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Declaration of James Kelley, Ph.D.

Volume 2 of 3

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WETLAND FUNCTIONAL ASSESSMENT AND IMPACT ANALYSIS

MASTER PLAN UPDATE IMPROVEMENTS
SEATTLE-TACOMA INTERNATIONAL AIRPORT

Prepared for

PORT OF SEATTLE
Seattle-Tacoma International Airport
Seattle, Washington 98158

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TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

The Seattle Tacoma International Airport (STIA) has updated its Master Plan to meet future aviation needs. This report describes the impact of Master Plan development projects on wetlands and wetland functions. The report updates earlier wetland analyses completed in support of the National Environmental Policy Act (NEPA)/State Environmental Policy Act (SEPA), Final Environmental Impact Statement (FEIS), and Final Supplemental Environmental Impact Statement (FSEIS) for the Master Plan. Master Plan Update improvements that affect wetlands and streams include:

- Runway safety area (RSA) extensions for existing runways
- An 8,500-ft-long runway
- Relocation of South 154th Street around the north end of the RSAs of existing and proposed runways
- Development of on-site borrow sources to provide fill material for the third runway
- Cargo and maintenance facilities in the South Aviation Support Area (SASA)
- Various utility improvements and expansions to service new facilities

Proposed construction projects will result in direct permanent impacts to 18.37[1] acres of wetlands and temporary impacts to 2.04 acres. In addition, 980 linear ft of Miller Creek and 1,290 linear ft of drainage ditches will be filled. About 9.05 acres of Category II wetlands, 7.31 acres of Category III wetlands, and 2.01 acres of Category IV wetlands will be permanently impacted by the proposed project.

Impacts to wetland functions were assessed for nine functions typically performed by wetlands. These functions were assessed by classifying wetlands onto hydrogeomorphic and habitat groups, and identifying wetland attributes that are recognized as indicators of wetland functions for western Washington wetlands. Based on the presence of these indicators and professional judgement, each wetland for each function, was rated using a "high," "medium," or "low" rating system.

With respect to biological functions, overall wildlife use of the study area and its associated wetlands is largely limited to species that are tolerant to disturbance. The area is fragmented by urban development, and faunal diversity is limited because wetlands are too small to meet habitat requirements for many wildlife populations. However, when compared to other urban wetlands, some larger wetlands that support native shrub and forest vegetation provide moderate to high function for songbirds, amphibians, and small mammals.

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[1] These permanent impacts include filling and potential indirect impacts.

With respect to physical functions, the riparian wetlands located on groundwater seeps adjacent to Miller and Des Moines Creeks provide base flow support functions and may enhance (reduce) stream temperatures during summer months. Most of the wetlands on-site have limited stormwater storage capacity due to their small size, lack of direct connections to the streams, or topographic conditions that limit water detention. The existing groundwater recharge function is also limited because most wetlands appear to be underlain by relatively compact soils that limit rates of groundwater infiltration. Wetlands that occur on relatively flat areas and receive runoff from urban areas function to improve water quality.

Temporary impacts during construction include removal of wetland vegetation (native and non-native) and potential sedimentation. Indirect impacts include potential alteration of wetland hydrology, ongoing disturbance of wildlife by aircraft noise, and human disturbance. Indirect impacts to the hydrology of wetlands adjacent to the fill are expected to be minimal and will not significantly alter the function of these wetlands. The project design allows groundwater and runoff to continue to flow to downslope wetlands. Indirect impacts resulting from noise and human disturbance are expected to be minor because most wetlands are already subject to aircraft noise, traffic noise, and human disturbances, and because the wildlife species present in these wetlands are tolerant of these activities.

About 2.4 acres of indirect wetland impacts could occur in certain locations where changes to wetland hydrology, shading, or fragmentation results in loss of functions. While these indirect impacts could result in the loss of some wetland functions from an area, they may not necessarily remove all wetland functions. The wetland losses that could result from indirect impacts are fully mitigated at ratios of 3:1.

Other indirect impacts to wetlands that could affect their function include noise and human disturbance, changes in water quality impacts, and changes in surface hydrology. These indirect impacts could alter or reduce the level of some functions, but would not eliminate the wetlands themselves. These indirect impacts are also mitigated because, in most cases, land use conditions that have degraded these wetlands are removed, and restoration actions are implemented to improve their functional performance.

Overall, the Master Plan Update improvement design and mitigation will protect wetlands and aquatic resources. The substantial mitigation compensates for identified impacts to hydrology (peak flow and low flow), water quality wetlands (temporary, permanent filling, and indirect), and streams. This mitigation prevents cumulative impacts, attributable to the proposed actions, from occurring.

1. INTRODUCTION

Implementation of the updated Seattle-Tacoma International Airport (STIA) Master Plan will result in unavoidable filling of wetlands and a 980-ft section of Miller Creek. This report describes the impacts of the proposed project on wetlands and streams. The report updates wetland analysis completed in support of the National Environmental Policy Act (NEPA)/State Environmental Policy Act (SEPA), Final Environmental Impact Statement (FEIS), and Final Supplemental EIS (FSEIS) for the Master Plan Update improvements. This report also addresses wetland impacts within project areas that were not identified in the previous documents because the Port of Seattle (Port) did not have access to some properties during the earlier analysis.

The report is organized into four sections. Section 1 describes the project, the study area, and the results of a comprehensive wetland delineation of the project site (see *Wetland Delineation Report, Master Plan Update Improvements, Seattle-Tacoma International Airport*; Parametrix 2000a). Section 2 describes the methodologies for evaluating project impacts to wetland area and function. The results of the impact analysis are presented in Section 3. These results are used to develop on-site and off-site mitigation projects (described in *Natural Resource Mitigation Plan, Master Plan Update Improvements, Seattle-Tacoma International Airport;* Parametrix 2000b) to compensate for wetland impacts. Section 4 describes permanent and temporary impacts and indirect impacts resulting from the project.

1.1 PROJECT DESCRIPTION

As currently configured, the STIA is unable to efficiently meet existing and future regional air travel demands. The airfield operates inefficiently during poor weather because it can accommodate only a single arrival stream. As a result, significant arrival delay occurs during poor weather. Aircraft are either held on the ground in their originating city, slowed en route, or are placed in holding patterns to await clearance to land at STIA. These conditions result in inefficient operation of the existing airfield, as described in the FEIS (FAA 1996) and FSEIS (FAA 1997).

With or without airport development, airport activity will increase as a consequence of regional population growth. As aviation demand grows, aircraft operating delay will increase exponentially. The increased passenger, cargo, and aircraft operations demands will place increasing burdens on the existing terminal and support facilities. Without improvements, the roadway system, terminal space, gates and cargo and freight processing space would become more inefficient and congested, and the quality of service would be reduced.

The proposed Master Plan Update addresses the following needs:

- Improve the poor weather operating capability to accommodate aircraft activity with an acceptable level of aircraft delay.
- Provide sufficient runway length to accommodate either warm weather operations or payloads for aircraft types operating to the Pacific Rim.

- Provide Runway Safety Areas (RSAs) that meet current Federal Aviation Administration (FAA) standards.

- Provide efficient and flexible landside facilities to accommodate future aviation demand.

1.2 KEY PROJECT ELEMENTS

The proposed Master Plan Update includes the following major components:

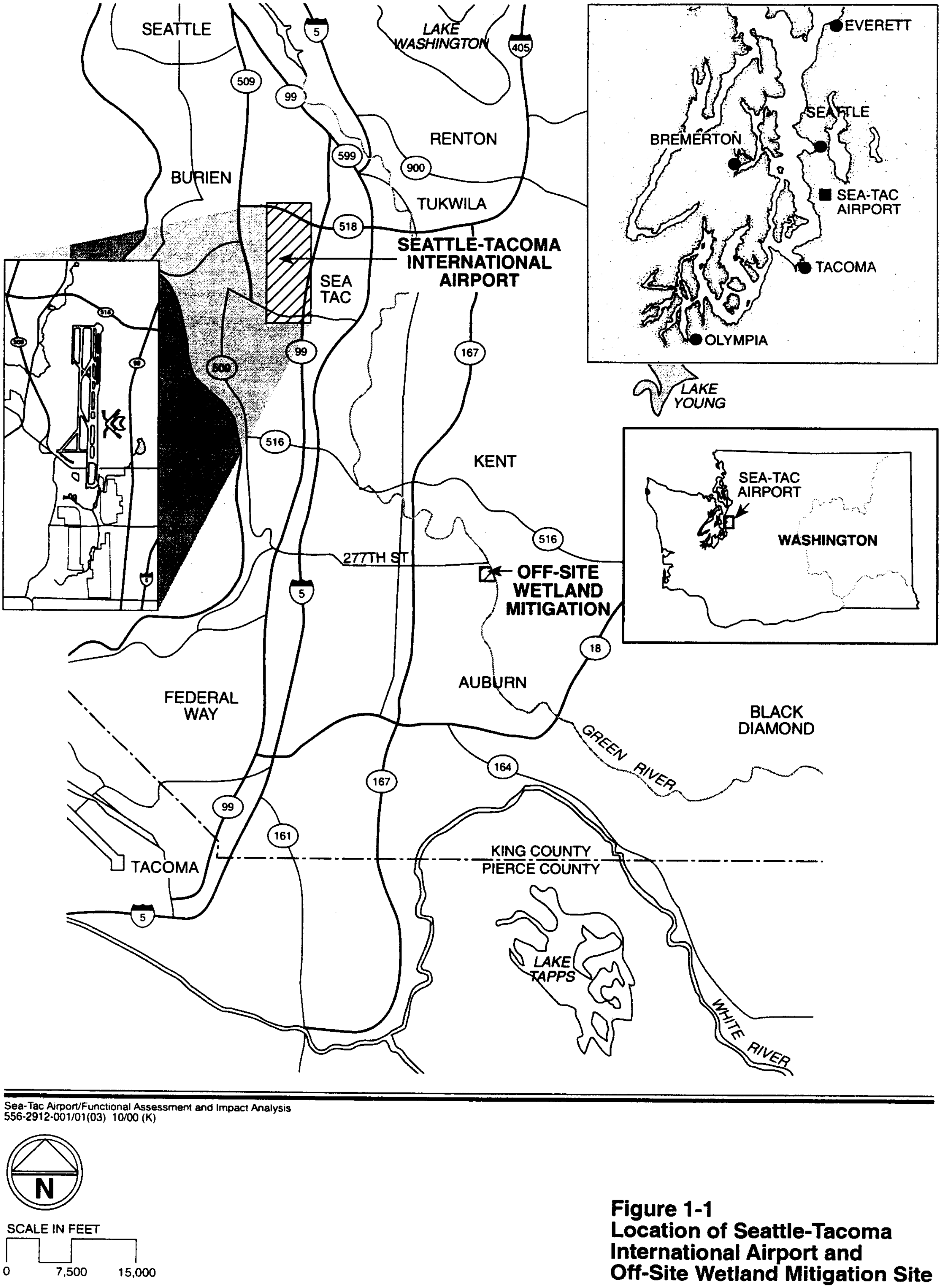
- Establishing standard RSAs for existing Runways 16R/34L and 16L/34R
- Adding a third parallel runway (16X/34X) with a length of 8,500 ft and associated taxiway and navigational aids
- Extending Runway 34R by 600 ft to the south
- Adding a new air traffic control tower
- Relocating South 154th Street to accommodate the RSAs and third runway
- Improving and expanding the main terminal and access system
- Developing new parking facilities and expanding existing facilities
- Developing a new north unit terminal, roadway system, and parking facility
- Developing the South Aviation Support Area (SASA) for cargo and/or maintenance facilities
- Relocating, redeveloping, and expanding support facilities

Airport improvements that will affect wetlands and streams are the RSA extensions and relocation of South 154th Street, the new (third parallel) runway, development of on-site borrow sources to provide fill for the runway, and the development of a SASA.

The project area is located at and near the STIA in SeaTac, Washington (Figure 1-1). Areas near the airport where construction activities could affect wetlands are discussed below.

1.2.1 Runway Safety Areas and Relocation of South 154th Street

The RSAs at the north end of the airfield (for Runways 16L and 16R) will be extended to meet FAA regulations (Figure 1-2). These safety area extensions will require the relocation of South 154th Street about 250 ft north of its existing location.



Sea-Tac Airport/Functional Assessment and Impact Analysis
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Figure 1-1
Location of Seattle-Tacoma International Airport and Off-Site Wetland Mitigation Site

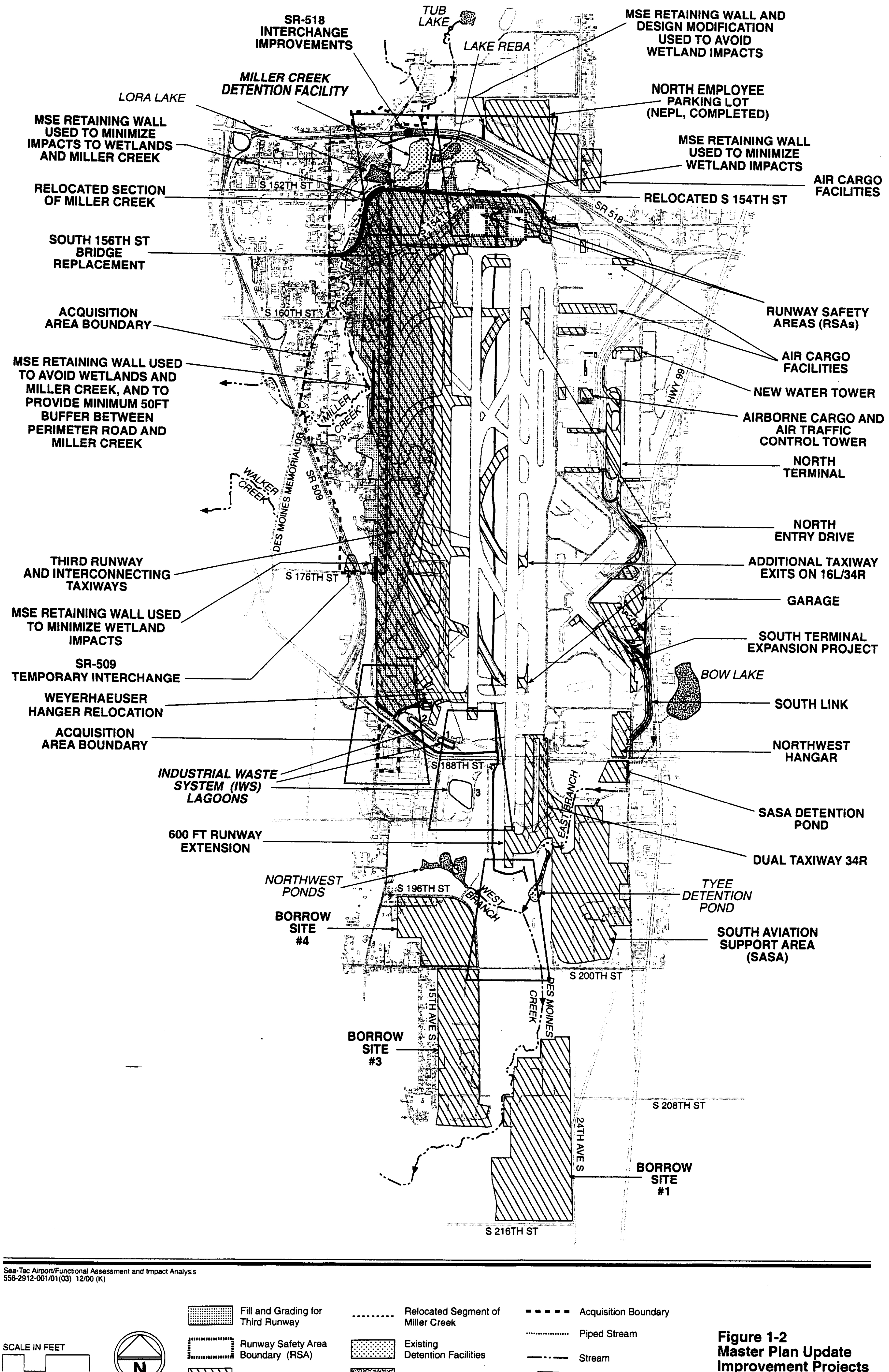

Figure 1-2
Master Plan Update Improvement Projects at STIA

1.2.2 New Third Runway

An 8,500-ft runway will be constructed about 1,000 ft west of existing Runway 34L. Construction of the third runway also requires relocation of South 154th Street north of its present location. Land for the new runway includes areas owned by the Port of Seattle (east of 12th Avenue West) and areas in private ownership (the acquisition area) (see Figure 1-2). The acquisition area is located between 12th Avenue West, Des Moines Memorial Drive, South 176th Street, and South 147th Street.

In addition to accommodating the new runway, the acquisition area will be used for stormwater management facilities, construction staging, and as a buffer between the airfield and residential areas farther to the west. Construction staging uses in the acquisition area could include vehicle and equipment parking, material storage, construction stormwater treatment facilities, and temporary office facilities.

1.2.3 Borrow Areas

Several areas of Port-owned property will be developed to provide fill material for construction of the new runway (see Figure 1-2). Borrow Area 1 is located east of Des Moines Creek and between South 200th Street and South 216th Street. Borrow Area 3 is located west of Des Moines Creek and between South 200th Street and 209th Street. Borrow Area 4 is located between South 196th Street and South 200th Street, near 18th Avenue South. These borrow areas would be operated during the dry season only, with disturbed areas hydroseeded or otherwise stabilized prior to late fall.

1.2.4 South Aviation Support Area

The SASA project site is located south and east of the airfield (see Figure 1-2). The site includes vacant land between South 188th Street and South 200th Street, including portions of the Tyee Valley Country Club. Prior to development of the SASA project, portions of this site may be used for construction staging. Construction staging uses could include vehicle and equipment parking, material storage, construction stormwater treatment facilities, and temporary office facilities.

1.2.5 Overview Of the Mitigation Plan

The Master Plan Update improvement projects also include the natural resource mitigation required to mitigate adverse impacts to the natural environment (wetlands, streams, floodplains, water quality, and hydrology). These mitigation actions are evaluated as a part of the impact analysis presented in this report. They are described in detail the *Natural Resources Mitigation Plan: Master Plan Update Improvements Seattle-Tacoma International Airport* (Parametrix 2000b). The mitigation focuses on compensatory mitigation to replace wetland and stream functions impacted by the project. Key elements of the mitigation restore wetland functions such as sediment and nutrient retention (water quality), surface water storage (flood water detention and storage), aquatic habitat functions (e.g., instream aquatic habitat and riparian habitat), and organic carbon production and export. In addition, the Port has made extensive efforts throughout the Master Plan Update planning process to avoid, minimize, and rectify, as well as compensate for, adverse impacts. Compensatory mitigation projects are summarized in Table 1-1.

Table 1-1. Summary of compensatory mitigation (on- and off-site) for watershed, wetland, and stream impacts at Seattle-Tacoma International Airport.

Description of Impact	Mitigation Action	Explanation/Comment
On-Site Mitigation[a]		
Permanent Impacts		
Fill approximately 980 linear ft of Miller Creek channel to accommodate third runway embankment.	Relocate approximately 1,080 ft of Miller Creek channel.	Channel relocation will enhance aquatic habitat by providing stream buffers and instream habitat features and increasing channel length by approximately 100 ft. Establish a buffer around the channel relocation project with native trees and shrubs. (This buffer extends into the floodplain area.)
Fill drainage channels to accommodate third runway embankment.	Create new drainage channel and establish protective buffers.	Create approximately 1,290 ft of new drainage channel(s) with associated buffer habitat.
Fill approximately 8,500 cy of Miller Creek floodplain to accommodate third runway embankment and South 154th Street relocation.	Replace lost floodplain.	Excavate approximately 9,600 cy to achieve storage of 5.94 acre-ft from the Vacca Farm site, providing an excess of 0.7 acre-ft of floodwater storage.
Impact approximately 18.37 acres of wetland during construction of the third runway embankment and other construction-related projects.	Restore Vacca Farm to historic floodplain shrub wetland.	Approximately 9.0 acres of prior converted cropland, farmed wetland, and existing low quality wetlands will be graded and planted with native trees, shrubs, and emergent species. Restoration of the area will stabilize soils, improve water quality, and enhance Miller Creek habitat. It will reduce wildlife habitat attractants and conform to FAA mandates regarding wildlife attractants for airport safety. Remove bulkheads and restore 25-ft buffer around Lora Lake. Restoration of entire Vacca Farm site will provide approximately 17 acres of enhanced stream habitat, floodplain wetlands, aquatic habitat in Lora Lake, and buffers.
	Establish a buffer between the floodplain enhancement area and Des Moines Memorial Drive.	The buffer will be established and enhanced by planting native upland trees and shrubs to provide approximately 1.5 acres of upland buffer. Enhance approximately 7.4 acres of wetlands along Miller Creek by removing structures and restoring native wetland vegetation.

Table 1-1. Summary of compensatory mitigation (on- and off-site) for watershed, wetland, and stream impacts at Seattle-Tacoma International Airport (continued).

Description of Impact	Mitigation Action	Explanation/Comment
	Restore wetlands on the Tyee Valley Golf Course.	Plant approximately 4.5 acres of historic peat wetlands in the Tyee Valley Golf Course Mitigation Area and 1.0 acre of wetland in the west branch Des Moines Creek buffer with native shrub communities. Plant native shrubs in approximately 1.6 acres of buffer in the Tyee Valley Golf Course mitigation area and approximately 3.4 acres in the west branch Des Moines Creek buffer. These enhancement will be coordinated with Des Moines Creek Basin Committee planned RDF. The enhancement and RDF will improve hydrologic functions of the watershed, reduce wildlife attractants near the airfield, and restore a peat wetland.
Temporary Impacts[a]		
Construct temporary stormwater management ponds and other construction impacts, which may impact up to 2.05 acres of wetland.	Restore wetland areas after construction is complete.	Wetlands that will be temporarily filled or disturbed will be restored. Restoration will include establishing pre-disturbance topography and planting with native shrub vegetation.
Indirect and Cumulative Impacts[a]		
Filled wetlands near Miller Creek reduce aquatic habitat value of the creek.	Establish and enhance buffers along Miller Creek corridor between South 156th Street and Des Moines Memorial Drive.	Establish a 100-ft buffer (on average) on both sides of Miller Creek; minimum buffer width on the east side of the stream will be 50 ft. These buffers will provide approximately 40 acres of riparian buffer habitat.
	Establish a 25-ft buffer around Lora Lake.	Approximately 0.60 acre of buffer around Lora Lake will be converted from lawn to native wetland and upland shrub vegetation.
Additional development in the watersheds could result in additional cumulative impacts.	Participate in developing and implementing Miller Creek and Des Moines Creek basin plans.	These planning processes will identify effective, long-term solutions to restore additional fish habitat to Miller and Des Moines Creeks. The Port will contribute both staffing resources and funds, and work with other cooperating jurisdictions to plan and implement appropriate watershed restoration projects.

Table 1-1. **Summary of compensatory mitigation (on- and off-site) for watershed, wetland, and stream impacts at Seattle-Tacoma International Airport (continued).**

Description of Impact	Mitigation Action	Explanation/Comment
The runway fill or borrow area excavation may eliminate water sources that contribute to remaining wetlands down slope of the runway.	Design internal drainage and conveyance channels.	Subsurface and surface replacement channels will continue to collect and distribute groundwater currently surfacing near 12th Avenue South to Miller Creek and associated wetlands.
	Monitor wetlands adjacent to the third runway embankment and borrow areas.	Surface drainage patterns and conveyance swales will be designed to collect and distribute groundwater seepage and surface runoff to wetlands downslope of the borrow areas. Wetlands subject to potential indirect impacts will be monitored to determine if unmitigated indirect impacts have occurred. If significant new wetland impacts are verified, corrective actions will be implemented.
Off-Site Mitigation		
Permanent Impacts		
Loss of approximately 18.37 acres of wetland wildlife (avian) habitat.	Replace high quality wetland and avian habitat functions off-site at an overall ratio of 2:1.	Due to conflicts with avian habitat and aviation safety concerns, new wetlands habitat will be created at a 67-acre site in Auburn, Washington. This wetland creation will increase overall avian and other wildlife use and diversity in an area that will not compromise aviation safety.

[a] All mitigation areas (including, but not limited to, streams, wetlands, buffers, and floodplains) located within 10,000 ft of a runway shall be subject to the provisions of the Port's Wildlife Hazard Management Plan (U.S. Department of Agriculture 2000) for the management of wildlife and wildlife attractant areas.

1.3 WETLAND DELINEATION

Wetlands in the study area[2] were identified through wetland delineation studies completed by FAA (1996) and Parametrix (2000a). Studies completed by Parametrix update wetland delineations and inventories completed in support of the EIS and FSEIS. While the focus of the delineation was within the acquisition area, all project areas for the Master Plan Update were re-evaluated for the presence of wetlands.

All wetlands were delineated between 1998 and 2000 using the criteria described in the *U.S. Army Corps of Engineers (ACOE) Wetlands Delineation Manual* (Environmental Laboratory 1987). The delineated boundaries were surveyed, mapped, and field verified by ACOE personnel. Incorporation of these survey data into a geographic information system (GIS) system allowed calculation of wetland areas, mapping of wetlands, and calculation of wetland impacts.

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[2] The study area addressed in this report and the supporting wetland delineation report includes all areas where development for Master Plan Update improvements are planned as well as adjoining areas where mitigation is planned or where indirect impacts would occur (see Figure 1-2).

Over 117 wetlands, 12 ponds, and 8 channels (excluding Miller and Des Moines Creeks) totaling 115.9 acres have been delineated at Master Plan Update improvement sites. Additional wetlands known to exist nearby (see Section 1.4) increase the total to more than 200 acres[3] (Table 1-2, Figures 1-2, 1-3, and 1-4). Approximately 18 acres of wetlands could be directly affected by development proposed in the Master Plan Update.

1.4 SIGNIFICANT WETLANDS AVOIDED BY MASTER PLAN IMPROVEMENTS

Over 200 acres of wetland are known to exist on or near STIA, and it is likely that un-inventoried wetlands exist on private property elsewhere in the watershed where detailed studies have not been completed. Un-inventoried wetlands are likely to include numerous small wetlands in developed and partially developed residential areas. These wetlands are likely to be similar in character and function to many of the smaller wetlands occurring within the acquisition area.

While a number of small wetlands would be impacted or eliminated by the proposed Master Plan Update improvements, several large wetland complexes both on-site and nearby would not be affected by the improvements. These wetlands contain physical and biological features that indicate they provide a variety of wetland functions within Miller and Des Moines Creek watersheds at moderate to high levels. These wetlands are discussed briefly below.

A 30-acre wetland (Wetland 43, see Table 1-2 and Figure 1-3) occurs between Des Moines Way and State Route (SR) 509 immediately north of South 176th Street. This wetland contains a diversity of vegetation types, including forested, shrub, emergent, and open water wetland classes. Walker Creek flows through the wetland. The diversity of plant types, the presence of permanent open water, and hydrologic connections to Walker Creek indicate the wetland provides moderate to high biological functions for a variety of wildlife groups (resident fish, passerine birds, small mammals, amphibians, and waterfowl). Its location near the headwaters, the presence of adjacent developments, and topographic conditions in the depression the wetland occupies all suggest it also provides substantial base flow support, surface runoff storage, sediment trapping, and water quality benefits.

A 17-acre wetland (see Figure 1-2) occurs north of SR 518 and includes Tub Lake. This wetland contains forest, shrub, emergent, and open water wetland habitats, and Miller Creek flows through the wetland. The diversity of wetland classes, the presence of permanent open water, connections to other undeveloped land, and hydrologic connections to stream habitat result in moderate to high biologic function for a variety of wildlife groups (resident fish, passerine birds, small mammals, amphibians, and waterfowl). The location near the headwaters of Miller Creek, presence of upslope development, and topography of the basin indicate the wetland provides major base flow support, surface runoff storage, sediment trapping, and water quality benefits.

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[3] This number includes 115.89 acres reported in Table 1-2 and wetlands associated with Bow Lake (25 acres), Tub Lake (17 acres), and other nearby significant wetlands (49.7 acres) described in Section 1.4.

Table 1-2. Summary of wetland areas in the Seattle-Tacoma International Airport Master Plan Update area.

Wetland [a]	Classification [b]	Area (Acres)	Drainage Basin
North Employee Parking Lot Area			
1	Forest	0.07	Miller
2	Forest	0.73	Miller
	Subtotal	**0.80**	
Runway Safety Area Extension			
3	Forest	0.56	Miller
4	Forest	5.00	Miller
5	Forest/Scrub-Shrub	4.63	Miller
6	Scrub-Shrub	0.86	Miller
	Subtotal	**11.05**	
Third Runway Project Area			
North Airfield			
7[c]	Forest/Open Water/Emergent	6.68	Miller
8	Scrub-Shrub/Emergent	4.95	Miller
9	Forest/ Emergent (40/60)	2.83	Miller
10	Scrub-Shrub	0.31	Miller
11	Forest/Emergent (80/20)	0.50	Miller
12	Forest/Emergent (20/80)	0.21	Miller
13	Emergent	0.05	Miller
14	Forest	0.19	Miller
West Airfield			
15	Emergent	0.28	Miller
16	Emergent	0.05	Miller
17	Emergent	0.02	Miller
18	Forest/Scrub-Shrub/Emergent (50/20/30)	3.56	Miller
19	Forest	0.56	Miller
20	Scrub-Shrub/Emergent (90/10)	0.57	Miller
21	Forest	0.22	Miller
22	Scrub-Shrub/Emergent (90/10)	0.06	Miller
23	Emergent	0.77	Miller
24	Emergent	0.14	Miller
25	Forest	0.06	Miller
26	Emergent	0.02	Miller
W1	Emergent	0.10	Miller
W2	Forest/Emergent (20/80)	0.22	Miller
	Other Waters of the U.S.	0.02	Miller
Vacca Farm Site			
FW1	Farmed Wetland	0.03	Miller
FW2	Farmed Wetland	0.09	Miller
FW3	Farmed Wetland	0.59	Miller
FW5	Farmed Wetland	0.08	Miller
FW6	Farmed Wetland	0.07	Miller
FW8	Farmed Wetland	0.03	Miller

Table 1-2. **Summary of wetland areas in the Seattle-Tacoma International Airport Master Plan Update area (continued).**

Wetland [a]	Classification [b]	Area (Acres)	Drainage Basin
FW9	Farmed Wetland	0.01	Miller
FW10	Farmed Wetland	0.02	Miller
FW11	Farmed Wetland	0.11	Miller
	Other Waters of the U.S.	0.02	Miller
West Acquisition Area			
35a-d	Forest/Emergent (40/60)	0.67	Miller
37a-f	Forest/Emergent (70/30)	5.73	Miller
39	Forest/Scrub-Shrub/Emergent (25/50/25)	0.90	Miller
40	Scrub-Shrub	0.03	Miller
41a and b	Emergent/Open Water	0.44	Miller
44a and b	Forest/Scrub-Shrub (70/30)	3.08	Miller
A1	Forest/Scrub-Shrub/Emergent (15/15/70)	4.66	Miller
A2	Scrub-Shrub	0.05	Miller
A3	Scrub-Shrub	0.01	Miller
A4	Scrub-Shrub	0.03	Miller
A5	Emergent	0.03	Miller
A6	Forest	0.16	Miller
A7	Forest	0.30	Miller
A8	Forest/Scrub-Shrub (30/70)	0.38	Miller
A9	Scrub-Shrub	0.04	Miller
A10	Scrub-Shrub	0.01	Miller
A11	Scrub-Shrub	0.02	Miller
A12	Scrub-Shrub	0.11	Miller
A13	Forest	0.12	Miller
A14a and b	Forest/Scrub-Shrub/Emergent (50/25/25)	0.19	Miller
A15	Emergent	0.04	Miller
A16	Scrub-Shrub/Emergent (20/80)	0.09	Miller
A17	Forest/Scrub-Shrub/Emergent (20/80)	2.66	Miller
A18	Scrub-Shrub	0.01	Miller
A19	Emergent	0.04	Miller
Lora Lake	Open Water	3.06	Miller
	Other Waters of the U.S.	0.33	Miller
Riparian Wetlands			
R1	Emergent	0.17	Miller
R2	Scrub-Shrub/Emergent (70/30)	0.12	Miller
R3	Scrub-Shrub	0.02	Miller
R4	Emergent	0.11	Miller
R4b	Forest/Emergent (25/75)	0.11	Miller
R5	Emergent	0.05	Miller
R5b	Forest/Emergent (25/75)	0.07	Miller
R6	Forest/Emergent (25/75)	0.21	Miller
R6b	Emergent	0.09	Miller
R7	Forest/Emergent (25/75)	0.04	Miller
R7a	Emergent	0.04	Miller

Table 1-2. **Summary of wetland areas in the Seattle-Tacoma International Airport Master Plan Update area (continued).**

Wetland [a]	Classification [b]	Area (Acres)	Drainage Basin
R8	Scrub-Shrub/Emergent (40/60)	0.40	Miller
R9	Forest	0.38	Miller
R9a	Forest/Scrub-Shrub/Emergent (25/50/25)	0.74	Miller
R10	Scrub-Shrub	0.04	Miller
R11	Emergent	0.42	Miller
R12	Forest	0.03	Miller
R13	Emergent	0.12	Miller
R14a	Scrub-Shrub/Emergent (25/27)	0.13	Miller
R14b	Emergent	0.08	Miller
R15a	Forest/Scrub-Shrub/Emergent (25/65/10)	0.79	Miller
R15b	Forest/Emergent (25/75)	0.25	Miller
R17	Forest	0.31	Miller
	Subtotal	51.33	
Borrow Area 1			
32	Emergent	0.09	Des Moines
48	Forest/Emergent (20/80)	1.58	Des Moines
B1	Forest/Scrub-Shrub (30/70)	0.27	Des Moines
B4	Scrub-Shrub	0.07	Des Moines
B11	Emergent	0.18	Des Moines
B12[d]	Scrub-Shrub	0.63	Des Moines
B14	Scrub-Shrub/Emergent (70/30)	0.78	Des Moines
B15 a and b[d]	Scrub-Shrub	2.05	Des Moines
	Other Waters of U.S.	0.01	Des Moines
	Subtotal	**5.66**	
Borrow Area 3			
29	Forest	0.74	Des Moines
30	Forest/Scrub-Shrub (80/20)	0.88	Des Moines
B5	Forest/Scrub-Shrub (40/60)	0.08	Des Moines
B6	Forest/Scrub-Shrub (30/70)	0.55	Des Moines
B7	Forest/Scrub-Shrub (30/70)	0.03	Des Moines
B9	Forest	0.05	Des Moines
B10	Forest	0.02	Des Moines
	Subtotal	**2.35**	
South Aviation Support Area (SASA)/Tyee Valley Golf Course			
28[d]	Scrub-Shrub/Emergent/Open Water (50/30/20)	35.45	Des Moines
52	Forest/Scrub-Shrub/Emergent (80/20/20)	4.70	Des Moines
53	Forest	0.60	Des Moines
G1	Emergent	0.05	Des Moines
G2	Emergent	0.02	Des Moines
G3	Emergent	0.06	Des Moines
G4	Emergent	0.04	Des Moines
G5	Emergent	0.87	Des Moines
G6	Emergent	0.01	Des Moines
G7	Forest/Scrub-Shrub (30/70)	0.50	Des Moines

Table 1-2. **Summary of wetland areas in the Seattle-Tacoma International Airport Master Plan Update area (continued).**

Wetland [a]	Classification [b]	Area (Acres)	Drainage Basin
G8	Emergent	0.04	Des Moines
WH	Open Water	0.25	Des Moines
DMC	Forest/Scrub-Shrub/Emergent	1.08	Des Moines
	Subtotal	**43.67**	
IWS Area			
IWS a and b	Forest	0.67	Des Moines
	Subtotal	**0.67**	
South Aviation Support Area Detention Pond			
E1	Forest	0.23	Des Moines
E2	Forest	0.04	Des Moines
E3	Forest	0.06	Des Moines
	Subtotal	**0.33**	**Des Moines**
TOTAL		**115.86**	

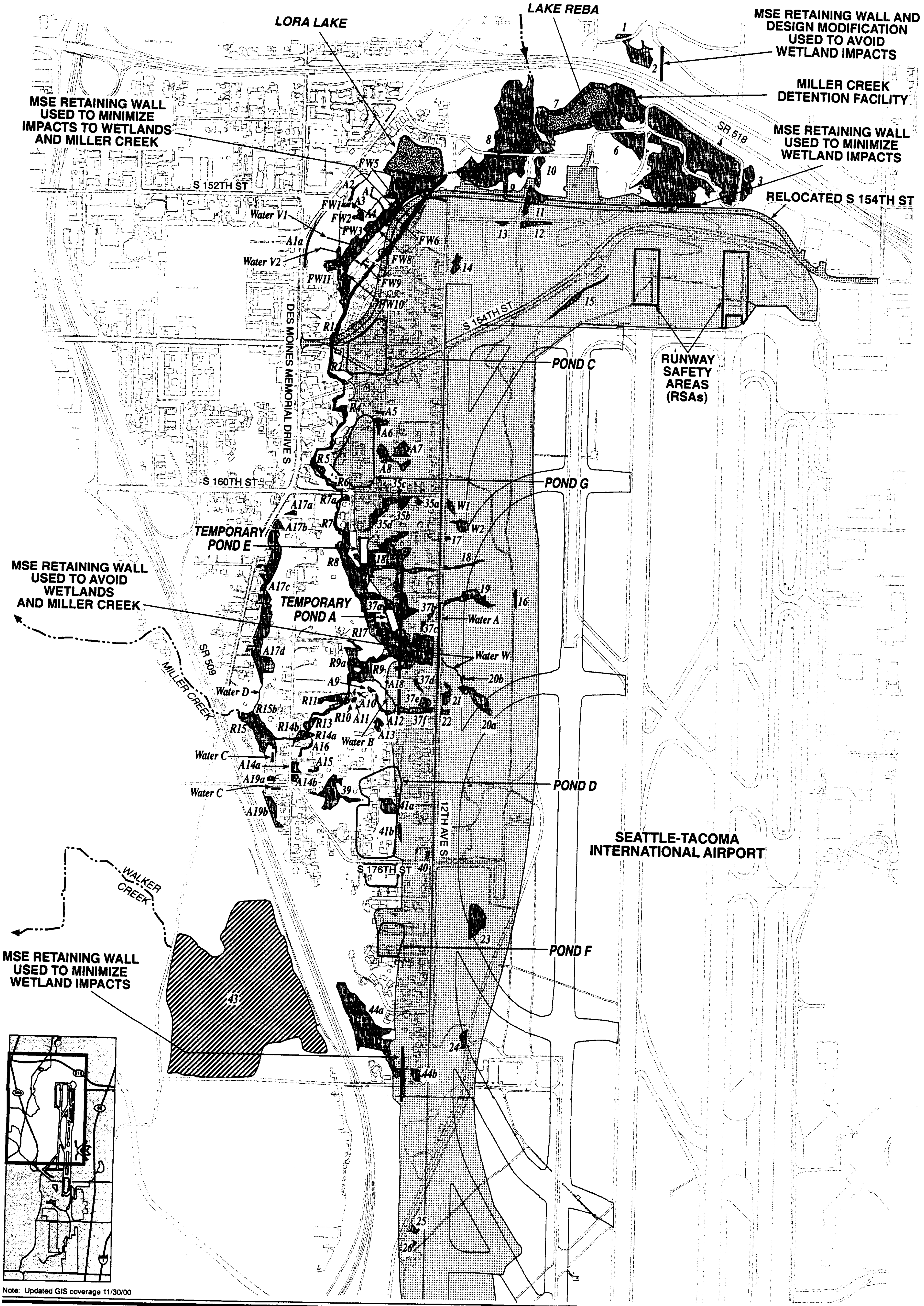
[a] Due to the number of wetlands, their location within the project area, and the history of their documentation, a wetland labeling protocol was developed.

