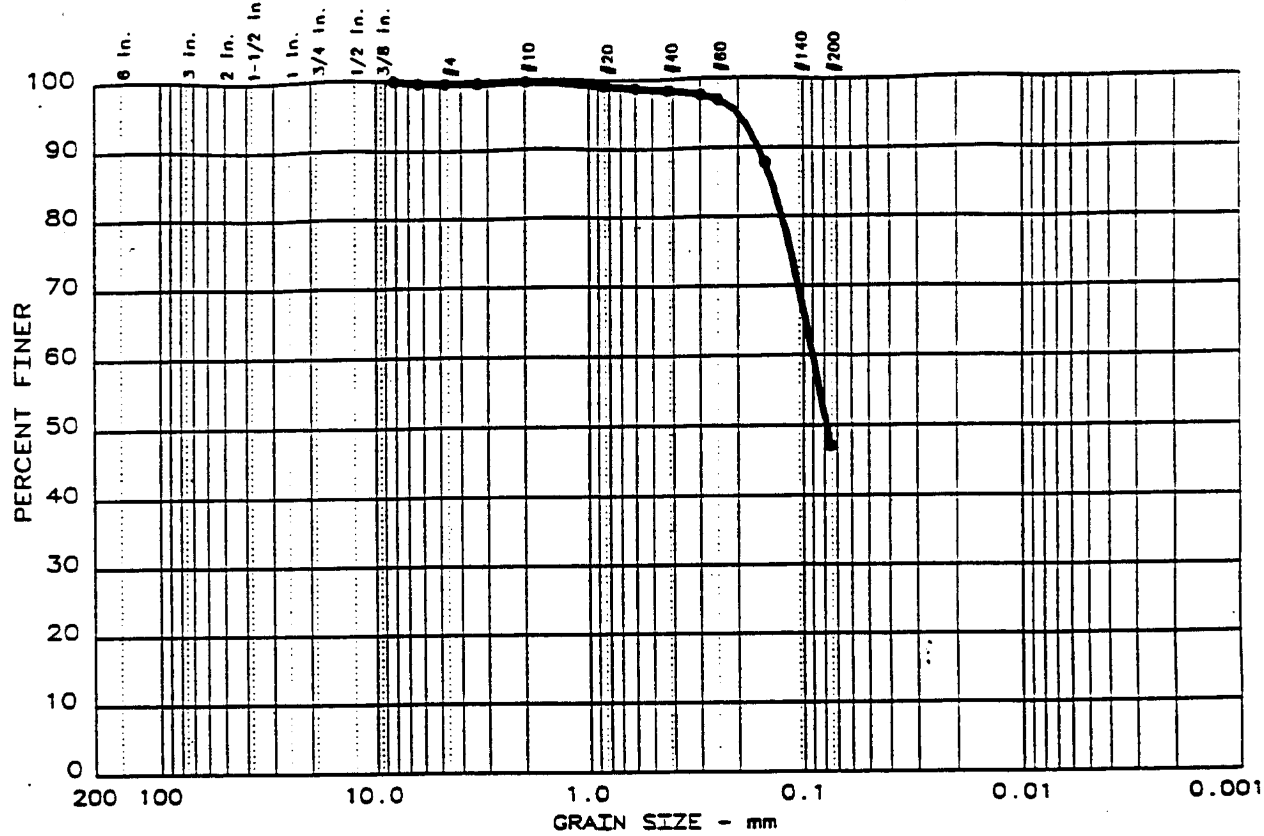
Date: 10/28/98

Remarks:
K98-1524
Moisture: 9.3%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	19	0.0	0.3	52.8	46.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.140	0.0905	0.0783					

MATERIAL DESCRIPTION	USCS	AASHTO
● Silty Sand	SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-9: 6.0' to 6.5'

ate: 10/28/98

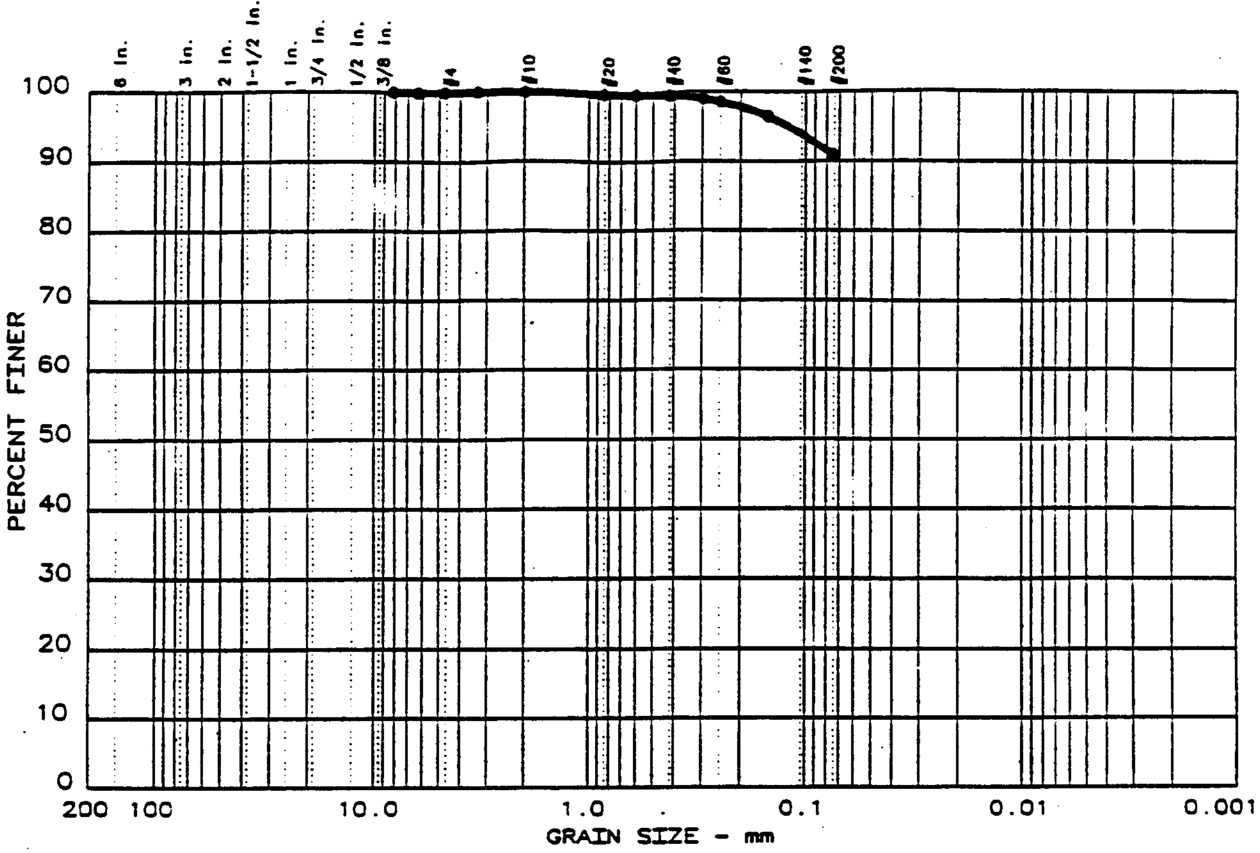
Remarks:
K98-1540
Moisture: 28.4%

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

Fig. No.: _____

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	20	0.0	0.1	9.0	90.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●										

MATERIAL DESCRIPTION	USCS	AASHTO
● Silt	ML	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-10: 14.0' to 14.5'

Date: 10/28/98

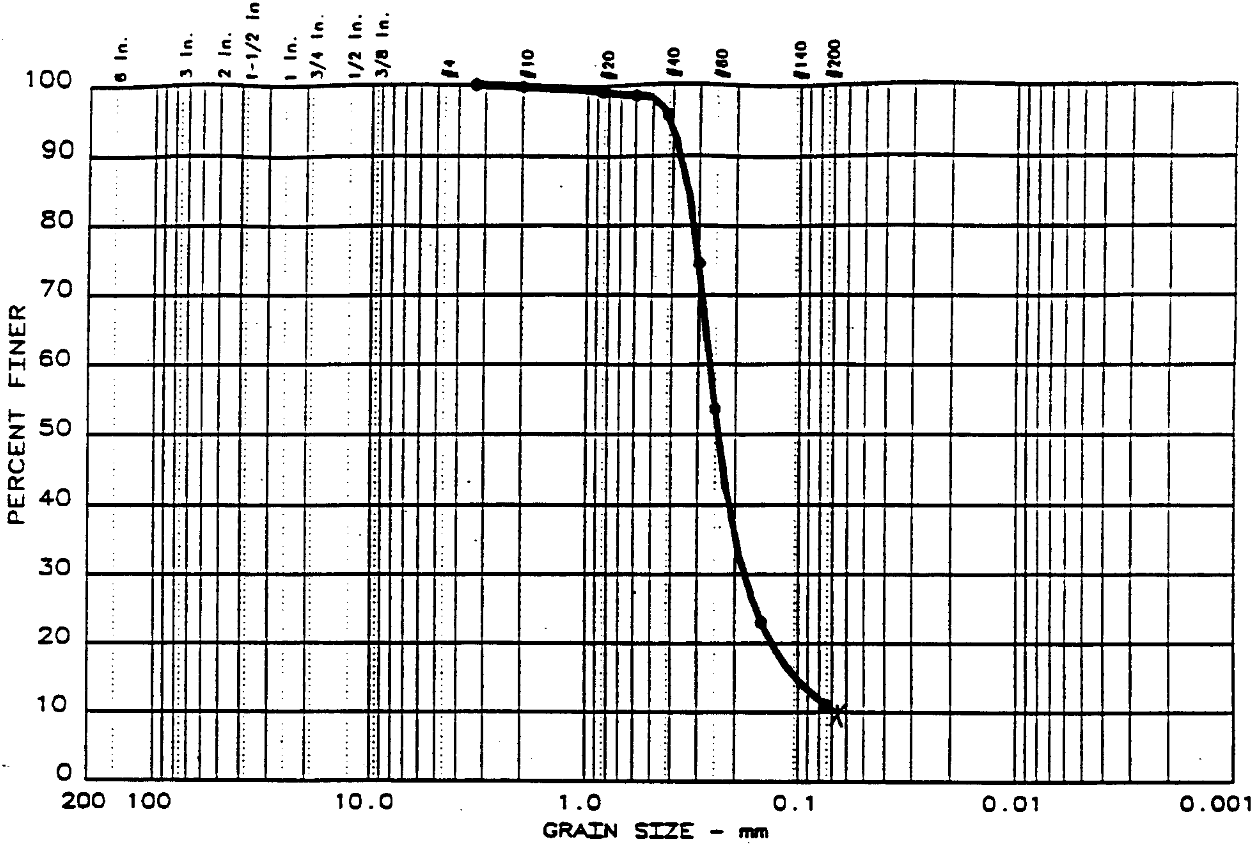
Remarks:
K98-1546
Moisture: 24.6%

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
1	0.0	0.0	88.9	11.1	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
		0.338	0.264	0.241	0.181	0.102	~0.066	~1.88	4.0

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt	SP-SM	

P-oject No.: 1A1767
-oject: Tyee Golf Course
● Location: B-11: 6.5' to 7.0'