- Wetlands with numbered designations (e.g., Wetland 35 or Wetland 44) were described by Shapiro and Associates, Inc. (FAA 1995).
- Wetlands with an 'A' designation (e.g., Wetland A5 or A10) are new wetlands occurring within the west acquisition area.
- Wetlands with an 'R' designation (e.g., Wetland R5 or R6) are new riparian wetlands occurring within the west acquisition area.
- Wetlands with a 'W' designation (e.g., Wetland W1 or W2) are new wetlands occurring within the west airfield area.
- Wetlands with a 'G' designation (e.g., Wetland G5 or G6) are new wetlands occurring within the Tyee Valley Golf Course or the SASA areas.
- Wetlands with an 'E' designation (e.g., Wetland E1 or E2) are new wetlands occurring within the SASA detention pond area.
- Wetlands with an 'IWS' designation (e.g., IWSa and IWSb) are new wetlands occurring near the IWS lagoon.
- Wetlands with a 'B' designation (e.g., Wetland B5 or B10) are new wetlands occurring within the borrow sites.
- Wetland numbers followed by a small case letter designate subsections of a wetland (i.e., Wetland 35a, or 35b) where constructed features (i.e., driveways) fragment a larger wetland.

[b] Numbers indicate approximate percentage of cover by respective wetland classes (Cowardin et al. 1979).

[c] Includes Lake Reba.

[d] Portions of the wetland area are estimated.



Note: Updated GIS coverage 11/30/00

Sea-Tac Airport/Functional Assessment and Impact Analysis
556-2912-001/01(03) 12/00 (K)

▨ Wetlands not Verified by ACOE

■ Delineated Wetlands Verified by ACOE

-··-··- Stream

▒ Water Features

░ Embankment Area (Fill and Grading Third Runway, Runway Safety Area and S 154th Street)

41a Wetland Number

SCALE IN FEET

0 400 800

N

Figure 1-3
Wetland Impacts in the Miller Creek Basin Near STIA

Bow Lake is a 25-acre wetland (Figure 1-4) located east of 28th Avenue South and north of South 188th Street. This wetland contains open water and shrub vegetation classes, and forms the headwaters of the east branch of Des Moines Creek. The biological functions of the wetland are limited by the proximity of adjacent commercial and residential development; however, the wetland likely provides moderate biological function for passerine birds, small mammals, waterfowl, and amphibians. Physical functions likely provided by the wetland include groundwater recharge, storage of runoff, and water quality benefits.

Wetland 28 (see Table 1-2 and Figure 1-4) is adjacent to the west side of Tyee Valley Golf Course and is about 35 acres. The wetland is composed of open water, emergent, and shrub wetland habitat. A tributary of Des Moines Creek flows through the wetland. The presence of open water, habitat diversity, and hydrologic connections to stream habitat result in moderate to high function for a variety of wildlife groups (resident fish, passerine birds, small mammals, amphibians, and waterfowl). The wetland is headwaters of the west branch of Des Moines Creek, is downslope of developed areas, and because of its topographic setting, it provides base flow support, surface runoff storage, sediment trapping, and water quality benefits.

Additional wetlands, Wetlands 43, 51, and A20, are located near Master Plan Update improvements, but will not be impacted by the improvements (Table 1-3). Delineated portions of these wetlands that are close to construction activities were confirmed by ACOE. Wetland A20 is located in the west acquisition area but will not be affected by Master Plan Update improvements and was not confirmed by ACOE.

Table 1-3. Significant wetlands near the STIA project area (areas are estimated).

Wetland	Classification [a]	Approximate Area (Acres)	Drainage Basin
43	Forest/Scrub-Shrub/Emergent (25/50/25)	33.4	Miller
51	Forest/Scrub-Shrub (30/70)	16.0	Des Moines
A20	Emergent	0.3	Miller
	Total	**49.7**	

[a] Numbers indicate approximate percentage of cover by respective wetland classes (Cowardin et al. 1979).

A series of wetlands (Wetlands 3, 4, 5[4], 6, 7, 8, and 9; see Table 1-1 and Figure 1-3) totaling about 25 acres comprise the Miller Creek detention facility. The wetlands consist of open water, emergent, shrub, and forested wetlands that are hydrologically connected to Miller Creek. The diversity of wetland classes, permanent open water, and hyrdologic connections to stream habitat indicate the wetlands provide moderate to high biological function to a variety of wildlife groups (resident fish, passerine birds, small mammals, amphibians, and waterfowl). The location near the headwaters, presence of adjacent developments, and topographic conditions suggest the wetland complex also provides physical functions such as base flow support, surface runoff storage, and sediment trapping.

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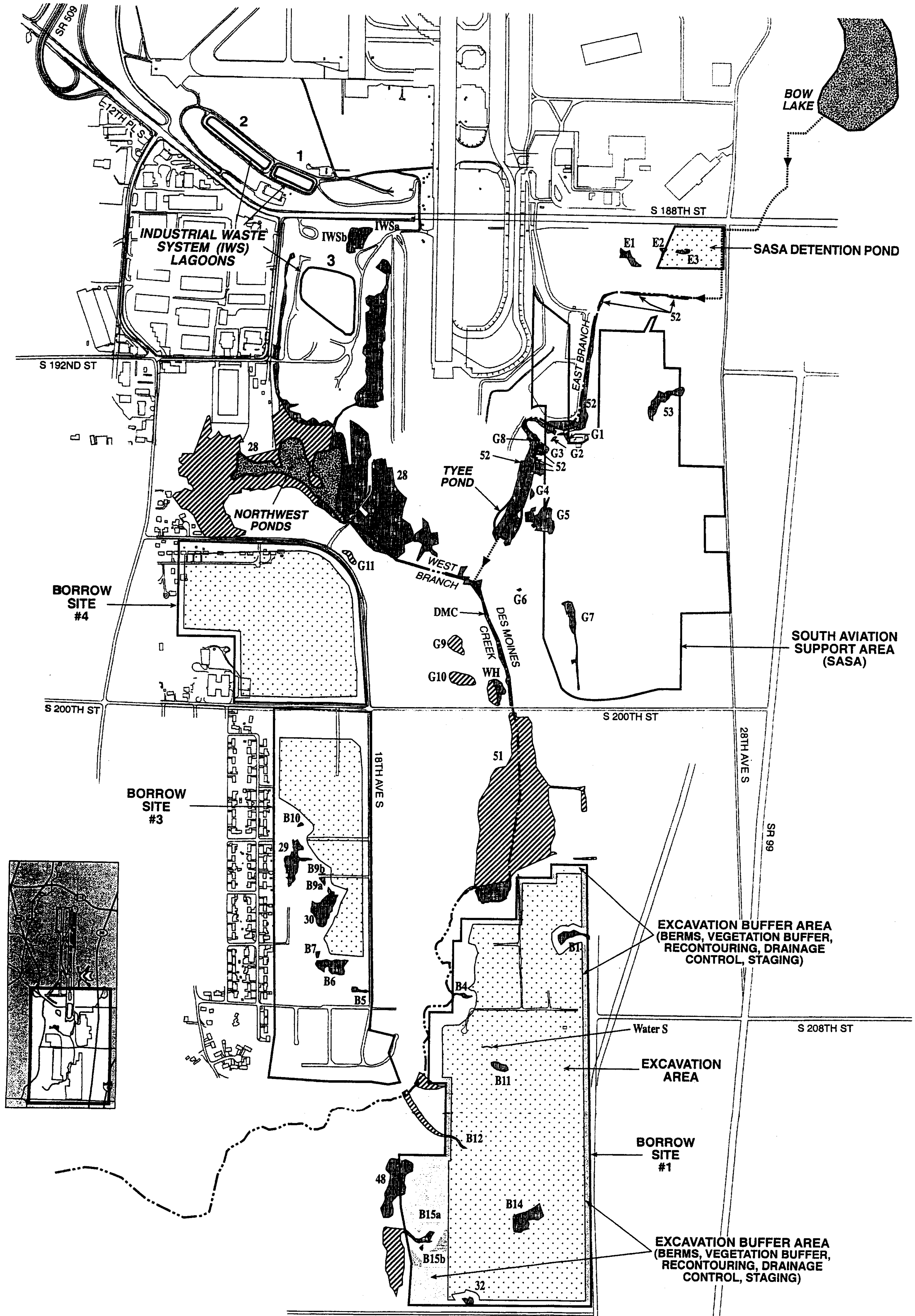
[4] Minor (0.14 acre) fill impacts likely will occur in Wetland 5. Because of the small area affected, location upslope of the floodplain, and proximity to other disturbance, the overall functions provided by the wetland will not be significantly affected.



Note: Updated GIS coverage 11/30/00

Sea-Tac Airport/Functional Assessment and Impact Analysis
556-2912-001/01(03) 12/00 (K)

▩ Water Features

▆ Delineated Wetlands Verified by the ACOE

—·— Stream

B12 Wetland Number

⠿ Excavation Area

▨ Wetlands not Verified by the ACOE

········ Piped Stream

SCALE IN FEET
0 400 800

Figure 1-4
Wetland Impacts in the Des Moines Creek Basin Near STIA

2. METHODS

Methods used to analyze impacts to wetlands are described in this chapter. The methods for evaluating impacts to wetland acreage affected by the project are described in Section 2.1. Impacts to the ecological functions provided by wetlands are described in Section 2.2.

2.1 IMPACTS TO WETLAND AREA

2.1.1 Direct Impacts

Direct impacts were considered to occur in those areas where wetlands would be filled by project development. These areas were calculated using engineering design data and maps of delineated wetland boundaries. These data were incorporated into GIS map layers, from which fill impacts were calculated. While most direct impacts would be permanent, some impacts are temporary and result from the need for temporary stormwater management facilities during the construction period.

2.1.2 Indirect Impacts

Indirect wetland impacts were defined as potential wetland impacts (excluding filling) that could affect the existence and ecological function of wetlands located near areas developed as part of the Master Plan. Examples of indirect impacts include alteration of surface or groundwater hydrology, changes in water quality, construction and operational noise, human disturbance, and landscape changes. For this analysis, indirect impacts were grouped as temporary (short term during project construction) and operational (those that occur throughout the life of the project). Temporary impacts include wildlife disturbance during construction and potential water quality impacts due to stormwater runoff during construction. Operational impacts include wildlife disturbance from airport operations and potential hydrologic modifications to wetlands downslope of the project.

2.2 IMPACTS TO WETLAND FUNCTIONS

2.2.1 Background

In addition to determining wetland areas potentially affected by the project, impacts to wetland functions[5] were also evaluated. Wetlands perform numerous ecological functions. However, for the purposes of this analysis, and consistent with implementation of Clean Water Act Sections 404 and 401, this study focused on beneficial biological and physical (hydrologic and water quality) functions that wetlands provide to their watersheds. These functions are:

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[5] Wetland functions are the physical, chemical, and biological processes and interactions that occur in a wetland.

- **Supports resident and anadromous fish.** Wetlands can provide direct habitat for fish, or provide indirect support to fish habitat by a number of processes.

- **Provides habitat for song birds.** A variety of avian species use wetlands for foraging and nesting habitat.

- **Provides waterfowl habitat.** Wetlands frequently provide aquatic and semi-aquatic habitat used by waterfowl for nesting and foraging.

- **Provides amphibian habitat.** Wetlands with seasonal ponding may be breeding and rearing habitat for amphibians, which then disperse to adjacent upland areas.

- **Provides small mammal habitat.** A variety of small mammals forage in and adjacent to wetlands. Some small mammals (beaver and muskrat) live in certain types of wetlands.

- **Exports organic matter.** Organic matter produced in wetlands (live or dead plant material, aquatic or terrestrial insects, etc.) can be exported to downslope areas and serve as food resources for other organisms.

- **Maintains groundwater exchange.** Wetlands can be areas where groundwater is discharged and enters surface water drainage systems. Less frequently, they are areas where surface water collects and recharges groundwater aquifers.

- **Provides flood-storage and runoff desynchronization.** Wetlands in floodplains store floodwater and can reduce downstream flooding. Other wetlands slow surface water runoff rates, which can also reduce peak runoff rates.

- **Enhances nutrient retention and sediment trapping.** Wetlands that reduce water velocities are areas where sedimentation occurs. Nutrients and pollutants are often attached to these sediments. Chemical and biochemical processes in wetlands can also remove nutrients and other chemical pollutants from surface water. These processes can improve the quality of surface water flowing through a wetland.

Several functional assessment methodologies are available to estimate wetland functions; these include the *Wetland Evaluation Technique* (WET) (Adamus et al. 1987), *Hydrogeomorphic Classification for Wetlands* (Brinson 1993), and the *Wetland Values: Concepts and Methods for Wetland Evaluation* (Reppert et al. 1979). Functional assessment methodologies for wetlands typically identify and evaluate physical and biological attributes that provide predictive rather than direct measurements of specific ecological functions (Reimold 1994). Due to the limitations of many of the available functional analysis methods, expert opinion is also important when assessing wetlands for indicators of functions (Washington State Department of Ecology [Ecology] 1996; Solomon and Sexton 1994).

Assessment methodologies typically do not recognize local variations in small wetlands on a scale such as the Master Plan Update improvement study area. Many of these methods emphasize the importance of waterfowl and flood control functions of wetlands (Adamus et al. 1987), but they do not address functions of smaller wetlands that lack aquatic habitat (typical of many wetlands within the Master Plan Update improvement study area) (Ecology 1996).

Because of the diversity of wetland systems nationwide, functional assessment procedures may not recognize regional variations in wetland functions. To address this gap in assessment methodologies, Hruby et al. (1995) developed a numeric assessment methodology (Indicator Value Assessment, or IVA) that establishes relative functional performance scores for wetlands within a limited geographic region. This system is based on assignment of the importance of functional indicators and the use of a numeric model (developed for the specific analysis area) to calculate the performance score. However, these models do not exist for most wetland types found in the project area. Ecology is developing wetland functional assessment models for a variety of wetland types in western Washington; however, these models are not yet available.

2.2.2 Assessment Methodology

Due to the limitations described above, a combined approach was used to assess wetland functions for this project. Biological and physical functions of wetlands were determined by evaluating a variety of wetland attributes (Tables 2-1 and 2-2). These attributes were identified using best professional judgement, as well as regional and national functional assessment methodologies (e.g., Hruby et al. 1995; Adamus et al. 1987; Smith et al. 1995; Reppert et al. 1979; Solomon and Sexton 1994; Ecology 1993). The attributes indicate the quality of functions provided within the wetland, its buffer, and its associated watershed. For biological functions, the attributes examined focused on structural complexity, hydrological connectivity to other aquatic habitat, hydrodynamics, habitat quality, and the degree of human disturbance. For physical functions, the attributes examined also focused on hydrodynamics, hydrologic connectivity, the degree of disturbance, as well as sediment transport. The presence, absence, and nature of these attributes helped determine the functions provided by the wetlands.

Table 2-1. Wetland attributes considered in evaluating biological functions of wetlands impacted by the proposed Master Plan Update improvements.

	Function				
Wetland Attribute	Resident/ Anadromous Fish	Passerine Birds	Waterfowl	Amphibians	Small Mammals
Wetland Physical Attributes					
Size of wetland		X	X	X	X
Wetland is hydrologically isolated		X	X	X	X
Wetland is hydrologically connected to fish-bearing stream	X	X	X	X	X
Wetland ditched or drained				X	
Connection of wetland to other natural areas		X	X	X	X
Seasonality, frequency, and amount of flooding in wetland	X	X	X	X	X
Depth and area of seasonal open water		X	X	X	X
Depth and area of permanent open water		X	X	X	X

Table 2-1. **Wetland attributes considered in evaluating biological functions of wetlands impacted by the proposed Master Plan Update improvements (continued).**

	Function				
Wetland Attribute	Resident/ Anadromous Fish	Passerine Birds	Waterfowl	Amphibians	Small Mammals
Hummocks/islands present in wetland		X	X	X	X
Wetland cultivated		X	X	X	X
Evidence of impacts from excess nutrients, toxic materials, or sediments				X	
Buffer attributes					
Amount of impervious surface within watershed	X	X		X	
Buffer is discontinuous by crops, pasture, or urban yard	X	X		X	X
Amount of buffer in forest, shrub, or undisturbed grass communities	X	X		X	X
Upland/wetland edge irregular (W:L ratio >2:1)	X	X	X	X	X
Vegetation Attributes					
Number of vegetation classes (vertical habitat diversity)		X	X		X
Interspersion of vegetation classes		X	X	X	X
Amount, diversity, and size of forested communities		X	X	X	X
Evidence of seasonal ponding in forest vegetation classes		X	X	X	
Areas of aquatic bed vegetation		X	X	X	
Areas permanently ponded with emergent vegetation		X	X	X	X
Areas seasonally ponded with emergent vegetation		X	X	X	X
Interspersion of water and emergent vegetation		X	X	X	X
Ratio of native to non-native vegetation		X	X	X	X
Amount and diversity of shrub communities		X			X
Buffer vegetation is deciduous, coniferous, or mixed	X				X
Avian perch sites adjacent to or above water		X	X		
Large woody debris present	X	X		X	X
Standing dead trees >12" diameter within wetland and buffer		X		X	X
Stream Attributes					
Documented evidence of use by fish (within 3 yrs)	X			X	
Stream channel sinuous	X			X	
Evidence of erosion and high stream velocities	X				
Pools and riffles present	X	X	X		X
Spawning gravels present	X				
Presence of undercut banks	X			X	
Stream channel shaded by vegetation	X	X			X
Presence of seeps and springs	X	X		X	

Table 2-2. Wetland attributes considered in evaluating physical functions of wetlands impacted by the proposed Master Plan Update improvements.

	Function			
Wetland Attribute	Exports Carbon	Groundwater Exchange	Flood Storage	Nutrient / Sediment Trapping
Wetland ditched or drained	X	X	X	X
Wetland contains seasonal open water	X	X	X	X
Wetland contains permanent open water		X	X	X
Multiple channels within wetland	X			X
Wetland discharging to stream	X	X	X	X
Receives storm flood water	X		X	X
Wetland has fluctuating water levels throughout year		X	X	X
Interspersion of vegetation and open water areas	X			X
Evidence of beaver dams	X	X	X	X
Amount of vegetation present in flooded portions of wetland	X			X
Direct evidence of sediment trapping				X
Outflow present during summer but no inlet	X	X		
Topography of wetland relative to outlet	X		X	X
Wetland has no inlet and no outlet	X	X		X
Wetland has outlet but no inlet	X	X		
Wetland has inlet but no outlet	X	X	X	X
Presence of organic soils	X			X
Underlying soil is clay, till, or hardpan		X		
Wetland in pasture or cultivation	X			X
Amount and type of human activities in upstream watershed			X	X
Man-made detention			X	X

Five biological functions were examined. These functions determine the degree to which the wetland: (1) supports resident and anadromous fish, (2) provides passerine bird habitat, (3) provides waterfowl habitat, (4) provides amphibian habitat, and (5) provides small mammal habitat. This assessment relied heavily on the factors incorporated into Ecology's wetland rating system (Ecology 1993) as indicators of significant wildlife habitat (i.e., Category I and Category II wetlands).

Four physical functions provided by wetlands were also examined. These functions examined the wetlands' ability to: (1) export organic matter to downslope systems, (2) maintain groundwater exchange, (3) provide flood storage, and (4) enhance nutrient retention and sediment trapping. Wetlands with similar landscape positions, water sources, and hydrologic fluctuation (i.e., the same hydrogeomorphic classification [Smith et al. 1995]) were compared. Wetland groupings in the study area were determined to be:

- **Riparian.** Wetlands directly adjacent to Miller or Des Moines Creeks.
- **Slope.** Wetlands that are generally free draining because they are on a hillside or slope.
- **Depression.** Wetlands that occur in topographic depressions, with or without restricted drainage outlets.

The functional assessment was completed on all wetlands impacted by proposed Master Plan Update improvements and is discussed in Section 3. To facilitate summarizing impacts of the project on wetland functions, the wetlands were grouped according to their physical and biological similarities. The primary attribute that accounts for physical (hydrologic and water quality) functions is whether the wetlands are riparian, slope, or depression (i.e., their hydrogeomorphic classification [HGM]). The primary attributes that control the biological functions are the types of dominant vegetation present, vegetation structure, and habitat connectivity (particularly with other aquatic habitats). For these reasons, the assessment is summarized by the U.S. Fish and Wildlife Service (USFWS) vegetation classes of wetlands impacted (palustrine emergent, palustrine shrub, and palustrine forested) as well as their topographic occurrence in riparian, slope, or depression areas (i.e., its hydrogeomorphic position).

Based on evaluations of the physical and biological indicators of wetland function observed in each wetland, professional judgement, and knowledge of other wetland ecosystems in the Puget Sound region (urban and non-urban), the functional performance of each wetland was evaluated. Functional performance ratings were assigned as follows:

- **High.** The wetland contains several important characteristics required to perform the function, and lacks indicators that prohibit the function from occurring in the wetland.
- **Moderate.** The wetland contains one or more characteristics required to perform the function; however, several of these may be secondary indicators. The wetland may contain one or more characteristics that interferes with or prevents optimal performance of the function in question.
- **Low.** The wetland lacks significant indicators that the wetland could perform the function in question. One or more indicators that the wetland does not perform the function are typically present.

3. RESULTS

Design of the STIA Master Plan Update improvements has focused, to the extent feasible and practical, on avoiding impacts to wetlands and streams. However, because of the design and siting criteria for the various elements of the Master Plan Update improvements and the proximity of over 170 acres of wetlands to STIA, not all wetland impacts can be avoided. Based on the revised wetland delineation data (Parametrix 2000a) and project design and planning reports (Appendices A and B; FAA 1997; HNTB et al. 1999; Parametrix 2000c), approximately 18.37 acres of wetland will be permanently impacted by the project (Table 3-1, and see Figures 1-3 and 1-4), and about 2.17 acres will be subject to direct temporary impacts during construction (Table 3-2). Finally, implementation of wetland mitigation, both on the project site and at the off-site mitigation site, will improve an additional 40.49 acres of lower quality wetlands in order to restore wetland functions and compensate for unavoidable impacts to wetlands.

In addition to wetlands delineated and verified by ACOE, 7.88 acres of prior converted (PC) wetlands were identified on Vacca Farm parcels (Appendix C, Parametrix 2000a). Most of these PC wetlands (6.96 acres) are located within the Vacca Farm floodplain restoration area, and will be restored to wetland as a result of on-site mitigation (Parametrix 2000b). The remaining PC wetland (0.92 acre) is located east of Miller Creek and will be impacted by relocation of South 154th Street.

The functions provided by affected wetlands are discussed in Section 3.1. The information on functions performed by the impacted wetlands, and the areas of impact, were used to evaluate the temporary and permanent impacts of the project on wetland functions.

3.1 EXISTING WETLAND FUNCTIONS

Wetlands within the project area provide a variety of functions, and a range of wetland conditions are present (Table 3-3). Impacted wetlands range from small, highly modified wetlands subject to ongoing human disturbance, to wetlands that have been modified but are gradually recovering from past logging or farming activities. Moderate to high habitat function occurs in larger wetlands (for example Wetlands 30, 37, and A1) where native vegetation is recovering from past disturbances. Low habitat functions typically occur in numerous smaller wetlands that are subjected to ongoing disturbance and rarely contain surface water. Hydrologic and water quality functions of wetlands vary depending on their landscape position and numerous site-specific factors. Several wetlands (Wetlands 37, 44, and 52) appear to provide groundwater discharge functions that enhance base flow in adjacent streams. Wetlands A1 and 28 provide high function for reducing flood flow and for water quality enhancement. The biological and physical functions of impacted wetlands are discussed further below.

3.1.1 Biological Functions

Wildlife use of the study area and its associated wetlands is largely limited to species tolerant of disturbance (McDonnell et al. 1993). The study area is fragmented by urban development, which limits access to the area for most large mammals (Gardner et al. 1993). Faunal diversity is frequently limited in wetlands because they are too small to meet habitat requirements for many

Table 3-1. Summary of permanent fill impacts to wetlands in the proposed Seattle-Tacoma International Airport Master Plan Update improvement area (in acres).

Wetland	Ecology Rating	HGM Class	Classification	Fill Impact	Vegetation Types Impacted		
					Forested	Shrub	Emergent
Runway Safety Area							
5	III	Slope	Shrub	0.14	0.07	0.07	0.00
			Subtotal	0.14	0.07	0.07	0.00
New Third Runway							
9	III	Slope	Forested/Emergent	0.03	0.01	0.00	0.02
11	III	Slope	Forested/Emergent	0.50	0.40	0.00	0.10
12	III	Slope	Forested/Emergent	0.21	0.04	0.00	0.17
13	III	Slope	Emergent	0.05	0.00	0.00	0.05
14	III	Slope	Forested	0.19	0.19	0.00	0.00
15	III	Slope	Emergent	0.28	0.00	0.00	0.28
16	III	Depression	Emergent	0.05	0.00	0.00	0.05
17	III	Depression	Emergent	0.02	0.00	0.00	0.02
18	II	Slope	Forested/Shrub/Emergent	2.84	1.28	0.75	0.81
19	III	Slope	Forested	0.56	0.56	0.00	0.00
20	II	Slope	Shrub/Emergent	0.57	0.00	0.51	0.06
21	III	Slope	Forested	0.22	0.22	0.00	0.00
22	III	Slope	Emergent/Shrub	0.06	0.00	0.01	0.05
23	IV	Depression	Emergent	0.77	0.00	0.00	0.77
24	III	Depression	Emergent	0.14	0.00	0.00	0.14
25	III	Depression	Forested	0.06	0.06	0.00	0.00
26	IV	Depression	Emergent	0.02	0.00	0.00	0.02
W1	III	Depression	Forested/Emergent	0.10	0.00	0.00	0.10
W2	III	Depression	Forested/Emergent	0.22	0.04	0.00	0.18
35a-d	III	Slope	Forested/Emergent	0.67	0.27	0.00	0.40
37a-f	II	Slope	Forested/Emergent	4.09	2.84	0.00	1.25
39	II	Slope	Forested	0.02	0.00	0.00	0.00
40	III	Depression	Forested	0.03	0.00	0.03	0.00
41a and b	III	Depression	Emergent [a]	0.44	0.00	0.00	0.44
44a and b	II	Slope	Forested	0.26	0.18	0.08	0.00
A1	II	Depression, Riparian	Forested/Shrub/Emergent	0.59	0.09	0.09	0.41
A5	IV	Depression	Emergent	0.03	0.00	0.00	0.03
A6	III	Slope	Forested	0.16	0.16	0.00	0.00
A7	III	Slope	Forested	0.30	0.30	0.00	0.00
A8	III	Slope	Forested/Shrub	0.38	0.07	0.31	0.00
A12	III	Slope	Shrub	0.08	0.00	0.08	0.00

Table 3-1. Summary of permanent fill impacts to wetlands in the proposed Seattle-Tacoma International Airport Master Plan Update improvement area (in acres) (continued).

Wetland	Ecology Rating	HGM Class	Classification	Fill Impact	Vegetation Types Impacted		
					Forested	Shrub	Emergent
A18	III	Slope	Shrub	0.01	0.00	0.01	0.00
FW5 and 6	IV	Depression, Riparian	Farmed Wetland	0.15	0.00	0.00	0.15
R1	III	Riparian	Emergent	0.13	0.00	0.00	0.13
			Subtotal	**14.23**	**6.73**	**1.87**	**5.63**
South Aviation Support Area (SASA)							
52	II	Slope	Forest/Shrub/Emergent	0.54	0.54	0.00	0.00
53	III	Depression	Forested	0.60	0.60	0.00	0.00
E2	III	Slope	Shrub	0.04	0.04	0.00	0.00
E3	III	Slope	Shrub	0.06	0.06	0.00	0.00
G1	IV	Slope	Shrub (Slope)	0.05	0.00	0.05	0.00
G2	IV	Slope	Emergent	0.02	0.00	0.00	0.02
G3	IV	Slope	Emergent	0.06	0.00	0.00	0.06
G4	IV	Slope	Emergent	0.04	0.00	0.00	0.04
G5	IV	Slope	Emergent	0.87	0.00	0.00	0.87
G7	III	Slope	Forest/Shrub	0.50	0.13	0.37	0.00
			Subtotal	**2.78**	**1.37**	**0.42**	**0.99**
Borrow Area and Haul Road							
28	II	Depression, Riparian	Emergent	0.07	0.00	0.00	0.07
B11	III	Depression	Emergent	0.18	0.00	0.00	0.18
B12[b]	II	Depression	Emergent	0.07	0.00	0.07	0.00
B14	III	Depression	Shrub	0.78	0.00	0.55	0.23
			Subtotal	**1.10**	**0.00**	**0.62**	**0.48**
Mitigation							
Auburn Area 7	III	Depression	Emergent	0.02	0.00	0.00	0.02
Auburn Area 9	III	Depression	Emergent	0.03	0.00	0.00	0.03
Auburn Area 10	III	Depression	Emergent	0.07	0.00	0.00	0.07
			Subtotal	**0.12**	**0.00**	**0.00**	**0.12**
TOTAL				**18.37**	**8.17**	**2.98**	**7.22**

[a] Includes 0.18 acre of open water habitat.

[b] These wetlands extend off-site.

Table 3-2. Summary of direct temporary construction impacts to wetlands in the proposed Seattle-Tacoma International Airport Master Plan Update improvement area.

Wetland	Classification [a]	Total Temporary Impact Area (acres)	Vegetation Type Impacted (acres) Forest	 Shrub	 Emergent
Runway Safety Area Extension					
4	Forested [b]	0.20	0.20	0.00	0.00
5	Forested /Shrub [b]	0.20	0.10	0.10	0.00
Third Runway					
9	Forested/Emergent	0.16	0.11	0.00	0.05
18	Forested/Shrub/Emergent	0.22	0.04	0.07	0.11
37	Forested/Shrub/Emergent	0.71	0.50	0.10	0.11
44a	Forested/Shrub	0.28	0.18	0.10	0.00
A1	Forested/Shrub/Emergent [b]	0.05	0.01	0.01	0.03
A12	Shrub	0.03	0.00	0.03	0.00
A13	Forested	0.01	0.01	0.00	0.00
R2	Emergent	0.02	0.00	0.00	0.02
South Aviation Support Area					
52	Forested/Shrub/Emergent [b]	0.17	0.00	0.05	0.12
TOTAL		**2.05**	**1.15**	**0.46**	**0.44**

[a] All wetlands are palustrine, based on USFWS wetland classification system (Cowardin et al. 1979).

[b] Temporary impacts will be limited to installation of sediment fencing and standard BMPs.

Table 3-3. Ratings for wetland functions impacted by fill for construction of Master Plan Update improvements at Seattle-Tacoma International Airport.