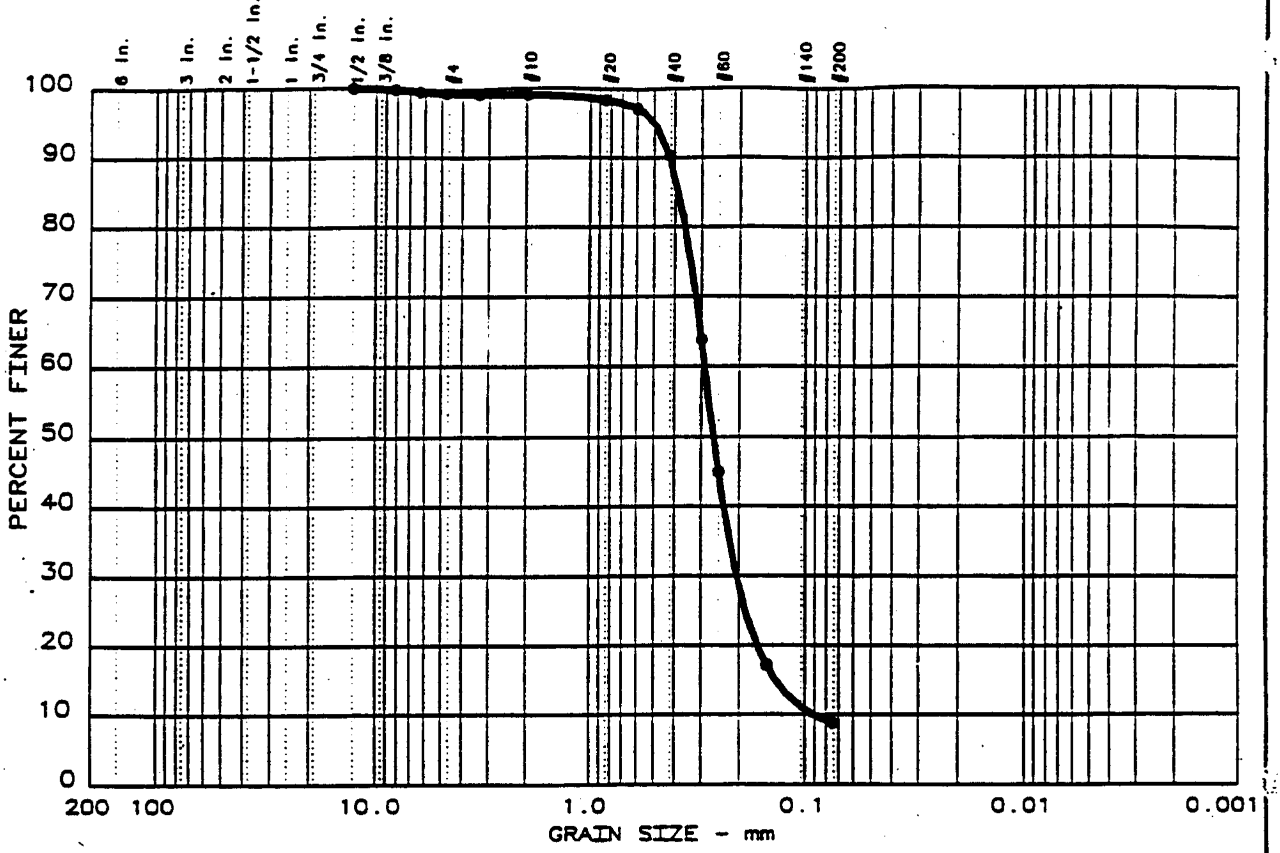
e: 10/28/98

Remarks:
K98-1548
Moisture: 21.7%

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	2	0.0	0.6	90.5	8.9	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.385	0.289	0.263	0.206	0.136	0.0918	1.59	3.1

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt	SP-SM	

Project No.: 1A1767
Project: Tyee Golf Course
● Location: B-11: 11.5' to 12.0'

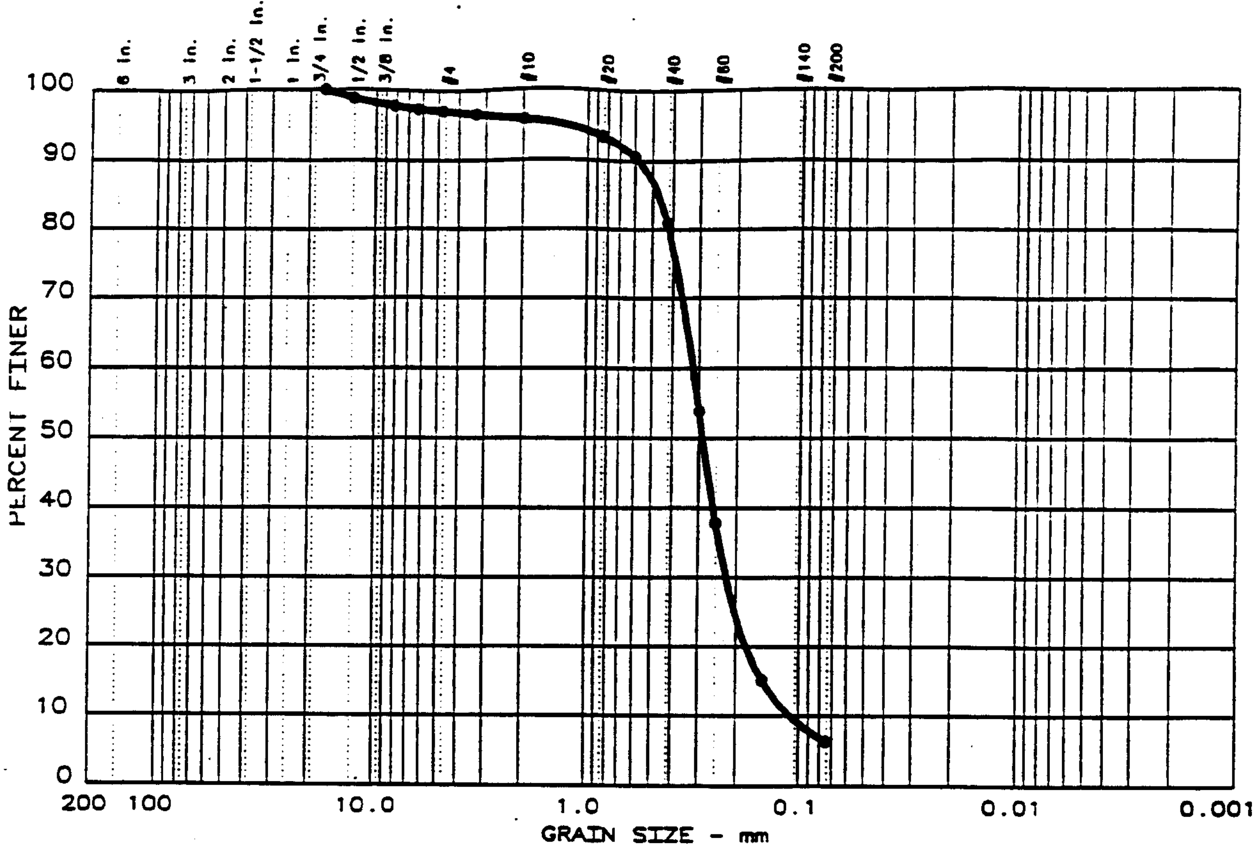
Date: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT
KING COUNTY MATERIALS LABORATORY

Remarks:
K98-1550
Moisture: 25.0%

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
● 3	0.0	3.0	90.7	6.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.466	0.321	0.287	0.223	0.149	0.110	1.40	2.9

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt	SP-SM	

Project No.: 1A1767

Project: Tyee Golf Course

● Location: B-12: 11.5' to 12.0'

e: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

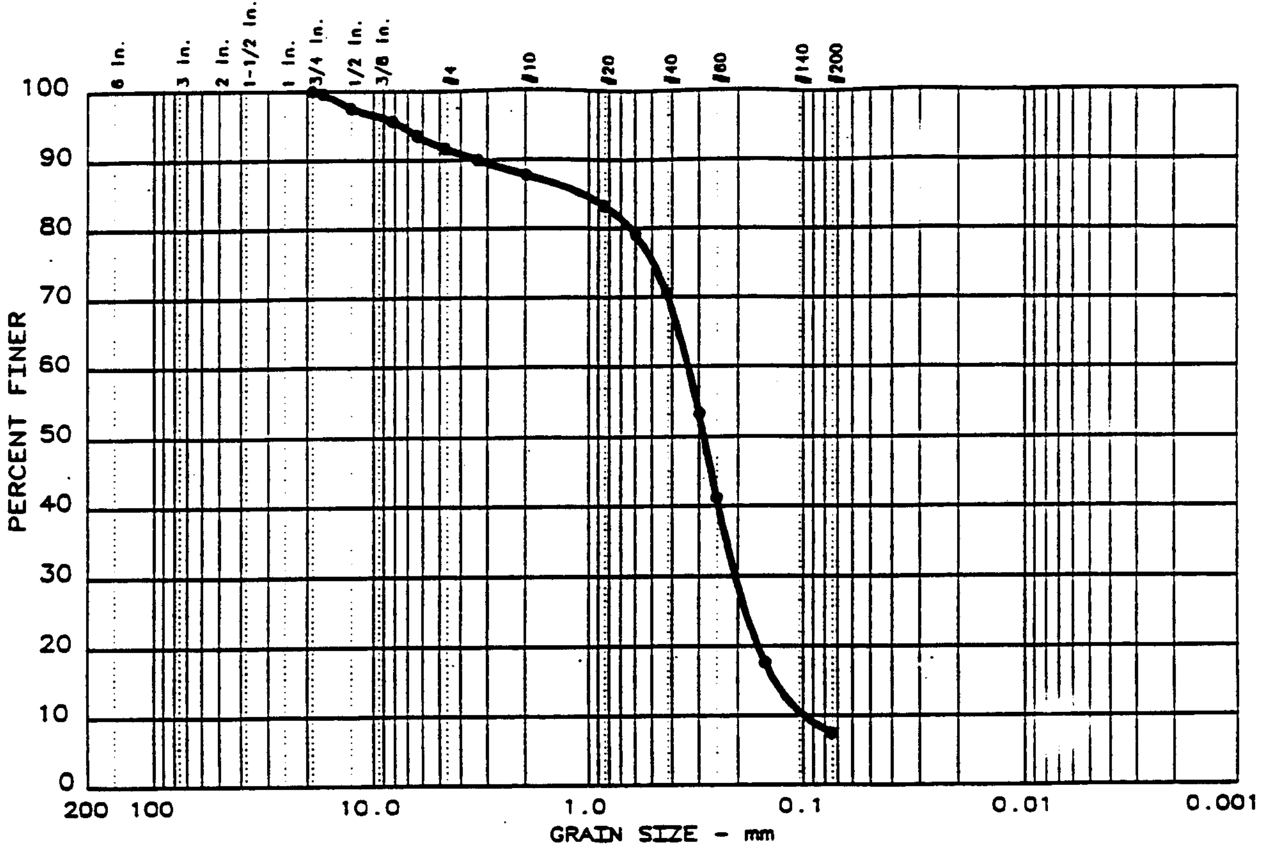
Remarks:

K98-1553

Moisture: 24.4%

Fig. No.: ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	4	0.0	8.3	84.2	7.5	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			1.08	0.336	0.285	0.206	0.134	0.0995	1.26	3.4

MATERIAL DESCRIPTION	USCS	AASHTO
● Poorly Graded Sand with Silt	SP-SM	

Project No.: 1A1767

Project: Tyee Golf Course

● Location: HA-1: 1.5' to 2.0'

Date: 10/28/98

GRAIN SIZE DISTRIBUTION TEST REPORT

KING COUNTY MATERIALS LABORATORY

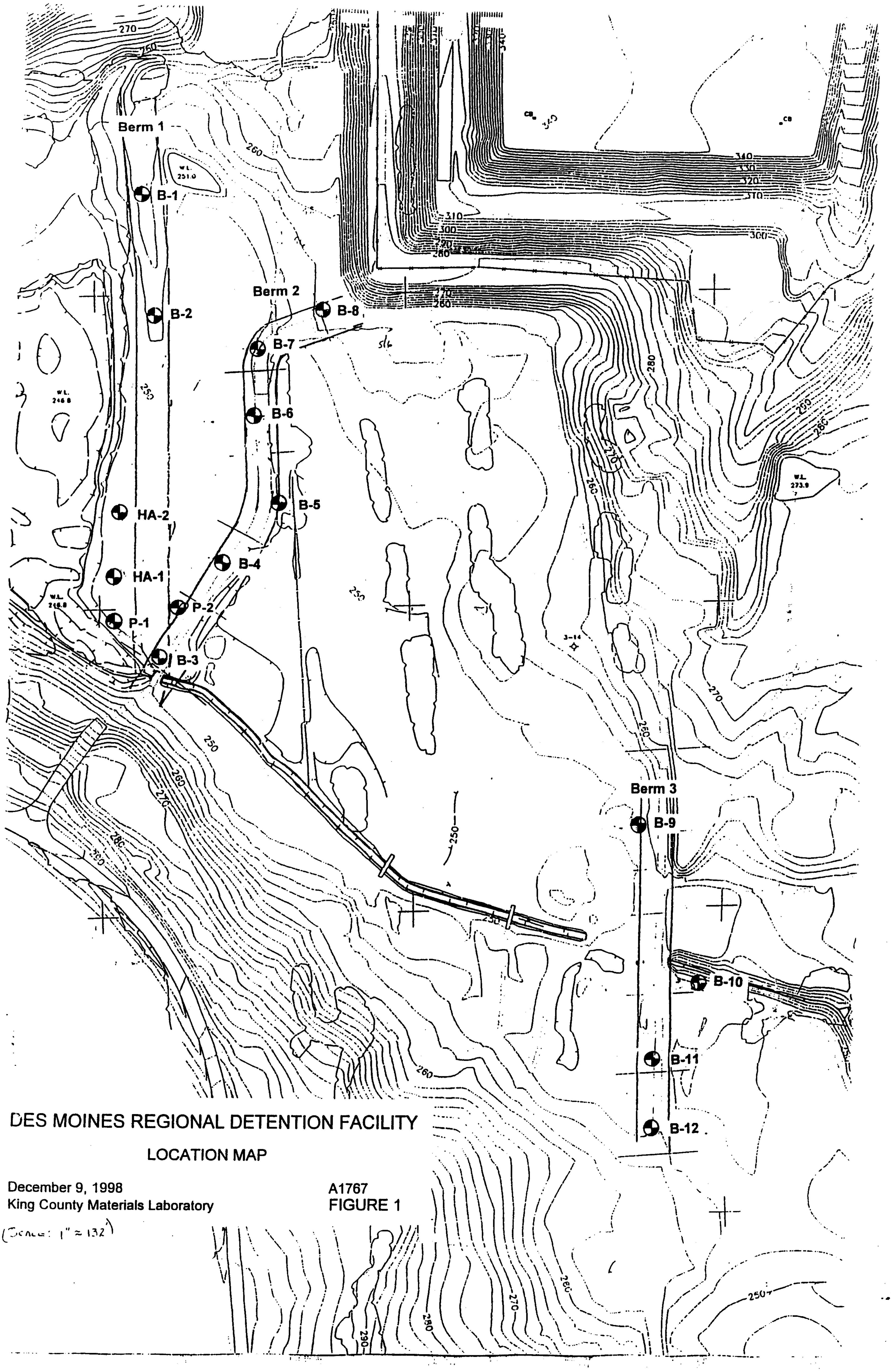
Remarks:

K98-1554

Moisture: 21.3%

Fig. No.: ______

DRAWINGS



DES MOINES REGIONAL DETENTION FACILITY

LOCATION MAP

December 9, 1998
King County Materials Laboratory

A1767
FIGURE 1

(Scale: 1" ≈ 132')

Appendix H

DES MOINES CREEK REGIONAL CIP
PRELIMINARY DESIGN REPORT

Appendix H
Dam Safety Review

Appendix H not included at this time.