Wetland	Resident/ Anadromous Fish	Passerine Birds	Waterfowl	Amphibians	Small Mammals	Exports Organic Carbon	Groundwater Exchange	Flood Storage	Nutrient/ Sediment Trapping
5	Low	Low	Low	Low-Moderate	Moderate-High	Low-Moderate	High	Low	Moderate
9	Low	Moderate-High	Low	Low-Moderate	Moderate-High	Low-Moderate	Low	High	Moderate
11	Low	Moderate-High	Low	Low	Low-Moderate	Low	Low	Low	Moderate
12	Low	Moderate-High	Low	Low	Low	Low	Low	Low	Low
13	Low	Low-Moderate	Low	Low	Low	Low	Low	Low	Low
14	Low	Moderate-High	Low	Low	Low	Low	Moderate	Low	Low
15	Low	Low-Moderate	Low	Low-Moderate	Low	Low	High	Low	Moderate
16	Low	Low-Moderate	Low	Low	Low	Low	Low	Low	Low
17	Low	Low-Moderate	Low	Low	Low-Moderate	Low	Low	Low	Moderate
18	Moderate	High	Low	Moderate	Moderate	High	High	Moderate	Moderate
19	Low	Moderate-High	Low	Moderate	Moderate	Moderate	High	Low	Moderate
20	Low	High	Low	Moderate	Moderate-High	High	High	Low	Low
21	Low	Moderate-High	Low	Low-Moderate	Low-Moderate	Low-Moderate	Low	Low	Low
22	Low	Moderate-High	Low	Low-Moderate	Low-Moderate	Low-Moderate	Low	Low	Low
23	Low	Low-Moderate	Low	Low	Low	Low	Low	Low-Moderate	High
24	Low	Low-Moderate	Low	Low	Low	Low	Low	Low-Moderate	High
25	Low	Moderate-High	Low	Low	Low	Low	Low	Low-Moderate	High
26	Low	Low-Moderate	Low	Low	Low	Low	Low	Low-Moderate	High
28	High	Low-Moderate	High	Moderate	High	Low	High	High	High
35	Low	Low	Low	Low	Low	Low-Moderate	Moderate	Low	High
37	High	High	Low	Moderate	Moderate-High	High	High	Low	Moderate-High
40	Low	Moderate	Low	Low-Moderate	Low	Low	Low	Low-Moderate	High
41	Low	Low-Moderate	Low	Low	Low	Low	Low	Low-Moderate	High
44	Low-Moderate	Moderate-High	Low	Moderate	Moderate-High	High	High	Low	Moderate-High
48	Low	Low-Moderate	Low	Low-Moderate	Low-Moderate	Low-Moderate	Moderate	Low	Low-Moderate

Table 3-3. **Ratings for wetland functions impacted by fill for construction of Master Plan Update improvements at Seattle-Tacoma International Airport (continued).**

Wetland	Resident/ Anadromous Fish	Passerine Birds	Waterfowl	Amphibians	Small Mammals	Exports Organic Carbon	Groundwater Exchange	Flood Storage	Nutrient/ Sediment Trapping
52	Moderate-High	Low-Moderate	Low	Low-Moderate	Moderate-High	High	High	Moderate	Moderate-High
53	Low	Moderate-High	Low	Low	Moderate	Low	Low	Low-Moderate	High
A1	High	Moderate	Moderate	Low	Moderate-High	High	Low	High	High
A12	Low-Moderate	Low	Low	Low	Moderate	Low- Moderate	Moderate	Low	Low
A5	Low	Low	Low	Low	Low	Low	Low	Low	Low
A6	Low	Moderate-High	Low	Low	Moderate	Low	Moderate	Low	Low-Moderate
A7	Low	Moderate-High	Low	Low	Moderate	Low	Moderate	Low	Low-Moderate
A8	Low	Low-Moderate	Low	Low	Moderate	Low	Moderate	Low	Low-Moderate
B11	Low	Low-Moderate	Low	Low	Low-Moderate	Low	Low	Low-Moderate	High
B12	Low-Moderate	Moderate-High	Low	Moderate	Moderate	Low-Moderate	Moderate	Low	Low-Moderate
B14	Low	Low	Low	Low	Moderate	Low	Low	Low-Moderate	High
B15	Low-Moderate	Low	Low	Low	Moderate	Low-Moderate	Moderate	Low	Low-Moderate
E2	Low	Low	Low	Low	Low	Low	Moderate	Low	Low
E3	Low	Low	Low	Low	Low	Low	Moderate	Low	Low
FW5, 6	Low	Low	Moderate	Low	Low	Low	Low	High	High
G2	Low	Low	Low-Moderate	Low	Low	Low	Moderate	Low	Low-Moderate
G3	Low	Low	Low-Moderate	Low	Low	Low	Moderate	Low	Low-Moderate
G4	Low	Low	Low-Moderate	Low	Low	Low	Moderate	Low	Low-Moderate
G5	Low	Low	Low-Moderate	Low	Low	Low	Moderate	Low	Low-Moderate
G7	Low	Moderate	Low	Low	Low	Low	High	Low	Low-Moderate
R1	Low	Low-Moderate	Low	Low	Moderate	High	Moderate-High	High	Moderate-High
W1	Low	Low	Low	Low	Low	Low	Low	Low-Moderate	High
W2	Low	Moderate	Low	Low	Moderate	Low	Low	Low-Moderate	High

wildlife populations and the high percentage of urbanization within the area may limit the numbers and diversity of amphibians present (Richter and Azous 1995). No federal or state-listed threatened or endangered wildlife species use the areas planned for Master Plan Update improvements (FAA 1996). Coho salmon, a federal candidate species, occurs in Miller and Des Moines Creeks downstream of development areas (Williams et al. 1975). (Note: A complete analysis of project impacts to listed species is presented in the *Biological Assessment* [FAA 2000].)

The forested wetlands within the study area lack true aquatic habitat (i.e., extended periods of inundation), and the wildlife function of these wetlands is similar to that of upland areas with comparable vegetation communities (Table 3-4). Small passerine birds (such as varied thrushes, orange-crowned warblers, black-capped chickadees, and fox sparrows) use forested habitat in the study area for nesting and feeding (Ehrlich et al. 1988). Forested areas are also used by small mammals (including mountain beaver, raccoon, opossum, Douglas squirrel, and deer mouse) for breeding and cover. Some amphibians (including northwestern salamander, Pacific chorus frog, and rough-skinned newt) may use portions of the wetlands for resting, foraging, and breeding (Nussbaum et al. 1983).

Habitat functions of shrub wetlands include nest and cover habitat for songbirds (such as Swainson's thrush, Bewick's wren, and kinglets) and small mammals (including the water shrew, raccoon, opossum, and Norway rat) (Table 3-5; Richter and Azous 1995). Shallow areas of seasonal ponding in shrub wetlands are uncommon, but when present they provide habitat for amphibian breeding. Shrub wetlands lack the woody debris that is desirable to terrestrial amphibians such as ensatina.

Emergent wetlands in the study area provide habitat to songbird species (such as red-winged blackbirds and marsh wrens) that use the vegetation for nesting and foraging (Table 3-6). Small mammals (such as muskrat and water shrew) forage on emergent vegetation. In certain wetlands (Wetland A1) amphibian species (including long-toed salamander, western toad, and Pacific treefrog) may use emergent vegetation that occurs in standing water for egg mass attachment. Many of the emergent wetlands in the study area are small, isolated, and recently disturbed by human activities. Wetlands located within the current airport operating area (AOA) and Tyee Valley Golf Course are mowed several to many times per year. This mowing limits their function as wildlife habitat. Most emergent wetlands have intermittent surface flows or seasonal standing water, which also limits their overall habitat function.

The wildlife habitat functions are generally significant to the local vicinity (rather than to a larger landscape or watershed) because urban development isolates the area for many terrestrial species of wildlife (Gavareski 1976). Most of the wetlands are smaller than the habitat requirements of many native mammal and bird species. The biological functions of many of the wetlands are further limited by the lack of permanent open water, the short duration of seasonal ponding or soil saturation, the amount of non-native plant species, and the fragmented habitats. The wildlife habitat function increases where trees and/or shrubs are adjacent to the grass-dominated emergent areas (see Tables 3-4 and 3-5).

Table 3-4. **Rating of habitat functions of forested wetlands impacted by the proposed Master Plan Update improvements.**

Function	Rating	Rationale
Supports Resident and Anadromous Fish	Low to Moderate	Most forested wetland habitat (Wetlands 11, 14, 21, 25, 39, 40, and 53) is isolated from streams and other fish habitat. These areas contain small amounts of standing water during winter and spring months and are thus unable to provide this function. Some forested wetlands (Wetlands 18, 19, 37, and 52) have intermittent connections or border Miller or Des Moines Creeks. These wetlands provide shade, buffer, and food resources to resident or migratory fish species.
Provides Songbird Habitat	Moderate to High	Several larger forested wetland habitat areas (Wetlands 3, 4, 5, 19, 29, 37, 51, 52, and 53) contain habitat for breeding birds. These habitat attributes include more than one wetland class, the presence of snags or logs, understory shrub and herbaceous vegetation, and forested buffers connecting to other habitat types. Some of the forested wetlands in the impact area are dominated by willow, alder, and cottonwood (Wetlands 11, 19, 37, 39, and 53) that are too young to provide cavity nesting habitat. The lack of dense coniferous forest habitat in all forested wetlands also reduces their habitat function for some bird species.
Provides Amphibian Habitat	Low to Moderate	Soil in forested wetland habitat is typically saturated but lacks significant amounts of standing water during the late spring and summer months. This condition limits the diversity of amphibians that can breed in the forested wetlands. Where extended seasonal ponding is present (Wetlands 3, 4, 5, 37, 40, and 52), Pacific chorus frog, red-legged frog, and long-toed salamander may be present.
Provides Small Mammal Habitat	Moderate	Forested wetlands provide habitat to small mammals such as raccoon, opossum, squirrels, mice, and rats. The wetlands typically do not support burrowing animals due to seasonally saturated soils. Large mammals are absent from the project area due to the lack of large, undeveloped areas of native vegetation.
Provides Waterfowl Habitat	Low	Forested wetlands lack open water or open areas to allow foraging, nesting, or resting by waterfowl. The forested wetlands in the impact area generally lack significant open water or standing water during the breeding season, limiting their function as waterfowl breeding habitat.

Table 3-5. Rating of habitat functions of shrub wetlands impacted by the proposed Master Plan Update improvements.

Function	Rating	Rationale
Supports Resident and Anadromous Fish	Low to Moderate	Most shrub wetland habitat (Wetlands 20, A8, B14, and B15) is isolated from streams and other fish habitat. These wetlands lack standing water and are thus unable to provide fish habitat. Some wetlands (Wetlands 18 and 52) have intermittent connections to, or border Miller or Des Moines Creeks. These wetlands provide shade, buffer, and food resources to resident or migratory fish species.
Provides Songbird Habitat	Low to High	Several larger wetlands (Wetlands 18, 20, 37, and 52) contain shrub communities with high habitat function for breeding birds. Their attributes include more than one wetland class, the presence of snags or logs, understory shrub and herbaceous vegetation, and forested buffers connecting to other habitat types. Most shrub-dominated areas are small (Wetlands 5, 22, 40, A12, B12, B15, E2, and E3) and do not provide significant habitat functions.
Provides Amphibian Habitat	Low	Shrub wetlands are typically saturated but lack standing water during the late spring and summer months. This condition limits the diversity of amphibians that can breed in the wetlands.
Provides Small Mammal Habitat	Moderate	Shrub wetlands provide habitat to small mammals such as raccoon, opossum, squirrels, mice, and rats. The wetlands typically do not support burrowing animals due to seasonally saturated soils. Large mammals are absent from the project area due to the lack of large, undeveloped areas of native vegetation.
Provides Waterfowl Habitat	Low	These wetlands lack open water or emergent vegetation that would allow foraging by waterfowl. Shrub habitat in the impacted area generally lacks significant open water or standing water during the breeding season, limiting its function as waterfowl breeding habitat.

Table 3-6. Rating of habitat functions of emergent wetlands impacted by the proposed Master Plan Update improvements.

Function	Rating	Rationale
Supports Resident and Anadromous Fish	Low	Most emergent wetlands (including Wetlands 15, 16, 17, 23, 24, and 32) do not provide fish habitat function because they are isolated from streams and other fish habitat and have only small amounts of standing water during winter and spring months. Some emergent wetlands have intermittent connections to streams by artificial ditches (Wetlands 18, 35, 44, 52, and G7). These hydrologic connections provide a potential export of food into fish habitat; however, these connections provide no significant habitat to fish, nor do they allow fish to access suitable aquatic habitat within the wetlands.
Provides Songbird Habitat	Low to Moderate	Emergent wetland habitat is small, ranging in size from less than 0.1 acre to about 1.0 acre. Due to their small size and location in shallow, seasonally wet depressions, these wetlands lack many of the habitat attributes associated with high function for breeding birds. Emergent wetlands lack significant open water or standing water during the breeding season. They are often vegetated by reed canarygrass, velvet-grass, or other emergent plant species that offer limited breeding, feeding, and resting habitat to birds such as the marsh wren, red-winged blackbird, song sparrows, and common yellowthroat. Emergent wetlands that have associated forest or shrub wetland classes and buffers (Wetlands A1, 20, 18, 37, 28, 52, and G7) provide habitat for a greater variety of breeding birds, including thrushes and flycatchers. In these wetlands, red alder and cottonwood provide nest and perch sites for birds, although many trees are too young to provide cavity nesting habitat.
Provides Amphibian Habitat	Low to Moderate	Soil in emergent wetlands is typically saturated, but lacks significant amounts of standing water during the late spring and summer months. In addition, there is a large percentage of developed land near these wetlands. These conditions limit the diversity of amphibians that can breed in the wetlands. Where water is present for extended periods (Wetlands 28, 52, and 37), Pacific chorus frog, red-legged frog, and long-toed salamander may be present.
Provides Small Mammals Habitat	Low to Moderate	Emergent wetlands, especially when bordered by forest or shrub communities (Wetlands A1, 36, 37, 39, and 52), are likely to provide habitat to small mammals. However, the small size of most of these wetlands, and the lack of diverse habitat structure within them, limit the use of these wetlands by small mammals. Species likely to inhabit the wetlands include deer mice, voles, and species tolerant of human activity.
Provides Waterfowl Habitat	Low	Emergent wetlands affected by the proposed airport improvements lack significant open water or meadow areas suitable for waterfowl. They may provide breeding sites for mallards when located near other water features (Wetland A1).

3.1.2 Physical Functions

Wetlands affected by the Master Plan Update improvements are grouped by HGM classification (i.e., riparian, slope, and depression) because the levels of hydrologic function these wetlands perform are generally similar within each HGM class (Tables 3-7, 3-8, and 3-9).

Riparian wetlands on groundwater seeps adjacent to Miller and Des Moines Creeks function to support stream base flows by providing seasonal or perennial sources of water and moderate stream temperatures. Wetlands associated with the Miller Creek detention facility temporarily store floodwaters, which may reduce downstream flooding and streambank erosion (Booth 1991; Childers and Gosselink 1990). Other riparian wetlands help reduce peak flows by collecting and storing storm runoff, thereby reducing the rate and volume of water that reaches the stream systems during storms (Reinelt and Horner 1990, 1991; Mitsch and Gosselink 1993). All of the on-site wetlands affected by the project have a limited ability to provide hydrological functions due to their small size, lack of direct connections to the streams, or topographic conditions that limit the amount and duration of seasonally detained stormwater.

The existing groundwater recharge function of the on-site wetlands also appears to be limited because many of them occur on low permeability till soils (Alderwood Series). The wetlands have formed in shallow depressions where a perched water table has developed. Due to the low soil permeability, evapotranspiration, and the short duration of soil saturation, it is unlikely these small wetlands contribute significantly to recharge of groundwater (FAA 1997).

3.1.3 Water Quality

The effectiveness of wetlands in providing improved water quality is closely related to the dominant water source and the presence or absence of an outlet. Water quality is also enhanced by the presence of vegetation and by microtopography.

Slope wetlands are frequently supported by groundwater seeps with minor inputs of sediment or pollutants from surface water sources. Those slope wetlands that receive storm runoff from streets or other sources provide biofiltration functions (Wetlands 18, 35, 37, 44, and A1), but the rate of water flow through these wetlands may be too rapid for optimal removal of nutrients or pollutants.

In contrast to slope wetlands, depressional wetlands typically provide significant water quality benefits if sediment or other pollutant sources enter them. When no outlet is present, depressional wetlands retain sediments as well as the nutrients adsorbed to the sediments. Dentrification can also occur in cases where soil is saturated for long periods.

Riparian wetlands are likely to be recipients of sediment, both from upslope sources and from overbank flow. Nutrients such as phosphorus and other chemical pollutants that adsorb to particulates are likely to accumulate in riparian wetlands. In addition, these wetlands are also sites for dentrification when soil is saturated for long periods. Riparian wetlands may act as a sediment source due to bank erosion that often occurs during periods of high streamflow.

Table 3-7. Rating of physical and chemical functions of riparian wetlands impacted by the proposed Master Plan Update improvements.

Function	Rating	Rationale
Exports Organic Matter	High	Most riparian wetlands contain deciduous and woody vegetation that overhangs Miller Creek. Coarse and fine particulate matter from plants and insects falls into the stream and supports the aquatic ecosystem.
Maintains Groundwater Exchange	Moderate to High	Most riparian wetlands that border Miller and Des Moines Creeks occur where groundwater surfaces (i.e., groundwater discharge sites). Groundwater discharge is visible in Wetland 52 during most of the year.
Provides Flood Storage/ Desynchronization	High	Portions of riparian wetlands are in the Miller or Des Moines Creek floodplain where they convey and/or store floodwater. The topography and hydrologic roughness of these systems help retain and detain floodwater. These functions are especially high in the Miller Creek detention facility, where engineering modifications have enhanced this function.
Enhances Nutrient Retention/ Sediment Trapping	Moderate to High	Riparian wetlands occur on alluvial soils, indicating sedimentation is present. Certain nutrients (i.e., phosphorus) and other chemicals that adsorb to particulates are likely to accumulate here. The long-term saturation will also create environments for dentrification. During periods of high streamflow, the riparian wetlands may act as a sediment source due to bank erosion.

Table 3-8. Ratings of physical and chemical functions of depressional wetlands impacted by the proposed Master Plan Update improvements.

Function	Rating	Rationale
Exports Organic Matter	Low	These wetlands have no outlet and no opportunity to perform this function.
Maintains Groundwater Exchange	Low	Many of the depressional wetlands occur on till soils where groundwater recharge rates are low due to low soil permeability. However, they likely perform some groundwater discharge.
Provides Flood Storage/ Desynchronization	Low to Moderate	These wetlands typically occur in shallow depressions with little surface water storage capacity. They likely play some role in desynchronizing runoff, and thus reducing peak storm flows.
Maintains Nutrient Retention/ Sediment Trapping	High	Without surface water outlets, most depressional wetlands are likely to retain sediments and nutrients that may be adsorbed to them. Wetlands 40 and 41 are proximate to runoff from roads or pastures and are likely to be effective in this regard.

Table 3-9. Ratings of physical and chemical functions of slope wetlands impacted by the proposed Master Plan Update improvements

Function	Rating	Rationale
Exports Organic Matter	Low to Moderate	While there is seasonal flow on some slope wetlands, they generally do not export organic matter to downslope systems due to low water volumes. An exception is Wetland 20, where flow transports detritus to Wetland 37 and Miller Creek during the winter months.
Maintains Groundwater Exchange	Low to High	Some slope wetlands (Wetlands 3, 4, 5, 18, 37, 44, and 52) appear to be areas where groundwater seasonally surfaces. Depending on the duration of the flow into the summer months, this flow enhances the base flows of Miller or Des Moines Creek. Most slope wetlands are discharge/recharge systems, where shallow groundwater temporarily surfaces in the wetland, yet infiltrates downslope near the edge of the wetland.
Provides Flood Storage/ Desynchronization	Low	These wetlands do not occur in floodplains. The wetlands could reduce peak flows by slowing runoff rates to Miller or Des Moines Creeks.
Enhances Nutrient Retention/Sediment Trapping	Low to Moderate	The limited input of surface water or sediments to these wetlands allows little opportunity for this function to occur. However, some wetlands (Wetlands 18, 35, 37, 44, and A1) receive storm runoff from streets. These wetlands provide biofiltration.

4. IMPACT ANALYSIS

Permanent, temporary, and indirect impacts to wetlands are described in this section. The analysis focuses on biological and physical functions that will be impacted by the proposed airport improvements. Permanent impacts are considered to result from direct filling of wetlands (Section 4.1). Temporary impacts are the short-term impacts due to construction in or near wetlands that will end or be removed when construction is complete (Appendix A, Section 4.2). Potential indirect impacts (Section 4.3) are largely associated with possible changes to wetland hydrology, increased noise or human disturbance impacts to wildlife, and potential changes to water quality.

4.1 PERMANENT IMPACTS

Permanent impacts will occur to forested, shrub, and emergent wetlands within the Master Plan Update development area (Table 4-1 and see Table 3-1). These impacts are generally limited to the physical footprint of planned areas of fill, excavation, or other project development.

Permanent impacts also include indirect impacts that could eliminate wetland functions from 2.40 acres of wetlands. These impacts could include elevations to wetland hydrology, fragmentation, and shading (from a planned bridge spanning wetlands at SASA).

Table 4-1. Summary of permanent wetland impacts by project and wetland category[a] (in acres).

Project	Category II	Category III	Category IV	Total
RSA	0.00	0.14	0.00	**0.14**
Third Runway	8.37	4.89	0.97	**14.23**
Borrow Area 1 and Haul Rd.	0.14	0.96	0.00	**1.10**
SASA	0.54	1.20	1.04	**2.78**
Off-site Mitigation[b]	0.00	0.12	0.00	**0.12**
TOTAL	**9.05**	**7.31**	**2.01**	**18.37**

[a] Ecology (1993).

[b] Impacts result from an access road in an emergent wetland at the Auburn mitigation project.

4.1.1 Runway Safety Areas

Biological Functions

Permanent wetland impacts associated with extension of the RSAs for existing runways and relocation of South 154th Street are limited to about 0.14 acre of Wetland 5 (see Figure 1-3). Forest and shrub vegetation will be removed from a Category III wetland that provides habitat for small mammals and songbirds. These habitat functions will be lost from the impacted area.

Physical Functions

The impacted portion of Wetland 5 is on a moderate slope where groundwater discharge occurs throughout most of the year. Due to the slope of the wetland, this area does not detain or store stormwater. The groundwater discharge supports wetland hydrology in downslope portions of the wetland, and ultimately contributes to base flow in Miller Creek. Design of retaining walls to avoid fill in Wetlands 3 and 4, and to minimize fill in Wetland 5, will incorporate internal drainage systems that allow groundwater to continue to discharge in this area, and this function will not be lost or significantly diminished (see Section 4.3.13 and Appendix B). The addition of best management practices (BMPs) for stormwater management (i.e., stormwater detention and water quality treatment facilities) will maintain or improve water quality conditions in the wetlands, which currently receive untreated runoff.

4.1.2 Third Runway

The embankment needed to support the third runway will impact about 14.23 acres of wetlands (see Figure 1-3 and Table 4-1). These wetlands vary from lower quality Category IV farmed wetlands to higher quality Category II riparian wetlands adjacent to Miller Creek.

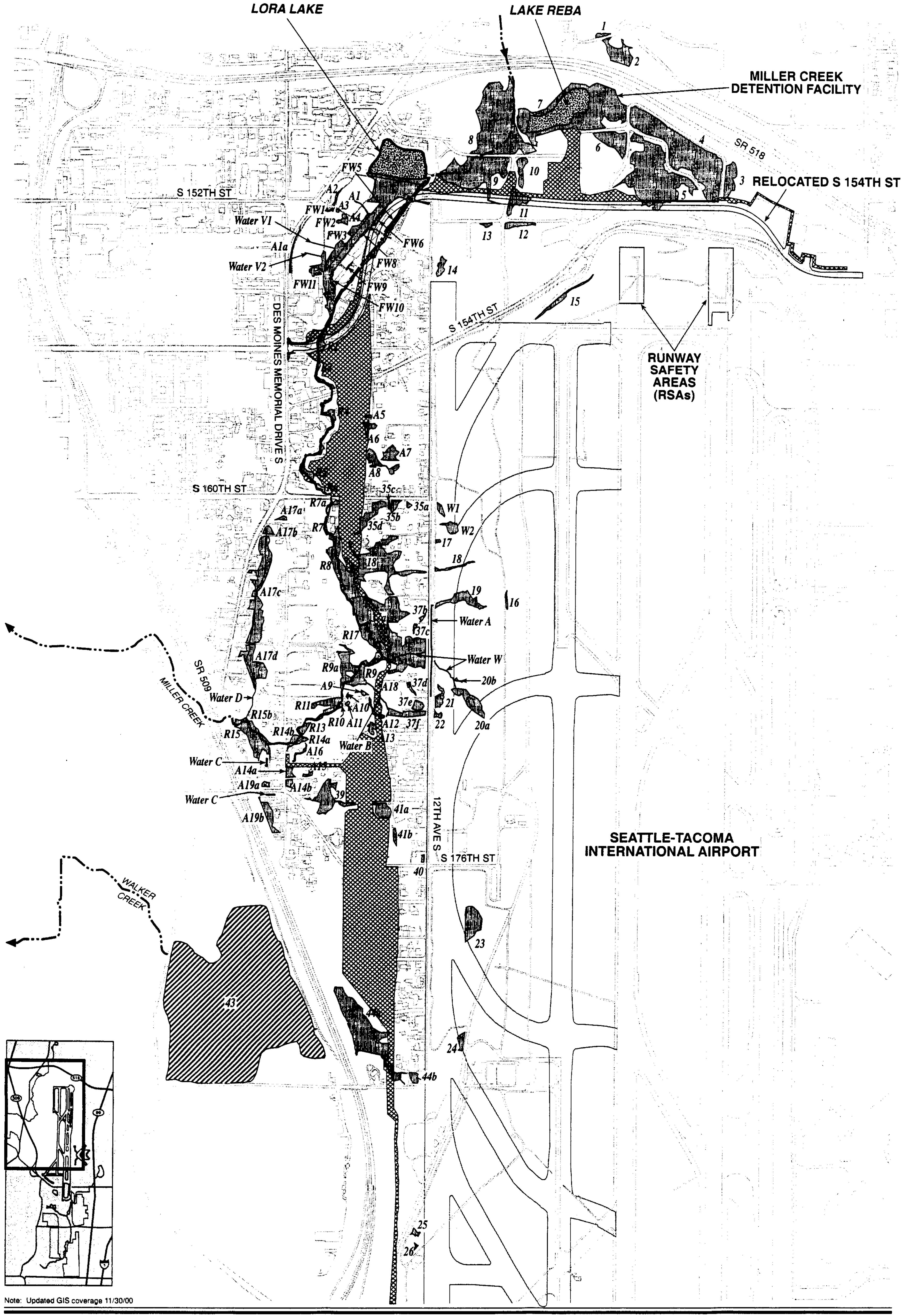
About 2.4 million cy of fill material will be obtained through excavation (i.e., a "cut") at the south end of the third runway. This area has been evaluated for wetland impacts, and includes Wetlands 23, 24, 25, and 26.

Fill and wall construction will alter ditch and drainage channels (Channel A and Channel W, Figure 4-1) that are connected to Wetland 37 via a culvert under 12th Avenue South. Channel A is a ditch constructed adjacent to 12th Avenue South. Water in drainage Channel A flows south from Wetland 19 and north from Wetland 21. Water in drainage Channel W flows from Wetland 20 to Channel A. The two water channels converge and are then culverted under 12th Avenue South and discharged into Wetland 37. Channelized flow continues through Wetland 37 to Miller Creek.

Biological Functions

About 8.37 acres of Category II wetlands will be impacted by the runway, including portions of Wetlands 18, 20, 37, 39, 44, and A1. These wetlands typically contain a mix of early successional forest, blackberry- and willow-dominated shrub, and non-native emergent wetland plant communities. All or portions of the wetlands are also subjected to ongoing human disturbances, including noise, stormwater runoff, and/or landscaping. The wetlands support a variety of wildlife, as described in Section 3.1, and these wildlife habitat functions will be lost from the filled areas.

With the exception of Wetlands 18, 37, and A1, these wetlands are not riparian to Miller Creek. Portions of Miller Creek will be relocated in conjunction with fill in part of Wetland A1. These riparian wetlands protect and provide fish habitat in Miller Creek through shade and detrital input that supports invertebrate food production within the stream. Most riparian functions provided by Wetlands 18 and 37 will not be lost because fill of these wetlands is limited to areas greater than 50 ft from the stream (Appendix B).



Note: Updated GIS coverage 11/30/00

Sea-Tac Airport/Functional Assessment and Impact Analysis
556-2912-001/01(03) 12/00 (K)

SCALE IN FEET
0 400 800

N

▨	Wetlands Not Verified by ACOE	▓	Water Features
▓	Delineated Wetlands Verified by ACOE	▒	Location of Temporary Construction Impacts
—··—	Stream	*41a*	Wetland Number

Figure 4-1
Location of Temporary Wetland Impacts in the Miller Creek Basin Near STIA

Several Category III wetlands (see Table 4-1) will be impacted by the runway embankment. Young deciduous forest, blackberry and willow shrubs, or non-native emergent plant species typically dominate these wetlands. The wetlands provide habitat to birds and small mammals, but because they are generally small in size, poorly buffered, and subjected to past or ongoing disturbance (vegetation clearing, human use, and/or stormwater), they represent lower quality habitat than the Category II wetlands. The wildlife habitat functions of these wetlands will be lost.

Several Category IV wetlands (Wetlands 23, 26, A5, FW5, and FW6) are dominated by non-native grasses or cultivated crops. Wetlands FW5 and FW6 provide habitat for a limited array of wildlife (waterfowl, pigeons, and crows). Most other Category IV wetlands are mowed lawn, and support small mammals and birds that are typical of disturbed urban environments (robin, sparrow, starling, etc.).

Physical Functions

Wetlands impacted by the third runway embankment occur on gentle slopes, shallow depressions, and riparian areas along Miller Creek. Their geomorphic positions control, in part, the hydrologic functions these wetlands provide, and some of their functions will be eliminated by the fill for the third runway embankment.

Most slope and depression wetlands are saturated during the winter and spring months (e.g., A5-A13, 35, 44a, W1, W2, and 16 through 24) when rainwater appears to perch on till soils (FAA 1997). These delay some runoff and thus provide winter base flow support to Miller Creek; they do not support low summer base flows because they are dry by late summer and early autumn. Slope and depression wetlands provide some detention and desynchronize stormwater runoff by reducing runoff rates. This function is limited by the small water storage volume provided by the shallow depressions or the lack of storage in slope wetlands.

Slope and depression wetlands also provide water quality functions in that they receive untreated runoff from adjacent streets and lawns and potentially remove pollutants. Depression wetlands are likely to provide higher water quality treatment functions due to longer storage times that promote contaminant removal when compared to slope wetlands. Slope wetlands have short retention times and would thus provide fewer water quality benefits.

Several slope wetlands are areas of groundwater discharge (Wetlands 15, 18, and 37) that are saturated throughout the year. These wetlands convey groundwater downslope to Miller Creek. The presence of surface water in the wetlands throughout much of the summer indicates that the wetlands support base flow in Miller Creek.

Retaining walls will be constructed at four locations along the fill for the RSAs, relocated South 154th Street, and the third runway to avoid impacts to riparian wetlands and to Miller Creek (see Figure 1-2). The fill embankment and the retaining walls have been designed with a drainage layer (underdrain) constructed of coarse rock that is placed over the existing soil surface. The underdrain enables discharge of groundwater that infiltrates into the embankment from above. This water is then conveyed downgradient to discharge into wetlands located between the embankment and Miller Creek. This water will maintain wetlands located west of the embankment and support base flows in Miller Creek (see Section 4.3.2.4).

4.1.3 Borrow Areas

Wetlands in Borrow Area 1 are isolated depressions and groundwater-fed slope or depressional wetlands located along the western perimeter of the borrow area. One slope wetland occurs on the southern boundary. Borrow Area 1 was purchased by the Port of Seattle for noise abatement.

Biological Functions

About 0.07 acre of Category II wetlands will be impacted in Borrow Area 1 (Wetland B12). The easternmost lobe of this slope wetland extends from near the western edge of the borrow area west to connect with Des Moines Creek. Shrub vegetation in 2.07 acres of Wetland B12 and adjacent forested areas provide habitat for passerine birds, amphibians, and small mammals. A portion of this habitat will be lost due to construction.

About 0.96 acre of Category III wetlands will be impacted in Borrow Area 1. Two isolated depressions (Wetlands B11 and B14) with emergent and shrub vegetation that provide habitat for small mammals and passerine birds will be filled, and these functions lost.

Physical Functions

The wetlands being impacted by development in Borrow Area 1 provide limited hydrologic functions. Slope wetlands (B12) convey groundwater downslope to Des Moines Creek. Depressional wetlands (B11 and B14) desynchronize stormwater runoff and likely provide some water quality benefits. Potential indirect impacts to a small portion of Wetland B12 (0.04 acre) may occur from potential changes to the hydrology of the upper portion of the wetland due to nearby grading.

4.1.4 South Aviation Support Area

Wetland impacts at the SASA site include filling 2.78 acres of wetlands on the Tyee Valley Golf Course. A bridge across Des Moines Creek will be constructed to allow aircraft to access the SASA site from the airfield, and this bridge will shade portions of the stream and riparian wetlands. This impact area includes a stormwater detention facility for the SASA development that will require filling of 0.10 acre of wetland.

Biological Functions

Wetlands in the SASA are typically dominated by early successional deciduous forests and shrub wetlands, or are emergent wetlands planted as golf course greens. The forest and shrub wetlands (Wetlands 52, 53, and G7) provide habitat functions similar to those described in Tables 3-4, 3-5, and 3-7. The golf course wetlands (Wetland 52, G1, G2, G3, G4, G5, G6, and G8) provide habitat to foraging waterfowl and songbirds, but their value to these species is limited due to ongoing disturbance (golf course operations and maintenance). The loss of Wetlands 53, E2, E3, golf course wetlands, and shading of portions of Wetland 52 will result in the loss of bird and small mammal habitat.

Physical Functions

Most wetlands that will be affected by the SASA are slope and shallow depression wetlands that are seasonally saturated. They likely provide biofiltration to stormwater runoff. Their lack of closed depressions and restricted outlets prevent them from providing stormwater detention functions. They provide base flow support to Des Moines Creek during the winter months, but are dry during the late summer months when low flows occur, and thus do not contribute to this function. An exception to this is Wetland 52 where groundwater discharges throughout the summer. This wetland provides base flow support to the stream during low flow periods; however, project impacts to Wetland 52 are limited to a bridge crossing, and the groundwater discharge functions will not be eliminated.

4.1.5 Other Master Plan Update Improvements

Direct wetland impacts have been avoided through the design of most Master Plan Update improvements or project elements (including temporary interchanges at SR 509 and SR 518, the North Employee Parking Lot, terminal expansions, Airport Surface Detection Equipment (ASDE) radar facilities, and utility upgrades). Several other airport-related projects (Industrial Waste System [IWS] expansion, FAA Tracon and Tower facilities) also avoid wetlands. Where appropriate, any indirect impacts of these projects are addressed in Section 4.3.

4.2 TEMPORARY CONSTRUCTION IMPACTS

Temporary (construction) impacts to wetlands are discussed in this section. Specific construction activities that could affect wetlands are the construction and use of temporary stormwater management ponds in wetlands, temporary disturbances from the installation of construction fencing, temporary erosion and sediment control (TESC) facilities, increased noise and human disturbance, and construction runoff (Appendix A, see Figure 4-1, Tables 4-2 and 3-2). In general, these impacts could affect the water quality, hydrologic, and wildlife functions or conditions of wetlands located near construction sites.

4.2.1 Construction Runoff

The primary potential water quality impacts resulting from construction activities (including excavation and transport of fill) are increased turbidity and sedimentation in wetlands located downslope of construction sites. The mitigation actions taken at construction sites to avoid these wetland and water quality impacts are summarized in this section.

4.2.1.1 Discharge Standards

The Port's National Pollution Discharge Elimination System (NPDES) permit for construction at STIA requires that stormwater discharges meet the turbidity standard for Class AA waters[6] (WAC 173-201A-030). This standard requires that turbidity in stormwater discharges not exceed 5 Nephelometric Turbidity Units (NTU) over background when background is 50 NTU or less, or register more than a 10 percent increase in turbidity when background exceeds 50 NTU. As a numerical standard, this pollution limit is protective of aquatic life (Ecology 1999b).

4.2.1.2 Treatment BMPs

A variety of treatment BMPs are applied at construction sites to ensure that discharge standards for construction water quality are met.

Construction Stormwater Treatment Systems

Advanced stormwater treatment systems (see Appendix D of the *Biological Assessment, FAA 2000*) are used by the Port to treat construction runoff when conventional BMPs do not remove sufficient turbidity to meet the required state water quality standards. Since autumn 1997, the Port has used advanced stormwater treatment systems to treat runoff from several construction sites, including the 1998 and 1999 construction phases of the third runway embankment. Since implementation of these systems, water quality monitoring at construction sites (Port of Seattle 1998b, 1999b, 2000) has demonstrated that stormwater discharges comply with required turbidity standards. The Port will continue to use these stormwater treatment systems on construction sites where necessary and appropriate.