Appendix I

DES MOINES CREEK REGIONAL CIP
PRELIMINARY DESIGN REPORT

Appendix I
Low Flow Augmentation Studies

Draft

Des Moines Creek Flow Augmentation Plan

Seattle-Tacoma International Airport Master Plan Update Improvements

Port of Seattle

Parametrix, Inc.
August 18, 1998

DRAFT

DES MOINES CREEK FLOW AUGMENTATION PLAN

SEATTLE-TACOMA INTERNATIONAL AIRPORT
MASTER PLAN UPDATE IMPROVEMENTS

Prepared for

PORT OF SEATTLE
P.O. Box 69727
17801 Pacific Highway South
Seattle, Washington 98168-0727

Prepared by

PARAMETRIX, INC.
5808 Lake Washington Blvd. N.E.
Kirkland, Washington 98033

August 18, 1998
55-2912-01 (03)

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1.0 INTRODUCTION

1.1 PURPOSE AND BACKGROUND

This Des Moines Creek Flow Augmentation Plan describes the design, operation, and monitoring of a streamflow augmentation facility that will be constructed on Port of Seattle (Port) property at the Tyee Valley Golf Course near Seattle-Tacoma International Airport. The flow augmentation facility will supply up to 400 gpm (0.88 cfs) of water to Des Moines Creek from an existing groundwater well on Port property. Introduction of the cool well water to the stream should improve water quality and aquatic habitat during critical low flow periods in mid- to late summer.

The plan for providing flow augmentation to Des Moines Creek was originally proposed by King County as part of the 1997 Des Moines Creek Basin Plan to mitigate existing or potential cumulative impacts on Des Moines Creek baseflows. The Port subsequently incorporated the plan in Section 2.1 of ***Amended Wetland Mitigation Plan and Supporting Documents, July 15, 1998***, which was prepared in support of the Section 401 Water Quality Certification for the proposed Master Plan projects. On July 20, 1998 the State of Washington Department of Ecology (Ecology) issued ***Order 96-4-02325: Port of Seattle Master Plan Improvements*** (the Order) requiring the Port to issue an operations plan to Ecology describing how the flow augmentation will be implemented. This Plan was prepared in response to that Order.

King County is preparing feasibility and engineering studies to implement this and other adopted Basin Plan elements. This operations plan would be modified by King County as necessary to meet Basin Plan objectives.

1.2 OPERATIONAL CRITERIA

The water supply for the flow augmentation facility will come from an existing well located on Port property. Well water will be pumped to the stream at a location just below the confluence of the East Branch and West Branch of Des Moines Creek based on the following criteria:

- When the streamflow rate immediately below the confluence drops below 1.0 cfs; or
- When the water temperature at that location is above a temperature considered detrimental to existing uses (16° C in the Order).
- Flow augmentation will occur between May and October.

Stream monitoring data will be reviewed after the first full year of operation to determine the effectiveness of these operational criteria, and modifications will be made as appropriate (subject to Ecology approval).

To meet these objectives, a water supply of 400 gpm (0.88 cfs) is proposed. Streamflow monitoring data collected by King County during 1996 and 1997 reported a minimum flow in the stream during this period of approximately 0.3 cfs. Thus, a 400 gpm well capacity should be able to maintain the 1.0 cfs minimum flow. The 1996-97 monitoring data indicate that the pump would need to operate between two and six weeks annually to maintain the 1.0 cfs minimum flow.

Temperature monitoring data collected for the Basin Plan during 1996 showed that stream temperatures at South 200th Street exceeded 16° C on only a few days during the months of April, May; on several days in June; and almost daily during July and August (the reported data ended on September 6, 1996). High water temperatures did not necessarily correspond to low stream flow rates, but appear to be more influenced by warm air temperature. During the period April 1 to September 6, 1996 the water temperature exceeded 16° C a total of 120 days, or about 75% of the days. Since the stream temperature probably exceeded 16° C during many days in September and October, the well pump would have to be operated at least 120 days per year on average to meet a 16° C temperature criteria.

The amount of pumping needed for keeping stream temperatures at 16° C may require a significant volume of water from the aquifer, potentially exceeding the available water right. In addition, a large amount of pumping may not be justified if the benefit of flow augmentation for temperature control has only limited effectiveness downstream. As discussed below in Section 3.1, the monitoring plan includes testing during the first year of operation to determine the effects of various temperature settings between 16° and 19° C on downstream temperatures and the corresponding pumping requirements at those levels.

1.3 WATER RIGHTS

The flow augmentation project will require a new or modified water right obtained from Ecology for consumptive use of groundwater. Water for the project would be obtained from either the golf course well or a nearby inactive well (see Section 2.2). These wells were originally constructed by King County Water District 75 (now Highline Water District) for municipal water supply. In addition, another abandoned KCWD 75 well is located on Port property, and an abandoned well owned by the Port of Seattle is located in the vicinity of the terminal parking garage. The KCWD 75 wells were abandoned several decades ago when the district was connected to City of Seattle water.

A preliminary search of water rights records filed with Ecology provided information on existing water rights that are associated with wells located on Port property. This information is summarized in Table 1-1. Copies of the certificates and associated documents are contained in Appendix A. In addition to these certificates, the Port has also filed a water rights claim for groundwater used for irrigation at the Tyee Valley Golf Course. That claim, which has a priority date of 1967, claimed an irrigation use of 450 gpm and 244 ac-ft/yr from the former KCWD 75 water supply well. According to Highline Water District there is no formal agreement between the district and the Port for use of the well for irrigation.

Table 1-1. Water rights on Port of Seattle property

Well	Certificate Number	Water Right Instant. Rate	Water Right Annual Quantity	Status
Golf course	2369	400 gpm	560 ac-ft/yr	Constructed in 1949 by KCWD 75 for municipal water supply. Currently used for golf course irrigation.
Inactive well near golf course well	2191	750 gpm	600 ac-ft/yr	Constructed in 1953 by KCWD 75 for municipal water supply. Currently inactive. Well cap is visible on 3rd fairway.
Abandoned Port of Seattle well (under terminal parking garage)	5233	250 gpm	82 ac-ft/yr	Constructed in 1965 by Port of Seattle for irrigation and condenser water uses. Currently abandoned.
Abandoned well (under Runway 34R safety fill).	2376	350 gpm	560 ac-ft/yr	Constructed in 1954 by KCWD 75 for municipal water supply. In 1962 the water rights for this well were assigned to Port of Seattle. Currently abandoned.

It appears from these water rights documents that the Port has a total potential water right of 600 gpm from two abandoned wells (from certificates 5233 and 2376). The ownership status of the water rights from these two wells, as well as the other two KCWD 75 wells (whose land parcels were purchased during previous land acquisition programs), would have to be clarified by Ecology. Following this, documentation for transfer or change of water rights for the project will be provided to Ecology. It is anticipated that the water rights from one or more of these wells would be transferred to the Port for the flow augmentation project and assigned the "environmental quality" purpose of use designation.

2.0 PROPOSED DESIGN

A description of available wells, well modifications that are needed for the flow augmentation system, and the control system to operate the system is provided below. The flow augmentation system will be designed to be fully automated. It will also not interfere with the existing golf course irrigation system, which would operate on a different pumping schedule. A conceptual design plan of a flow augmentation system is shown on Figure 1.

2.1 EXISTING WELLS

Two wells having sufficient capacity for the project are located at the southern end of Tyee Valley Golf Course. The well presently being used to irrigate the golf course (Certificate No. 2369) is located at a pump house located just east of the 3rd fairway and north of South 200th Street. Based on the well log provided with the water right certificate, this well has a 12-inch casing extending from the surface to 245 feet, and an 8-inch casing from 245 feet to 545 feet. Well perforations (1/4" x 4") extend between the 72-foot and 160-foot depths, and between the 190-foot and 243-foot depths.

According to Roy Moore, the golf course manager, a previous pump test showed the golf course well has a capacity of 1,200 gpm with an eight-foot draw down (documentation of that test could not be located). The water level is apparently near the surface. The maximum production is reported to be 350 gpm, and is limited by the size of the irrigation system installed for the golf course. A turbine pump is installed in the well, and the header line from the pump is eight-inch diameter steel. The well casing appears to be in good condition.

The second well (Certificate No. 2191) is an inactive well located within the 3rd fairway. It was abandoned as a water supply well several decades ago, but apparently is still usable (it is reported to be artesian). The drilling log reported a pump test capacity of 750 gpm for this well, but no other information on the well was found. Since this well is located in the fairway, a pump house for the well would need to be constructed underground to avoid disrupting the golf course.

Based on available information, it appears likely that both wells have sufficient capacity to serve the flow augmentation system on Des Moines Creek. Further investigations should be conducted during the design phase to gather more information on these wells.

2.2 WELL UPGRAGES, CONVEYANCE SYSTEM, AND STREAM DISCHARGE

Two alternative designs are discussed below and shown on Figure 1. Selection of the preferred alternative would be made during the design phase after the condition of the existing wells is thoroughly investigated, the costs of upgrading the existing well versus installing new equipment at the inactive well are compared, and water rights permitting is addressed.

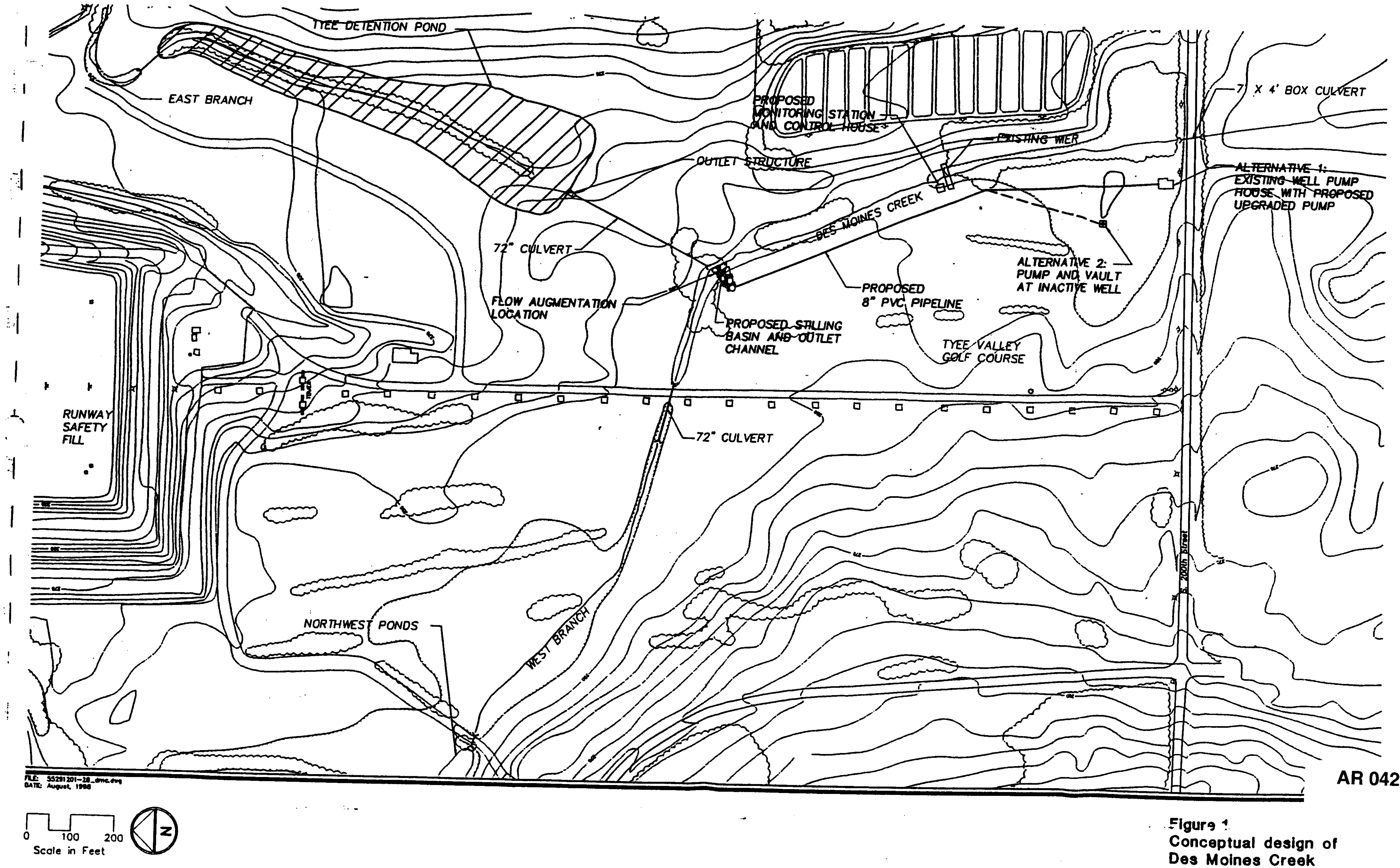


Figure 1
Conceptual design of
Des Moines Creek
flow augmentation

Alternative 1 would use the existing golf course well. Since the existing 350 gpm pump at that well is at capacity for the irrigation needs of the golf course, the pump, motor, electrical service, and control system would need to be upgraded. A pump with a flow capacity of 800-1,000 gallons per minute would be required. A turbine pump is recommended for this size and depth of inlet pipe. The pump house may also need remodeling to contain the new equipment.

Alternative 2 would use the inactive well located in the 3rd fairway. To reactivate the well, and not make the 3rd fairway unsuitable for golf, a vault would be installed over the well. Access to the underground vault would be through a small hatch of approximately two feet by four feet. A variable speed submersible pump with a minimum capacity of 400 gpm is recommended for this well. The variable speed pump would allow flexible operation of the flow augmentation system. The pump controls would be located in a new control house adjacent to the stream monitoring station. This house would also contain all the sensors, gauges and readouts for the monitoring station.

A new 8-inch PVC pipe would be installed between the pump house and the flow augmentation outlet. The pipe would be buried at least two feet below ground surface to protect the pipe from freezing and crushing. The outlet to Des Moines Creek would be located just below the confluence of the West Branch and East Branch. The outlet would consist of a manhole-type structure that acts as a stilling basin, followed by a 20-foot channel of small riprap or quarry spalls leading to the stream. Water cascading down the rock channel would aerate the groundwater before it enters the stream. The entry to the stream would be designed to prevent erosion of the existing channel.

2.3 FLOW AND TEMPERATURE MONITORING

Three concrete weirs were constructed along Des Moines Creek above South 200th Street during the 1960s to control erosion along this portion of the stream. Currently, King County operates a stream gauging station at the furthest upstream weir, which is located about midway between the confluence of the West and East Branches and South 200th Street. It is proposed that a monitoring station be located at that weir to measure stream stage and temperature, and possibly contain the pump control equipment. The rectangular weir would be modified by adding a V-notch plate or by installing a Parshall flume to achieve more accurate flow measurement at low flow. A trash rack would be installed to prevent debris from accumulating in the flow measurement section, and a stilling well would be constructed at the weir to contain the sensors.

An ultrasonic sensor will be used to continually monitor the stream depth at the weir. Using a streamflow rating curve that is established for the weir, the flow depth corresponding to a flow rate of 1.0 cfs will be determined and used by the well control system to set the pump variable speed rate for flow augmentation. A 4-20 ma signal from the level sensor will automatically adjust the variable speed pumping rate to maintain a 1.0 cfs minimum flow rate.

Temperature measurements would be made using a thermister probe at or near the stream gauge stilling well. As with the streamflow measurements, temperatures would be converted to a 4-20 ma signal. The pump controls would respond to the temperature readings in a manner similar to that for the flow readings. When the water temperature is above the established temperature criteria, water would be pumped into the stream at a rate proportional to the temperature difference, up to a maximum of 400 gpm. When the stream temperature drops below established temperature criteria, the pump flow would be ramped down while maintaining a minimum flow rate of 1.0 cfs.

A data logger located at the monitoring station will record continuous (i.e., 15-minute interval) readings of stream stage, stream temperature, pumping rate, and pumping time. These data will constitute the permanent monitoring record of the flow augmentation system.

3.0 MONITORING AND MAINTENANCE

3.1 MONITORING PLAN

A monitoring plan will be implemented to collect streamflow and temperature data in Des Moines Creek. The objectives of the monitoring plan are to:

- Obtain streamflow measurements at the monitoring station to calibrate the flow gauging equipment.
- Obtain streamflow and temperature data at several locations above and below the flow augmentation point to evaluate the effectiveness of different pumping rates on streamflow levels, temperature control, and dissolved oxygen.
- Establish a permanent and continuous monitoring system to document groundwater pumping rates, the total annual quantity of water used, and compliance with Ecology's Order.

In addition, potential improvements to instream habitat due to increased low flows could be evaluated using the Instream Flow Incremental Methodology (IFIM) model developed for Des Moines Creek for the basin plan. This element of the monitoring plan will be conducted by King County as part of the continuing Des Moines Creek Basin Plan program.

A summary of specific monitoring activities is provided in Table 3-1. These elements of the monitoring plan will be further detailed in the Inspection and Maintenance Manual (Section 3.2).

Table 3-1. Monitoring plan

Activity	Methods and Locations	Period and Frequency
1. Monitoring station rating curve	Several point measurements of streamflow rate and stage at monitoring station weir.	Up to six measurements after weir modifications and gauging station installation.
2. First year monitoring and pump flow testing	Point measurements of temperature and dissolved oxygen at: • Confluence • South 200th Street • South 208th Street • Midway WWTP Continuous monitoring of flow and temperature at monitoring station, pumping rates and volume at pump station,	Up to 12 monitoring events to evaluate effectiveness of different temperature criteria (i.e., 16°, 17°, 18°, and 19° C) on stream water quality. To be conducted in mid summer when stream flow is above 1.0 cfs and weather is stable.
3. Permanent monitoring	Continuous monitoring of flow and temperature at monitoring station, pumping rates and volume at pump station.	Annually during May-October flow augmentation period.

3.2 INSPECTION AND MAINTENANCE MANUAL

Following construction of the flow augmentation facility, an inspection and maintenance manual will be prepared to provide guidance for Port of Seattle employees who will inspect and maintain the facility. The purpose of the manual is to ensure that the facility is inspected and maintained on a regular basis, and the facility remains functioning as designed. Similar manuals have been prepared for the Port's stormwater detention facilities, including nearby Tyee Pond.

The inspection and maintenance manual will include the following sections:

- Facility description and operation
- Site access
- Personnel and emergency contacts
- Inspection and maintenance procedures
- Inspection and maintenance schedule
- Inspection form and maintenance checklist
- Monitoring plan
- Monitoring station data downloading

Regular inspection of the facility will occur monthly between May and October of each year, and twice monthly during July and August. The facility will be shut down between November and April, when no flow augmentation is required and the pump and conveyance system are dewatered for the winter.

3.3 ANNUAL REPORT

An annual report documenting rates and volume of groundwater flow augmentation, streamflow rates and temperature at the monitoring station, and a summary of the operations during the year will be prepared at the conclusion of each season. The report will be issued the following January.

4.0 IMPLEMENTATION

4.1 SCHEDULE

An estimated schedule for implementing the proposed Des Moines Creek flow augmentation system is summarized in Table 4-1. Project startup and monitoring activities are contingent on obtaining a water right from Ecology. Project delay would occur if the water right cannot be secured by the planned startup date.

Table 4-1. Implementation schedule

Activity	Date	Comments
1.0 Design		
1.1 Flow augmentation plan	August 20, 1998	This document.
1.2 Preliminary design	February 1, 1999	Prepared by King County
1.3 Water Rights application	February 1, 1999	Prepared by King County
1.4 Final design	June 1, 1999	Prepared by King County
2.0 Construction		
2.1 Monitoring station	July 1999	Constructed by King County
2.2 Flow augmentation system	July-August, 1999	Constructed by King County
2.3 Calibration and testing	September, 1999	
2.4 Startup	May 1, 2000	Contingent on obtaining water rights
3.0 Monitoring		
3.1 Monitoring station rating curve	July-September, 1999	
3.2 First year monitoring	May-October, 2000	
3.3 Operational review	December, 2000	Review and possible revision of operational criteria
3.4 Start of permanent monitoring	May 1, 2000	Annual reports issued in January.

4.2 FUNDING OF MAINTENANCE AND OPERATIONS

Maintenance and operation of the Des Moines Creek flow augmentation facility will be funded by the Port of Seattle.

4.3 CONTINGENCY

Should the flow augmentation project not succeed, such as due to the inability to obtain a new water right from the wells described above, other options for flow augmentation will be pursued. This effort would be primarily directed at acquiring other water rights in the basin.

APPENDIX A

WATER RIGHTS CERTIFICATES

Certificate No. 2191

2191

S. F. No. 7301—3-53—5M. 38150.

CERTIFICATE RECORD No. 5 PAGE No. 2191-A

STATE OF WASHINGTON, COUNTY OF King

Certificate of Ground Water Right

Issued in accordance with the provisions of Chapter 263, Laws of Washington for 1945, and amendments thereto, and the rules and regulations of the State Supervisor of Water Resources thereunder.

THIS IS TO CERTIFY That KING COUNTY WATER DISTRICT NO. 75 of Seattle, Washington, *has made proof to the satisfaction of the State Supervisor of Water Resources of Washington, of a right to the use of the ground waters of a* well *located within* the SE¼ of NW¼ of Sec. 4, Twp. 22 N., Rge. 4 E.W.M.

for the purpose of domestic supply for community *under and subject to provisions contained in Ground Water Permit No.* 3075 *issued by the State Supervisor of Water Resources and that said right to the use of said ground waters has been perfected in accordance with the laws of Washington, and is hereby confirmed by the State Supervisor of Water Resources of Washington and entered of record in Volume* 5 *at page* 2191-A*; that the right hereby confirmed dates from* May 14, 1953*; that the quantity of ground water under the right hereby confirmed for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed* 750 gallons per minute; 600 acre-feet per year for domestic supply for ~~irrigation of~~ community. ~~acres~~

A description of the lands to which such ground water right is appurtenant, and the place where such water is put to beneficial use, is as follows:

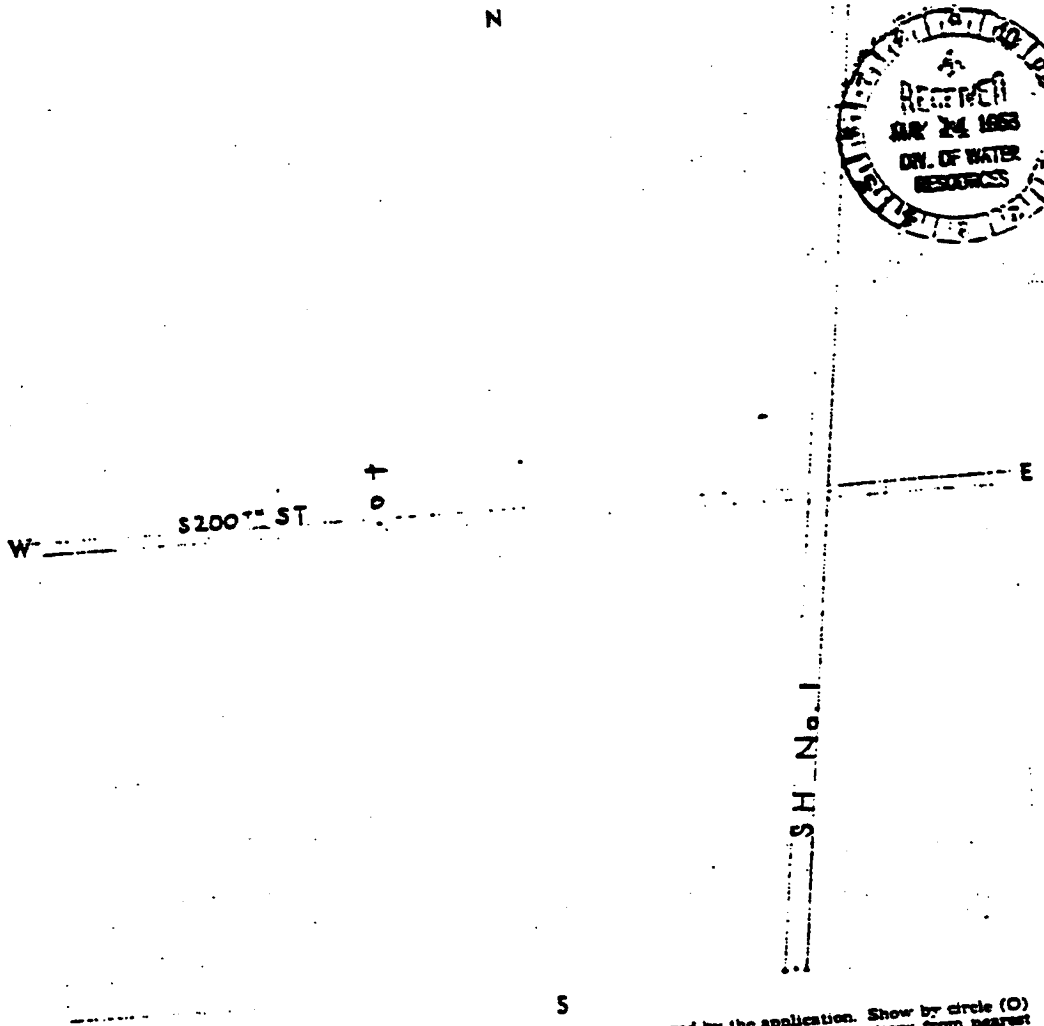
Water District No. 75, King County, Washington.

The right to the use of the ground water aforesaid hereby confirmed is restricted to the lands or

S. F. No. 1514-B—1-43—10M. [illegible]

SECTION PLAT

Sec. 4 Twp. 22 N. R. 4 E WM



Show by a cross (X) the location of the well or other works covered by the application. Show by circle (O) the locations of other wells or works within a quarter of a mile. Also indicate traveling directions from nearest town on main highway.

Scale: 1 inch = 800 feet.

3218

Certificate No. 2369

[illegible]

CERTIFICATE RECORD NO. 5 PAGE NO. 2369-A

STATE OF WASHINGTON, COUNTY OF King

Certificate of Ground Water Right

Issued in accordance with the provisions of Chapter 263, Laws of Washington for 1945, and amendments thereto, and the rules and regulations of the State Supervisor of Water Resources thereunder.

THIS IS TO CERTIFY THAT KING COUNTY WATER DISTRICT NO. 75

of Seattle, Washington, has made proof to the satisfaction of the State Supervisor of Water Resources of Washington, of a right to the use of the ground waters of a well

located within the SW¼ of SE¼ of NW¼ of Sec. 4, Twp. 22 N., Rge. 4 E.W.M.

for the purpose of domestic supply

under and subject to provisions contained in Ground Water Permit No. 1006 issued by the State Supervisor of Water Resources and that said right to the use of said ground waters has been perfected in accordance with the laws of Washington, and is hereby confirmed by the State Supervisor of Water Resources of Washington and entered of record in Volume 5 at page 2369-A; that the right hereby confirmed dates from February 9, 1949; that the quantity of ground water under the right hereby confirmed for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 400 gallons per minute; 560 acre-feet per year for domestic supply.

A description of the lands to which such ground water right is appurtenant, and the place where such water is put to beneficial use, is as follows:

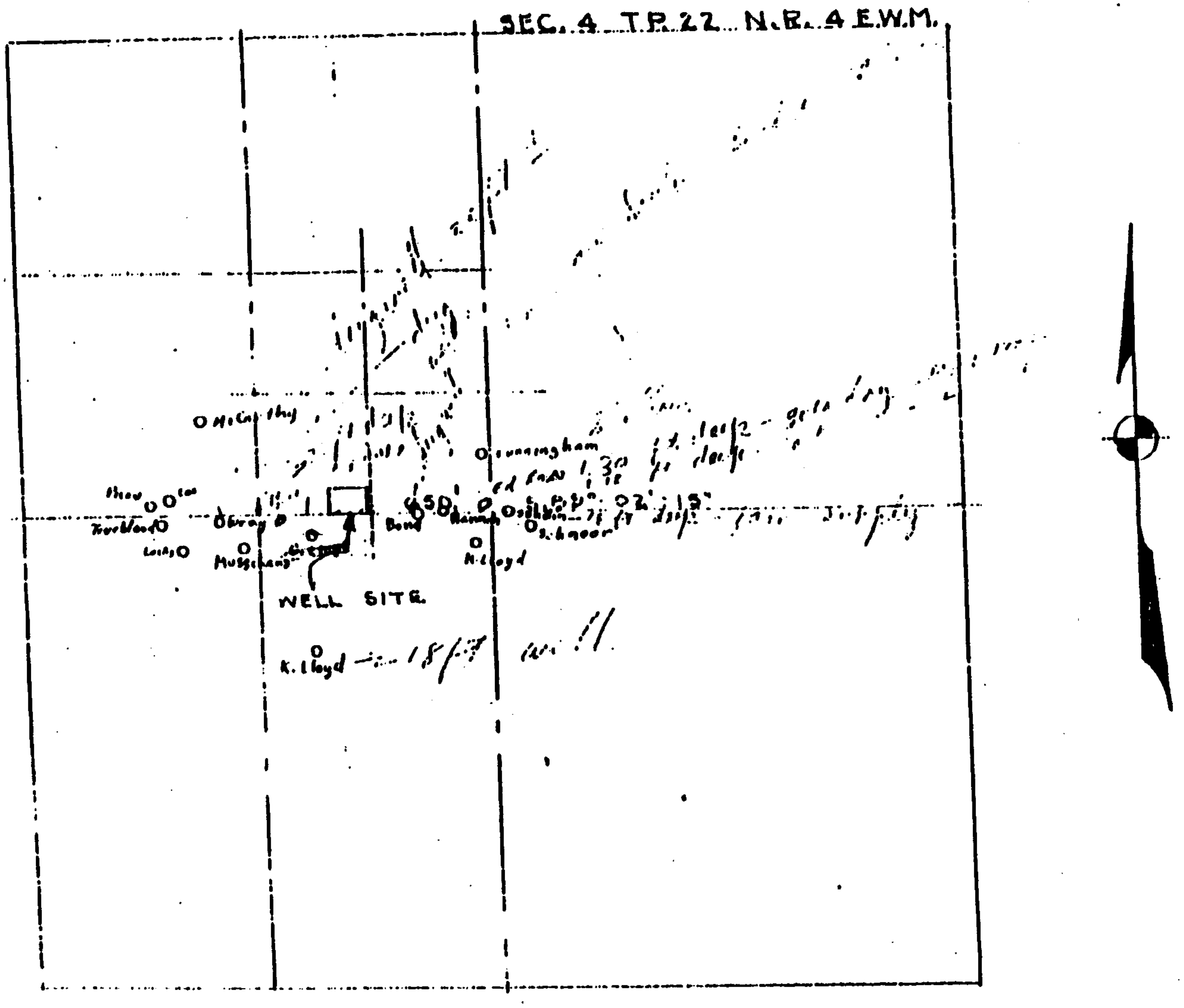
King County Water District No. 75

The right to the use of the ground water aforesaid hereby confirmed is restricted to the lands or place of use herein described, except as provided in Sections 6 and 7, Chapter 122, Laws of 1929.

WITNESS the seal and signature of the State Supervisor of Water Resources affixed this 18th day of October, 1955.

State Supervisor of Water Resources.

[illegible] SING MAIL



GENERAL ENGINEERING COMPANY

D

STATE OF WASHINGTOI
DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WELL LOG

No. Appli. #1065
Permit #1006

Date November 22 1949

Record by F. C. Yatt

Source well driller's record

Location: State of WASHINGTON

County King

Area

Map

SW¼ SE ¼ NW ¼ sec 4 T22 N., R 4 E

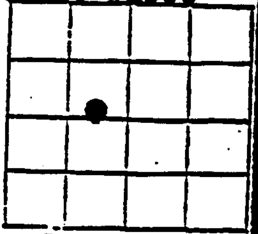


Diagram of Section

Drilling Co. N. C. Janssen Drilling & Mfg. Co.

Address Seattle, Washington

Method of Drilling drilled Date November 1949

Owner King County Water District #75

Address Midway, Washington

Land surface, datum ft. above below

Correlation	Material	Thickness (feet)	Depth (feet)
	Sandy clay	10	10
	Brown sand	20	38
	Coarse gravel, dry	53	83
	Sand & gravel, water	67	150
	Sand & clay, wet	10	160
	Blue clay	30	190
	Clay, little gravel	20	210
	Sand & gravel, water	33	243
	Sand, clay, gravel	27	270
	Fine sand & clay	240	510
	Coarse sand, water	35	545

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Pump Test:

Dim: 545' x 18"

SWL: at ground level

Dd: 43' Yield: 150 g.p.m. (permit)

Casing: 12" standard steel from 0-245

Turn up

Sheet ___ of ___ sheets

over

②

WELL LOG—Continued

No. 2214-9E

Correlation	Material	Thickness (feet)	Depth (feet)
	Depth forward		
	8" standard steel from 245 to 545'		
	Shoe: 8" to 12" increaser & 12" pipe		
	total length 3'-6"-bottom at 545		
	Perfor: ¼" x 4" from 72 to 160'		
	" " " from 190 to 243'		
	sand cup screen from 511 to 541'		
	Pump: 12" deep well turbine		
	Motor: 60 h.p. Elec. motor - standby		
	gas engine		

S. F. No. 7---12-64--3M. ---88.

Certificate No. 2376

2376

S. F. No. [illegible]

CERTIFICATE RECORD No. 5 PAGE No. 2376-A

STATE OF WASHINGTON, COUNTY OF King

Certificate of Ground Water Right

Issued in accordance with the provisions of Chapter 263, Laws of Washington for 1945, and amendments thereto, and the rules and regulations of the State Supervisor of Water Resources thereunder.

THIS IS TO CERTIFY THAT KING COUNTY WATER DISTRICT NO.75 of Seattle, Washington; *has made proof to the satisfaction of the State Supervisor of Water Resources of Washington, of a right to the use of the ground waters of a* well *located within* the NE¼ of NW¼ of Sec. 4, Twp. 22 N., Rge. 4 E.W.M.

for the purpose of domestic supply for community *under and subject to provisions contained in Ground Water Permit No.* 3757 *issued by the State Supervisor of Water Resources and that said right to the use of said ground waters has been perfected in accordance with the laws of Washington, and is hereby confirmed by the State Supervisor of Water Resources of Washington and entered of record in Volume* 5 *at page* 2376-A; *that the right hereby confirmed dates from* January 19, 1955; *that the quantity of ground water under the right hereby confirmed for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed* 350 gallons per minute; 560 acre-feet per year for domestic supply for community.

A description of the lands to which such ground water right is appurtenant, and the place where such water is put to beneficial use, is as follows:

King County Water District No. 75.

The right to the use of the ground water aforesaid hereby confirmed is restricted to the lands or place of use herein described, except as provided in Sections 6 and 7, Chapter 122, Laws of 1929.

WITNESS the seal and signature of the State Supervisor of Water Resources affixed this 18th *day of* October 19 55.

M. Walker
State Supervisor of Water Resources.

[illegible]

Seattle

SECTION PLAT

Sec. 4 Twp. 22 N. R. 4 EWM

So. 142nd St.

N

W [illegible]

E

S

Show by a cross (X) the location of the well or other works covered by the application. Show by circle (O) the locations of other wells or works within a quarter of a mile. Also indicate traveling directions from nearest town on main highway.

Scale: 1 inch = 800 feet.

Check Legal descr. as shown on 2nd plat attached & determine which piece of land is correct above. Spot Correctly.

JKB.

3843

ASSIGNMENT OF WATER RIGHTS

Know all men by these presents that on this 14th day of December, 1962, KING COUNTY WATER DISTRICT NO. 75, a municipal corporation, located in the County of King, State of Washington, does hereby assign and transfer to PORT OF SEATTLE, a municipal corporation, all of its rights to withdraw ground waters from a well located within the

> Northeast 1/4 of the Northwest 1/4 of Section 4, Township 22 North, Range 4 East, W.M., not to exceed 350 gallons per minute, 560 acre feet per year under State certificate issued October 18, 1955, to King County Water District No. 75 by M.G. Walker, recorded under Auditor's File No. 4629222.