Data from the 1999-2000 wet season (Table 4-2 and Appendix D of the *Biological Assessment*, FAA 2000) demonstrate that the Port's advanced stormwater treatment system is highly effective at producing clear water. Between November 8, 1999, and March 4, 2000, a total of 164 batches (the average batch size was approximately 70,000 gallons) of construction site runoff were treated. All discharged stormwater met the required Washington Water Quality Standard (WAC 173-201A) for turbidity. On average, the site discharge was 9.9 NTUs less than background measurements taken in Miller Creek, demonstrating that the construction discharge was typically clearer than the stream itself.

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[6] Washington surface waters are classified as Class AA (extraordinary), Class A (excellent), Class B (good), Class C (fair), or Lake Class. Class designation is based largely on characteristic uses of the waters. As defined by WAC 173-201A-030, Class AA waters shall "markedly and uniformly exceed the requirements for all or substantially all" of the following characteristic uses: water supply; stock watering; fish and shellfish migration, rearing, spawning, and harvesting; wildlife habitat; recreation; and commerce and navigation.

Table 4-2. Summary of third runway embankment stormwater treatment plant performance results from November 8, 1999 to March 4, 2000.

Number of batches treated	164
Percentage of treated batches meeting water quality standard for turbidity	100%
Average post-treatment turbidity (NTU)	2.7
Average Miller Creek turbidity on days when discharge occurred (NTU)	12.6

Source: Port of Seattle (2000).

Potential water quality impacts from the advanced stormwater treatment BMPs include changes to pH and the potential toxicity of treatment compounds. The Port has used both organic polymers (such as CatFloc) and inorganic compounds (such as alum) in stormwater treatment systems. Aquatic bioassay testing of treatment system effluent has demonstrated that the effluent is not toxic (FAA 2000). Aquatic toxicity testing of the polymer compounds has demonstrated that effective treatment concentrations are several orders of magnitude below toxic concentrations (Calgon 1997). These potential impacts have been evaluated and the treatment system has been found to be environmentally safe. The BMP has been used safely for more than 3 years at STIA and several construction sites (e.g., several Washington State Department of Transportation [WSDOT] projects and Microsoft construction sites in Redmond) with Ecology's review and approval (Ecology 1998a). The draft *Ecology Stormwater Manual Update* (Ecology 1999b) includes a BMP for construction stormwater chemical treatment.

When applied, advanced treatment would consist of Ecology-approved alum or polymer flocculation systems. All chemical treatment facilities would operate in accordance with the conditions of BMP C250, Construction Stormwater Treatment, as it appears in the Ecology Stormwater Manual Update. The draft Manual Update (Ecology 1999b) provides criteria the Port will follow for polymer product use:

- Polymer-treated stormwater discharged from construction sites must be nontoxic to aquatic organisms.
- Petroleum-based polymers are prohibited.
- Prior to authorization for field use, jar tests must demonstrate that the turbidity reduction necessary to meet the receiving water criteria can be achieved. Test conditions, including but not limited to, raw water quality and jar test procedures should be indicative of field conditions.
- Prior to authorization for field use, the polymer-treated stormwater must be tested for aquatic toxicity. Applicable procedures defined in Chapter 173-205 WAC, Whole Effluent Toxicity Testing, and Limits, will be used. Testing will use (a) stormwater from the construction site at which the polymer is proposed for use, or (b) a water solution using soil from the proposed site.
- Testing must show that the dosage at which the polymer becomes toxic is at least twice the anticipated operational dose.

- The approval of a proposed coagulant or flocculent aid will be conditional, subject to the full-scale bioassay monitoring of treated stormwater required by Ecology. The Port will use only polymer products that have been evaluated and are currently approved for use.

Other Construction Stormwater BMPs

In addition to the construction stormwater treatment systems described above, sedimentation from Master Plan Update construction sites will not affect wetlands or downstream habitat because implementation of other construction BMPs will prevent sediment discharges from construction sites to wetlands or streams. These BMPs further ensure construction runoff meets water quality standards. Construction erosion control measures will protect surface water quality and meet Ecology's water quality standards. To ensure that these measures will be properly implemented and maintained, the following protection measures will be used:

- Funding independent third-party oversight of construction erosion control and stormwater management and compliance,
- Writing and implementing construction stormwater pollution prevention plans (SWPPPs) and monitoring plans for individual Master Plan Update improvement activities,
- Supervising contractor erosion control compliance with a full-time erosion control and stormwater engineer,
- Monitoring construction stormwater runoff whenever it rains, and
- Additionally monitoring construction stormwater runoff when rainfall exceeds 0.5 inch in a 24-hour period.

The BMPs listed in Table 4-3 will be applied as specified in the Stormwater Management Manual for Puget Sound (the Ecology Manual [Ecology 1992]) or the King County Surface Water Design Manual (King County DNR 1998). Detailed information on erosion and sediment control for the third runway embankment construction is provided in Appendix D of the *Biological Assessment* (FAA 2000).

Table 4-3. Summary of the Ecology Manual BMPs generally applicable to Master Plan construction sites.

Category	Applicable BMPs
Temporary cover practices	Temporary seeding, straw mulch, bonded fiber matrices, and clear plastic covering
Permanent cover practices	Preserving natural vegetation, maintaining buffer zones, and seeding and planting following construction
Structural erosion control BMPs	Stabilized construction entrance, tire wash, construction road, stabilization, dust control, interceptor dike and swale, and check dams
Sediment retention	Filter fence, storm drain inlet protection, and sedimentation basins

A Construction Spill Control and Countermeasures Plan containing the following elements will be implemented on each site:

- Spill control measures, including designated fueling areas

- Secondary containment of spillable substances
- Use of drip pans and pads
- Contractor education
- Labeling and proper storage of spillable substances
- Designated spill containment procedures
- Proper notification and cleanup procedures

4.2.2 Other Potential Construction Water Quality Impacts

Sediment ponds store stormwater runoff for treatment, and during storage, water temperature can be altered due to solar warming. Storage of stormwater that results in increases in water temperature above levels in downstream waters or water quality standards could be detrimental to fish. This is unlikely to occur downstream of Master Plan Update improvements because storms that would result in several days of water storage generally do not occur during warm weather or low flow periods when such discharges could be quantitatively significant. The Port has observed that little or no runoff from embankment construction areas occurs during smaller, summer-season storms when temperature impacts are of greatest concern. For example, 1998 and 1999 observations in treatment facilities show the construction sites did not generate sufficient runoff to require operation of the treatment system until mid-November. By October and November, temperature impacts from stormwater would not occur due to the cool air temperatures (Table 4-4), lack of solar radiation, cool stream water, and high streamflows. Similarly, by April 1999, stormwater runoff quantities from construction sites had decreased to the point where the plant operation was discontinued, thus eliminating discharges during the warmer months (see Table 4-4).

Table 4-4. Temperature ranges and sky conditions for the warmest months when extended storage of stormwater at the Seattle Tacoma International Airport is expected.

Parameter	November	April
Average Maximum Temperature[1]	49.6°F	58.2°F
Average Minimum Temperature	38.1°F	40.1°F
Average Temperature	43.9°F	49.2°F
Highest Temperature	65°F	77°F
Lowest Temperature	23°F	30°F
Number of clear days	3	3
Number of partly cloudy days	4	7

[1] Salmon undergo stress if water temperatures are generally above 17° C (64.3° F) (Groot et al. 1995 and McCullough 1999). Since maximum temperatures are low and little solar radiation occurs during months when significant stormwater is likely to be held and released, temperature impacts that could affect fish are unlikely.

Source: WSU (1968).

4.2.3 Wetland Alterations During Construction

Temporary construction impacts that will occur in wetlands near construction sites are described below. Temporary construction impacts are anticipated to occur in up to 2.05 acres (Table 4-5).

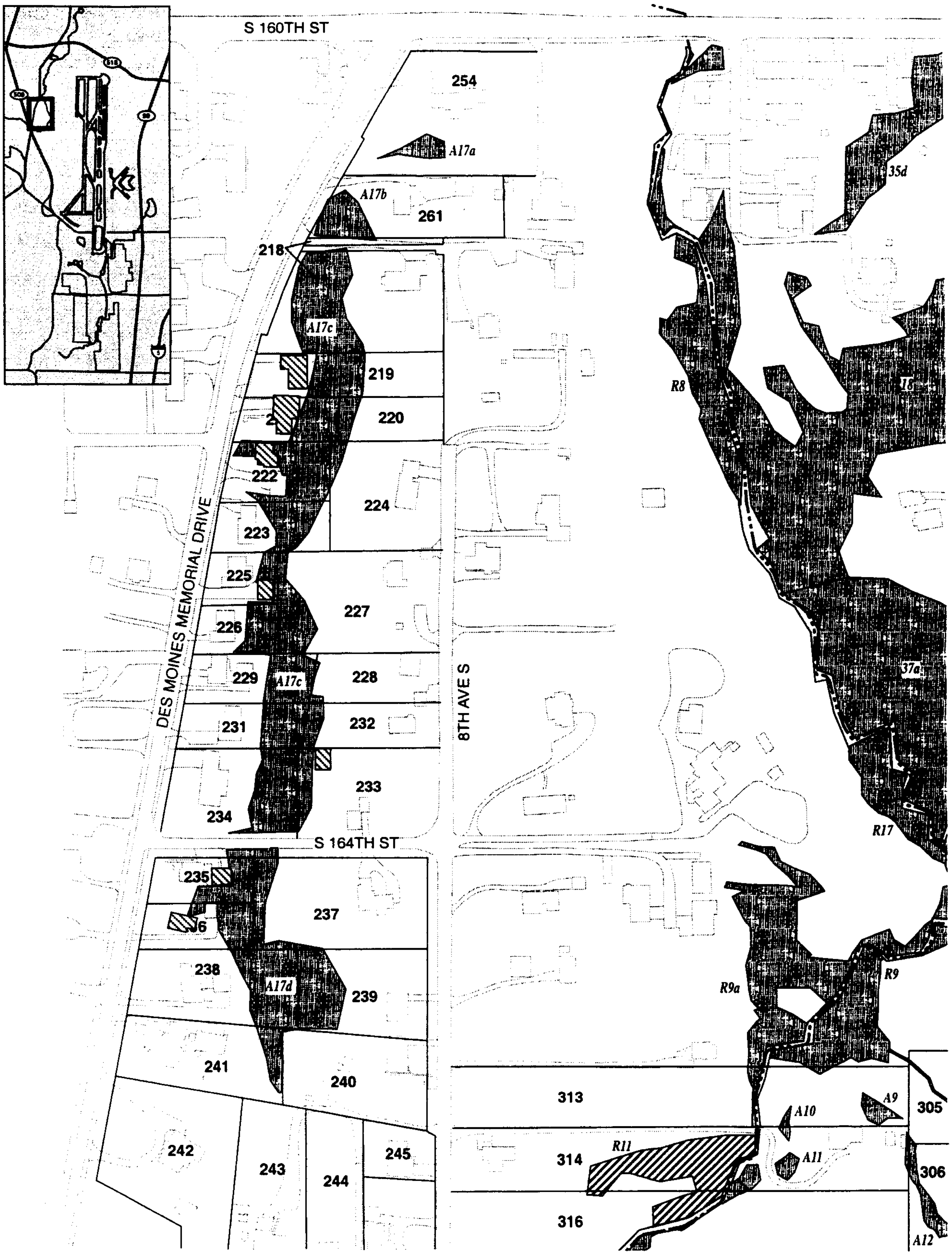
The temporary construction impacts will occur in areas that may be used for temporary access roads, temporary sediment and erosion control ponds, staging areas, and stockpiling areas. Other minor temporary impacts to wetlands may occur as a result of demolition (Figure 4-2). During construction and demolition, all practicable efforts will be made to avoid and minimize impacts to wetlands within this temporary construction impact zone (e.g., flagging and protecting wetlands with barrier fencing and sediment fencing, locating access roads and staging areas wherever possible outside of wetlands, implementing TESC BMPs).

Demolition of houses and other buildings at several locations (Table 4-5) within the west-side acquisition area requires operating equipment and temporarily placing demolition debris on lawns and yards that are also wetlands. Demolition on Parcels 314 and 321 may also require Hydraulic Project Approval (HPA) review prior to reinforcement of existing Miller Creek crossings (a small bridge on Parcel 321 and a culvert on Parcel 321) so trucks can haul out demolition debris.

In general, the duration of these temporary impacts will be approximately one to two construction seasons. While the overall construction period for the Master Plan Update improvements will extend over several years, near any given wetland, the construction period will be shorter. Temporary construction impacts are generally anticipated to occur early in construction sequencing.

Restoring wetland functions to temporarily disturbed areas will mitigate temporary construction impacts associated with Master Plan Update improvements. Wetlands temporarily impacted by construction clearing and filling will be restored by removing all temporary fill material, re-establishing pre-disturbance conditions, aerating compacted soils, and planting with native forest and shrub vegetation. Removing sediment fencing and construction debris will restore wetlands with only minor disturbances that have not been subject to clearing of vegetation or filling (e.g., sediment fences placed along edge of wetland, demolition of adjacent buildings, etc).

Most wetlands subject to significant temporary construction impacts are typically adjacent to the Third Runway Embankment. Upon restoration, these areas will remain part of larger undisturbed wetlands, and in many cases incorporated into mitigation that includes buffer and wetland enhancement actions. These actions ensure that the functions of the restored (as well as remaining wetlands) are maintained at pre-project levels (See Section 4.3 for evaluations of and mitigation to avoid indirect impacts).



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SCALE IN FEET
0 225

N

243 Parcel Number

R9a Wetland Number

▨ Building Demolition Near Wetlands

▩ Wetlands

Figure 4-2
Potential Temporary Impacts to Wetlands Resulting from Building Demolition

Table 4-5. Description of temporary impacts to wetlands from the Seattle-Tacoma International Airport Master Plan Update improvements.

Wetlands	Temporary Impacts
Runway Safety Areas and Relocation of South 154th Street	
Wetlands 3, 6, 7, and 10	Wildlife could be disturbed by construction noise near Wetlands 3, 6, 7, and 10; however, wildlife in the area are already tolerant of air traffic and roadway (SR 518 and South 154th Street) noise.
Wetlands 3, 4, and 5	Temporary construction disturbance could occur in the portion of the wetlands that borders the construction area. These impacts could include disturbance to wildlife and minor soil disturbance or siltation caused by the installation of silt fences.
Wetlands R1 and R2	Minor soil disturbance and siltation could cause impacts at the bridge crossing area. There could be disturbance to wildlife from construction activity and noise.
Third Runway	
Wetlands 9 and 11	A small portion of Wetland 9 and the remaining portion of Wetland 11 that is not permanently impacted could be disturbed. Soil disturbance and minor siltation could occur along the southern portion of Wetland 9 and the remaining portion of Wetland 11 where silt fences are installed. Construction activity and noise could disturb wildlife.
Wetlands R1, R2, R3, R4, R5, R6, R7, R8, R9, and R10	Construction activity and noise could disturb wildlife.
Wetlands A1, A9, A10, A11, A12, A13, and 39	Temporary construction disturbance could occur in portions of Wetland A1 adjacent to the embankment fill. Temporary disturbance is possible to small portions of Wetlands A12 and A13 outside the footprint of fill slope and perimeter road. Minor soil disturbance and siltation is possible within portions of Wetlands A12, A13, and 39 that are immediately adjacent to the footprint of fill slope, perimeter road, or other construction areas. Construction activity and noise could cause disturbance to wildlife in Wetlands A9, A10, A11, A13, and 39.
Wetlands 18 and 37	These wetlands are subjected to 0.93 acre of temporary impact. Disturbance is possible from the construction of temporary stormwater management facilities (e.g., detention pond) in Wetland 37. (Note: Permanent stormwater management facilities will be located outside of wetland areas.) A narrow band of temporary disturbance is likely immediately adjacent to the fill footprint and the security road (outside of temporary stormwater facility areas). This disturbance will be within 30 ft of Miller Creek for about 100 linear ft. There may be limited areas of siltation within Wetlands 18 and 37. Construction activity and noise could cause disturbance to wildlife. Temporary disturbance is possible to wetland drainage patterns/hydrology in Wetland 37 due to the construction of the temporary stormwater management facilities.

Table 4-5. **Description of temporary impacts to wetlands from the Seattle-Tacoma International Airport Master Plan Update improvements (continued).**

Wetlands	Temporary Impacts
Wetland 44	Temporary disturbance adjacent to construction include: • Soil disturbance related to the placement of silt fences, • Construction stormwater management • Construction activity and noise could cause disturbance to wildlife.
Demolition	Demolition of several houses and other buildings within the west-side acquisition area requires operating equipment and temporarily placing demolition debris on lawns and yards that are also wetlands. These occur in Wetland 17 (Parcels 219, 221, 222, 225, 235, 236, and 243), Wetland R13 (Parcels 317 and 321), Wetland A16 (Parcel 322), Wetland A15 (Parcel 325), and Wetland 52 (golf course storage shed). Demolition on Parcels 314 and 321 may also require HPA approval to improve existing Miller Creek crossings so trucks can haul out demolition debris.
Staging Areas	No temporary impacts are expected. Staging areas will be a minimum of 50 ft from Miller Creek and placed outside of wetland areas. In wetlands bordering intended staging areas, activity and noise during construction of each staging location may disturb wildlife.
Borrow Area 1	
Wetlands B1, B4, and 32	Excavation will avoid Wetlands B1, B4, and 32; all other wetlands will be permanently impacted by excavation or dewatering. Interruption in hydrology for Wetlands B1, B4, and 32 is not anticipated; 50-ft buffers will maintain seasonal perched water regime. Excavation activities and noise will disturb wildlife.
Wetlands 48 and B15	Surface flows to these wetlands will not be affected because the upslope watershed of the wetlands (which extends east the stormwater drainage system located along 20th Avenue South) will not be altered.
Borrow Area 3	
Wetlands 29, 30, B5, B6, B7, B9, and B10	All wetlands are being avoided and a 50-ft buffer maintained. Wetland hydrology will be maintained by preserving conditions in the watershed basin upgradient and immediately surrounding each wetland. To ensure wetland hydrology is maintained, a drainage swale will be constructed along the upslope face of the borrow cut that will direct seepage water to Wetland 29 (Appendix C). Excavation activity and noise will disturb wildlife.
South Aviation Support Area	
Wetland 52	Construction activity and noise will disturb wildlife. Minor soil disturbance and siltation may occur along the perimeter of construction due to the installation of silt fences.
IWS Lagoon Expansion	
Wetland 28	No filling or construction occurs in this wetland. (Note this project is not a Master Plan Update improvement.)

4.2.3.1 Runway Safety Areas and Relocation of South 154th Street

Wetlands 3, 4, and 5 are located near the north end of the existing runways where required RSA extensions will be built. As part of the RSA extensions, South 154th Street will be relocated up to several hundred ft north and west of its present location and will lie adjacent to Wetlands 3, 4, and 5. Temporary disturbance to small portions of these wetlands (about 0.25 acre) could result from placement of silt fences and required TESC actions. Minor siltation could occur within the 0.25-acre disturbance area during construction[7].

During the relocation of South 154th Street, temporary disturbance to wildlife is likely to occur in Wetlands 3, 4, and 5. Wildlife in these wetlands are tolerant of aircraft noise from existing runways and roadway noise from SR 518 and the existing South 154th Street. Additional disturbance to wildlife is likely to be minor, and limited to the south edges of the wetlands.

4.2.3.2 Third Runway

Wetlands A1, 9, and 11 are located near the northern end of the proposed third runway. During the relocation of South 154th Street, small portions of Wetland A1 (0.05 acre) and Wetland 9 (0.16 acre) will be temporarily impacted. Minor siltation within these wetlands during construction could occur. Wildlife will likely be disturbed near the south edge of Wetland 9 by construction activity and noise.

This area includes: six small, isolated wetlands near the edge of fill for the third runway embankment (Wetlands A5 and A9 through A13), two larger riparian wetlands (Wetlands 18 and 37), and a third sizable wetland (Wetland 44a) that drains into a wetland complex west of SR 509. Temporary disturbance will occur in portions of Wetlands A12 (0.03 acre), A13 (0.01 acre), 18 (0.22 acre), 37 (0.71 acre), and 44 (0.28 acre), located outside the footprint of the embankment and the perimeter road.

Minor siltation could occur in limited portions of these wetlands as a result of installing silt fences and upslope construction. No physical disturbance to Wetlands A9, A10, A11, and A13 is proposed, although temporary disturbance to wildlife could result from construction activity and noise.

Temporary impacts to Wetlands 18, 37a, and 44a include disturbance from the construction of temporary stormwater management facilities, including detention ponds, during the construction phase of the third runway project. These stormwater facilities will be removed and the wetland area

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[7] TESC BMPs will be implemented prior to construction of all Master Plan Update improvement projects (see Section 4.2.2), and their effectiveness will be strictly monitored. The adequacy of these BMPs is reviewed by Ecology through approval of stormwater pollution and prevention plans prior to implementation. During 1998-1999 embankment construction, no water quality violations (including sediment discharge to wetlands) occurred.

restored after the placement of the third runway embankment fill. Permanent stormwater facilities will be located outside of wetland areas.

Ten small wetlands (Wetlands R1 through R10) lie immediately adjacent to Miller Creek along the western periphery of the third runway expansion area. No impacts from runway construction are expected because the riparian wetlands will be incorporated into the Miller Creek buffer. However, disturbance to riparian wetlands will occur in two limited areas: at the proposed South 156th Street bridge crossing (affecting the southern edge of Wetland R1 and the northern edge of Wetland R2) and at a stormwater outfall that will lie adjacent to Wetland R6. Minor siltation could occur in the temporarily disturbed portions of Wetlands R1 and R2. Disturbance to wildlife from construction activity and noise could occur in all riparian wetlands, but is most likely in Wetlands R1, R2, and R6 because in these areas construction will be near the wetland edge. In the case of Wetland R1, some construction will occur within the wetland.

4.2.3.3 Borrow Areas

Borrow Area 1

Within Borrow Area 1, Wetlands B1, B4, and 32 will be avoided and protected with a minimum 50-ft buffer. Temporary impacts to wildlife using the Category III wetlands may occur during project construction.

Wetlands 15 and 48 will not be affected by excavation, and their upslope watersheds will be protected to ensure that the areas will remain as wetland. The watersheds for these wetlands extend east from the wetland edge upslope to 20th Avenue South. Existing stormwater drainage facilities located along this street from the eastern edge of the watershed for these wetlands and, therefore, to prevent indirect impacts to wetland hydrology, the Borrow Area 1 excavation does not extend west of this street.

Impacts to Des Moines Creek are not anticipated from Borrow Area 1 excavation because the excavation will generally be 200 ft or more east of the stream. All excavation will occur east of the top of the stream ravine. In a small area (about 0.5 acre) near 20th Avenue South and the associated abandoned residential property, borrow excavation will occur 150 ft east of the stream. Another small area (about 0.2 acre) will be excavated about 175 ft east of the stream.

Borrow Area 3

All direct impacts to wetlands in Borrow Area 3 are avoided by limiting the area of excavation to provide a minimum 50-ft buffer around wetlands. Hydrogeologic studies indicate perched groundwater that intersects the surface in the central and northwestern part of Borrow Area 3 creates an area of surface seepage, forming Wetland 29. Other wetlands in Borrow Area 3 occur below this zone of seepage and are formed in shallow surface depressions that perch water. Precipitation and runoff from upslope areas west and north of the wetlands maintain these wetlands. Borrow Area 3 excavation can be completed without disrupting the upgradient sources of water needed to maintain these wetlands. The plan for excavating Borrow Area 3 would preserve a 50-ft undisturbed buffer around the downslope (east) side of the wetlands and not impact their upslope watersheds (see Appendix C).

Temporary impacts to wildlife using Category II Wetlands (29 and 30) and Category III wetlands (B5, B6, B7, B9, and B10) could result from construction noise and other human activity. Excavation in the borrow area will be more than 150 to 200 ft from Des Moines Creek and will thus avoid impacts to the stream or riparian buffers.

Borrow Area 4

Borrow Area 4 is located about 400 ft south of Wetland 28. Wetland 28 is maintained by several water sources, including groundwater that emanates from beneath the existing airfield, runoff from wetlands located east of Des Moines Memorial Drive, and runoff from surrounding developments. Some water infiltrating into Borrow Area 4 may also reach the south and southeastern portion of Wetland 28; however, unlike the Borrow Area 3 excavation, Borrow Area 4 will not be excavated deep enough to reach any groundwater table. Excavation of the borrow area would thus not alter groundwater flows that may reach Wetland 28, and no indirect impacts of the excavation on this wetland are likely.

4.2.3.4 South Aviation Support Area

Wetland 52, a Category II wetland adjacent to the SASA, would be temporarily affected by construction. Impacts to this wetland would include temporary disturbance to wildlife due to construction noise and other human activities. Construction impacts to the wetland could also include minor sedimentation or soil disturbance resulting from construction of the taxiway bridge connecting the SASA to the airfield.

4.2.3.5 Mitigation Impacts

A number of wetlands will be affected by construction of on-site and off-site wetland mitigation (Table 4-6). In general, these impacts affect Category II, III, and IV wetlands that are farmed or dominated by non-native vegetation. These impacts are described in this section.

Since the affected areas will be incorporated into the mitigation design, no loss of wetland will occur[8]. Following implementation of the mitigation projects, wetland areas will be restored to higher quality wetlands, including converting Category III and IV wetlands to Category II wetlands. These Category II wetlands will typically have extended wetland hydroperiods and greater diversity of plant community types that improve water quality and habitat functions.

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[8] A small (0.12 acre) area of emergent wetland (dominated by pasture grasses) will be filled by an access road to the Auburn mitigation site.

Table 4-6. Summary of wetlands subject to mitigation activities.

				Vegetation Type Impacted		
Wetland	Rating	Vegetation Types	Total	Forest	Shrub	Emergent
Miller Creek Buffer/Vacca Farm Mitigation Projects (on-site)						
FW 1, 2, 3, 8, 9, 10, and 11	IV	Farmed Wetlands	0.88	0.00	0.00	0.88
18	II	Forest/Shrub/Emergent	1.27	1.27	0.00	0.00
37a	II	Forest/Emergent	1.96	1.50	0.00	0.46
A1	II	Forest/Shrub/Emergent	4.08	0.90	0.56	2.62
A2	IV	Shrub	0.05	0.00	0.05	0.00
A3	IV	Shrub	0.01	0.00	0.01	0.00
A4	IV	Shrub	0.03	0.00	0.03	0.00
A9	III	Shrub	0.04	0.00	0.04	0.00
A10	IV	Shrub	0.01	0.00	0.01	0.00
A11	III	Shrub	0.02	0.00	0.02	0.00
A13	III	Forest	0.12	0.12	0.00	0.00
A16	III	Shrub/Emergent	0.05	0.00	0.00	0.05
R1	III	Emergent	0.04	0.00	0.00	0.04
R2	III	Shrub/Emergent	0.12	0.00	0.06	0.06
R3	III	Shrub	0.02	0.00	0.02	0.00
R4	III	Emergent	0.11	0.00	0.00	0.11
R4b	III	Forest/Emergent	0.11	0.03	0.00	0.08
R5	III	Emergent	0.05	0.00	0.00	0.05
R5b	III	Forest/Emergent	0.07	0.02	0.00	0.05
R6	III	Forest/Emergent	0.21	0.05	0.00	0.16
R6b	III	Emergent	0.09	0.00	0.00	0.09
R7	III	Forest/Emergent	0.04	0.04	0.00	0.00
R7a	III	Emergent	0.04	0.04	0.00	0.00
R8	II	Shrub/Emergent	0.40	0.00	0.20	0.20
R9	III	Forest	0.38	0.38	0.00	0.00
R9a	II	Forest/Shrub/Emergent	0.30	0.30	0.00	0.00
R10	III	Shrub	0.04	0.04	0.00	0.00
R11	II	Emergent	0.42	0.00	0.00	0.42
R12	III	Forest	0.03	0.03	0.00	0.00
R13	III	Emergent	0.12	0.00	0.00	0.12
R14a	III	Shrub/Emergent	0.13	0.13	0.00	0.00
R14b	III	Emergent	0.08	0.00	0.00	0.08
R15a	II	Forest/Shrub/Emergent	0.79	0.25	0.40	0.14
R15b	III	Forest/Emergent	0.25	0.06	0.00	0.19
R17	II	Forest	0.31	0.31	0.00	0.00

Table 4-6. Summary of wetlands subject to mitigation activities (continued).

				Vegetation Type Impacted		
Wetland	Rating	Vegetation Types	Total	Forest	Shrub	Emergent
Waters B, V1, and V2	III	Open Water	0.05	0.00	0.00	0.05
		Subtotal	**12.72**	**5.47**	**1.40**	**5.85**
Tyee Valley Golf Course Mitigation Project (on-site)						
28	II	Emergent	4.50	0.00	0.00	4.50
		Subtotal	**4.50**	**0.00**	**0.00**	**4.50**
Auburn Mitigation Project (off-site)						
Auburn	III	Emergent	21.56	0.00	0.00	21.56
		Subtotal	**23.27**	**0.00**	**0.00**	**23.27**
TOTAL			**40.49**	**5.47**	**1.40**	**33.62**

[a] Other Waters of the U.S. V1 and V2 (0.02 acre) not included in this table.

[b] Temporary impact resulting from temporary road providing access to the mitigation site.

[c] Temporary impact resulting from temporary road located on-site.

[d] Temporary impact to area that will be excavated and replanted.

[e] Impacts to this area result from converting existing ditches and farmed wetland to a wetland drainage channel that connects the mitigation project to the 100-year floodplain.

Vacca Farm Wetland Restoration Site

Mitigation at the Vacca Farm Restoration Site (Figure 4-3) will result in modification of existing emergent wetland, farmed wetlands, and prior converted cropland (Table 4-7). Relocation of the Miller Creek channel will result in channel excavation, grading, construction in 2.21 acres of wetland. Placement of fill to create channel banks will require fill placement in 1.79 acres of wetland. Finally, excavation of new floodplain in currently farmed areas will modify 1.56 acres of wetland.

Table 4-7. Summary of wetland modification to implement mitigation at Vacca Farm.

Wetland Modification	Area (acres)
Excavation and Grading for Miller Creek Channel	
Wetland A1	1.22
Farmed Wetland 3, 8, and 9	0.99
Subtotal	**2.21a**
Excavation for Floodplain Compensation and Wetland Enhancement	
Water V1 and V2	0.02
Wetlands (A1, A1a, A2, A3, A4)	0.85
Farmed Wetlands (1, 2, 3, 9, 10, 11)	0.73
Subtotal	**1.69**
Total	**3.81**

[a] Includes placement of fill in existing ditches and farmed wetlands (1.79acres).

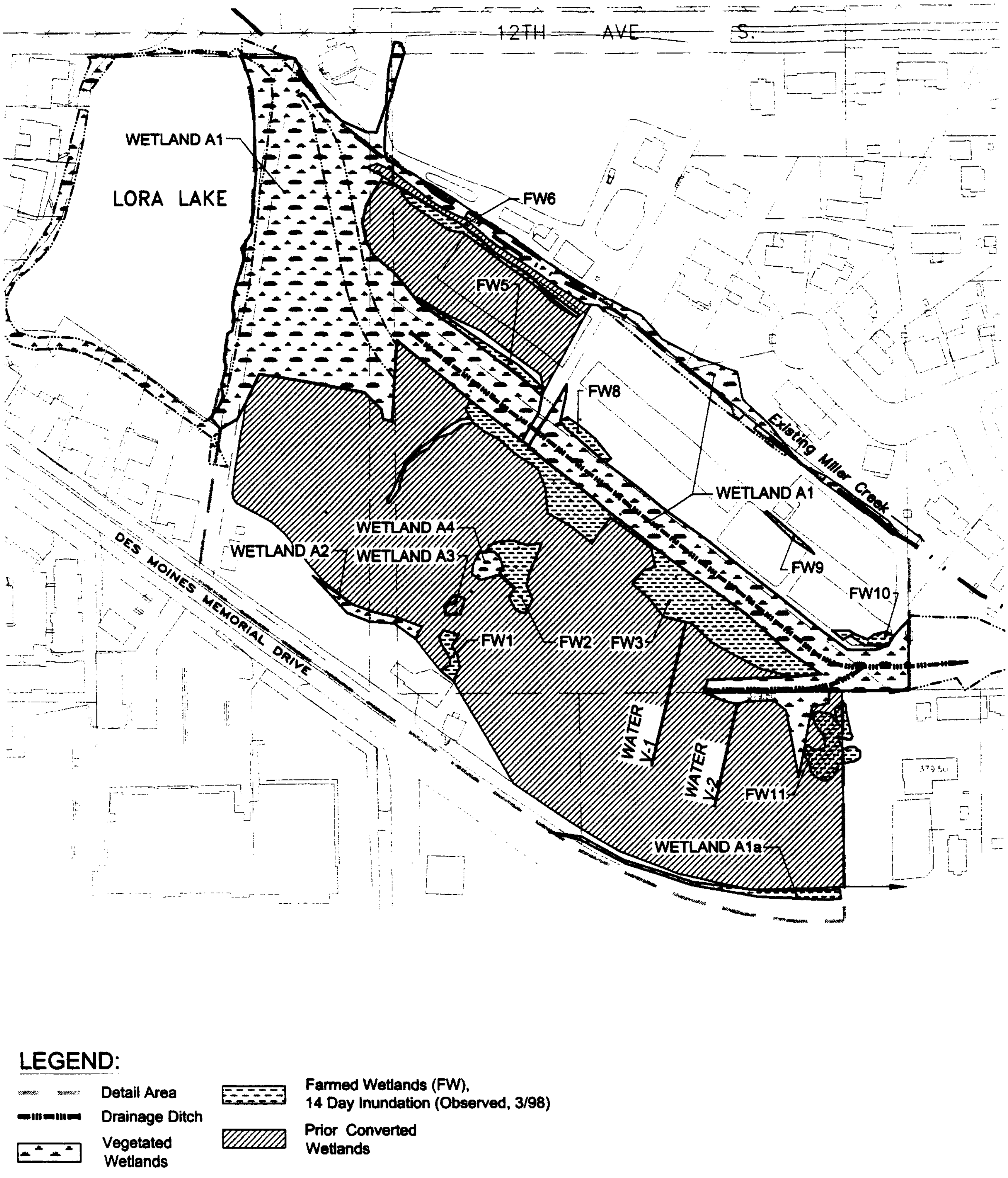

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Figure 4-3
Jurisdictional Wetlands on the Vacca Farm Site

Miller Creek Riparian Buffer

Enhancement of 7.40 acres of wetland in the Miller Creek Buffer (Figure 4-4) will involve minor disturbance. The planting of trees and shrubs will redistribute wetland soils. In some wetlands, prior to planting with native trees and shrubs, clearing and grubbing to remove existing non-native vegetation will redistribute topsoils. In these areas, a temporary mitigation system may also disturb wetland soils.

Tyee Valley Golf Course Wetland and Des Moines Creek Buffer Mitigation

Enhancement of 6.07 acres of wetland on the Tyee Valley Golf Course (Figure 4-5) will involve some soil disturbance during demolition of pathways and other structures located in wetlands. The planting of trees and shrubs on the site will redistribute wetland soils.

Auburn Wetland Mitigation Site

Temporary impacts will occur as a result of excavation in existing lower quality, Category III wetlands to create more diverse or higher quality Category II wetland system with more diverse functions at the Auburn Wetland Mitigation Site (Figure 4-6). Excavation as part of wetland enhancement will allow establishment of open water, flooded emergent, shrub, and forest dominated wetlands habitat and affect about 10.39 acres of Category III wetlands. The wetlands will also provide floodwater storage and conveyance functions, provided by a channel excavated to connect to existing ditches. This excavation will impact about 2.2 acres of existing low quality emergent wetland.

In some wetlands, prior to planting with native trees and shrubs, clearing and grubbing to remove existing non-native vegetation will occur. This work will cause minor redistribution of soils, and will be performed to reduce the quantity of undesirable vegetation and increase the rate of colonization by desirable vegetation in wetland enhancement areas. This activity could occur in up to about 9.13 acres of low-quality wetland.