DATED the day and year first above written.

KING COUNTY WATER DISTRICT NO. 75

By ______________________
President

By ______________________
Secretary

STATE OF WASHINGTON)
) ss.
COUNTY OF KING)

On this 14th day of December, 1962 before me the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Henry B. Lyle and R. L. Eaton, Jr. to me known to be the President and Secretary, respectively, of Water District No. 75, King County 19803-28th Ave. South, Seattle, Washington the corporation that executed the foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that they are authorized to execute the said instrument and that the seal affixed is the corporate seal of said corporation.

Witness my hand and official seal hereto affixed the day and year first above written.

____
Notary Public in and for the State

MUTUAL 2-9191
AREA CODE 206

LAW OFFICES OF
BOGLE, BOGLE & GATES
14TH FLOOR NORTON BUILDING
SEATTLE 4

CABLE ADDRESS
BOGLE SEATTLE

December 21, 1962

Supervisor, Water Resources
335 General Administration Building
Division of Water Resources
Department of Conservation
Olympia, Washington

RE: Filing Assignment of Water Rights.
Port of Seattle Re: SEA-TAC. FAA
Project No. 15.

Dear Sir:

Enclosed for filing is an original copy of an Assignment of Water Rights by the King County Water District No. 75 to the Port of Seattle.

Enclosed you will also find a check in the amount of $4.00 to cover the filing fee.

Very truly yours,

BOGLE, BOGLE & GATES

Bertram L. Metzger, Jr.

cc: Port of Seattle
Attn: Mr. Howard M. Burke
Port Commissioners (6)

C-2376 file
[illegible]

December 26, 1962

Bogle, Bogle & Gates
14th Floor Norton Building
Seattle 4, Washington

ATTENTION: Bertram L. Metzger, Jr.

Gentlemen:

Re: Ground Water Certificate No. 2376,
King County Water District No. 75

Receipt is acknowledged of your letter of December 21 containing a copy of an assignment transferring King County District's interest in said water right to the Port of Seattle, together with warrant in the amount of $4 to record the transfer.

Please be advised that Section 90.03.310 RCW authorizes the transfer of applications and permits only and once the appropriation has ripened into a certificate of water right, it becomes appurtenant to the property and title to the water right passes automatically with the title to the property. For that reason we would not be able to formally process the assignment and change ownership as shown on the certificate. However, we will place the copy of the assignment in file No. 2376 to show that the Port of Seattle now has title to the water right and any future correspondence will be directed to their attention.

Your warrant in the amount of $4 is returned herewith.

Very truly yours,

DEPARTMENT OF CONSERVATION
EARL COE, DIRECTOR

ROBERT H. RUSSELL, Asst. Supervisor
Division of Water Resources

RHR: jo
Enc.

Certificate No. 5233

S. F. No. 7361—1-64—3M. [illegible]

CERTIFICATE RECORD No. 11 PAGE No. 5233-A

STATE OF WASHINGTON, COUNTY OF King

Certificate of Ground Water Right

Issued in accordance with the provisions of Chapter 263, Laws of Washington for 1945, and amendments thereto, and the rules and regulations of the State Supervisor of Water Resources thereunder.

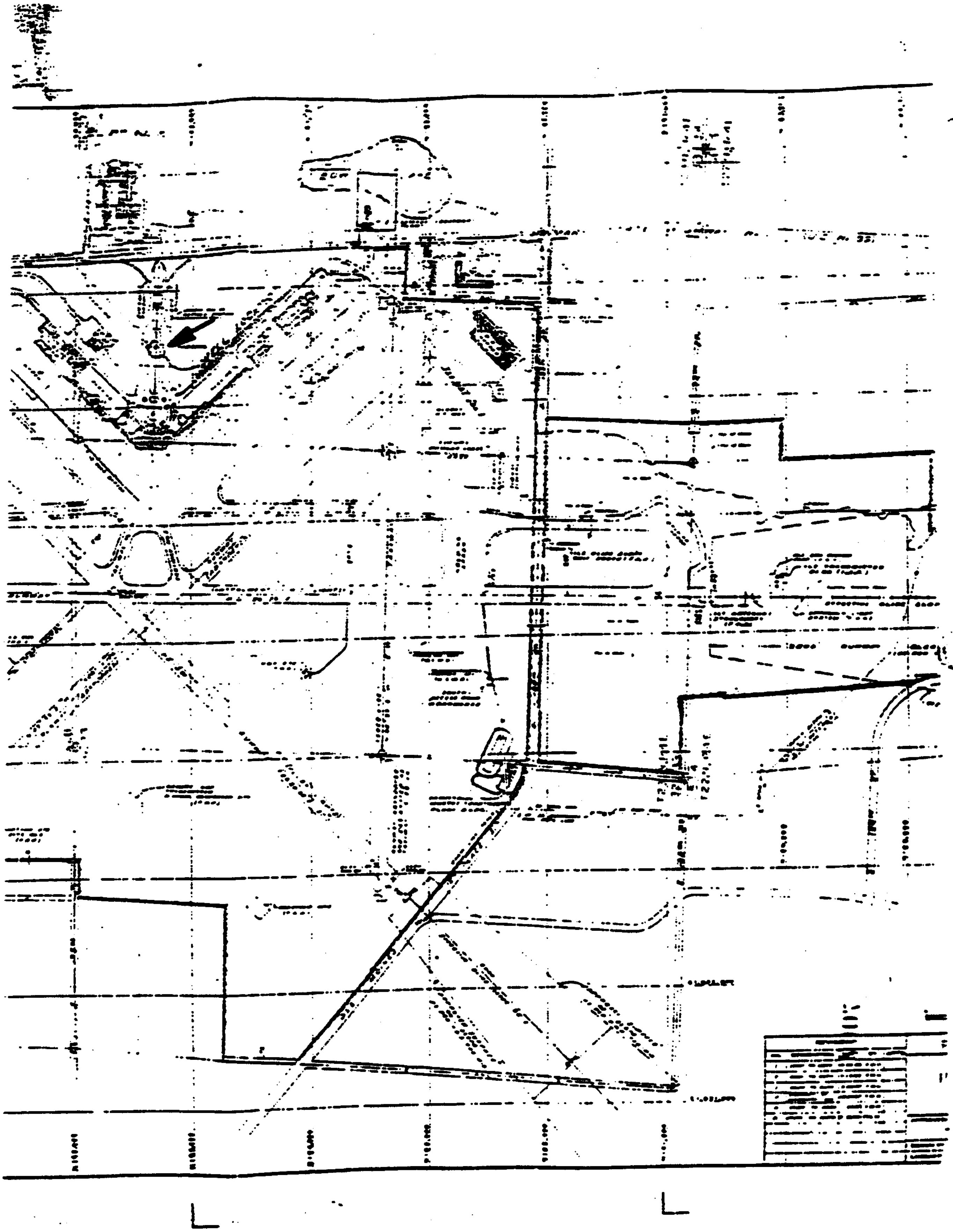
THIS IS TO CERTIFY That THE PORT OF SEATTLE COMMISSION of Seattle, Washington, has made proof to the satisfaction of the State Supervisor of Water Resources of Washington, of a right to the use of the ground waters of a well located within NE¼NW¼ Sec. 33, Twp. 23 N., R. 4 E. W.M. for the purpose of air conditioning, irrigation and emergency commercial and industrial use under and subject to provisions contained in Ground Water Permit No. 6682 issued by the State Supervisor of Water Resources and that said right to the use of said ground waters has been perfected in accordance with the laws of Washington, and is hereby confirmed by the State Supervisor of Water Resources of Washington and entered of record in Volume 11 at page 5233-A; that the right hereby confirmed dates from March 5, 1964; that the quantity of ground water under the right hereby confirmed for the purposes aforesaid, is limited to an amount actually beneficially used for said purposes, and shall not exceed 250 gallons per minute, 82 acre-feet per year, for the irrigation of 2 acres, for air conditioning and emergency commercial and industrial use.

Special provisions required by the Supervisor of Water Resources:

A description of the lands to which such ground water right is appurtenant:

Seattle-Tacoma International Airport, within T. 23 N., R. 4 E.W.M.

The right to the use of the ground [illegible] aforesaid hereby confirmed is restricted to the lands or



Appendix J

DES MOINES CREEK REGIONAL CIP
PRELIMINARY DESIGN REPORT

Appendix J
Cost Estimates

DES MOINES CREEK REGIONAL CAPITAL IMPROVEMENT PROJECTS
PRELIMINARY CONSTRUCTION* COST ESTIMATES

Costs Common to all Alternatives

Marine View Drive Bridge**	$3,850,000
Excavation, Cells 1-3	$3,674,340
Berm B Construction	$443,826
Habitat Improvements - Zone 1 and 2	$132,000
Channel Reconstruction -Zone 3	$697,192
Bypass downstream of S. 200th	$299,369
Treatment Plant Bypass	$189,863
Low Flow Augmentation	$86,602
Total	**$9,373,192**

Costs for Alternative 1

Berm A	$678,137
Alternative 1 & 2- Tyee Diversion Pipe	$610,790
Bypass from Northwest Ponds	$468,798
Costs Common to all Alternatives	$9,373,192
Total	**$11,130,917**

80-90%
grant $
SRF fund
Can not pay
1.7% for years
[illegible]

Costs for Alternative 2

Berm A	$678,137
Alternative 1 & 2- Tyee Diversion Pipe	$610,790
Bypass from Tyee	$244,733
Costs Common to all Alternatives	$9,373,192
Total	**$10,906,852**

Costs for Alternative 3

Alternative 3 Tyee Diversion Pipe	$194,033
Bypass from Approach Light Road	$301,158
Costs Common to all Alternatives	$9,373,192
Total	**$9,868,383**

[illegible] x 13

* Except as noted, costs are adjusted for construction in 2001 and do not include design, permitting, project management, contract administration and inspection, monitoring, operation & maintenance, etc.

** Cost of Marine View Drive bridge is adjusted for construction in 2000. Costs not included are $500,000 for development of Plans, Specs and Estimate ($450,000 already spent by the City of Des Moines, and $50,000 needed to finish), and $450,000 for construction contract administration and inspection. Adding these costs would bring the total to $4.8 million.

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: TDP

PROJECT: ALTERNATIVE 1- BYPASS FROM NORTHWEST PONDS

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$27,636
2	Clearing and Grubbing (Light cover)	0.75	ACRES	$3,000	/ACRES	$2,250
3	Access Road (15' wide, 6" gravel depth)	1850	L.F.	$18	/L.F.	$33,300
4	Gravel, Crushed Rock (1.85 tons/yd3)	25	TON	$26	/TON	$650
5	Hydroseeding	0.75	ACRES	$1,600	/ACRES	$1,200
6	Topsoil	260	C.Y.	$30	/C.Y.	$7,800
7	Connect to Existing MH	1	LS	$450	/LS	$450
7	24" Diam. R.C.P.	670	L.F.	$60	/L.F.	$40,200
8	30" Diam. R.C.P.	1256	L.F.	$75	/L.F.	$94,200
9	48" Type II S.D.M.H. (<12 ft.)	2	EACH	$3,500	/EACH	$7,000
10	48" Type II S.D.M.H. (>12 ft.)	3	EACH	$4,500	/EACH	$13,500
11	54" Type II S.D.M.H. (>12 ft.)	1	EACH	$5,100	/EACH	$5,100
	54" Type II S.D.M.H. (<12 ft.)	2	EACH	$4,100	/EACH	$8,200
11	96" Control Structure with Birdcage	1	EACH	$14,000	/EACH	$14,000
12	Footing for 96" Control Structure	1	EACH	$9,000	/EACH	$9,000
13	Chain Link Fence (Type 1)	80	L.F.	$21	/L.F.	$1,680
14	Chain Link Gate (14' wide)	1	EACH	$1,050	/EACH	$1,050
15	Asphalt Patching including crushed surfacing	31	S.Y.	$30	/S.Y.	$930
16	Landscaping (Sod Replacement)	1	LS	$23,000	/LS	$23,000
17	High Visibility Fence	500	L.F.	$4	/L.F.	$2,000
18	Straw Bales	60	EACH	$20	/EACH	$1,200
19	Filter Fabric Fence (Erosion Control)	600	L.F.	$5	/L.F.	$3,000
20	Clear Plastic Covering including removal	1100	S.Y.	$1.5	/S.Y.	$1,650
21	Survey	1	LS	$5,000	/LS	$5,000

SUBTOTAL:		$303,996
SALES TAX:	8.60%	$26,144
SUBTOTAL:		$330,140
CONTINGENCY:	20.00%	$66,028
CONSTR. SUBTOTAL:		$396,168
INFLATION '98 TO '01	10.00%	$72,631
CONSTRUCTION TOTAL		$468,798

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration, and closed-cell foam cushion (for low clearance pipe crossings.) This cost assumes a min. 6 ft trench depth or 2 feet of cover over the top of the pipe.