A temporary construction access road to the Auburn Wetland Mitigation Site must be constructed. This access road must cross emergent wetlands located on-site and on properties to the west. About 1.55 acres of wetland will be temporarily affected by this access road. To minimize these construction impacts, the road will be constructed on geotextile fabric and a quarry rock base. While the base will allow surface water to equilibrate across the road, culverts will also be placed to convey water at existing ditches.[9]

On-site construction staging (temporary stockpiling of soil, storage of equipment, contractor offices, materials storage, parking, etc.) is necessary and will occur on wetland and uplands, prior to enhancement. A geotextile fabric and gravel would be placed on portions of the site prior to their use for staging. Following excavation, the staging area will be removed and the existing wetlands enhanced.

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[9] Surface water, up to several inches deep, occurs in portions of the wetland for short periods following excessive rain.

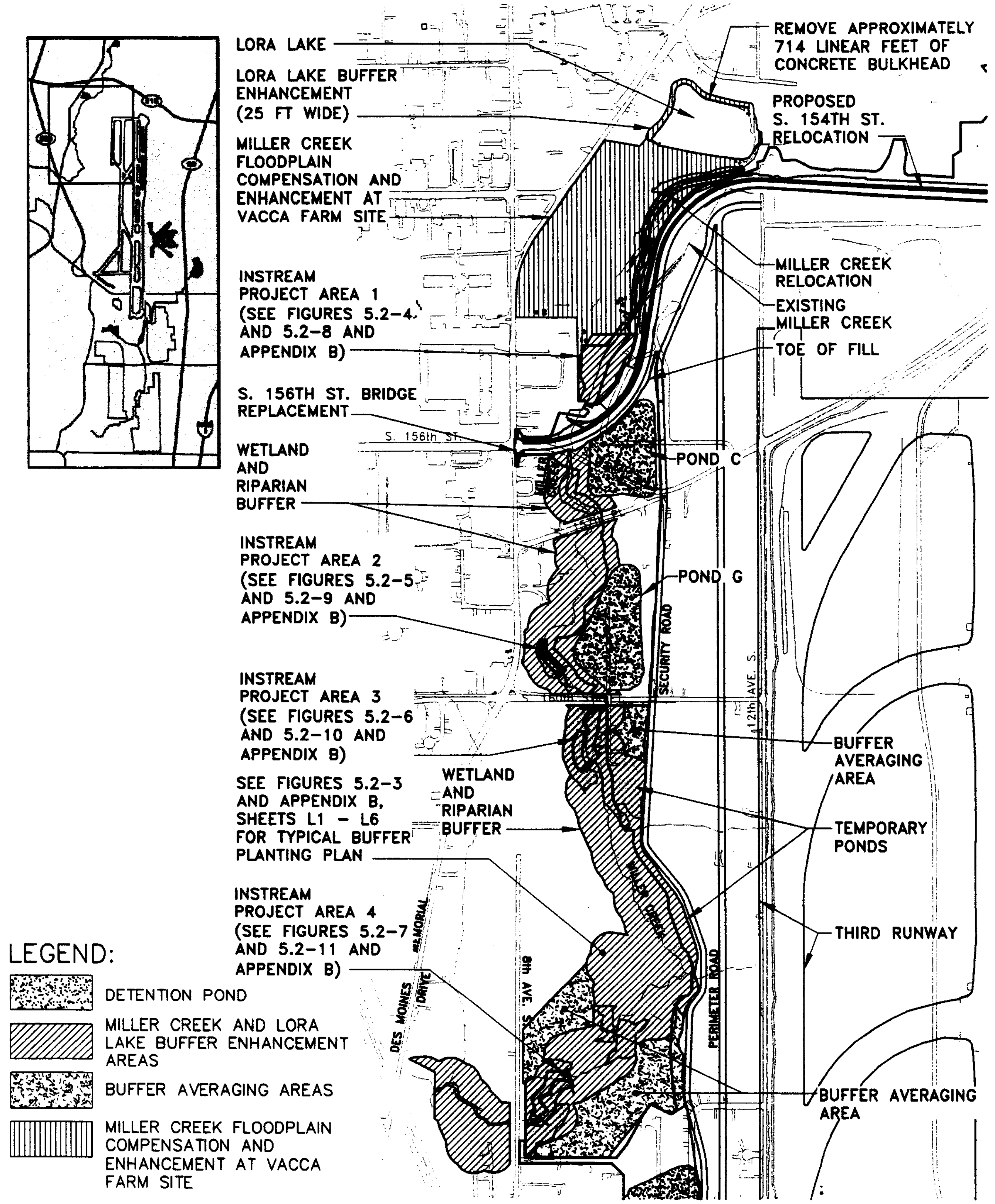

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**Figure 4-4
Locations of Mitigation Projects in the Miller Creek Basin**

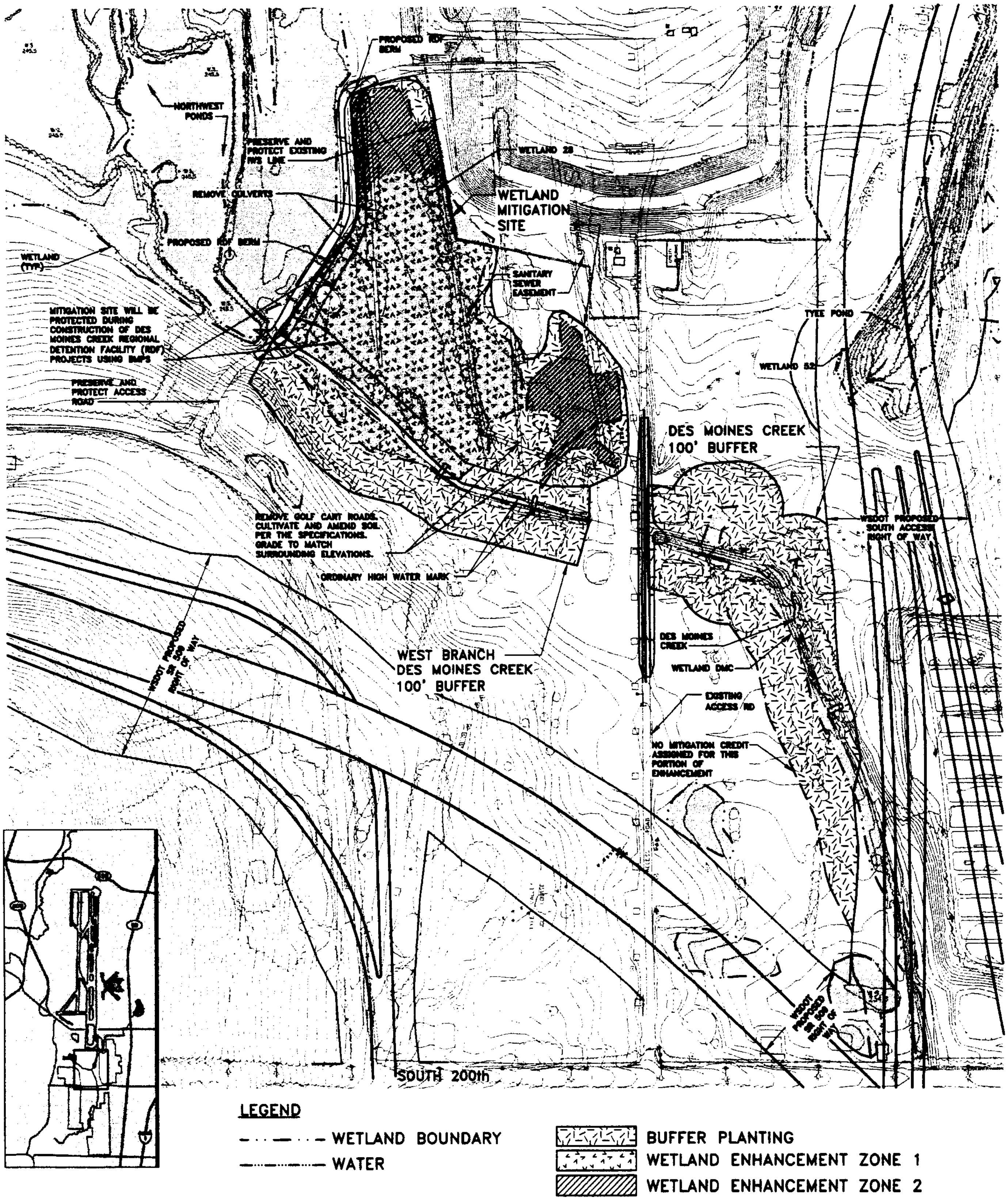

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Figure 4-5
Location of Wetland Mitigation in the Des Moines Creek Basin

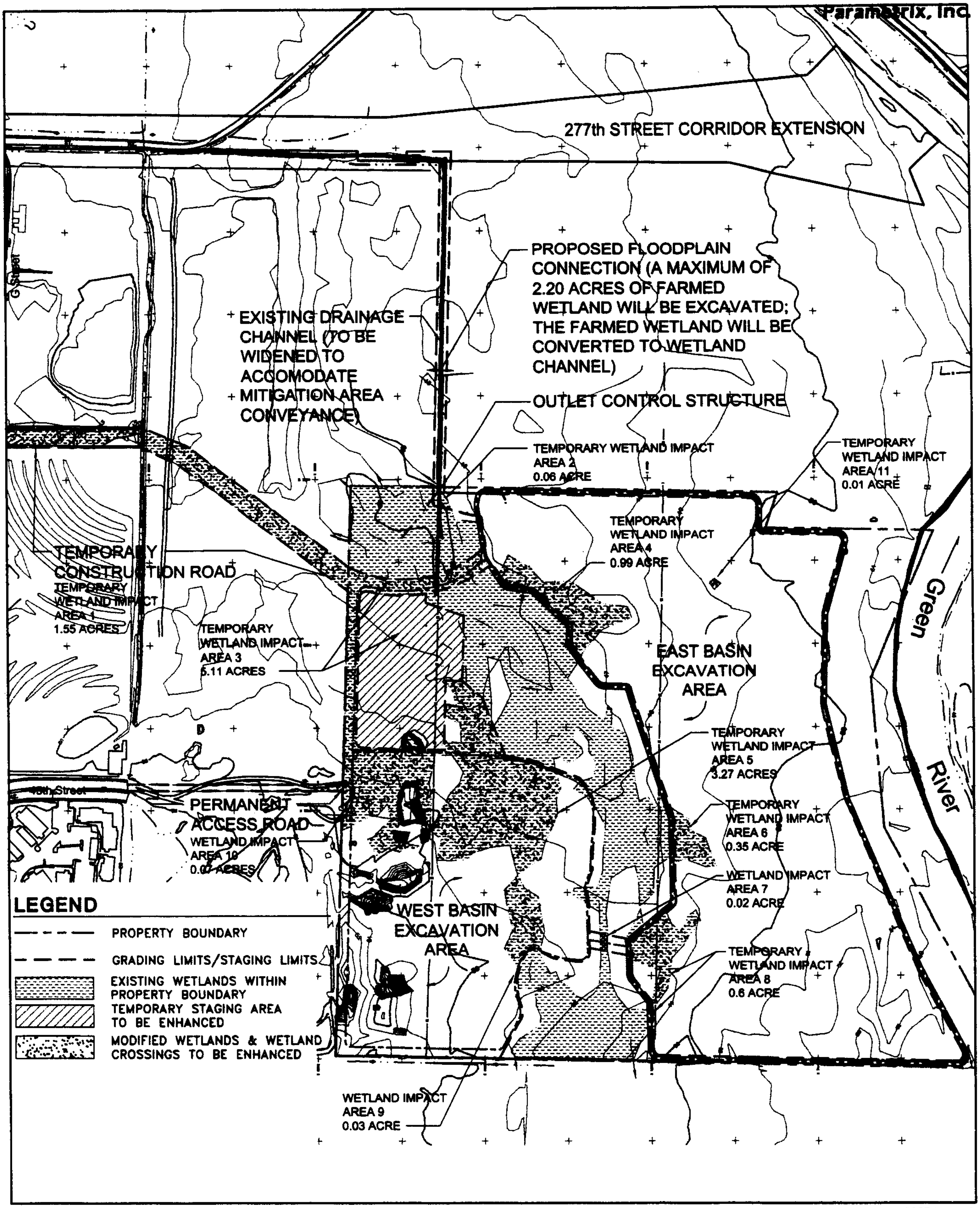

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Figure 4-6
Location of Wetland Impacts at the Auburn Mitigation Site

Other activities that will occur in portions of wetlands during enhancement may include the use of vehicles to deliver plants to planting areas, soil disturbance during the installation of plants, installation of temporary irrigation systems, mulching, and weed management (including mowing, discing, and herbicide applications).

4.3 INDIRECT WETLAND IMPACTS

Indirect impacts to wetlands include potential impacts to wetland functions or areas that result from the long-term effects of construction and operation of the Master Plan Update improvements. These potential indirect impacts, which could result from a variety of activities, are evaluated in this section and include the following:

- Placement of fill near or adjacent to wetlands
- Placement of fill in portions of wetlands
- Stormwater management upslope of wetlands
- Aircraft noise
- Human disturbance from nearby construction or operation
- Wildlife management activities
- Excavation for retaining wall footings or stormwater management ponds upslope of wetlands
- Potential discharges to wetlands of stormwater runoff from construction sites

Wetland functions potentially impacted by these activities include:

- Wildlife habitat support, by altering habitat conditions or wildlife use of wetlands
- Hydrological, including groundwater discharge functions that occur in wetlands
- Water quality, resulting from impacts to vegetation structure and surface water drainage patterns

The discussion of indirect impacts includes evaluations of the various mitigation actions taken to avoid and minimize wetland impacts. These mitigation actions include natural resource mitigation described in the *Natural Resource Mitigation Plan* (Parametrix 2000b), as well as various design modifications that reduce or eliminate potential indirect impacts to wetlands.

4.3.1 Analytical Approach

The analytical approach to evaluating potential indirect impacts to wetland functions by Master Plan Update improvement construction are identified in this section. Potential indirect impacts to five wetland biological functions were examined, including:

- resident and anadromous fish support

- songbird habitat support
- waterfowl habitat support
- amphibian habitat support
- small mammal habitat support

Potential indirect impacts to four wetland physical functions were also examined, including:

- organic matter export to downslope systems
- maintenance of groundwater exchange
- flood storage
- nutrient retention and sediment trapping

In the following discussions these functions are analyzed and grouped as "biological impacts" and "physical impacts."

4.3.1.1 Supports resident and anadromous fish

Indirect impacts to fish habitat can result from physical changes in riparian wetlands adjacent to Miller, Walker, or Des Moines Creeks that provide fish habitat. The changes that could alter adjacent aquatic environments and the functions riparian wetlands provide in supporting fish and fish habitat include:

- Increased turbidity and sediment runoff above water quality standards
- Degradation of water quality such as increases in temperature, chemical content, or reductions in dissolved oxygen
- Changes to wetland vegetation that affect stream habitat conditions including shade and export of organic matter
- Changes to wetland hydrology that may affect the ability of a wetland to provide base flow to streams

4.3.1.2 Provides habitat for song (passerine) birds

Indirect impacts to songbird habitat can result from:

- Increased noise and human disturbance
- Changes in hydrology that eliminate special habitat conditions (i.e., hydrologic changes eliminate standing water that might be used by certain bird species) or change the dominant vegetation types in the wetlands
- Alterations of vegetation by clearing

4.3.1.3 Provides waterfowl habitat

Indirect impacts to the characteristics of the wetland that provide waterfowl habitat functions could occur from changes to the degree or amount of flooding in a wetland. These changes could alter the habitat wetland vegetation provides to waterfowl or the occurrence and duration of flooded habitat these species use.

4.3.1.4 Provides amphibian habitat

Indirect impacts to amphibian habitat functions could occur from changes in habitat conditions discussed above for fish, passerine birds, and waterfowl.

4.3.1.5 Provides small mammal habitat

Indirect impacts to small mammal[10] habitat functions could occur from changes in habitat conditions discussed above for passerine birds and waterfowl.

4.3.1.6 Exports organic matter

Indirect impacts to this function could occur from the alteration of flow patterns in wetlands that transport organic matter to adjacent streams, changes in hydrologic conditions (rates or timing), or modification of riparian areas where organic production is produced and falls into streams.

4.3.1.7 Maintains groundwater exchange

Indirect impacts to this function could result from significant changes in upslope groundwater recharge or alteration of groundwater discharge patterns (location and timing). Groundwater exchange functions could be altered by new impervious surfaces, soil compaction, or sediment deposition.

4.3.1.8 Provides flood storage and runoff desynchronization

This function could be altered by physical modifications of wetlands that are in stream floodplains. Filling of wetland depressions that temporarily store runoff during storm events would also impact this function. These modifications are evaluated as direct impacts, and include modifications to wetland area, hydrologic connections, wetland topography, and wetland vegetation.

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[10] The wetlands do not provide significant habitat for large mammals because they are too small to independently support the habitat requirements of large mammals found in western Washington. Large mammals (except coyote and fox) cannot use the wetlands because adjacent development and habitat fragmentation prevents access.

4.3.1.9 Enhances nutrient retention and sediment

Indirect impacts that alter a wetland's ability to retain nutrients and trap sediments during the construction and operation of the temporary interchange include changes to vegetation, hydrology, water quality, and topographic conditions.

4.3.2 Analysis Summary

Potential indirect impacts to wetlands affected by various elements of the Master Plan Update improvements include the potential reductions in wetland functional performance (Table 4-8) and, in some cases, loss of wetland area (Table 4-9). Design modifications and/or wetland mitigation actions described in the *Natural Resource Mitigation Plan* (Parametrix 2000b) typically mitigate potential losses of functional performance.

Indirect impacts could result in the loss of wetland functions from an area, they may not necessarily remove all functions. For example, where the SASA bridge crosses Wetland 52, shading will eliminate wetland vegetation and wildlife habitat, however, the corridor and hydrologic functions provided by this area will remain. In other areas, if wetland hydrology is reduced or eliminated, existing vegetation will remain and wildlife habitat functions will remain similar.

Other indirect impacts to wetlands that could affect their function include noise and human disturbance, changes in water quality impacts, and changes in surface hydrology. These impacts could alter or reduce the level of some functions, but would not eliminate the wetlands themselves or their functions. These impacts are also mitigated by this plan because, in most cases, land use conditions that have degraded these wetlands are removed, and restoration actions are implemented.

The calculated permanent impacts to wetlands (18.37 acres) include about 2.4 acres of indirect wetland impacts (see Tables 3-1 and 3-2)(Table 4-9) that could occur in certain locations where changes to wetland hydrology, shading, or fragmentation of wetlands occur. While these indirect impacts could result in the loss of some wetland functions from an area, they may not necessarily remove all functions. For example, where the SASA bridge crosses Wetland 52, shading will eliminate wetland vegetation and wildlife habitat, however, the corridor and hydrologic functions provided by this area will remain. In other areas, if wetland hydrology is reduced or eliminated, the existing vegetation will remain and wildlife habitat functions of a wetland will not change significantly. Regardless, to be conservative, the 2.4 acres of indirect impacts are fully mitigated at ratios of 3:1, as explained in the NRMP (Parametrix 2000b).

Other indirect impacts to wetlands that could affect their function include noise and human disturbance, changes in water quality impacts, and changes in surface hydrology. These impacts could alter or reduce the level of some functions, but would not eliminate wetlands. These impacts are also mitigated by the NRMP because, in most cases, land use conditions that have degraded the wetlands are removed, and restoration actions are implemented to increase wetland functions (Parametrix 2000b).

Table 4-8. Summary of potential indirect impacts to wetlands and actions taken to mitigate indirect impacts of the Seattle-Tacoma International Airport Master Plan Update improvements.

Wetlands	Functions	Potential Indirect Impacts and Mitigation
Runway Safety Areas and Relocation of South 154th Street		
Wetlands 3, 4, 5, 6, 7, and 10	Wildlife Habitat	Disturbance to wildlife is minimized because new roadway is constructed on top of a retaining wall; wildlife using these areas are already tolerant of aircraft and automobile noise (from SR 518 and South 154th Street). Aircraft noise will decrease as some take-off and landing operations are shifted to the new runway. Since aircraft noise is much greater than traffic noise, the closer proximity of the road to these wetlands would be unlikely to eliminate wildlife from the area. Potential wildlife disturbance from wildlife management activities would continue, as a result of ongoing maintenance of emergency access roads, stormwater management facilities, and airport navigation aids.
	Hydrologic and Water Quality	Disturbance to wetland hydrology is not anticipated because the projects do not add substantial new impervious surfaces (The RSA is unpaved, and the street relocation replaces existing impervious surfaces). RSAs will incorporate an internal drainage system that will infiltrate rainwater falling on its non-paved surface and allow it to discharge near its base, where this water can then enter downslope wetlands. Existing wetlands receive stormwater runoff from South 154th Street and the STIA airfield. Following project construction, stormwater from the road and airfield will be detained and treated with BMPs for water quality, as described in the SMP (Parametrix 2000c). This will improve water quality conditions in the wetland compared to the existing condition.
Third Runway		
North End		
Wetlands A1, 8, and 9	Wildlife Habitat	Disturbance to wildlife from automobiles and aircraft noise should not increase because wildlife in these wetlands are already exposed to these noises. For Wetland A1, substantial disturbances related to ongoing farm activities will be eliminated, and mitigation will be completed to restore non-habitat wetland functions on the site. This mitigation will reduce habitat conditions for waterfowl that currently feed on the farmland. Habitat for small mammals and aquatic organisms will improve. Habitat in these wetlands will continue to be subjected to potential wildlife management according to the Wildlife Hazard Management Plan (Port of Seattle 2000)

Table 4-8. Summary of potential indirect impacts to wetlands and actions taken to mitigate indirect impacts of the Seattle-Tacoma International Airport Master Plan Update improvements (continued).

Wetlands	Functions	Potential Indirect Impacts and Mitigation
	Hydrologic and Water Quality	Disturbance to wetland hydrology is not anticipated because wetland hydrology in most of these areas is maintained by Miller Creek, and its hydrology will not be substantially altered by the project. The projects do not add substantial new impervious surfaces near these wetlands (the RSA for the new runway is unpaved, and the street relocation replaces existing impervious surfaces). The runway RSA will incorporate an internal drainage system that will infiltrate rainwater falling on its non-paved surface and allow it to discharge near its base, where this water can then enter downslope wetlands. Existing wetlands receive stormwater runoff from South 154th Street. Following project construction, stormwater from the road and airfield will be detained and treated with BMPs for water quality, as described in the SMP. This will improve water quality conditions in the wetland compared to the existing condition.
Riparian Areas		
Wetlands R1 through R17	Wildlife Habitat	Disturbance to wildlife will be minimal because of the project buffer to Miller Creek; the elimination of human and domestic animal activity from the overall area; and sparse vehicular traffic on security road. No increased level of disturbance to wildlife is expected in Wetlands R1 and R2 at the South 156th Street bridge crossing since the roadway already crosses these two wetlands. Wildlife in the riparian area will be exposed to noise from increased air traffic; however, wildlife in the area is already tolerant of disturbance. A small area of Wetland R1 will be shaded under the new South 156th Street bridge.
	Hydrologic and Water Quality	Disturbance to wetland hydrology is not anticipated because wetland hydrology in most of these wetlands is maintained by Miller Creek, and its hydrology will not be substantially altered by the project. The projects do not add substantial new impervious surfaces near these wetlands, and removal of development, the beneficial impact of the embankment on hydrology (see above), and establishment of wetland buffers will improve natural hydrologic processes in these wetlands. Some riparian wetlands receive stormwater runoff from adjacent developed property. Following project construction, the provision of 50- to 100-ft buffers will provide water quality functions and reduce the amount of untreated stormwater. This will improve water quality conditions in the wetland compared to the existing condition.

Table 4-8. Summary of potential indirect impacts to wetlands and actions taken to mitigate indirect impacts of the Seattle-Tacoma International Airport Master Plan Update improvements (continued).

Wetlands	Functions	Potential Indirect Impacts and Mitigation
Central Area		
Wetlands 18, 37, 39,and 44	Wildlife Habitat	Disturbance to wetlands and their wildlife from human or domestic animal activity will be eliminated due to property access restrictions. Disturbance to wildlife from increased air traffic noise may occur; however, wildlife living in this region are already tolerant of airplane noise; therefore, no significant impacts are expected. Disturbance from sparse vehicular traffic on the security road will not adversely affect wildlife.
	Hydrologic and Water Quality	Permanent disturbance to wetland hydrology is not anticipated except for a small (0.02 acre) portion of Wetland 39. Following construction, temporarily disturbed areas will be restored to original topography. The embankment for the third runway will allow infiltration of water outside paved areas and an internal drainage system will convey infiltrated stormwater to discharge locations at the base of the fill pad. This water will be dispersed into or immediately adjacent to Wetlands 18 and 37 to maintain long-term site hydrology.
Downslope Isolated Wetlands		
Wetlands A9 through A17 and A19	Wildlife Habitat	Disturbance to wetlands and associated wildlife from human or domestic animal activity will be eliminated due to property access restrictions. Disturbance to wildlife from increased noise may occur; wildlife living in this region are tolerant of airplane noise; therefore, adverse impacts are not expected.
	Hydrologic and Water Quality	Disturbance to wetland hydrology is not anticipated. The fill embankment for the third runway will allow infiltration of rainwater into non-paved areas. The internal drainage system in the embankment will convey infiltrated stormwater to discharge locations at the base of the fill pad; routed stormwater will be dispersed into or immediately adjacent to existing wetland areas to maintain site hydrology. Some riparian wetlands receive stormwater runoff from adjacent developed property. Following project construction, the provision of 100-ft buffers will reduce the amount of untreated stormwater. This will improve water quality conditions in the wetland compared to the existing condition.
Borrow Area 1		
Wetlands B1, B4, and 32	Wildlife Habitat	Disturbance to songbirds and small mammals using these wetlands could occur during construction.

Table 4-8. Summary of potential indirect impacts to wetlands and actions taken to mitigate indirect impacts of the Seattle-Tacoma International Airport Master Plan Update improvements (continued).

Wetlands	Functions	Potential Indirect Impacts and Mitigation
	Hydrologic and Water Quality	Interruption in hydrology for Wetlands B1 and 32 is not anticipated since a 50-ft buffer will maintain seasonal perched water regime, and upslope sources will remain. A constructed stormdrain that discharges to the incised channel that forms most of Wetland B4 will be removed, reducing erosive flows in the channel.
Borrow Area 3		
Wetlands 29, 30, B5, B6, B7, B9, and B10	Wildlife Habitat	Disturbance to wildlife from increased air traffic noise may occur; however, wildlife living in this region are already tolerant of airplane noise.
	Hydrologic and Water Quality	Potential changes to wetland hydrology are not anticipated because the upslope areas that supply runoff and groundwater to the wetlands will not be disturbed (see Appendix C).
Borrow Area 4		
Wetland 28	Wildlife Habitat	Borrow Area 4 is located 100 to 300 ft from Wetland 28. The borrow area is separated from the wetland by the Tyee Valley Golf Course and/or 196th Street South or 18th Avenue South. Noise and human intrusion from these existing impacts will reduce the potential disturbance construction activity at the borrow area could have on the existing wetland. The location of the wetland in the approach zone to runway 34L also means wildlife in the wetland are subjected to high noise levels that exceed noise generated by construction.
	Hydrologic and Water Quality	The borrow area will not be excavated to elevations that intercept groundwater (Hart Crowser 2000), and impacts to hydrologic sources of Wetland 28 would not occur.
South Aviation Support Area		
Wetland 52	Wildlife Habitat	Disturbance to wildlife will be minimal because of a 75-ft buffer. Wildlife in riparian area will be exposed to noise from increased air traffic; however, wildlife already using these areas are already tolerant of this type of disturbance.
	Hydrologic and Water Quality	No adverse impacts to water quality in riparian wetlands bordering Des Moines Creek are anticipated because stormwater runoff will not be directed toward them.

Table 4-8. **Summary of potential indirect impacts to wetlands and actions taken to mitigate indirect impacts of the Seattle-Tacoma International Airport Master Plan Update improvements (continued).**

Wetlands	Functions	Potential Indirect Impacts and Mitigation
IWS Lagoon Expansion		
Wetland 28	Wildlife Habitat	Expansion of the IWS lagoon will not directly impact Wetland 28. The expansion will result in temporary impact to wetland buffers that currently consist of non-native shrub and herbaceous vegetation that is growing on fill soils. Construction will clear this vegetation and soil, eventually replacing it with the fill soils of the new lagoon embankment. Wildlife using the adjacent shrub and forest habitat is of the wetland (primarily songbirds and small mammals) could be temporarily disturbed by these activities. Because the wetland is in the approach departure zone of the existing runway 34L, aircraft routinely fly within several hundred ft of the wetland. This noise level would exceed the noise from construction, so wildlife use may not be reduced from existing levels.
	Hydrologic and Water Quality	The IWS lagoon construction results in a reduction in surface water runoff that enters Wetland 28 because about 5-acres of relatively compacted fill soils will be removed and converted to a lined lagoon system. Water falling on the lagoon will enter the IWS treatment system instead of Wetland 28. The lagoon system includes an underdrain that will collect groundwater from beneath the lagoon (approximately 260-ft elevation) and convey it to Wetland 28. The discharge point for the underdrain is located upslope of the major portion of Wetland 28, and distribution of water to the wetland at this location will ensure that it is available to maintain high groundwater conditions downslope and prevent dewatering of the wetland. Water quality impacts to the wetland will be prevented from occurring during the construction period by construction BMPs, as described in Section 4.2.1. The IWS lagoon design prevents potential water quality impacts due to a liner and its capacity. During operation, the lagoon liner will prevent untreated water stored in it from entering groundwater or Wetland 28. The lagoon volume and IWS treatment capacities are large enough to ensure that overtopping and release of untreated runoff through the emergency spillway is unlikely to occur (Parametrix 2000c).

Table 4-9. Summary of indirect impact analysis and wetlands partially filled by STIA Master Plan Update improvements.

Wetland Number[a]	Wetland Area (acres)				Explanation and Mitigation
	Total	Fill	Indirect[b]	Remaining	
Runways Safety Areas					
3	0.56	0.00	0.00	0.56	Precipitation, the embankment drainage layer, and an existing stormwater outfall will maintain wetland hydrology in this wetland. Retrofitting existing SDS for water quality and quantity will enhance hydrologic conditions in the wetland.
4	5.00	0.00	0.00	5.00	Precipitation, discharge from Wetland 3, and the embankment drainage layer will maintain wetland hydrology in this wetland.
5	4.63	0.14	0.00	**4.49**	Precipitation, the embankment drainage layer and existing stormwater outfalls will maintain wetland hydrology in this wetland. Retrofitting existing SDS for water quality and quantity will enhance hydrologic conditions in the wetland.
Third Runway					
9	2.83	0.03	0.00	**2.80**	A small portion of this wetland will be filled. While most of the wetland receives water from the Miller Creek riparian zone, seasonal seeps along the south side of the wetland will continue as groundwater conveyance through the fill will be maintained by the embankment design (i.e., the drainage layer). The wetland will receive surface water inputs from a biofiltration swale located adjacent to the relocated South 154th Street.
11	0.50	0.34	0.16	0.00	Indirect impacts result from nearby construction of South 154th Street, runway embankment, and runway safety areas over extended time periods.
12	0.21	0.21	0.00	0.00	
18	3.56	2.29	0.55	**0.72**	Precipitation and the embankment drainage layer will maintain wetland hydrology in the remaining portion of the wetland. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that habitat functions are maintained or improved. Portions of the wetland may have indirect hydrologic impacts if water collected by channels draining the embankment do not distribute water efficiently to this wetland.
37	5.73	3.75	0.34	**1.64**	See 18.
39	0.90	0.00	0.02	**0.88**	Indirect impacts could result from construction of a nearby stormwater pond. Incorporation of the wetland into the Miller Creek buffer and upslope water sources will ensure remaining portions are functional.
43	30.30	0.00	0.00	30.30	Maintenance of hydrology to Wetland 44 will ensure no significant impact to this wetland occurs.

Table 4-9. Summary of indirect impact analysis and wetlands partially filled by STIA Master Plan Update improvements (continued).

Wetland Number[a]	Wetland Area (acres) Total	Fill	Indirect[b]	Remaining	Explanation and Mitigation
44	3.08	0.26	0.00	**2.82**	Hydrology from precipitation and groundwater discharge through the embankment and drainage channels will maintain wetland hydrology in the downslope portions of the wetland. The removal of existing residential development will reduce human impacts to the area and maintain or enhance wildlife habitat.
A1	4.66	0.59	0.00	**4.07**	Riparian portions of channelized Miller Creek will be filled, and the stream relocated. The new stream channel and the restoration of the Vacca Farm area will ensure that the remaining portions of the wetland are functional.
A5	0.03	0.01	0.02	0.00	Indirect impacts attributed ~~to~~ proximity of wetland to embankment and stormwater management facilities.
A6	0.16	0.07	0.09	0.00	See A5.
A9	0.04	0.00	0.00	0.04	Precipitation and the embankment drainage layer will maintain wetland hydrology. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that habitat functions are maintained or improved.
A10	0.01	0.00	0.00	0.01	See A9.
A11	0.02	0.00	0.00	0.02	See A9.
A12	0.11	0.02	0.06	**0.03**	Precipitation and the embankment drainage layer will maintain wetland hydrology in the remaining portion of the wetland. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that habitat functions are maintained or improved. If distribution of water to the wetland is inefficient, indirect impacts to hydrology could result.
A13	0.12	0.00	0.00	0.12	Portions of this wetland are subjected to temporary impacts. Precipitation and the embankment drainage layer will maintain wetland hydrology in the remaining portion of the wetland. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that habitat functions are maintained or improved.
A18	0.01	0.00	0.01	0.00	The proximity of this small wetland to construction would eliminate its hydrology and function.
R1	0.17	0.13	0.00	**0.04**	Hydrology from Miller Creek, precipitation, and groundwater will maintain wetland hydrology in the remaining portions of the wetland. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that riparian and habitat functions are maintained or improved.

Table 4-9. Summary of indirect impact analysis and wetlands partially filled by STIA Master Plan Update improvements (continued).

Wetland Number[a]	Wetland Area (acres)				Explanation and Mitigation
	Total	Fill	Indirect[b]	Remaining	
R2	0.12	0.00	0.00	0.12	Hydrology from Miller Creek, precipitation, and groundwater will maintain wetland hydrology following construction. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that riparian and habitat functions are maintained or improved.
R3	0.02	0.00	0.00	0.02	See R2.
R9	0.38	0.00	0.00	0.38	Hydrology from Miller Creek, precipitation, and groundwater discharge from the embankment drainage channels will maintain wetland hydrology in the remaining portions of the wetland. The incorporation of the wetland into the Miller Creek buffer and removal of existing nearby development will ensure that riparian and habitat functions are maintained or improved.
Borrow Area 1					
48	1.58	0.00	0.00	1.58	Wetland hydrology will be maintained this wetland through precipitation and preservation of the upslope drainage system between the wetlands and 20th Avenue South.
32	0.09	0.00	0.00	0.09	A 50-ft buffer and preservation of upslope runoff will prevent impacts to wetland hydrology.
B1	0.27	0.00	0.00	0.27	See Wetland 32.
B4	0.07	0.00	0.00	0.07	Groundwater sources that support this wetland will remain. Removal of constructed drainage systems will reduce erosive flows.
B12	0.63	0.03	0.04	**0.56**	Grading may alter distribution of water to upslope portions of the wetland and result in indirect impacts to hydrologic functions. The remaining wetland area will remain functional because of groundwater and precipitation water sources and its preservation in the Des Moines Creek buffer.
B15	2.07	0.00	0.00	2.07	See Wetland 48.
Borrow Area 3					
B5	0.08	0.00	0.00	0.08	Borrow Area 3 has been designed to avoid impacts to the hydrology of this wetland. Further assurance that hydrologic impacts are avoid is provided by a drainage ditch that intercepts groundwater emanating on the face of the excavation and directs it to downslope wetlands.
B6	0.55	0.00	0.00	0.55	See B5.
B7	0.03	0.00	0.00	0.03	See B5.
B9	0.05	0.00	0.00	0.05	See B5.
B10	0.02	0.00	0.00	0.02	See B5.
29	0.74	0.00	0.00	0.74	See B5.
30	0.88	0.00	0.00	0.88	See B5.