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: FB

PROJECT: Alternative 1 - Tyee Diversion Pipe

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$36,007
2	Clearing and Grubbing (Light cover)	1	LS	$3,000.00	/LS	$3,000
3	Hydroseeding	1	LS	$1,700.00	/LS	$1,700
4	Topsoil	140	CY	$35.25	/CY	$4,935
5	* 72" Diam. H.C.M.P.	1,413	LF	$155.00	/L.F.	$219,015
6	96" Type II S.D.M.H. (<12 ft.)	4	EACH	$9,500.00	/EACH	$38,000
7	96" Type II S.D.M.H. (>12 ft.)	2	EACH	$10,500.00	/EACH	$21,000
8	120" Type II S.D.M.H. with Debris Cage	1	EACH	$15,000.00	/EACH	$15,000
9	Erosion Control Measures (Filter fence, etc...)	1	LS	$5,500.00	/LS	$5,500
10	Landscaping (sod, etc.)	1	LS	$34,000.00	/LS	$34,000
11	Connect existing pipe to new MH	1	EACH	$450.00	/EACH	$450
12	Crushed Surfacing Top Course	20	TON	$22.00	/TON	$440
13	Quarry Spalls	30	TON	$17.50	/TON	$525
14	Trash Rack 72" Diameter	1	EACH	$1,500.00	/EACH	$1,500
15	Adjust Tyee outlet controls	1	LS	$10,000.00	/LS	$10,000
16	Construction Survey	1	LS	$5,000.00	/LS	$5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

SUBTOTAL:		$396,072
SALES TAX:	8.60%	$34,062
SUBTOTAL:		$430,134
CONTINGENCY:	20.00%	$86,027
SUBTOTAL:		$516,160
INFLATION '98 TO '01	10.00%	$94,629
CONSTRUCTION TOTAL		$610,790

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: FB

PROJECT: Alternative 1 & 2- Tyee Diversion Pipe

PRELIMINARY CONSTRUCTION COSTS

ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$36,007
2	Clearing and Grubbing (Light cover)	1	LS	$3,000.00	/LS	$3,000
3	Hydroseeding	1	LS	$1,700.00	/LS	$1,700
4	Topsoil	140	CY	$35.25	/CY	$4,935
5	* 72" Diam. H.C.M.P.	1,413	LF	$155.00	/L.F.	$219,015
6	96" Type II S.D.M.H. (<12 ft.)	4	EACH	$9,500.00	/EACH	$38,000
7	96" Type II S.D.M.H. (>12 ft.)	2	EACH	$10,500.00	/EACH	$21,000
8	120" Type II S.D.M.H. with Debris Cage	1	EACH	$15,000.00	/EACH	$15,000
9	Erosion Control Measures (Filter fence, etc...)	1	LS	$5,500.00	/LS	$5,500
10	Landscaping (sod, etc.)	1	LS	$34,000.00	/LS	$34,000
11	Connect existing pipe to new MH	1	EACH	$460.00	/EACH	$450
12	Crushed Surfacing Top Course	20	TON	$22.00	/TON	$440
13	Quarry Spalls	30	TON	$17.50	/TON	$525
14	Trash Rack 72" Diameter	1	EACH	$1,500.00	/EACH	$1,500
15	Adjust Tyee outlet controls	1	LS	$10,000.00	/LS	$10,000
16	Construction Survey	1	LS	$5,000.00	/LS	$5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

SUBTOTAL:		$396,072
SALES TAX:	8.60%	$34,062
SUBTOTAL:		$430,134
CONTINGENCY:	20.00%	$86,027
SUBTOTAL:		$516,160
INFLATION '98 TO '01	10.00%	$94,629
CONSTRUCTION TOTAL		$610,790

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
PROJECT: ALTERNATIVE 2 - BYPASS FROM TYEE
ESTIMATOR: TDP

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$14,427
2	Clearing and Grubbing (Light cover)	0.25	ACRES	$3,000	/ACRES	$750
3	Access Road (15' wide, 6" gravel depth)	500	L.F.	$18	/L.F.	$9,000
4	Gravel, Crushed Rock (1.85 tons/yd3)	27	TON	$26	/TON	$702
5	Hydroseeding	0.25	ACRES	$1,600	/ACRES	$400
6	Quarry Spalls	14	TON	$35	/TON	$490
7	Topsoil	70	C.Y.	$30	/C.Y.	$2,100
8	Temporary Stream Bypass	1	LS	$4,000	/LS	$4,000
9	Connect to Existing MH	1	LS	$450	/LS	$450
10	* 24" Diam. R.C.P.	100	L.F.	$60	/L.F.	$6,000
11	* 30" Diam. R.C.P.	775	L.F.	$75	/L.F.	$58,125
12	54" Type II S.D.M.H. (<12 ft.)	3	EACH	$4,100	/EACH	$12,300
13	54" Type II S.D.M.H. (>12 ft.)	3	EACH	$5,100	/EACH	$15,300
14	96" Type II S.D.M.H. (>12 ft.) with overflow	1	EACH	$12,000	/EACH	$12,000
15	Landscaping (Sod Replacement)	1	LS	$12,000	/LS	$12,000
16	High Visibility Fence	500	L.F.	$4	/L.F.	$2,000
17	Straw Bales	50	EACH	$20	/EACH	$1,000
18	Filter Fabric Fence (Erosion Control)	300	L.F.	$5	/L.F.	$1,500
19	Clear Plastic Covering including removal	770	S.Y.	$1.5	/S.Y.	$1,155
20	Survey	1	LS	$5,000	/LS	$5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, and restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

SUBTOTAL:		$158,699
SALES TAX:	8.60%	$13,648
SUBTOTAL:		$172,347
CONTINGENCY:	20.00%	$34,469
CONSTR. SUBTOTAL:		$206,817
INFLATION '98 TO '01	10.00%	$37,916
CONSTRUCTION TOTAL		$244,733

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: TDP

PROJECT: ALTERNATIVE 3 - BYPASS FROM APPROACH LIGHT ROAD

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$17,754
2	Clearing and Grubbing (Light cover)	0.5	ACRES	$3,000	/ACRES	$1,500
3	Access Road (15' wide, 6" gravel depth)	920	L.F.	$18	/L.F.	$16,560
4	Gravel, Crushed Rock (1.85 tons/yd3)	95	TON	$26	/TON	$2,470
5	Hydroseeding	0.5	ACRES	$1,600	/ACRES	$800
6	Topsoil	160	C.Y.	$30	/C.Y.	$4,800
7	24" Diam. R.C.P.	916	L.F.	$60	/L.F.	$54,960
8	30" Diam. R.C.P.	237	L.F.	$75	/L.F.	$17,775
9	Connect to Existing MH	1	LS	$450	/LS	$450
10	48" Type II S.D.M.H. (>12 ft.)	2	EACH	$4,600	/EACH	$9,200
11	48" Type II S.D.M.H. (<12 ft.)	2	EACH	$3,500	/EACH	$7,000
12	54" Type II S.D.M.H. (>12 ft.)	1	EACH	$5,100	/EACH	$5,100
13	96" Control Structure with Birdcage	1	EACH	$14,000	/EACH	$14,000
14	Footing for 96" Control Structure	1	EACH	$9,000	/EACH	$9,000
15	Chain Link Fence (Type 1)	80	L.F.	$21	/L.F.	$1,680
16	Chain Link Gate (14' wide)	1	EACH	$1,050	/EACH	$1,050
15	Asphalt Patching includinc crushed surfacing	31	S.Y.	$30	/S.Y.	$930
16	Landscaping (Sod Replacement)	1	LS	$20,000	/LS	$20,000
17	High Visibility Fence	450	L.F.	$4	/L.F.	$1,800
18	Straw Bales	50	EACH	$20	/EACH	$1,000
19	Filter Fabric Fence (Erosion Control)	300	L.F.	$5	/L.F.	$1,500
20	Clear Plastic Covering including removal	640	S.Y.	$1.5	/S.Y.	$960
21	Survey	1	LS	$5,000	/LS	$5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration, and closed-cell foam cushion (for low clearance pipe crossings.) This cost assumes a min. 6 ft trench depth or 2 feet of cover over the top of the pipe.

SUBTOTAL:		$195,289
SALES TAX:	8.60%	$16,795
SUBTOTAL:		$212,083
CONTINGENCY:	20.00%	$42,417
CONSTR. SUB. TOTAL:		$254,500
INFLATION '98 TO '01	10.00%	$46,658
CONSTRUCTION TOTAL		$301,158

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: FB

PROJECT: Alternative 3 - Tyee Diversion Pipe

PRELIMINARY CONSTRUCTION COSTS

ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$11,438
2	Clearing and Grubbing (Light cover)	1	LS	$1,500.00	/LS	$1,500
3	Hydroseeding	1	LS	$950.00	/LS	$950
4	Topsoil	43	CY	$28.35	/CY	$1,219
5	* 48" Diam. H.C.M.P.	530	LF	$97.00	/L.F.	$51,410
6	72" Type II S.D.M.H. (<12 ft.)	2	EACH	$7,500.00	/EACH	$15,000
7	120" Type II S.D.M.H. with Debris Cage	1	EACH	$15,000.00	/EACH	$15,000
8	Erosion Control Measures (Filter fence, etc...)	1	LS	$3,000.00	/LS	$3,000
9	Landscaping (Sod, etc.)	1	LS	$9,000.00	/LS	$9,000
10	Connect existing pipe to new MH	1	EACH	$450.00	/EACH	$450
11	Crushed Surfacing Top Course	15	TON	$22.00	/TON	$330
12	Quarry Spalls	30	TON	$17.50	/TON	$525
13	Trash Rack48" Diameter	1	EACH	$1,000.00	/EACH	$1,000
14	Adjust Tyee outlet controls	1	LS	$10,000.00	/LS	$10,000
15	Construction Survey	1	LS	$5,000.00	/LS	$5,000

SUBTOTAL:		$125,822
SALES TAX:	8.60%	$10,821
SUBTOTAL:		$136,643
CONTINGENCY:	20.00%	$27,329
CONSTR. SUBTOTAL:		$163,972
INFLATION '98 TO '01	10.00%	$30,062
CONSTRUCTION TOTAL		$194,033

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE:
ESTIMATOR: Fatin Kara

PROJECT: Berm A Construction

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	9%	% OF SUM	$36,309
2	Clearing and Grubbing (Light cover)	1.0	ACRES	$3,000	/ACRES	$3,000
3	Excavation (including haul off-site)	5800	CY	$9	/CY	$54,810
4	Structural Fill (Including compaction)	10000	CY	$16	/CY	$157,500
5	Access Road (15' wide, 6" gravel depth)	613	L.F.	$18	/L.F.	$10,942
6	Rip Rap (1.6 tons/yd3)	13.0	TON	$53	/TON	$683
7	Hydroseeding	1.0	ACRE	$1,600	/ACRE	$1,600
8	* 72" Diam. H.C.M.P.	110.0	L.F.	$147	/L.F.	$16,170
9	Flow Appurt. and Cradle	1	EACH	$50,000	/EACH	$50,000
10	12 feet by 12 feet inlet vault	1	EACH	$40,000	/EACH	$40,000
11	Trash Rack 72" Diameter	2	EACH	$1,500	/EACH	$3,000
12	Chain Link Fence (Type 1)	80.0	L.F.	$21	/L.F.	$1,680
13	Chain Link Gate (14' wide)	1	EACH	$1,050	/EACH	$1,050
14	Erosion Control Measures and Grasscrete for 16,000 sqft	1	LS	$40,000	/LS	$40,000
15	Landscape back side of berm	18000	S.F.	$1	/S.F.	$18,000
16	Construction Survey	1	LS	$5,000	/LS	$5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

SUBTOTAL:		$439,744
SALES TAX:	8.60%	$37,818
SUBTOTAL:		$477,562
CONTINGENCY:	20.00%	$95,512
SUBTOTAL:		$573,074
INFLATION '98 TO '01	10.00%	$1[illegible]
CONSTRUCTION TOTAL		$6[illegible]

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: WHK

PROJECT: Excavation, Cells 1-3

PRELIMINARY CONSTRUCTION COSTS

ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$216,605
2	Clearing and Grubbing (Light cover)	7.5	ACRES	$3,000	/ACRES	$22,500
3	Clearing and Grubbing Heavy cover)	6.4	ACRES	$3,850	/ACRES	$24,640
4	Excavation (including haul off-site) *	124060	CY	$9	/CY	$1,116,540
5	Hydroseeding	3	ACRES	$1,600	/ACRE	$4,800
6	Cell 3 Acquisition	80000	SF	$5	/SF	$400,000
7	Chain Link Fence (Type 1)	500	L.F.	$20	/L.F.	$10,000
8	Flooding impacts to private property	1	LS	$20,000	/LS	$20,000
9	Cell 1-Investigate & Level 1 Assessment Haz. Material	0 (Port doing)	LS	$0	/LS	$0
10	Cell 2-Investigate & Level 1 Assessment Haz. Material	1	LS	$10,000	/LS	$10,000
11	Cell 3-Investigate & Level 1 Assessment Haz. Material	1	LS	$10,000	/LS	$10,000
12	Hazardous Material Contingency	1	LS	$50,000	/LS	$50,000
13	Coir Fabric	290	S.Y.	$8	/S.Y.	$2,320
14	Straw Bales	250	EACH	$20	/EACH	$5,000
15	High Visibility Fence	1500	L.F.	$4	/L.F.	$6,000
16	Filter Fabric Fence	2200	L.F.	$5	/L.F.	$11,000
17	Clear Plastic Covering including removal	1500	S.Y.	$2	/S.Y.	$2,250
18	Wetland Plants	600000	SF	$0.75	/SF	$450,000
19	Surrounding site restoration (sod, gravel, roads, etc.)	1	LS	$15,000	/LS	$15,000
20	Construction Survey	1	LS	$6,000	/LS	$6,000
				SUBTOTAL:		$2,382,655
				SALES TAX:	8.60%	$204,908
				SUBTOTAL:		$2,587,563
				CONTINGENCY:	20.00%	$517,513
				CONSTR. SUBTOTAL:		$3,105,076
				INFLATION '98 TO '01	10.00%	$569,264
				CONSTRUCTION TOTAL		$3,674,340

* Excavation costs could be lowered if excavated soils used for a nearby project.

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: Fatin Kara

Project: Berm B Construction

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	9%	% OF SUM	$23,763
2	Clearing and Grubbing (Light cover)	0.5	ACRES	$3,000	/ACRES	$1,500
3	Excavation (including haul off-site)	3360	CY	$9	/CY	$30,240
4	Structural Fill (including compaction)	4300	CY	$15	/CY	$67,725
5	Access Road (15' wide, 6" gravel depth)	525	L.F.	$18	/L.F.	$9,371
6	Rip Rap (1.6 tons/yd3)	13	TON	$53	/TON	$683
7	Hydroseeding	0.5	ACRES	$1,600	/ACRE	$800
8	* 72" Diam. H.C.M.P.	170	L.F.	$147	/L.F.	$24,990
9	Flow Appurt. and Cradle	1	EACH	$50,000	/EACH	$50,000
10	12 feet by 12 feet inlet vault	1	EACH	$40,000	/EACH	$40,000
11	Trash Rack 72" Diameter	2	EACH	$1,500	/EACH	$3,000
12	Chain Link Fence (Type 1)	80	L.F.	$21	/L.F.	$1,680
13	Chain Link Gate (14' wide)	1	EACH	$1,050	/EACH	$1,050
14	Erosion Control Measures and Grasscrete for 16,000 sqft	1	LS	$25,000	/LS	$25,000
15	Landscaping & Restoration	1	LS	$3,000	/LS	$3,000
16	Construction Survey	1	LS	$5,000	/LS	- $5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

SUBTOTAL:		$287,802
SALES TAX:	8.60%	$24,751
SUBTOTAL:		$312,553
CONTINGENCY:	20.00%	$62,511
SUBTOTAL:		$375,064
INFLATION '98 TO '01	10.00%	$68,762
CONSTRUCTION TOTAL		$443,826

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: WHK

PROJECT: Channel Reconstruction - Zone 3

PRELIMINARY CONSTRUCTION COSTS

ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$41,100
2	Clearing and Grubbing (Light cover)	2	ACRES	$3,000	/ACRES	$6,600
3	Excavation (Including haul off-site)	6500	CY	$9	/CY	$61,425
4	Streambed Gravel (1.7 tons/yd3)	820	TON	$32	/TON	$25,830
5	Rip Rap (1.6 tons/yd3)	38	TON	$53	/TON	$1,995
6	Hydroseeding	2	ACRES	$1,600	/ACRE	$3,200
7	* 18" Diam. D.I. Sewer Pipe	200	L.F.	$60	/L.F.	$12,000
8	* 21" Diam. R.C.P. Sewer Pipe	120	L.F.	$60	/L.F.	$7,200
9	Connection to Existing Manhole	3	EACH	$450	/EACH	$1,350
10	48" Type II S.D.M.H. (>12 ft.)	4	EACH	$4,500	/EACH	$18,000
11	Golf Cart Bridge 10' wide x 50' long	1	EACH	$19,000	/EACH	$19,000
12	Footbridge 4' wide x 25' long	2	EACH	$7,000	/EACH	$14,000
13	Logs and Rootwads	75	EACH	$400	/EACH	$30,000
14	Small Stream Boulders	375	EACH	$50	/EACH	$18,750
15	Large Stream Boulders	300	EACH	$30	/EACH	$9,000
16	Remove Weir	2	EACH	$450	/EACH	$900
17	Coir Fabric	1200	S.Y.	$8	/S.Y.	$9,600
18	Coir Lift	270	L.F.	$40	/L.F.	$10,800
19	Straw Bales	150	EACH	$20	/EACH	$3,000
20	High Visibility Fence	400	L.F.	$4	/L.F.	$1,600
21	Filter Fabric Fence	300	L.F.	$5	/L.F.	$1,500
22	Clear Plastic Covering including removal	1500	S.Y.	$2	/S.Y.	$2,250
23	Temporary Stream Bypass	1	LS	$12,000	/LS	$12,000
24	Riparian Landscaping above approach light road**	45000	SF	$1	/SF	$45,000
25	Riparian Landscaping below approach light road**	50000	SF	$1.5	/SF	$75,000
26	Golf Course Restoration (sod, gravel roads, etc.)	1	LS	$15,000	/LS	$15,000
27	Construction Survey	1	LS	$6,000	/LS	$6,000

SUBTOTAL:		$452,100
SALES TAX:	8.60%	$38,881
SUBTOTAL:		$490,981
CONTINGENCY:	20.00%	$98,196
CONSTR. SUBTOTAL:		$589,177
INFLATION '98 TO '01	10.00%	$108,016
CONSTRUCTION TOTAL		$697,192

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

** Planting costs could be reduced if planting is less extensive or dense.

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: TDP

Project: Bypass Downstream of South 200th Street

PRELIMINARY CONSTRUCTION COSTS

ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$17,648
2	Cleaning and Grubbing (Light cover)	0.5	ACRES	$3,000	/ACRES	$1,500
3	Removal Portion of Existing Structure	1	LS	$2,500	/LS	$2,500
4	Access Road (15' wide, 6" gravel depth)	170	L.F.	$18	/L.F.	$3,060
5	Asphalt Concrete Pavement Class B	162	TON	$65	/TON	$10,530
6	Crushed Surfacing Top Course	137	TON	$30	/TON	$4,110
7	Crushed Surfacing Base Course	26	TON	$30	/TON	$780
8	Hydroseeding	0.5	ACRES	$1,600	/ACRES	$800
9	Topsoil	150	CY	$30	/CY	$4,500
10	* 24" Diam. R.C.P.	475	L.F.	$60	/L.F.	$28,500
11	* 30" Diam. R.C.P.	1045	L.F.	$75	/L.F.	$78,375
12	54" Type II S.D.M.H. (>12 ft.)	3	EACH	$5,050	/EACH	$15,150
13	60" Type II S.D.M.H. (>12 ft.)	2	EACH	$5,300	/EACH	$10,600
14	Conection to Existing MH	2	EACH	$450	/EACH	$900
15	High Visibility Fence	900	LF	$4	/LF	$3,600
16	Straw Bales	90	LS	$20	/LS	$1,800
17	Filter Fabric Fence (Erosion Control)	700	L.F.	$5	/L.F.	$3,500
18	Clear Plastic Covering including removal	850	S.Y.	$1.5	/S.Y.	$1,275
19	Survey	1	LS	$5,000	/LS	$5,000

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, and restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

SUBTOTAL:		$194,128
SALES TAX:	8.60%	$16,695
SUBTOTAL:		$210,823
CONTINGENCY:	20.00%	$42,165
CONSTR. SUBTOTAL:		$252,988
INFLATION '98 TO '01	10.00%	$46,381
CONSTRUCTION TOTAL		$299,369

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: FB

PROJECT: Des Moines Treatment Plant Bypass

PRELIMINARY CONSTRUCTION COSTS						
ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1.00	LS	10%	% OF SUM	$11,193
2	Clearing and Grubbing (Light cover)	1.00	LS	$1,250.00	/LS	$1,250
3	Clearing and Grubbing (Heavy cover)	1.00	LS	$1,600.00	/LS	$1,600
4	Hydroseeding	1.00	LS	$1,300.00	/LS	$1,300
5	Asphalt Patching (incl. crushed rock)	95.00	SY	$67.35	/SY	$6,398
6	Topsoil	70.00	CY	$35.25	/CY	$2,468
7	* 24" Diam. R.C.P.	655.00	LF	$95.00	/LF.	$62,225
8	48" Type II S.D.M.H. (<12 ft.)	2.00	EACH	$3,500.00	/EACH	$7,000
9	48" Type II S.D.M.H. (>12 ft.)	1.00	EACH	$4,515.00	/EACH	$4,515
10	54" Type II S.D.M.H. (>12 ft.)	1.00	EACH	$5,040.00	/EACH	$5,040
11	Erosion Control Measures (Filter fence, etc...)	1.00	LS	$6,500.00	/LS	$6,500
12	Traffic Control	30.00	HOUR	$25.00	/HOUR	$750
13	Landscaping (sod, trees)	1.00	LS	$6,500.00	/LS	$6,500
14	Connection to Existing MH	2.00	EACH	$450.00	/EACH	$900
15	Crushed Surfacing Top Course	20.00	TON	$24.00	/TON	$480
16	Construction Survey	1.00	LS	$5,000.00	/LS	$5,000

SUBTOTAL:		$123,118
SALES TAX:	8.60%	$10,588
SUBTOTAL:		$133,707
CONTINGENCY:	20.00%	$26,741
CONSTR..SUBTOTAL:		$160,448
INFLATION '98 TO '01	10.00%	$29,415
CONSTRUCTION TOTAL		$189,863

* Pipe estimate includes: Material, excavation, shoring, installation, bedding, backfill, compaction, restoration. This cost assumes a min. 6 ft. trench depth or 2 ft. of cover over the top of the pipe.

DES MOINES CREEK REGIONAL CIP
PRELIMINARY CONSTRUCTION COST ESTIMATE

DATE: 4/15/99
ESTIMATOR: WHK

PROJECT: Low Flow Augmentation

PRELIMINARY CONSTRUCTION COSTS

ITEM	ITEM DESCRIPTION (Furnished and Installed)	QUANTITY	UNITS	UNIT COST	$/UNIT	COST
1	Mobilization	1	LS	10%	% OF SUM	$5,105
2	Clearing and Grubbing (Light cover)	0.1	ACRES	$3,000	/ACRES	$300
3	Excavation (Including haul off-site) *	25	CY	$9	/CY	$225
4	Hydroseeding	0.1	ACRES	$1,600	/ACRE	$160
5	Wellhouse upgrades	1	LS	$20,000	/LS	$20,000
6	Pump and motor	1	LS	$8,000	/LS	$8,000
7	Discharge piping and wire	1	LS	$4,000	/LS	$4,000
8	Control panel	1	LS	$4,500	/LS	$4,500
9	Automated on/off trigger	1	LS	$3,000	/LS	$3,000
10	* 24" Diam. H.D.P.P.	20	L.F.	$89	/L.F.	$1,785
11	* 12" Diam. H.D.P.P.	45	L.F.	$53	/L.F.	$2,363
12	Weir	3	EACH	$500	/EACH	$1,500
13	Coir Fabric	40	S.Y.	$8	/S.Y.	$320
14	Straw Bales	25	EACH	$20	/EACH	$500
15	High Visibility Fence	75	L.F.	$4	/L.F.	$300
16	Filter Fabric Fence	75	L.F.	$5	/L.F.	$375
17	Clear Plastic Covering including removal	150	S.Y.	$2	/S.Y.	$225
18	Surrounding site restoration (sod, gravel, roads, etc.)	1	LS	$2,000	/LS	$2,000
19	Construction Survey	1	LS	$1,500	/LS	$1,500
				SUBTOTAL:		$56,158
				SALES TAX:	8.60%	$4,830
				SUBTOTAL:		$60,987
				CONTINGENCY:	20.00%	$12,197
				CONSTR. SUBTOTAL:		$73,185
				INFLATION '98 TO '01	10.00%	$13,417
				CONSTRUCTION TOTAL		$86,602