Table 4-9. Summary of indirect impact analysis and wetlands partially filled by STIA Master Plan Update improvements (continued).

Wetland Number[a]	Wetland Area (acres) Total	Fill	Indirect[b]	Remaining	Explanation and Mitigation
Borrow Area 4 and Tyee Valley Golf Course Mitigation Area					
28	35.45	0.07	0.00	35.38	Portions of Wetland 28 will be enhanced by mitigation planned at the Tyee Valley Golf Course, where existing golf course green will be converted to shrub dominated wetland. Master Plan Update improvements occurring near Wetland 28 are limited to portions of the third runway, which could, without mitigation, generate hydrologic and water quality impacts. The stormwater report addresses detention facilities and water quality BMPs that will minimize these impacts to the wetland and downstream Des Moines Creek. Excavation of Borrow Area 4, located south of Wetland 28 will not intercept groundwater flowing to the wetland or Des Moines Creek, and is thus unlikely to impact the hydrology of the wetland.
South Aviation Support Area					
G3	0.06	0.04	0.02	0.00	The SASA project may eliminate upslope runoff that may maintain unfilled portions of this wetland.
G4	0.04	0.00	0.04	0.00	See G3.
G5	0.87	0.40	0.47	0.00	See G3.
52	4.70	0.00	0.54	**4.16**	Following construction, hydrology in this wetland will be maintained by Des Moines Creek and groundwater seepage. Shading results in indirect impacts to habitat functions.
Auburn Mitigation Area					
1		0.12	0.00	19.42	Remaining wetland will be converted from Category III emergent wetland to Category II forest, shrub, and emergent wetlands.
TOTAL		**15.97**	**2.40**		

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[a] Wetland numbers in bold are partially impacted and subject to fragmentation impacts. For these wetlands (except Wetland 5) mitigation and removal of existing detrimental land uses mitigate fragmentation impacts because the remaining portions of these wetlands will be in less disturbed areas with greater connectivity to other habitat areas.

[b] The acreage of indirect wetland impacts reported in this table is included in the total wetland impacts for the Master Plan Update improvements (18.37 acres). Mitigation for the indirect impacts reported here is provided at a minimum 3:1 replacement ratio (see Parametrix 2000b).

4.3.2.1 Wildlife

Noise and Human Activity

Wildlife species exhibit a wide range of tolerances to human disturbance, including noise (Gladwin et al. 1988; Manci et al. 1988; and Newman and Beattie 1985). Near commercial airports, a wide variety of wildlife frequently habituates to aircraft noise and other human disturbance (Gladwin et al. 1988; Manci et al. 1988; Conomy et al. 1998). Some wildlife species appear to be inherently tolerant of loud noise, or they can adapt to noise, as evidenced by wildlife presence at airports and the variety of wildlife frequently struck by aircraft (FAA 1997). Other less tolerant species are frequently absent from urban areas.

Studies of aviation noise impacts to wildlife have focused on areas where aircraft flight is infrequent or where aircraft disturbance is of an extreme intensity. These studies have examined low-flying military aircraft over undeveloped areas and aircraft that fly at speeds that produce sonic booms (Manci et al. 1988; Gladwin et al. 1988; Weisenberg et al. 1996; Newman and Beattie 1985). The results of these studies are not necessarily applicable to typical commercial airports such as STIA, where more constant but often lower intensity noise occurs in areas that are largely developed.

Disturbance of habitats adjacent to the new third runway at STIA due to increased aircraft noise should not be significant because the new runway will be constructed in areas that are currently subject to significant human disturbance (residential development). Existing noise, visual, and habitat disturbances within or adjacent to wetlands in the acquisition area will be removed, while aircraft noise will generally increase. However, wildlife occurring in the acquisition area are limited to those species that are tolerant of human disturbance (including aircraft noise) and have already habituated to substantial noise and human disturbance. Wildlife habitat near the new runway is also near existing runways, and thus it currently receives aircraft noise. For these reasons, the wildlife species present are likely habituated to aircraft noise, and unlikely to abandon suitable habitat upon operation of the new runway.

Most wetlands that occur adjacent to Master Plan Update improvements are subjected to substantial human disturbances, and in many cases, following construction, will be subjected to the same or less disturbance than currently exists (see Tables 4-8 and 4-9). Existing land uses and associated disturbances occurring in the acquisition area that will be removed from wetlands include mowing, clearing, plowing, chemical applications for yard maintenance and farming, uncontrolled stormwater runoff, wildlife disturbance from domestic animals, and general urban noise. Some wetlands will be somewhat closer to potential airport-generated noise disturbance, but this disturbance is not expected to eliminate wildlife from the affected wetlands for reasons explained above.

Wildlife Management

The Port and FAA are mandated to take emergency actions to protect life and property in all areas near the airport (U.S. Department of Agriculture [USDA] 2000), including the mitigation sites. This need is reflected in the restrictive covenants (see Parametrix 2000b). The Wildlife Hazard Management Plan (WHMP) for STIA (USDA 2000) identifies the Port's responsibility to restore and mitigate wetland impacts should emergency actions damage mitigation sites. Indirect impacts from wildlife management are not anticipated.

Emergency Response

Spill prevention, control, and response procedures are described in the Port's Spill Prevention Control and Countermeasure Plan (SPCCCP). The plan emphasizes prevention of spills in the stormwater drainage system (SDS) basins (spill/source control measures are summarized in the attached table), and also includes complete control and response procedures for spills (summarized in the flowcharts that are part of the plan). Two spills in the SDS have occurred in the last 5 years, both in subbasin SDS-4. In both cases, the spill was completely contained on Port property using the SPCCCP response procedures and no total petroleum hydrocarbons (TPH) were detected in Des Moines Creek downstream of the spills.

4.3.2.2 Wetland Fragmentation

Potential loss of wildlife habitat resulting from a reduction in the size and numbers of the remaining wetlands adjacent to the embankment or adjacent to other areas of project activity is not anticipated. The 18.37-acre impact value accounts for all losses of wetland and wetland habitat.

Wildlife habitat impacts that result from wetland fill are proportional to the area of wetland filled when specialized habitat requirements are not lost, and substantial areas of adjacent habitat remain. Wildlife could be eliminated from a wetland area if (a) the remaining wetland habitat is smaller than the minimum habitat requirements of a wetland-dependent species, or (b) if unique wetland habitat features that wetland dependent species use are eliminated.

Filling of existing wetlands may potentially affect populations of wetland-dependent species that are restricted to specialized habitats (e.g., waterfowl) by eliminating the specific habitat that a given species requires. However, because the existing wetlands occur in an already highly urbanized and disturbed environment, many of the wildlife species that occur in these wetlands are widespread, cosmopolitan species with wide environmental tolerances. Filling existing wetlands may reduce the amount of habitat available, but should not eliminate habitat on which these species depend. Wildlife species with specialized wetland habitat requirements (e.g., beaver, muskrat, and green-backed heron, etc.) have not been observed in the wetlands affected by the project, and it is unlikely they are present in the project area due to the condition of existing habitat.

For the wetlands being partially impacted, no unique or special habitats will be filled that would affect the ability of a species to use the remaining portion of the wetland. For example, if breeding amphibians were present in a wetland, and all the open water breeding habitat were filled, the remaining wetland could lose its ability to support amphibians and experience an indirect impact to its wildlife diversity. This or similar cases are not present at the airport.

The typically terrestrial wildlife species using upland and wetlands partially filled by Master Plan Update improvements (Appendix M, FAA 1996) are not dependent on the wetlands for their life history functions, and these species are expected to use the remaining habitat matrix of uplands and wetlands.

Mitigation adjacent to the embankment includes protection and ecological enhancement on over 56 acres of wetland and upland (Table 1-3) that is currently degraded by human uses. In the landscape context, the proposed mitigation (Parametrix 2000b) will improve habitat connectivity, patch size, and habitat quality, and their positive effect will mitigate the potential for indirect impacts to habitat resulting from the Master Plan Update improvement projects. On the west side of the embankment, connecting the smaller wetlands via the riparian and wetland buffer, eliminating human and domestic animal use of the area, and enhancing the habitat through planting of native vegetation will eliminate the potential for indirect wetland impacts. Additional benefits to aquatic habitat and the Miller Creek watersheds are derived from four instream enhancement projects.

The presence of undisturbed corridors between habitat patches and groups of smaller but interconnected habitat, patches can increase wildlife population persistence and species diversity (Forman and Gordon 1986). For example, the minimum 200-ft-wide by 6,500-ft-long riparian buffer along Miller Creek and the Vacca Farm restoration will lead to: (1) increased connectivity between individual wetlands, (2) increased connectivity between riparian zone wetlands and stream systems, and (3) protection of riparian habitats by upland buffers.

Finally, as discussed in Section 4.3.2.4, the runway embankment projects, with their planned mitigation, are expected to maintain or improve hydrologic conditions in downslope wetlands.

4.3.2.3 Wetland Habitat Complexity and Biological Diversity

The project will not result in a loss of wetland habitat complexity or species diversity because it will not eliminate any species from the project area nor affect any rare or specialized habitat type. Genetic diversity, source populations to recolonize disturbed areas, and a gene pool necessary to adapt to long-term change will not be lost because, as explained below, plants and animals in wetlands affected by the project are part of widely distributed, homogenous populations.

Existing habitat complexity and plant diversity within wetland systems affected by the project are generally low for several reasons. Historical and ongoing logging, farming, grazing, golfing, and landscaping have eliminated natural plant communities and wetland habitats. As some of these wetlands have been more or less abandoned of human activity, they have been colonized with native and non-native plants. These early successional plant communities consist of cosmopolitan plant species,[11] including native and non-native invasive grasses, forbs, and shrubs (e.g., reed canarygrass, creeping buttercup, and Himalayan blackberry). Because the wetlands have generally had only a few decades or less to recover from significant disturbance, there has not been enough time to establish a full diversity of native plants that might typically occur in these habitats.

Another reason existing plant diversity in the wetlands is low is because of the limited number of wetland types present. For example, most wetlands have seasonally saturated soils and lack seasonal ponding. They frequently lack saturated soil during the summer and early fall months. Given these relatively homogenous environmental conditions coupled with the existing disturbance regime, the plant communities and the variety of habitats ("niches") they provide for different species is limited and frequently similar to adjacent upland areas.

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[11] Cosmopolitan plant species are those that are capable of and generally do occur in a wide range of habitats and over large geographical areas. They are frequently tolerant of a wide range of soil, climate, and other habitat conditions.

Plant species found in the wetlands are expected to be genetically similar to those plants in the region because of the relatively homogenous distribution of native plant communities in western Washington. The seed and pollen dispersal mechanisms found in these plants promote genetic homogeneity at local and regional levels. For example, many of the tree (willow, black cottonwood, red alder, and redcedar) and shrub (willow, western hazel) species are wind pollinated. The small pollen grains are readily dispersed hundreds of yards to tens of miles by wind. Likewise, the seeds of most of these species are equally adapted to be dispersed significant distances by wind (nearly all common trees and many shrubs in Washington) or animals (berry and nut producing trees and shrubs). These pollination and seed dispersal mechanisms for these common wetland plants found in the area generally prevent development of specific genotypes at the local level.

Because wind and animals readily disperse the species, seed sources that allow plants to colonize disturbed areas are typically abundant. The planned in-basin mitigation that preserves large existing wetlands, maintains corridors, and restores native plant communities to over 67 acres of land near STIA will ensure that the watershed and local area is not deprived of seed sources of these wetland plants. For these reasons, a change in the resistance of the wetlands or watersheds to disturbance is not likely.

The recent plant colonization of the wetlands following various disturbances that have been ongoing for at least several decades also affects their diversity. For species of plants that have colonized the wetlands since recent disturbance, the flora consists of a single generation of perennial plants, a condition that presents little or no opportunity for genetic divergence to occur.

As demonstrated in the mitigation plan (Parametrix 2000b), most mitigation for impacts to wetland functions (except wildlife habitat) are occurring on-site and in-basin. The mitigation plan increases the level of post-mitigation wetland function on the mitigation site, as well as the numerous additional mitigation actions (e.g., upland buffers, stream habitat enhancement, implementation of additional stormwater management, etc.) that protect or enhance ecological functions. Functions to be provided by natural resource mitigation projects are described in the mitigation plan (Parametrix 2000b).

4.3.2.4 Impact to Wetland Hydrology and Hydroperiod

The potential for construction of the third runway embankment and retaining walls to alter the water available to maintain adjacent wetlands and their function is addressed in this section. The hydroperiod (i.e., the depth, duration, and timing of soil saturation and flooding) of a wetland is the most important determinant for maintenance of wetland types and ecological functions (Mitsch and Gosselink 1993). For this reason, significant alterations of wetland hydrology can result in potential changes to wetland type and the functions they provide. Eliminating significant portions of a wetlands water source could convert the wetland to upland habitat.

The wetlands adjacent to the proposed third runway embankment include forested and shrub-dominated wetlands on seepage slopes or shallow depressions (see Figure 1-3). Seasonal (fall-spring) precipitation and groundwater seepage are the dominant sources of water to these wetlands. For several wetlands (especially Wetlands 18 and 37), groundwater seepage extends the period of soil saturation within the wetland to the mid-summer period, and sustains the groundwater discharge functions of the wetlands.

The third runway embankment has been designed with retaining walls to reduce the volume of runway fill and impervious surfaces, which significantly alter the hydrology of downslope wetlands and streams. Design features incorporated into the project that help maintain wetlands and reduce base flow impacts include:

- A permeable rock drainage layer will be constructed atop existing soils, beneath the embankment footprint. This drainage layer will allow groundwater[12] that currently surfaces in the wetlands to be conveyed downslope to wetlands at the edge of the embankment.
- Drainage channels constructed along the west base of the embankment that will collect water that emanating from the embankment and convey and distribute it to downslope wetlands.
- Engineered fill materials of sufficient permeability to infiltrate rainwater falling on non-paved portions of the embankment (this feature reduces the amount of surface runoff generated from the embankment and maintains shallow groundwater sources for downslope wetlands).
- Use of permeable stone columns[13] as retaining wall footings that will avoid altering the patterns of groundwater movement in the vicinity of retaining walls.
- Use of retaining walls to reduce the size of the fill footprint and reduce the filling of wetlands. Retaining wall designs allow water to move vertically and laterally to prevent interruption of water flow to downslope wetlands (see Appendices B and E).

Several hydrologic modeling analyses have been conducted (Hart Crowser 2000 [Appendix F], 1999 [Appendix B]; EarthTech 2000 [Appendix G]) to evaluate the effect of the runway embankment on base flow conditions in Miller Creek and downslope wetlands. These studies indicate that overall annual groundwater base flow to the wetlands will be reduced slightly. However, due to a hydraulic lag, base flows to the wetlands will be reduced during winter and early spring months, and increased base flow will be available to downslope wetlands and Miller Creek during summer months (EarthTech 2000; Hart Crowser 1999, 2000).

The *SeaTac Runway Fill Hydrologic Studies Report* (Ecology 2000) identifies 1.68 acres of wetlands that could be indirectly impacted due to hydrologic changes associated with the embankment (especially the Wetland 18 and Wetland 36 complex). Further analysis of this potential impact is discussed in Sections 3.2 and 3.6 of Ecology (2000) report. The analysis concludes (pages 7, 51, 52, and 60) that seepage into the embankment and delay in water

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[12] The sources of this water include water that infiltrates onto the existing airfield (a quantity which will remain unchanged) and water that infiltrates in undeveloped land west of the airfield.

[13] These permeable stone columns and other subgrade improvements are described in Appendices B and E.

movement through the embankment would not result in the loss of these downslope wetlands. Water will infiltrate into the embankment and eventually discharge to the downslope wetlands. Although the report identifies potential secondary impacts, it also identifies a potential net benefit to wetland hydrology during the summer months due to the delay between the time water infiltrates into the embankment and when it discharges from its base.

This analysis of potential benefit to wetland hydrology for downslope wetlands is applicable to the indirect impact analysis for the following wetlands: 3, 4, 5, 7, 8, 9, 11, A1, A11, A13, 18, 37, Channel B, and all riparian wetlands located in the west side acquisition area.

The hydrology of riparian wetland areas, located on the east and west side of Miller Creek (see Table 4-5), will not be altered from a loss of seepage water as described in the above referenced analysis for Master Plan Update improvements. In addition, the extensive stormwater management system will prevent increases in peak flow rates and duration of peak flows, that may otherwise result in significant down cutting and bank erosion (SMP Parametrix 2000c; section 4.3.2.5 of this report.)

The results of the analysis completed by Hart Crowser (2000, Appendix F) also concludes that groundwater flow rates will be similar to existing conditions. However, existing conditions are predicted to be slightly higher or lower depending on annual precipitation. This study concludes:

- Groundwater flow rates beneath the proposed embankment will generally be similar to or slightly lower than for existing conditions during wet years.
- Groundwater flow rates beneath the embankment would show a small increase over existing conditions during dry years.
- Although the runway project will produce slightly more surface runoff volume (especially in wet years) compared to existing conditions, the overall long-term average flows are very similar in all years.
- The longer seepage path through the embankment results in a seasonal lag, which produces a net increase in base flow to Miller Creek and adjacent wetlands in the summer and early fall.

The most recent Hart Crowser (2000, Appendix F) base flow modeling findings are consistent with Ecology (2000) report, which concluded: "Flows would be lower in the winter than under current condition, and greater in summer compared to the current condition." Ecology also noted that "flows to local wetlands and the streams will be reduced only in winter when abundant water is typically present."

Finally a comprehensive evaluation of the potential low streamflow impacts in Miller, Walker, and Des Moines Creeks from the planned STIA improvements has been completed (Earth Tech 2000, Appendix G). This evaluation used an HSPF model to evaluate the expected low flow conditions during August and September in the three creeks based on 1994 land use conditions and land use conditions following all Master Plan Update improvements in 2006. This evaluation specifically addressed the following conditions:

- Late summer discharge of infiltrated water stored in the proposed Third Runway embankment fill.
- Changes in non-hydrologic flows within the buy-out area in the watersheds. (Discontinued irrigation withdrawals from the watershed and discontinued discharge of imported water through septic system drainfields).
- Secondary recharge of runoff from pavement atop the proposed Third Runway embankment fills.
- Extended duration discharge from stormwater detention facilities through infiltration galleries that would provide input to the shallow groundwater regime adjacent to Miller Creek.
- Managed release of stormwater from reserved storage to ensure that low flow discharges in streams do not fall below pre-project levels.

The results of this analysis (See Appendix G) show that for Miller, Walker, and Des Moines Creeks, average August and September flows are predicted to increase above existing conditions, and the 7-day low flows are expected to match pre-project conditions. A net increase of 0.04 cfs in August/September average flows is predicted in Miller Creek at SR 509. In the upper reach of Walker Creek, average August and September flows are predicted to increase by 0.009 cfs. Des Moines Creek average August and September discharges at South 200th Street would increase by 0.12 cfs.

While analysis indicates that it is unnecessary, the groundwater hydrology of riparian and isolated wetlands adjacent to Master Plan Update improvements will be monitored for a minimum of 10 years as described in the *Natural Resource Mitigation Plan* (Parametrix 2000b). The purpose of this monitoring will be to collect data that can be used to determine if hydrologic conditions in the wetlands are sufficient to maintain the existing wetland vegetation types. If necessary, the groundwater collected in drainage channels or stormwater management systems can be redistributed to specific wetlands in amounts sufficient to maintain the desired conditions.

4.3.2.5 Stormwater Management During Operations

This section discusses the potential impacts of stormwater runoff to streams and wetlands. The analysis considers the potential for runoff generated by Master Plan Update improvements to affect aquatic habitat, and considers and describes the stormwater management facilities incorporated into project planning to protect aquatic habitat. The features of aquatic habitat protected by this mitigation include:

- water quality (e.g., DO, nutrients, temperature, etc.)
- substrate composition
- water quantity, depth, and velocity
- cover/shelter
- habitat and floodplain connectivity
- habitat complexity (e.g., large woody debris, channel complexity, etc.)
- aquatic vegetation
- food resources
- riparian vegetation

These habitat features can be protected by preventing increases in peak flow discharges, protecting streams from degradation of water quality, and maintaining base flow conditions. Potential impacts and protection of water quality and hydrologic conditions are evaluated in detail in the *Comprehensive Stormwater Management Plan* (Parametrix 2000c) and the *Biological Assessment* (FAA 2000) and summarized briefly here.

Stormwater Quality and Mitigation

Overall, the Master Plan Update improvements will result in a greater volume of stormwater undergoing detention and treatment. This will be accomplished through retrofitting areas with new stormwater management facilities at STIA as well as detaining and treating all stormwater associated with new impervious surfaces from Master Plan Update improvements. A result of the retrofitting will be reductions in copper and zinc currently discharged to Miller, Walker, and Des Moines Creeks through the collection and routing of stormwater to the IWS system.[14] However, operations at STIA following implementation of the Master Plan Update improvements could still affect water quality through the discharge of conventional pollutants and chemicals used in ground and aircraft de-icing to adjacent streams and the discharge of these same chemicals to the Puget Sound in IWS effluent. However, failure or overflow of the IWS system is unlikely, as discussed in the *Comprehensive Stormwater Management Plan* (Parametrix 2000c). Analysis of aircraft de-icing and anti-icing fluids (ADAFs) used at STIA as well as the projected concentrations of pollutants in stormwater and IWS effluent indicate that the concentrations of these chemicals will not adversely affect wetlands and aquatic habitat in Miller, Walker, and Des Moines Creeks as discussed below.

Water quality impacts will be mitigated (to maintain or improve the existing condition) by establishing and maintaining water quality treatment BMPs. These BMPs are sufficient to protect wetlands and other surface waters and also meet or exceed the requirements of the Ecology Manual (Ecology 1992; Parametrix 2000c). Additionally, existing developed areas that currently lack water quality treatment BMPs will be retrofitted with water quality treatment BMPs, to the maximum extent practicable (Parametrix 2000c). This retrofitting will further ensure wetlands and streams are protected from water quality degradation. Water quality treatment of new surfaces plus treatment

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[14] Analysis of stormwater quality is evaluated in FAA (2000) and concludes that changes in the IWS discharges resulting from the project will not adversely affect fish habitat in Miller and Des Moines Creeks or the IWS outfall.

retrofitting of existing surfaces will result in treatment provided for 189 percent of new impervious surfaces (FAA 2000). Additional measures to mitigate water quality impacts include source control and the operation and expansion of an IWS to treat stormwater runoff generated from high-use areas (Parametrix 2000c).

Characterization of STIA stormwater, potential effects on aquatic habitat, and mitigation measures are discussed below.

Bioassay Testing. The effect of stormwater runoff on aquatic habitat downstream of the Port discharge points has been evaluated using knowledge of stormwater toxicity as described in FAA (2000). Bioassay screening tests in Miller and Des Moines Creeks downstream of existing STIA stormwater outfalls demonstrated no toxicity to either fathead minnows or the invertebrate *Daphnia pulex*. For all tests, there was 100 percent survival in the undiluted stormwater and the stormwater was thus non-toxic to the exposed test organisms.

Whole-effluent toxicity performed on effluent from existing STIA stormwater outfalls, to satisfy NPDES Permit requirements (see FAA 2000), used standard protocols and sensitive species (the freshwater crustacean, *Daphnia pulex,* and the freshwater fish, *Pimephales promelas*) protocols.[15] The WET test results are conservative because they represent conditions before dilution in the receiving waters. WET samples did not account for flow through facilities such as Lake Reba, where physical, chemical, and biological processes will capture or transform dissolved pollutants.

Of the four outfalls tested, three met the WET performance standards, demonstrating an overall lack of toxicity in samples consisting of 100 percent STIA stormwater. The runoff from the three outfalls in which no toxicity was measured are most representative of runoff expected from airport activities included in the Master Plan Update, including drainage from runways, taxiways, hangers, terminal facilities, cargo handling areas, etc. Only one outfall (SDN-1) demonstrated toxicity. Runoff from galvanized rooftops was identified as the source of toxicity (Port of Seattle 2000b). These rooftops cover a limited area of the SDS (approximately 2 acres, or about 0.5 percent of the SDS), and are not representative of Master Plan Update improvement projects, which will not use zinc-treated roofing materials. Furthermore, the toxicity observed in SDN-1 does not result in instream toxicity, as demonstrated by the results of the instream toxicity screening (see above). The lack of toxicity is likely the result of runoff flowing through vegetated drainage channels and Lake Reba, where physical, chemical, and biological processes would remove and dilute dissolved pollutants prior to entering Miller Creek. The Port is reducing or eliminating the source of zinc from the SDN-1 rooftops through the application of roof coatings or other treatments.

Although the above observations demonstrate that stormwater runoff is not toxic, May et al. (1997) conducted a comprehensive study of Puget Sound streams (including Miller and Des Moines Creeks), which concluded that chemical water quality does not represent the critical factor to biota

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[15] The invertebrate *Daphnia pulex* is more sensitive to the types of pollutants expected to cause toxicity in STIA stormwater than salmonids (USEPA 1985).

in urban streams. Rather, they found streambed and bank stability (altered by changes in runoff volume) were determined to be the "most significant problems" in Puget Sound urban streams.

Water Quality Impacts from Filling Wetlands. Although the water quality functions of the existing wetlands will be lost when these wetlands are filled, the overall project, including the planned mitigation, is likely to result in improved water quality in Miller and Des Moines Creeks. This is true for several reasons.

First, a number of the existing wetlands that will be impacted by Master Plan Update improvements do not provide optimal water quality treatment functions. The treatment function in some of these wetlands is sub-optimal due to a short residence time (as inferred by wetlands on slopes, small size, topography that limits ponding and storage of water, and channelized flow) and a lack of dense emergent vegetation. The above mentioned factors are typically associated with wetlands with high function for water quality improvement.

Second, the proposed stormwater management facilities will include water quality treatment (Parametrix 2000c). This will primarily consist of biofiltration swales and filter strips, as well as wet vaults where biofiltration is not feasible. These water quality treatment facilities will be constructed to meet Ecology and NPDES requirements. These facilities will be at least partially effective in replacing the water quality functions of the wetlands to be filled.

It is noteworthy that existing wetlands (to be filled) receive untreated stormwater runoff from non-STIA areas. For example, existing wetlands downslope of 12th Avenue receive untreated stormwater runoff from 12th Avenue and provide treatment (at less than optimal rates) prior to discharge to Miller Creek. Treating stormwater likely degrades some of the biological functions also provided by the wetlands. Following construction of the embankment, runoff will be treated by water quality treatment BMPs (Parametrix 2000c) which should enhance the biological functions of the remaining wetlands.

Third, and perhaps most important, construction of Master Plan Update improvements and mitigation measures will improve the quality of water draining to the streams and wetlands. These include:

- Removal of existing pollution-generating impervious areas within the buy-out area (e.g., streets and driveways) without water quality treatment facilities;
- Restoration of farmed areas in the Miller Creek floodplain with native vegetation, to eliminate/reduce erosion and pollutant sources;
- Removal of residential and commercial land-uses in the buy-out area will eliminate pollutant sources, including failing septic tanks, fertilizer, runoff, and other potential pollutants (pesticides, pesticide residues); and
- Establish riparian buffers along Miller Creek and develop setbacks along Des Moines Creek.

In addition, a $300,000 trust fund will be created to support watershed restoration projects that may improve the water quality in the streams and wetlands. The overall effect of all these changes and measures is likely to be improved water quality in Miller, Walker, and Des Moines Creeks.

Mitigation. Water quality mitigation actions include pollutant source control, water quality treatment (including the IWS), and off-site enhancements of wetland and stream water quality functions. These actions are listed in Table 8-1 of the BA (FAA 2000) and Section 7.1.4 of the BA. As described in Section 7.1.4.4 of the BA, stormwater treatment is designed to serve 189 percent of the new impervious surface associated with the project. This level of treatment compensates for the potential inefficiencies of BMPs, therefore no significant water quality degradation would occur.

Quality Treatment BMPs. All new Master Plan Update PGIS in STIA subbasins will receive water quality treatment to meet or exceed the requirements of the Ecology Manual as discussed above and in the SMP (Parametrix 2000c). Where existing developed areas do not have BMPs consistent with the Ecology Manual, these areas will be retrofitted with water quality treatment BMPs to the maximum extent practicable.

The primary water quality BMPs for existing and proposed pollution generating impervious surfaces (PGIS) will be filter strips and bioswales. In these facilities, water quality treatment occurs as runoff from impervious surfaces sheet flows over broad, shallow-sloped grassy areas (filter strips), or is directed through grass-vegetated swales (bioswales). The gentle slopes and large surface area slow runoff rates and enhance the settling of particulates. Water infiltrates into the ground as it flows over the vegetated area, further filtering out particles. Removal of metals and organic compounds is also significant, as these pollutants bind to trapped particles and/or the organic material in the soil and vegetation. In areas where adequate space is not available, treatment may also be provided by wet vaults, which remove particulates and other sorbed pollutants by settling.

Filter strips and bioswales have proven effective for most pollutants in runoff from STIA, as demonstrated by pollutant concentration data and toxicity testing at STIA outfalls. As required by the Port's NPDES Permit, ongoing monitoring will demonstrate the effectiveness of BMPs and, where necessary, will indicate where additional levels of protection may be necessary. The Port's NPDES Permit provides appropriate and effective mechanisms for monitoring BMP performance and improving BMPs when necessary.

The King County Manual (King County DNR 1998) requires that high-vehicle-use areas[16] (i.e., road intersections with high vehicle counts) have oil control treatment. The upper and lower

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[16] The *King County Surface Water Management Manual* (King County DNR 1998) defines high-use sites as any one of the following:

- commercial or industrial site subject to average daily traffic count equal to or greater than 100 vehicles per 1,000 square ft of gross built area, or
- commercial or industrial site subject to petroleum storage and transfer in excess of 1,500 gallons per year, or
- commercial or industrial site subject to use, storage, or maintenance of a fleet of 25 or more diesel vehicles that are over 10 tons gross vehicle weight, or
- a road intersection with average daily traffic of 25,000 vehicles or more on the main roadway and 15,000 vehicles or more on any intersecting roadway.

terminal drives appear to fall under the high-use definition, and will be retrofitted with oil control treatment or runoff will be diverted to the IWS (Parametrix 2000c). The IWS meets or exceeds the requirements for oil control treatment.

Source Control. Source identification and controls used at STIA are listed in Table 4-10. Source controls include passive measures (such as warning signs on catch basins and education of airport and tenant employees) and active measures (such as sweeping near and cleaning of catch basins).

Table 4-10. Seattle-Tacoma International Airport source control BMPs (as approved by Ecology).

Activity	BMPs
Aircraft servicing	Restrict to IWS areas or block drains Store glycol in IWS areas Confine parking of lavatory waste trucks to IWS Identify and divert potential sources of industrial pollutants to IWS Restrictions for fueling on taxiway Alpha Monitor SDS outfalls during de-icing
Aircraft Movement Area (AMA) anti-icing/de-icing	Minimize de-icing chemical use Use calcium magnesium acetate (CMA)/sand mixture for roadways
Snow storage	Operate pump stations to divert snowmelt to IWS
Spill control	Implement spill plan
Vehicle washing and maintenance	Prohibit vehicle washing in SDS areas Place signs in key locations Clean sumps in Taxi Yard annually Sweep Taxi Yard and control litter Maintain catch basin inserts
AMA maintenance	Sweep pavement frequently Inspect catch basin sumps annually and clean as needed Store and dispose of sediments properly Construct secondary containment for used engine fluids
Inappropriate connections and discharges	Inspect outfalls for evidence of illicit connections
Temporary storage of surplus and used materials	Store liquids in approved secondary containment or IWS areas only Control entry of surplus materials
Landscape management (in developed areas)	Use environmentally benign chemicals only when necessary. If landscape chemicals are used: • Follow proper cleaning/disposal procedures • Apply during dry periods • Restrict use near waterways • Incorporate BMPs into contractor specifications • Follow Ecology guidelines for herbicide application • Apply herbicides/pesticides according to instructions • Fertilize shrubs and trees by hand • Avoid catch basin grates when applying fertilizer or pesticides

Table 4-10. Seattle-Tacoma International Airport source control BMPs (as approved by Ecology) (continued).

Activity	BMPs
	Implement Integrated Pest Management Plan as appropriate Give priority to biological methods of pest management Conduct regular weeding and pruning Trim ivy-covered areas by hand (do not use herbicides) Do not use beauty bark in drainageways
Tenant activities in SDS areas	Monitor and educate tenants on source and spill control De-ice aircraft according to established procedures Encourage drip pans beneath fueling trucks if leakage is observed Sweep around dumpsters Store liquids in secondary containment Do not store used fluids or hazardous waste in SDS areas Do not maintain vehicles or equipment in SDS areas Inspect catch basin grates Require tenant water pollution control plans Enforce tenant compliance with Port SWPPP Require tenant spill control plans
Other operational BMPs	Evaluate operations and revise standard operating procedures to minimize pollution Designate an SWPPP implementation monitor Conduct regular inspections of SWPPP elements Assemble pollution prevention team Conduct SDS outfall monitoring Sign catch basins ("dump no waste – drains to salmon stream") Establish packing material source control

Source identification is also an important part of source control. As required by its NPDES Permit, if elevated pollution levels or toxicity are measured in STIA stormwater, the Port updates its Stormwater Pollution Prevention Plan to eliminate or provide treatment for the source. Source control BMPs are reviewed and approved by Ecology and meet or exceed the requirements of the King County and Ecology Manuals.

Industrial Wastewater System. The IWS collects stormwater from the terminal, air cargo, hangars, maintenance, and parking areas. Stormwater from these areas may be contaminated by accidental fuel spill, de-icing chemicals, and washwater from cleaning of aircraft or ground support vehicles. The IWS system prevents runoff and pollutants from reaching Miller or Des Moines Creeks, and the critical habitat located near their mouths at Puget Sound. The IWS consists of collection piping, two primary storage lagoons (Lagoons 1 and 2), a third lagoon for additional storage (Lagoon 3), and an Industrial Wastewater Treatment Plant (IWTP).

The IWS lagoons detain industrial wastewater, settle solids, and equalize flows to the IWTP. The IWTP treats water by (1) flash-mixing aluminum chloride into the influent water to flocculate particulates and oils, (2) using dissolved air flotation to carry the floc to the surface, and (3) employing a skimmer to remove the floated contaminants. A pipe then conveys treated water approximately 2 miles to the Midway Sewer District effluent pipe which discharges directly into Puget Sound via a 200-ft-long diffuser located 1,800 ft offshore at a depth between 156 and 178 ft below mean sea level. The discharge is permitted by the Port's NPDES Permit (Ecology 1998b). IWTP effluent is monitored continuously for flow; weekly for pH, TSS, and oil/grease; and monthly for biochemical oxygen demand (BOD), glycols, and TPH.

Effluent water quality limits, established in the Port's NPDES Permit, have been met since November 1996 with one exception in July 2000[17] (Ecology 1998c).

Pollutant Removal in Lake Reba. Lake Reba, a stormwater facility constructed by the Port in 1973, collects and detains stormwater from the north end of STIA and discharges it to Miller Creek. In addition to stormwater detention provided by live storage (volume that drains dry between storms), Lake Reba has a permanent pool that allows the facility to act as a wetpond. Wetponds are water quality treatment BMPs that function by settling solids and by allowing physical, chemical, and biological mechanisms to capture and/or transform dissolved pollutants (Horner et al. 1994). Pollutants such as heavy metals and nutrients that adsorb to particulates are removed as well.

Snowmelt Facility. The Port uses a snowmelt facility to store melting snow after de-icing chemicals have been applied to the runways and taxiways. The facility drains to a pump station that diverts meltwater to the IWS. This BMP reduces the amount of BOD in runoff reaching Miller and Des Moines Creeks.

Aircraft Anti-Icing and De-Icing Within IWS. Aircraft anti-icing and de-icing is performed only within areas draining to the IWS and conforms to the operational source control BMPs for airports as identified by Ecology (1999b). This BMP minimizes glycols in stormwater runoff to Miller and Des Moines Creeks.

Enhancement of Wetland Water Quality Functions. Existing degraded wetlands in the Miller and Des Moines Creek basins will be enhanced to restore their natural water quality functions (Parametrix 2000b).[18] As described in Mitsch and Gosselink (1993), wetlands naturally benefit water quality by:

- Increasing settling and mechanical trapping of particulates
- Removing metals and other toxins that bind to particulates
- Reducing and binding metals in humic material
- Biological removal/uptake of nutrients

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[17] A single TSS excursion occurred in Summer 2000, during an atypical event. Under current conditions, pumping Lagoon 3 completely empty would disturb sediment on the bottom of the Lagoon. Therefore, a small amount of water normally is allowed to remain in the bottom of the Lagoon. To allow for Lagoon 3 expansion construction, it was necessary to pump and treat this water. Algae concentrated in this small amount of water was sufficient to cause a TSS excursion. This excursion is a result of one-time operational conditions. Furthermore, cleaning and lining of the Lagoon will occur in 2001, inhibiting future algae growth.

[18] No natural wetlands will receive untreated stormwater from Master Plan Update improvements.

Additionally, some restored wetlands will replace existing cultivated land and golf course that are current pollution sources.

Miller Creek Buffer Enhancement. Riparian buffers along approximately 6,500 linear ft of Miller Creek will be enhanced (Parametrix 2000b). Native trees, understory plants, and ground cover will replace lawns, agricultural areas, golf course, and other areas, which will remove pollutant sources and restore buffer quality and continuity. As described in Committee on Protection and Management of Pacific Northwest Anadromous Salmonids (CPMPNAS) (1996) and Forman and Gordon (1986), enhanced buffers will:

- Increase biofiltration of runoff flowing into the stream from riparian areas
- Reduce erosion in riparian areas
- Shade the stream to reduce stream temperatures and to increase DO

Miller Creek Stream Channel Restoration and Enhancement. Approximately 1,500 ft of the Miller Creek channel will be restored and enhanced by revegetating eroding and hardened streambanks and by installing large woody debris in the channel (Parametrix 2000b). These restoration activities will provide water quality benefits to Miller Creek by reducing channel erosion and downstream sedimentation.

Hydrologic Impacts and Mitigation

Master Plan Update improvements will increase impervious surface areas in the Miller and Des Moines Creek watersheds. Stormwater detention facilities will prevent increases in peak flow rates and erosive flow durations (Parametrix 2000c). The proposed, detention and treatment facilities will manage runoff from both newly developed project areas and existing airport areas. The net result of flow controls for the Master Plan Update improvements will be to reduce peak flows and erosive flow durations in Miller, Walker, and Des Moines Creeks downstream of the STIA discharges. These actions will enhance hydrologic conditions in the streams and associated estuaries and will prevent impacts to aquatic habitat.

Wetland Fill Impacts. The potential impacts to the hydrology of Miller, Des Moines, and Walker Creeks from filling 18.37 acres of wetlands are the loss of stormwater storage, groundwater recharge, and groundwater discharge. These functions are discussed below, and all wetland hydrologic functions are accounted for in the HSPF model, which assesses runoff impacts by various input parameters and calibration.

Stormwater Storage. Most wetlands filled by the project provide limited stormwater storage because the wetlands do not occur in closed basins or basins with restricted outlets that would allow water to pond during storms, and release water slowly following storms. Most wetlands occur on moderate to gentle slopes and are free-draining and they seldom, if ever, store water.

Flood Storage and Peak Flow Attenuation. The riparian wetlands located in the 100-year floodplain of Miller Creek provide flood storage functions. Approximately 8,455 cy of flood storage would be filled at Vacca Farm, and approximately 9,589 cy of new floodplain will be excavated adjacent to the stream. All flood storage, including that provided by wetlands, is accounted for in the calibration of the HSPF model; design of stormwater detention facilities using this model will ensure that flow mitigation is provided to account for impacted wetlands.

Groundwater Discharge. Several wetlands are sites of groundwater discharge, and thereby potentially provide base flow support to streams during all or portions of the year. Where fill occurs in these wetlands, the project has been designed to allow these discharge functions to continue. For example, the third runway embankment is designed with an internal drainage system that will collect water that currently infiltrates on the airfield and discharges in wetlands near 12th Avenue South. The drainage system will also collect water that infiltrates into the new embankment, and discharge it to wetlands and Miller Creek (see Section 4.3.2.4 and Appendices F and G). Drainage systems associated with the retaining wall, which will be constructed to reduce wetland impacts, will also convey groundwater downslope to wetlands and the stream. Groundwater discharge effects on base flow are accounted for in the calibration of the HSPF model.

Groundwater Recharge. Most wetlands affected by fill are unlikely to have significant groundwater recharge functions because they occur on till soils, where layers of low-permeability till restrict groundwater recharge. The low permeability of till soils results in poor drainage conditions, which in combination with topography and surface drainage features, promotes the development of wetlands. Other wetlands occur in areas of known groundwater discharge (i.e., wetlands formed by local groundwater discharges) and thus cannot recharge groundwater. However, the HSPF model is based on the premise that all wetlands infiltrate; thus the model conservatively accounts for potential impacts to groundwater recharge as a result of filling these wetlands. Overall, development of impervious surfaces from Master Plan Update improvements could reduce groundwater recharge and eventual groundwater discharge to streams. These functions are accounted for in the HSPF model, and mitigation for these effects is included in the activities discussed in the NRMP (Parametrix 2000b) and the SMP (Parametrix 2000c).

Stormwater Peak Flow Mitigation. The Port will construct stormwater conveyance, detention, and water quality treatment facilities to manage runoff from both newly developed project areas and existing airport areas, as described below. Additional detail on the proposed stormwater controls is provided in the *Comprehensive Stormwater Management Plan for Seattle-Tacoma International Airport Master Plan Update Improvements* (SMP; Parametrix 2000c). The SMP describes stormwater management for the STIA Master Plan Update improvements. The stormwater management facilities will mitigate the impacts of new impervious surfaces in the Miller, Walker, and Des Moines Creek basins, as required by current stormwater regulations and mitigation goals identified during the environmental review process. The facilities will also mitigate stormwater impacts from current development by reducing the magnitude and duration of existing peak flows.

Level 2 Stormwater Discharge Standards for New Master Plan Update Improvements and Retrofitting for Existing Airport Areas. To protect instream habitat, the Port has committed to achieving Level 2 flow controls. The Level 2 flow control standard, as defined by the King County

(1998) Manual, requires matching or improving post-developed flow duration to pre-developed flow durations[19] for all flow magnitudes between 50 percent of the 2-year event and the full 50-year event.

The Level 2 flow control standard analysis is more protective than the Level 1 standard and current Ecology standards (Ecology 1992). As opposed to modeling peak flows for a single design event, the Level 2 analysis requires that a continuous simulation of 50 years of rainfall be modeled, and that facilities be designed to control the duration of erosive flows as well as the peaks. Level 2 is therefore more protective of stream morphology, habitat (such as stream substrate), and hydrologic flow patterns.

The pre-developed condition for the Level 2 standard will be based on a *target flow regime*. The target flow regime assumes that the existing watershed land cover is 10 percent impervious (or less if the existing impervious area is less than 10 percent impervious), 15 percent pervious "grass," and 75 percent pervious "forest."[20] By achieving target flows based on a theoretical basin development of 10 percent impervious (Miller and Des Moines Creeks existing impervious areas are 23 percent and 32 percent, respectively) Master Plan Update improvements stormwater facilities will reduce existing peak flows and durations, restore a more natural hydrologic regime, and stabilize stream channels.

In the Des Moines Creek Basin, the target flow regime was determined in a study by the University of Washington (King County CIP Design Team 1999). The flow regime determined for Des Moines Creek coincides with a target flow regime that would occur with an effective watershed impervious area of 10 percent. In studies of several Puget Sound streams, Booth and Jackson (1997) identified an approximately 10 percent impervious area threshold above which stream channel instability and habitat degradation occur.

Flow retrofitting in the watersheds will replicate a flow regime that would occur at a watershed imperviousness of 10 percent or less. That is, even though the Miller and Des Moines Creek watersheds have an existing impervious area of about 23 and 32 percent, respectively, the planned facilities will reduce flows to a level corresponding to approximately 10 percent impervious.[21,22]

Estimated Detention Storage Requirements. Proposed stormwater detention facilities for the Master Plan Update were designed based on the drainage area served by each facility, the detention

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[19] Flow duration control refers to limiting the duration of geomorphically significant flows (i.e., those flows that initiate bedload movement) to baseline (pre-Master Plan Update conditions).

[20] In areas where existing impervious area is less than 10 percent, the difference between actual percent impervious and the 10 percent threshold is assumed to be grass.

[21] The HSPF model was calibrated with recorded streamflow data and analysis of basin land uses prior to simulation with Level 2 flow controls. The calibration accounts for flows attributable to each land use, based on existing conditions. Flows for other land uses (10 percent impervious surfaces and conditions with Master Plan Update improvements) and Level 2 flow controls were then simulated with the HSPF model (Parametrix 2000c).

[22] This retrofit analysis applies to the basin upstream of the Miller Creek detention facility and the Des Moines RDF.

standard, and potential for waterfowl attraction. Approximately 326 acre-ft of new stormwater detention storage will be needed to mitigate the impacts of increased stormwater runoff (Table 4-11) associated with Master Plan Update improvements. The locations of new facilities are shown in Figure 4-6 of the *Preliminary Comprehensive Stormwater Management Plan for Seattle-Tacoma International Airport Master Plan Update Improvements* (Parametrix 2000c) (see Appendix A for a reprint of this figure).

Pond and Vault Construction and Operation. The feasibility of proposed stormwater ponds and vaults is demonstrated by the recent construction of similar facilities at STIA, including the North Employees' Parking Lot (NEPL) Vault in 1997 and the Interconnecting Taxiways Vault in 1998. The SASA detention pond will displace a 0.06-acre shrub wetland, and Pond D will eliminate Wetland 41. All other on-site detention facilities will be constructed in non-wetland areas. The relation of stormwater facilities to downslope wetlands and groundwater tables is evaluated in Section 4.3.2.10.

The primary discharge from the detention facilities will surface discharge and infiltration. Detention facilities will consist of dry ponds with live storage[23] and will not include wet ponds with dead storage.

Low Streamflow Impacts. The effect of the Master Plan Update improvements on low flows in nearby streams and groundwater discharges to downslope and riparian wetlands are discussed in Section 4.3.2.4.

Net Result of Hydrologic Mitigation. The net result of flow controls for the Master Plan Update improvements will be to reduce flows in Miller, Walker, and Des Moines Creeks to a stable flow regime downstream of STIA discharges. Level 2 facilities will retrofit existing flows to the target watershed flow regime before new development in considered. The net effect of flow controls for Miller, Walker, and Des Moines Creeks (Figures 4-7, 4-8, and 4-9) will be to maintain flows below existing conditions or the target watershed flow regimes following Master Plan construction and flow mitigation, whichever is less. The target flow regime will reduce flows in the stream channels, thereby reducing erosion and improving channel stability.

4.3.2.6 Floodplain Impacts

Filling of wetlands within 100-year floodplains is limited to those in the Vacca Farm area. On-site floodplain mitigation is incorporated into restoration at the Vacca farm site (Parametrix 2000b) to replace this impacted function (see "Hydrologic Impacts and Mitigation" in Section 4.3.2.5. The mitigation consists of regrading upland areas to match elevations of filled floodplain and restoring the area with native wetland vegetation.

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[23] Live storage is that volume of stormwater stored in a detention facility that drains following the storm. Live storage is used for hydrologic benefit to reduce flow peaks and durations.

Table 4-11. Summary of required detention facility volumes.

Watershed	Hydrologic Evaluation Point	Volume Required (acre-ft)	Type of Facility[a]	Comments
Miller Creek	NEPL	13.9[b]	Vault	In addition to existing 4 ac-ft
	CARGO	4.5	Vault	
	SDN2x + SDN4x	14.9	Vault	
	SDN3/3x	25.6	Vault	
	SDN1	5.6	Vault	
	SDN3A	Pond: 14.8 / Vault: 7.0	Pond/Vault	
	SDW1A	Pond: 25.5 / Vault: 7.4	Pond/Vault	Infiltration used
	SDW1B	38.3	Pond	Infiltration used
Total Miller Creek		**157.5**		
Total Walker Creek	SDW2	**7.2**	Pond	
Des Moines Creek	SASA Detention Facility	33.4[c]	Pond	
	Interconnecting taxiway (SDS3A)	5.5	Vault	
	Third Runway South (SDS7 and 6)	21.6	Vault	
	SDS3	88.3	Vault	
	SDS4	12.9	Vault	
Total Des Moines Creek		**161.7**		
TOTAL		**326.4**		

[a] Types of facilities: Vault – enclosure with multiple orifice outlets on vertical riser with overflow spillway; Pond – open earth construction with netting or other means to provide wildlife deterrent.

[b] Volume needed to retrofit existing facility.

[c] Retrofit STIA area only.

4.3.2.7 Hydrologic Impacts of Retaining Walls

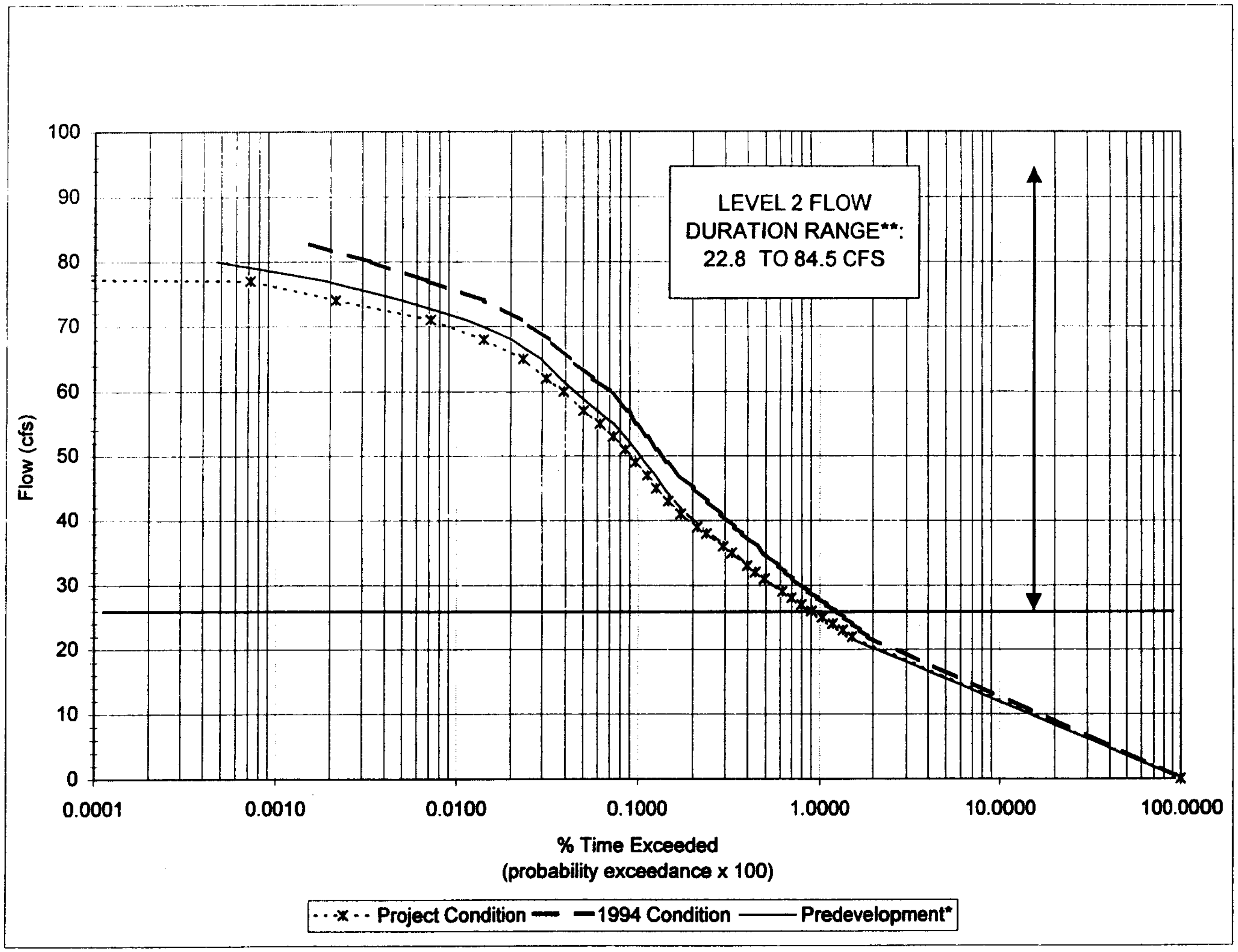
The Port has taken a number of important steps to avoid risk of instability or other adverse impacts from the mechanically stabilized earth (MSE) walls. These include:

- Completion of detailed explorations and in-situ tests to thoroughly and completely identify conditions in the subgrade soils that will support the MSE walls
- Replacement or improvement of subgrade soils to support the MSE walls
- Development of construction quality control specifications by specialists in MSE wall technology, and who have successfully completed more than 10 MSE walls exceeding 90 ft in height
- Use of select soil materials for construction to provide adequate drainage behind and below the walls

The design and geotechnical evaluations of the MSE stabilized earth wall are explained in *Geotechnical Engineering Report-404 Permit Support-Third Runway Embankment* Hart Crowser 1999, Appendix B). Additional geotechnical evaluation of subgrade conditions and the structural foundation of the MSE wall is provided in *Proposed MSE Wall Subgrade Improvements-Seattle-Tacoma International Airport* (Hart Crowser 2000; Appendix E), where the components of the MSE wall foundation and subgrade soil improvements are described.

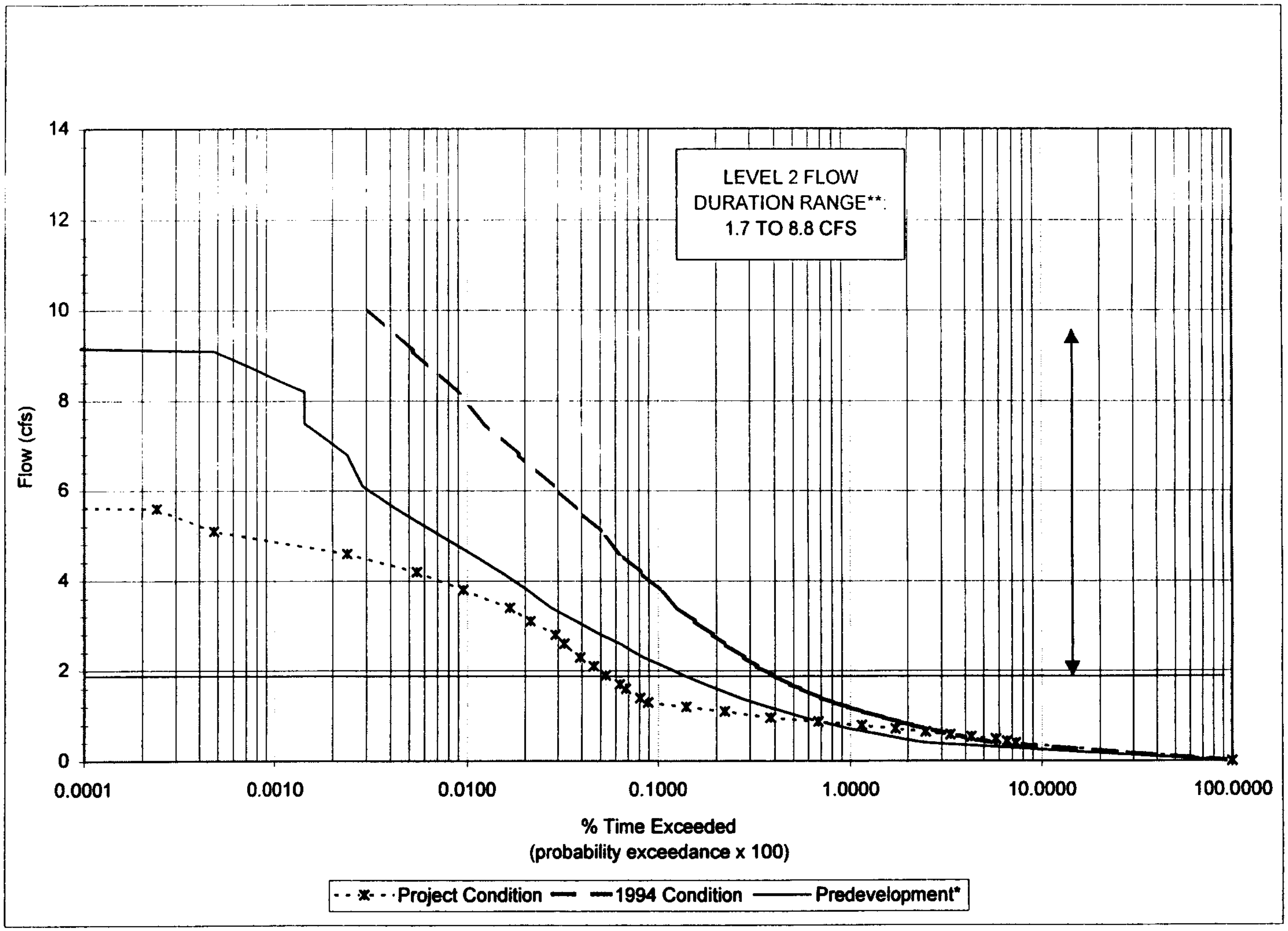
A potential indirect impact to downslope wetland hydrology could occur if the MSE wall and its subgrade improvements significantly altered the movement of ground or surface water to wetlands. The design of MSE walls prevent impacts to groundwater movement and downslope wetlands, as explained below:

- *Removal/replacement of unsuitable subgrade soils-* Where subsoils are unsuitable for wall construction they will be removed and backfilled with relatively free draining structural fill. The permeability of this fill will be greater than the existing surficial soils it replaces, and will readily transmit groundwater. While the new subgrade materials are capable of transmitting groundwater at relatively high rates, the overall flow of water through the soils beneath the embankment will remain similar to existing rates. The reason flow rates will remain similar is because of the limited spatial area where unsuitable soils will be replaced and because the hydraulic conductivity of the existing subsoils will continue to control groundwater flow.
- *Stone columns-* Stone columns (Appendices B and E) would be used as subgrade improvements in some locations. Stone columns would be constructed of coarse gravel, of greater permeability than the existing silt and clay soils that they are placed in. Because of their permeability and because they will occupy only about 17 percent of the soil volume, they will not impede groundwater movement.
- *Concrete bearing pad-* The bottom of the MSE wall will rest on a 6-inch high concrete pad. This structure will not impede groundwater flow because if its small height relative to the thickness of the aquifer or perched water zones.



* Port basins use target flow regime (10-75-15). Off-site basins use 1994 conditions.
** For the target flow regime.

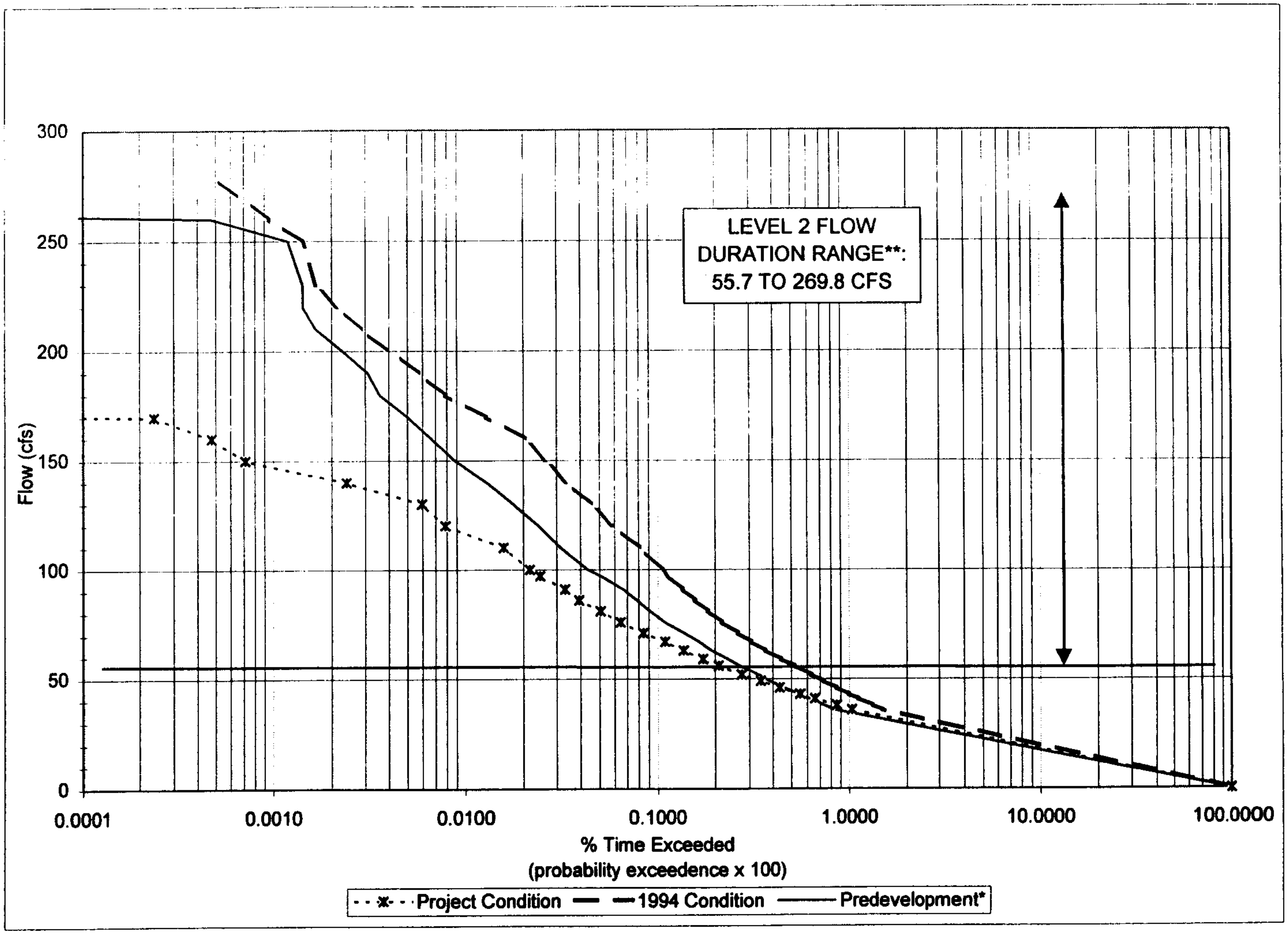
Figure 4-7
Flow Duration Curve for
Miller Creek at SR 509



* Port basins use target flow regime (10-75-15). Off-site basins use 1994 conditions.

** For the target flow regime.

Figure 4-8
Flow Duration Curve for
Walker Creek at South 12th Street



* Port basins use target flow regime (10-75-15). Off-site basins use 1994 conditions.
** For the target flow regime.

Figure 4-9
Flow Duration Curves for Des Moines Creek at South 200th Street

- *Concrete facing panels*- The MSE wall will be faced with concrete panels that are spaced with a ¾ inch gap around their perimeter. This gap allows the MSE reinforced zone to drain through the facing, and prevents water from accumulating behind the panels.
- *Reinforced zone*- The reinforced zone itself consists of free draining backfill reinforced with steel strips (about ¼ inch thick x 4 inches wide) that extend laterally into the backfill. The reinforcing will not impede groundwater movement because of the small area occupied by the strips relative to aquifer conditions and the high permeability of the soils in the reinforced zone.

4.3.2.8 Runway Safety Areas and Relocation of South 154th Street

Six wetlands (Wetlands 3, 4, 5, 6, 7, and 10) are near the north end of the existing airport runways. The relocation of South 154th Street to accommodate the RSAs will decrease the amount of wetland buffer, which could result in increased disturbance from traffic noise for wildlife using these wetlands. This impact is not expected to be significant because wildlife species in these wetlands are tolerant of high levels of noise from aircraft and automobile traffic on SR 518.

Other impacts could occur from changes to wetland hydrology as a result of construction near the wetlands. The retaining wall used to minimize wetland fill will include an internal drainage system that will allow groundwater to continue to enter the wetland. Stormwater runoff (water quality and quantity) conditions will be improved because the new roadway will include stormwater detention and water quality treatment, which it does not currently have.

4.3.2.9 Third Runway: North End

Wetlands 8, 9, and A1 are near the north of the new third runway. These wetlands will be subjected to greater amounts of aircraft noise, which may increase disturbance of wildlife.

The relocation of South 154th Street to accommodate the new runway embankment will decrease the amount of wetland buffer, which could result in increased disturbance to wildlife using these wetlands. This impact is not expected to be significant because wildlife species in these wetlands are tolerant of high levels of noise from aircraft and automobile traffic on SR 518.

Wildlife species occurring in these wetlands are similar to wildlife in Wetlands 3 through 7, which are beneath the flight paths of the existing runway, suggesting that wildlife use may not change significantly.

Changes to wetland hydrology could occur as a result of construction near the wetlands. However, the runway embankment design (Appendix B) will allow groundwater to continue to enter the wetlands. Stormwater runoff (water quality and quantity) conditions will be improved because the new facilities will include detention and water quality treatment in contrast to existing streets that they replace. In the event of an airfield fuel spill, design of the embankment provides an opportunity to mobilize source control and to remediate contaminated soils before the contaminants reach the stream or wetlands.

4.3.2.10 Third Runway South of South 154th Street

Several isolated Category III wetlands (Wetlands A5, A6, and A8 through A13) and three Category II wetlands (Wetlands 18, 37, and 44) occur between Miller Creek and the edge of the new third runway. These wetlands may be subject to indirect impacts from the operation of the project.

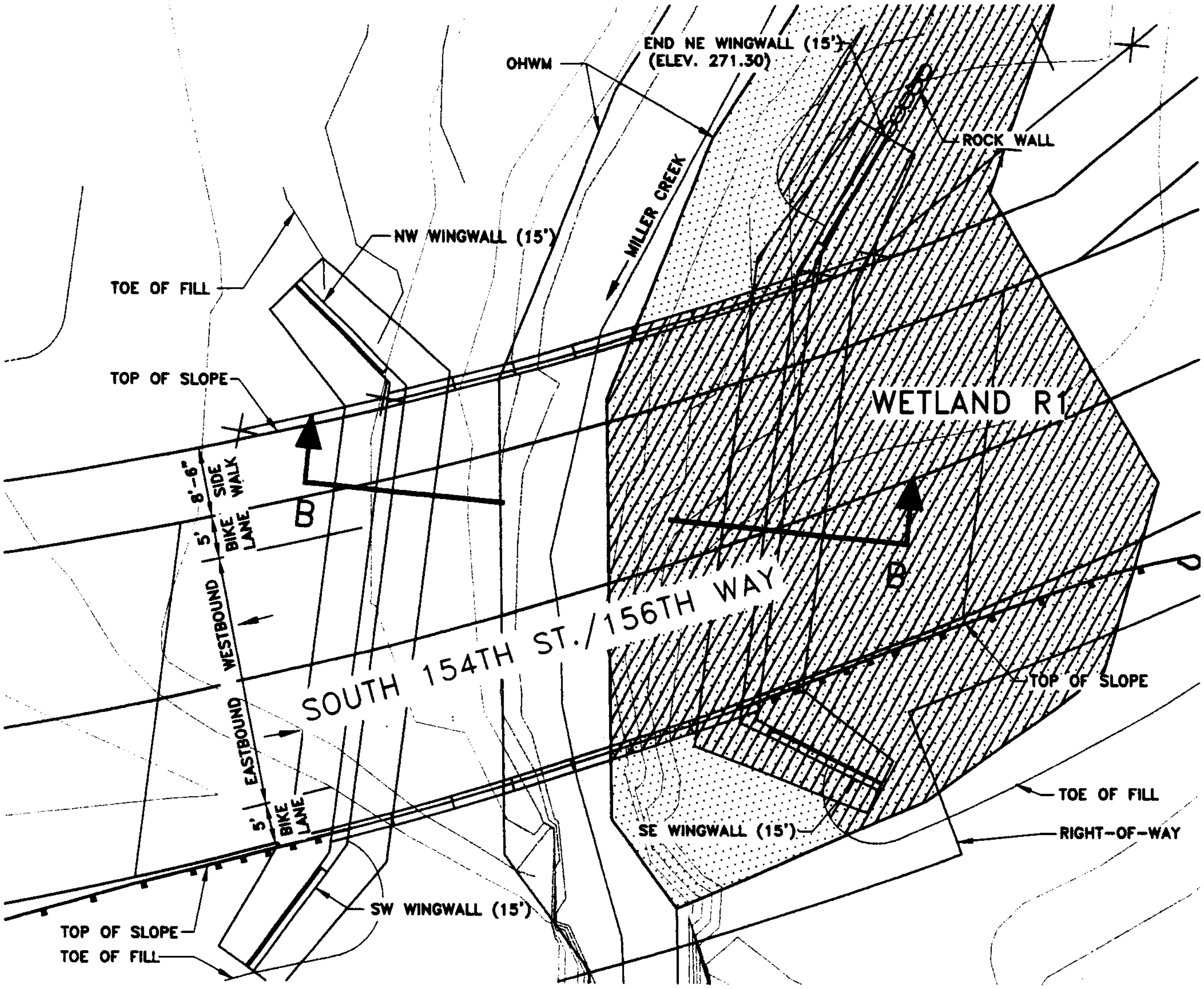
The *SeaTac Runway Fill Hydrologic Studies Report* (Ecology 2000) identifies the potential of 1.68 acres of secondary, indirect hydrologic impacts from the embankment (especially to the Wetland 18 and Wetland 36 complex). Further analysis of this potential impact is the subject of Section 3.2 and 3.6 of the hydrologic report. The analysis concludes (pages 7, 51, 52, and 60) that seepage into the embankment and delay in water movement through the embankment would not result in the loss of these downslope wetlands. Water will infiltrate into the embankment and eventually discharge to the downslope wetlands. The report identifies that some potential net benefit to wetland hydrology during the summer months is possible due to the delay in discharge.

Impacts to riparian Wetland R1 will occur as a result of the 154th/156th Street bridge crossings (Figure 4-10). Following construction, the small area of remaining wetland will continue to receive hydrology from Miller Creek, and thus the area will remain jurisdictional. The wetland will retain existing functions because, despite the loss of adjacent riparian wetland, remaining portions will be restored and incorporated into the buffer enhancement for the Miller Creek relocation mitigation at Vacca Farm. This action will remove lawn and nearby houses, and restore native plants to the wetland and adjacent area, and ensure that the riparian and habitat functions provided by the wetland remain.

Impacts to riparian wetlands along the bank of Miller Creek will be beneficial (Ecology 2000). These wetlands will retain wetland hydrology from their association with Miller Creek and groundwater moving downslope. As discussed above, the embankment will not prevent groundwater from continuing to move downslope to support wetlands.

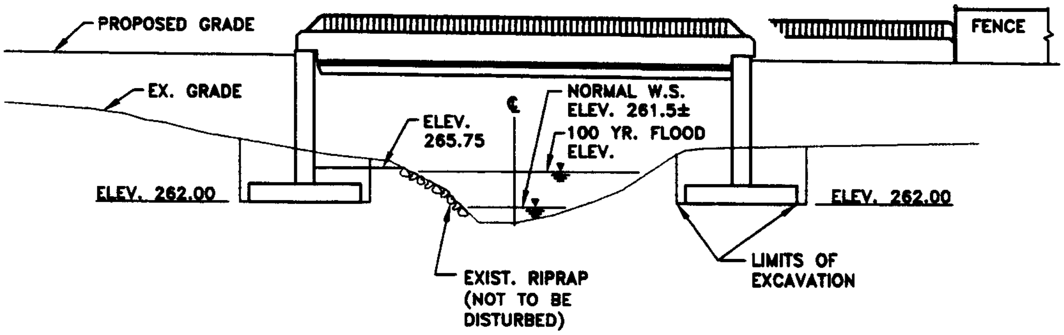
Impacts from humans and domestic animals will be eliminated from the overall area, which may improve the riparian area for wildlife. The sparse vehicular traffic on the safety and perimeter roads will be over 50 ft from the wetlands and thus will not adversely affect wildlife. No increased level of disturbance to wildlife is expected in Wetlands R1 and R2 at the new 156th Street bridge crossing since this new bridge will simply replace an existing bridge.

The mitigation plan shows the replacement drainage channel lengths necessary to mitigate impacts to non-wetland Waters of the U.S. and channelized flow that occurs in Wetland 37 (Parametrix 2000b). These channels would be used to distribute water to downslope wetlands. As reported in the hydrologic study, adequate water should be available to support downstream wetlands. As a contingency, if additional groundwater flow is desirable to enhance wetland hydrology, the channels could be lengthened at the north or south ends to capture additional water emanating from the embankment and to convey it to the wetlands. This would be accomplished in the upland areas immediately west of the embankment, to the north of 160th Street, and/or to the south of 166th Place.



PLAN

SCALE 1"=20'



NOTE:
ALL DISTURBED AREAS WILL BE
STABILIZED USING APPROPRIATE BMPS.

SECTION – B

SCALE 1"=20'

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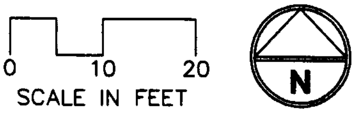


LEGEND
░ WETLAND R1
▨ WETLAND IMPACTS

Figure 4-10
Impacts to Wetland R1 from the New South 154th/156th Street Bridge

4.3.2.11 Wetlands in the Walker Creek Watershed

Impacts to Wetlands 43 and 44 are discussed in the *Analysis Of Indirect Impacts to Wetlands from the Temporary SR 509 Interchange – Seattle-Tacoma International Airport* (Parametrix 2000d). Additional pertinent analysis is presented in Ecology (2000), which demonstrates that the fill embankment design will not interrupt the water source to wetlands downslope of the embankment.

Wetland 44

Fill to construct the embankment will be placed in about 0.26 acres of wetland 44, eliminating degraded forest and shrub wetland habitat. There are no perennial "headwater seeps" that provide significant base flow to Walker Creek in the area where the embankment fill impacts Wetland 44. Fill for the runway embankment will not be placed in any perennial "headwater seep" that provides significant base flow to Walker Creek. One of the most significant perennial sources of water to the Walker Creek base flow is from the constructed drainage system beneath SR 509 near 176th Street, which enters Wetland 43 on the west side of SR 509. Based on flow volume, the outlet of this drainage system may be construed to be the headwaters of Walker Creek, and it will not be affected by the project.

Temporary SR 509 Interchange Design

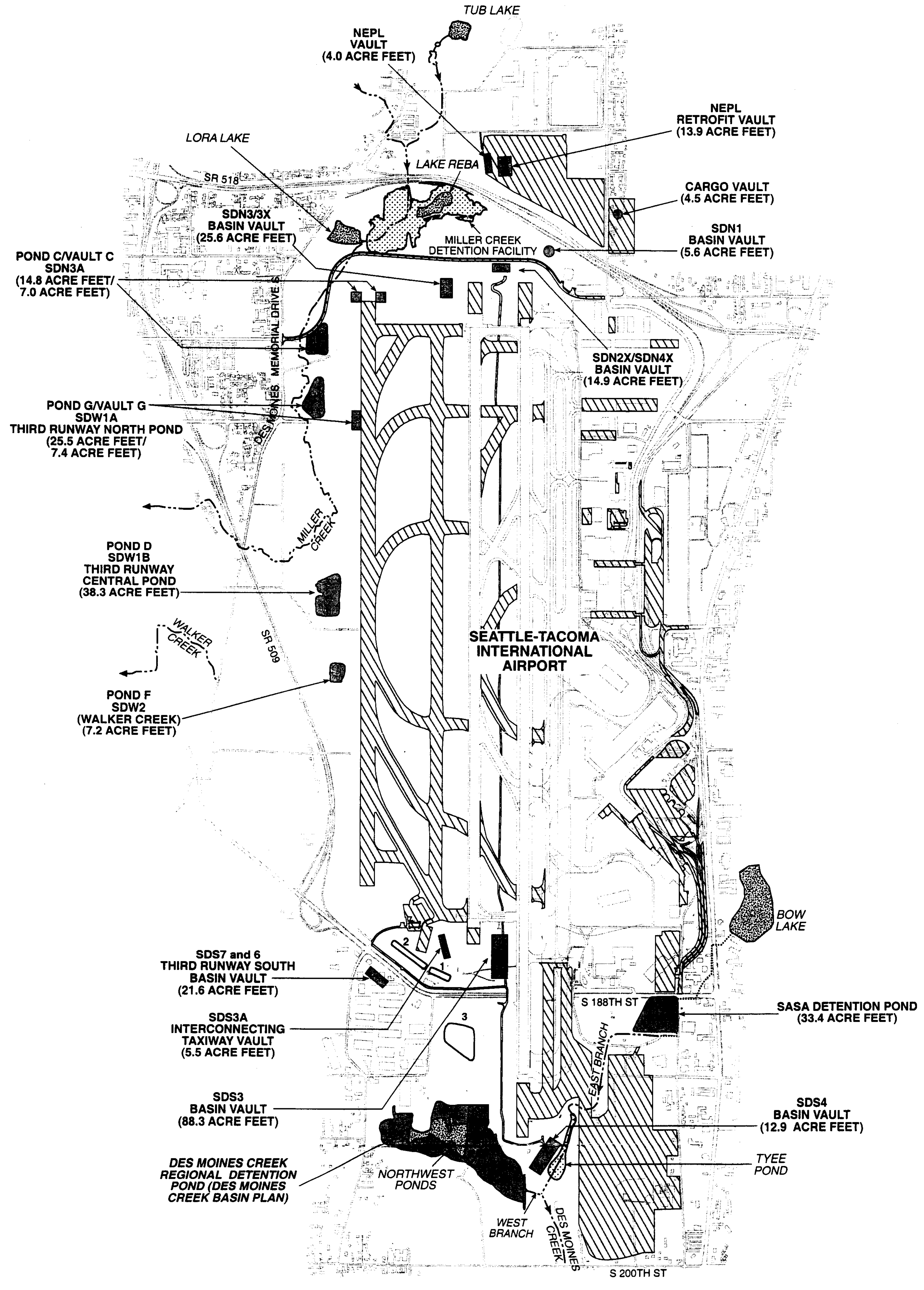
The temporary SR 509 interchange has been redesigned to avoid direct impacts to Wetland 44 and 43 (see Appendix H).

Negative impacts to wildlife in the wetlands could occur from increased aircraft noise. This potential impact would be offset by elimination of humans and domestic animals from the overall area, which will improve the wetlands for wildlife. The sparse vehicular traffic on the safety and perimeter roads will not adversely affect wildlife.

Potential impacts to water quality in the wetlands would not occur. Any stormwater entering the wetlands will be treated using water quantity and water quality BMPs. Since the existing area lacks water quality and quantity treatment BMPs, a net improvement may occur.

4.3.2.12 New Stormwater Detention Facilities

Construction of new stormwater mitigation ponds and vaults in upland locations could result in indirect impacts to wetlands located downslope of them if excavation of these facilities intercepted significant amounts of groundwater that was required to support downslope wetlands. Stormwater vaults excavated in upland areas would not result in indirect impacts to wetlands even if they were excavated into a groundwater table because these sealed vaults could not collect groundwater and reduce its flow to wetlands. Stormwater detention ponds and vaults required to mitigate potential stormwater impacts (Figure 4-11) are evaluated in this section for potential impacts to downslope wetland hydrology. Plans and cross sections for new stormwater ponds are presented in Appendix I.



Sea-Tac Airport/Functional Assessment and Impact Analysis
556-2912-001/01(03) 12/00 (K)

▩ Water Features

■ Proposed Stormwater Detention Facilities (With Simulated Maximum Storage Volume)

▨ Master Plan Projects

—··— Creek

··········· Piped Creek

░ Detention Facility

SCALE IN FEET
0 750 1,500

N

Figure 4-11
Stormwater Detention Facilities for MPU Projects

Potential infiltration of groundwater near stormwater management facilities could potentially extend the period downslope wetlands receive wetland hydrology. This increased soil saturation could create new wetlands by increasing the area of soil saturation, resulting in beneficial increases in wetland functions and area. Within existing wetlands, increasing the period of soil saturation into late spring and early summer could be beneficial to wetland vegetation and functions. These potential impacts are discussed below.

Pond C

Pond C is a 14.8 acre-ft detention facility located south of the relocated South 156th Street. The pond is located about 100 ft east of Miller Creek. It is about 60 and 100 ft east of riparian Wetlands R1 and R2, respectively.

The facility will be excavated to an elevation of about 268 ft. At this elevation, the base of the pond, will be 0-8 feet above the elevation of wetlands R1 and R2. Excavation of a temporary at this location has intercepted some perched groundwater, which now discharges to existing stormwater drainage systems near wetland R1. Monitoring of wetlands R1 and R2 will be performed to verify that wetland hydrology remains in these areas following pond construction and relocation of South 156th Street. Based on the location of these wetlands next to Miller Creek, their elevation relative to the pond excavation, and the potential for infiltration to supplement groundwater, wetland hydrology is expected to remain in these wetlands, and be sufficient to support native shrub and forest wetland vegetation.

Infiltration south of this pond (Appendix J) may be feasible, and if implemented, could augment the hydrology to Wetlands R2 and R4.

Pond G

Pond G is a 25.5 acre-ft detention facility to be located north of South 160th Street. The pond is located about 60 ft east of Miller Creek. It is about 50 ft from riparian Wetlands R5 and R6. The facility will be excavated to about 251 ft, with the base of the pond about 2 feet higher than the elevation of Wetland R6. The base of the pond would be about 4 feet below the small portions of Wetland R5.

Excavation of the pond is above the elevation of measured groundwater tables, and thus, hydrologic impacts to nearby wetlands are not anticipated. Infiltration north of this pond (Appendix J) may be feasible, and if implemented, could augment the hydrology to Wetland R4. Since the pond is not lined, some infiltration may occur through the bottom that could augment groundwater flow to Wetlands R5 and R6.

Pond D

Pond D is a 38.3 acre-ft detention facility to be located near South 170th Street. The pond is located about 700 ft southeast of Miller Creek. It is about 50 feet from Wetland 39. Construction of the pond, embankment, and security road will eliminate all of Wetland 41 (see Section 4.1). Excavation of the facility will be to about 340 feet elevation. This elevation is about 10 feet below the uppermost portion of Wetland 39. Given the close proximity of the wetland to the detention pond excavation, about 0.06 acres of wetland above elevation 340 ft could be impacted.

To mitigate this potential impact, a discharge orifice from the pond is designed to discharge from the pond to near Wetland 39. This 3.5-inch orifice will discharge at elevation 347.2 ft, and reduce potential dewatering to 0.02 acres of wetland (that portion of the wetland above 347 feet).

Hydrology in Wetland 39 will be monitored to determine if this potential impact occurs. This portion of the wetland is dominated by red alder and Himalayan blackberry, plant capable of growing on upland soils. It is unlikely that if indirect impacts occur to 0.02 acres of this wetland, the vegetation and habitat functions of the wetland will be altered, but if plant dieback is observed, affected areas will be replanted.

Excavation of the pond is about 55 ft above measured groundwater tables, and thus, hydrologic impacts to nearby wetlands are not anticipated. Infiltration north of this pond (Appendix J) may be feasible, and if implemented, could augment the hydrology to Wetlands R10 and A11. Since the pond is not lined, some infiltration may occur through the bottom that could augment groundwater flow to these wetlands as well as Wetland 39.

Fill of Wetland 41 for stormwater facilities could reduce water available to Wetland 39. To mitigate this potential impact, the drainage channel located at the base of the embankment and security road will have a discharge point to Wetland 39. This channel will collect water that infiltrates into the embankment through the underdrain (Appendices B, F, and G, Ecology 2000) and direct it to the wetland.

Pond F

Pond F provides 10.3 acre-ft of storage and is located in the Walker Creek subbasin, near South 173rd Street. There are no wetlands near this facility (Wetland 44 is located about 250 ft to the southwest, at elevation 280 feet). The excavation of the facility to an elevation of 342 ft is about 82 feet above the groundwater table of 260 ft. Thus, the pond will not intercept groundwater, and alter groundwater movement.

SASA Detention Pond

The SASA pond will provide 33.4 acre-ft of storage to the Des Moines Creek basin. It is located near South 188th Street and 24th Avenue South. Construction of the facility will eliminate Wetlands E2 and E3 (0.1 acres). Following construction, no wetlands will be downslope of this facility.

4.3.2.13 Staging Areas

Staging will not occur in wetlands. Potential indirect impacts from construction staging areas, including temporary staging areas at the SASA site (see Figure 4-11) and temporary offices near Stormwater Pond D and 170th Street South (see Figure 4-11), would not occur due to erosion control and stormwater treatment facilities. Staging is a temporary land use that would be removed following project construction.

4.3.2.14 Borrow Area 1

Five wetlands in Borrow Area 1 (Wetlands 32, 48, B1, B4, and B15) will be avoided; all remaining wetlands will be permanently impacted by excavation. The upslope watersheds of Wetlands B1 and 32 will not be affected by borrow site development, and setbacks around the wetlands will maintain the seasonal perched water regime. No long-term impacts are expected for Wetlands B1 and 32. The excavation boundaries for Borrow Area 1 are designed to avoid hydrologic impacts to Wetlands B15 and 48. To preserve the surface watershed-supplied runoff and interflow to these wetlands, no excavation will occur west of 20th Avenue South.

Wetland hydrology in Wetland B15 appears to be maintained primarily by direct precipitation. Its location above a relatively thick (>20 ft) layer of dense, low-permeability till soils likely encourages the shallow ponding and storage of water within the wetland. The water supply to the wetland appears to be supplemented by overland flow and shallow interflow from a small watershed area to the southeast. The eastern extent of this watershed is limited by 20th Avenue South, which is elevated slightly relative to the surrounding land, and which currently includes a drainage ditch and storm drains with catch basins along its eastern side. These features prevent surface runoff from the east to cross the street and flow to the wetland. Preservation of the small watershed for these wetlands (west to and including 20th Avenue South) will therefore maintain these hydrologic sources.

Wetland 48 occurs above a similar thick section of till soils in a shallow surface depression. Wetland hydrology is likely maintained by direct precipitation onto the wetland, and supplemented by overland flow and shallow near-surface interflow. The watershed for this wetland also extends eastward toward 20th Avenue South, where the elevation and drainage features of the street from its eastern edge.

Portions of Wetland 48 and B15a that are not excavated as part of Borrow Area 1 will be maintained by surface water directed to them by the finished grades established at the end of the project. Wetland hydrology in these areas appears to be maintained by seasonal groundwater that perches on till soils. The existing stormwater drainage system in the streets found in the borrow area collects surface runoff and directs it away from these wetlands. Demolition of this drainage system may establish a more natural flow pattern to the site and extend the hydroperiod of the wetlands.

Wetland B4 is an incised channel and slope wetland that has eroded as a result of a constructed stormwater drainage system. Removal of the drainage system will reduce peak flows to the wetland, while precipitation and groundwater will continue to support the wetland. For this reason, detrimental indirect impacts are not likely. Habitat functions are not affected due to the wetland's location in the Des Moines Creek buffer.

Wetland B12 could experience some change in hydrology in the east end of the wetland as a result of excavation. Downslope portions would continue to receive precipitation and groundwater to maintain wetland conditions. The presence of forested riparian habitat as part of buffer to Des Moines Creek would maintain habitat functions in the remaining wetland.

4.3.2.15 Borrow Area 3

All wetlands in Borrow Area 3 will be avoided and a 50-ft buffer will be maintained. Wetland hydrology will be maintained by preserving conditions in the watershed basin upgradient and immediately surrounding each wetland (Appendix C). Groundwater analyses indicate that groundwater movement is from northwest to southeast; the areas west and northwest of the wetlands will remain undisturbed.

Potential wetland impacts at Borrow Area 3 have been evaluated to determine potential impacts to wetland in Borrow Area 3 (Appendices C and D). This study found that potential losses in hydrology to wetlands avoided in Borrow Area 3 are minimal (0 to 20 percent). However, collecting and directing water that drains to the Borrow Area to the adjacent wetlands could mitigate any such impacts. This contingency would prevent indirect impacts to the hydrology supporting Wetlands B5, B6, B7, B9a & b, B10, and 29.

The hydrology of downslope wetlands will be monitored by the Port to verify that these contingency measures prevent indirect hydrological impacts to downslope wetlands, as explained in the *Natural Resource Mitigation Plan* (Parametrix 2000b). Wetlands adjacent to Borrow Area 3 will meet a performance standard of having saturated soils present during the December through April period. For Wetland 30, the performance standard shall be standing water present during the resident amphibian-breeding season (i.e., December through May during years of average rainfall).

4.3.2.16 Borrow Area 4

Borrow Area 4 is located about 400 ft south of Wetland 28. Wetland 28 is maintained by several water sources, including groundwater that emanates from beneath the existing airfield, runoff from wetlands located east of it, and runoff from the surrounding impervious area. Some water infiltrating into Borrow Area 4 may also reach the south and southeastern portion of this wetland.

Unlike Borrow Area 3, excavation in Borrow Area 4 will not reach the groundwater table, and thus would not be expected to alter groundwater flow or availability for Wetland 28, and no indirect impacts are likely.

Portions of Wetland 28 will be enhanced by mitigation planned at the Tyee Valley Golf Course, where existing golf course green will be converted to shrub-dominated wetland. Master Plan Update improvements occurring near Wetland 28 are limited to portions of the third runway, which could, without mitigation, generate hydrologic and water quality impacts. The stormwater report addresses detention facilities and water quality BMPs that will minimize these impacts to the wetland and downstream Des Moines Creek. Excavation of Borrow Area 4, located south of Wetland 28, will not intercept groundwater flowing to the wetland or Des Moines Creek, and is thus unlikely to impact wetland hydrology.

4.3.2.17 South Aviation Support Area

In the SASA area, indirect impacts to Wetland G5 have been considered, and the wetland will likely be eliminated by the project. The full 0.87 acre is included in the area of permanent impact acres listed in Table 3-1. The wetland was assumed to be fully impacted because it may be maintained by stormwater runoff and interflow generated by the golf course, which will be converted to impervious surface.

The east branch of Des Moines Creek and perennial groundwater seeps support Wetland 52 in the SASA area. Wetland 52 will receive permanent impacts from an aircraft bridge that will span and shade portions of the wetland. Non-impacted portions of this wetland are expected to remain because the SASA project would not eliminate water sources for the stream or wetland.

The SASA will be designed to avoid significant impacts to Wetland 52 by avoiding much of the wetland and providing a 75-ft buffer. This wetland will be subjected to greater amounts of aircraft noise, which may increase disturbance of wildlife. This impact is not expected to be significant because wildlife species in these wetlands are tolerant of noise from aircraft.

Long-term stormwater runoff (water quality and quantity) conditions will be improved because the SASA facility will be built with water quantity and quality treatment BMPs that would replace golf course and parking areas that currently lack stormwater management facilities.

4.3.2.18 Other Areas

Impacts to riparian Wetland R1 will occur as a result of the 154th/156th Street bridge crossings. Following construction, the areas of remaining wetland will continue to receive hydrology from Miller Creek and groundwater sources. They will continue to support existing hydric soil and wetland vegetation, and thus the areas will remain jurisdictional. The wetland will retain existing functions because, despite the loss of adjacent riparian wetland, remaining portions will be restored and incorporated into the 100-ft-wide buffer enhancement for the Miller Creek mitigation. This mitigation will include removing lawn and nearby houses, and restoring native plants to the wetland and adjacent area. These actions will ensure that riparian and habitat functions provided by these wetlands will continue to be provided.

Industrial Waste Treatment System

The Industrial Waste System expansion is not a Master Plan Update improvement, and is not included in the permit application. The lining of Lagoon 3 is required as a condition of the Port's NPDES permit and is intended to prevent potentially contaminated wastewater from infiltrating into groundwater. The IWS project will not fill any wetlands. The project is located on existing fill, near Wetland 28 (Appendix K). The project involves: (1) excavating and creating a berm to increase the volume of IWS Lagoon 3 from 29 to 76.5 million gallons, (2) cleaning the existing Lagoon, and (3) lining the entire newly enlarged lagoon. Indirect impacts to nearby Wetland 28 are minimized by the extensive TESC methods employed to prevent sedimentation and/or construction water quality impacts to the wetland. In particular, most of the site is sloped to drain into the excavation, and the slopes around the outside of the site are surrounded by a ditch/berm system that intercepts stormwater before it enters the wetland. All collected construction runoff in the excavation and the perimeter ditch/berm system is conveyed to a stormwater treatment plant similar to the systems used for the third runway embankment and other projects at STIA.

Constructing a lined pond will create about 12.3 acres of area that will effectively act as impervious surface. This is not expected to reduce discharge to Wetland 28 or to Des Moines Creek because this is an area of groundwater discharge rather than infiltration (Kennedy Jenks 2000).

A new underdrain system beneath the lined treatment lagoons will allow groundwater beneath the lagoon to drain to Wetland 28. Thus, the liner and underdrain system will actually allow more water to reach Wetland 28 and Des Moines Creek because rainwater and upwelling groundwater that currently reaches unlined Lagoon 3 is pumped to the IWTP and discharged outside the Des Moines Creek basin. Furthermore, this may have a potential water quality benefit in that it will prevent intermingling of untreated industrial wastewater with groundwater. All water contained within the lagoon will be treated in the IWTP and discharged to Puget Sound or the King County Treatment Plant, and therefore will not affect peak flows in Des Moines Creek.

Surface runoff and seepage from the constructed embankment maintain wetland hydrology for the wetlands adjacent to Lagoon 3. Surface runoff will be unchanged. Lost seepage from the small pond area (small relative to the area providing groundwater hydrology to the wetland) is unlikely to adversely affect the adjacent wetlands.

Off-Site Mitigation

Dewatering activities on the Auburn site are not likely to affect existing wetlands located on the site or near the site. Dewatering of the site is expected to occur from May through September, over one or two seasons. The purpose of dewatering is to increase the rate at which the water table falls during the May to September period. In May, at the time dewatering starts, the water level in the wetlands is typically about 24 inches below the ground surface, and by late May it is as much as 36 inches below the surface. Water levels in these wetlands drop to 7 to 8 ft below the ground surface during the summer months, and by late fall, they are at or near the surface. Because the timing of dewatering occurs after water levels in the wetlands have already dropped below the majority of the root zone, wetland vegetation or hydrology will not be impacted. Dewatering will not lower the water level below the elevation it normally reaches by late summer, and thus the period of time for the water level to rise during the fall will not change.

4.3.2.19 Summary

The above analyses of potential permanent indirect impacts to wetland located near or downslope of Master Plan Update Improvement projects considers how a variety of project activities and alterations could indirectly affect wetlands and wetland functions. The analyses conclude that up to about 2.4 acres of wetland could be subject to indirect impacts such that wetlands or wetland functions could be lost. This area is thus includes as a permanent impact of the Master Plan Update improvements on wetlands, and is fully mitigated at a 3:1 mitigation ratio (Parametrix 2000b).

As discussed above, hydrologic analyses demonstrate that the significant wetlands located downslope of the embankment will not be eliminated or experience significant reductions in groundwater sources from embankment construction.. The permanent replacement channels designed to convey water from the embankment to these downslope wetlands help assure that they will continue to provide hydrologic and biological functions to Miller Creek.. The planned Miller

Creek wetland and buffer mitigation (Parametrix 2000b) will enhance many of these degraded wetlands, and lift the ecological function of the area above the existing baseline conditions.

4.4 CUMULATIVE IMPACTS

Additional impacts to wetlands could occur as a result of other projects planned by project proponents in the vicinity of STIA. These projects include projects sponsored by other agencies (the proposed SR 509 and South Access Road (Washington State Department of Transportation 1999), the Link light rail project (Regional Transit Authority 1998), the Des Moines regional detention facility (RDF) (Des Moines Creek Basin Planning Committee 1999) and development planning undertaken by the City of SeaTac). In addition, STIA is planning and implementing development non-Master Plan Update projects at STIA, including electrical substation upgrades, South Terminal Expansion, Satellite Transit System upgrades, upgrade and expansion of the IWS lagoon #3, Air Cargo Development Plans, Aircraft Hydrant Fueling System, and the Part 150 Noise Compatibility Plan.

4.4.1 Projects Sponsored by Other Agencies

4.4.1.1 SR 509 / South Access

Projects in the airport vicinity sponsored by agencies other than the Port of Seattle are at various stages of design and implementation. These projects are not expected to cause significant adverse cumulative impacts that, when considered in relation to the potential impacts of the Master Plan Update projects, would necessitate preparation of another SEIS.

The Washington Department of Transportation is the lead agency for the proposed extension of State Route 509 south of the Airport. The SR 509/South Access Road project would extend the SR 509 freeway south from South 188th Street to a connection with Interstate 5 and improve related local traffic circulation patterns. Southern access to the Airport would be provided by construction of a new roadway, the South Access Road.

Five alternatives are currently under consideration for the location the SR 509 extension. The preliminary preferred alternative is Alternative C2. Alternative C2 would cross the southern one-third of the FAA extended object-free zone at the south end of Runway 16L/34R. The roadway would continue to the southeast and encroach on the northeast corner of Des Moines Creek Park and require the acquisition of approximately 8.1 acres of parkland. Continuing toward I-5, the SR 509 mainline would pass through an area of mobile homes and would join 1-5 at near the intersection of SR99/South 208th St. The length of the extension would be approximately 3.3 miles.

In 1996, WSDOT published a draft environmental impact statement for the project. Between February 2000 and August 2000, WSDOT released updated information on the project in a number of *Discipline Reports* in the following areas:

Geology and Soils

Water Quality

Hazardous Waste

Historical and Archeological Preservation

Relocation

Section 4(f)—23 U.S.C. § 138 evaluation re: use of land from public park, recreation area, wildlife or waterfowl refuge, or historic site

Social

Visual Quality

Vegetation, Wildlife and Fisheries

Wetlands

The potential impacts in several of these areas are summarized below. Readers are referred to the *Discipline Reports* for detailed discussion of these and other potential project-related impacts.

Wetlands: Impacts to wetlands and wetland buffers varies depending on the alternative considered, and impacts could include alteration of existing wetland hydrology and water quality. Thirty-five wetlands or buffer areas lie within the cut or fill lines of the five Build alternatives. Based on the data available in April 2000, the predicted impacts are between 7.7 to 9.29 acres of wetland impacts and 14.5 to 18.56 acres of buffer impacts. The predicted impacts are described in more detail in the April 2000, *Wetland Discipline Report* (WDR) (WSDOT 2000a), pp. 57-65. Mitigation measures are discussed at *WDR*, pp. 66-70. Wetland impacts will be avoided where possible and reduced through design changes. Impacted wetlands will be rehabilitated or restored, and wetlands will be replaced through agreement with local governments and regulatory agencies, in compliance with the Clean Water Act and local regulations that protect wetlands and streams. This wetland impact could require from 13.6 to over 21 acres of wetland mitigation.

Vegetation, Wildlife and Fisheries: No substantial impacts to vegetation or wildlife are anticipated. The primary effects on habitat from road construction would be the removal of vegetation and increased habitat fragmentation. Wider roads and new roads could create barriers to wildlife movements. Noise could cause wildlife to seek new foraging or nesting areas. Excavated streams would be restored and wildlife habitat would be mitigated in consultation with the FAA, federal, state, and local agencies. Impacts to vegetation, wildlife, and fisheries vary between the alternatives and range from 113 acres to 170.8 acres of impacts to various categories of natural habitat. March 2000 *Vegetation, Wildlife and Fisheries Discipline Report* (VWFDR) (WSDOT 2000c), pp.39-47 (discussing impacts) and pp. 48-50 (discussing mitigation measures).

__Water Quality__: Potential impacts to water quality could occur from the construction and operation of the highway (WSDOT 2000b). Construction activities would include clearing of vegetation, demolishing existing roads and buildings, regrading the existing ground surface, installing culverts at stream crossings, handling construction materials, and operating machinery. If unmitigated, these activities have the potential to disrupt surface water flows, increase surface runoff volumes, cause erosion and sedimentation in receiving streams, and increase water temperature in streams. In addition, a variety of foreign materials could enter surface water bodies including sediment, fuel, lubricants, paving oils, construction debris, and uncured concrete.

Activities and events that could occur during operation of the highway, such as stormwater runoff, accidental spills, sanding, de-icing, and vegetation control all have the potential to affect surface water quality. Contaminant concentrations in stormwater coming from the roadway would most likely not exceed Washington State Water Quality standards due to treatment by selected Best Management Practices ("BMPs").

A number of measures can be taken to reduce the potential impacts on water quality, including integration of a stormwater management system into the roadway design. Also, WSDOT's Municipal NPDES permit will require mitigation of potential adverse effects from the long-term operation of the road. This mitigation includes collection of stormwater, control of flow rate, and water quality treatment in accordance with King County's 1998 Stormwater Management Guidelines, WSDOT's 1995 Stormwater Management Guidelines and WSDOT's 1999 ESA Stormwater Guidelines. To minimize accumulation of sediments in streams and wetlands, WSDOT is currently considering the use of thirteen wet vaults, located along the roadway as necessary to allow collected stormwater to be discharged at natural locations in the highway's subbasins.

4.4.1.2 Central Link Light Rail Transit System

The cumulative impacts of the proposed light rail transit system were considered in the FSEIS, p. 5-1-8. The Central Puget Sound Regional Transit Authority (1999) ("Sound Transit") is proposing construction and operation of an approximately 25-mile electric light rail system known as the Central Link Light Rail Transit Project, which will connect to the eastside of the airport. The portion of the project near STIA is referred to as "Segment F" in the *Central Link Light Rail Transit Project, Final Environmental Impact Statement,* November 1999.

The preferred alternative for Segment F includes an elevated line along Tukwila International Boulevard from 152nd Street, continuing southwest to cross over SR 518, travel west of Washington Memorial Park, and connect to the Airport's proposed North End Airport Terminal or Intermodal Center. The line would then continue elevated along the west side of International Boulevard, turn southwest to cross 188th Street and continue elevated along the east side of 28th Avenue South to South 200th Street. Three stations are proposed: North SeaTac, with a 260-, 454-, or 670-stall park-and-ride, North Central SeaTac (at the Airport Intermodal Center), and South SeaTac. *Central Link Light Rail FEIS,* p. S-5.

Potential environmental impacts in of the light rail project in the vicinity of the STIA (Segment F) include the following:

Four of the Project Alternatives would require 0.60 acre of tree removal along the eastern edge of Washington Memorial Park and the loss of 0.12 acres of forested and palustrine emergent wetland and 0.21 acres of wetland buffer. One alternative would affect Bow Lake (AR-44) through the loss of less than 0.01 acres of scrub/shrub wetland and 0.06 acre of wetland buffer, loss of some riparian vegetation that provides wildlife habitat and water quality functions, and incremental degradation of fish habitat from in-water piers and clearing of littoral vegetation.

There are a number of options under consideration for construction of the South SeaTac Station (Options A-F). South SeaTac Station Option A would remove 5.0 acres and station options B and C would remove 4.0 acres of trees and dense shrubs. South SeaTac Station options D, E, and F would remove 0.60 acres of urban songbird habitat. No long-term impacts on wetlands or fish habitat are expected under the other alternatives in Segment F. None of these alternatives is expected to affect the bald eagle nesting territory at Angle Lake. No impacts on threatened and endangered fish species are expected to result from any of the alternatives in this segment. *Central Link Light Rail FEIS*, pp. 4-121, 4-125, 4-126.

Water Resources: The various Alternatives create up to 120,000 square feet of new impervious surface from trackage, 18,000 square feet from road improvements, and 130,600 square feet at the South 200th Street park-and-ride if the 950 proposed stalls are constructed. Increased impervious surface associated with the proposed South 200th Street park-and-ride facility could impact local drainage systems and water quality by increasing runoff; however, this project is not expected to have significant impacts on the East Fork of Des Moines Creek, which lies downstream from the project. Park-and-ride facilities at South 154th and South 160th are proposed at existing developed sites with 100 percent impervious surface and would decrease the total amount of impervious surface area within the Des Moines Creek watershed, although the amount of pollutant-generating impervious surface would increase.

The Preferred Alternative would have stations at South 154th Street, the Intermodal Center or North End Airport Terminal, and South 184th Street (possibly) and south of South 200th Street. The stations at South 154th Street, the Intermodal Center/North End Airport Terminal, and South 184th Street would decrease impervious surface. The proposed park-and-ride facility at South 200th would add 130,600 square feet of impervious surface area if the proposed 630 stalls are constructed. Trackage associated with this alternative would add an additional 80,000 square feet of new impervious surface along International Boulevard South, and road widening would add 7,200 square feet of new impervious surface.

City of SeaTac regulations, which are based upon the King County Surface Water Design Manual (1998), govern the area that would be impacted by all the alternatives in Segment F. Stormwater detention and treatment and water quality treatment would be provided at the proposed park-and-ride at International Blvd. and South 200th Street, and at 28th Avenue South and South 200th Street to meet KCSWM Level 2 requirements. Water quality treatment would be provided at the South 154th Street park-and-ride facilities. *Central Link Light Rail FEIS*, pp. 4-134 to 4-138.

4.4.2 Regional Detention Facility

Construction of the Regional Detention Facility ("RDF") is recommended in the Des Moines Creek Basin Plan, which was developed by the Des Moines Creek Basin Committee, a group comprised of the Port of Seattle, King County, and local jurisdictions. The Des Moines Creek Plan is intended to improve stormwater runoff management in the Des Moines Creek basin.

The RDF is part of the recommendations of the Des Moines Creek Basin Plan, which was created by the Des Moines Creek Basin Committee, a group comprised of the Port of Seattle, King County, and local jurisdictions. The Des Moines Creek Plan is intended to improve stormwater runoff management in the Des Moines Creek basin. During the Des Moines Creek watershed basin planning process, King County chose to rely upon regional detention facilities to mitigate existing and future development impacts.

The Des Moines RDF will be located at the head of the west branch of Des Moines Creek at the Northwest Ponds and is anticipated to provide a total of 180 acre-ft of storage. The facility would mitigate impacts of stormwater runoff from all past and future (beyond Level 1 of the King County standards) development in the Des Moines Creek watershed. The facility would reduce existing peak flood impacts in the Des Moines Creek basin. With construction of the RDF, peak flows in Des Moines Creek downstream of the RDF should decrease by 25% to 65%.

The three alternatives for the design of the RDF facility are described in the November 1, 1999 *Des Moines Creek Regional Capital Improvement Projects Preliminary Design Report.* On November 1, 1999, the Des Moines Creek Basin Committee also published an *Addendum to the Des Moines Creek Regional Capital Improvement Project Preliminary Design Report ("Addendum").* In the *Addendum*, the Des Moines Creek Basin Committee selected the Alternative 2 design option, which is described on page 16 of the *Preliminary Design Report.*

Wetland Impacts: The area proposed for the RDF, the Northwest Ponds, is part of a large wetland system that includes the ponds themselves, portions of an existing golf course, and extensive areas both northeast and southwest of the ponds. To accommodate additional water storage necessary for stream protection, portions of the existing wetland will need to be modified. This modification would include construction of one or two berms and regrading approximately 11 acres of wetland area. Of this area, roughly five acres lies within the golf course and are dominated by turf grasses while another two to three acres are dominated by invasive scrub-shrub species. Although the modifications will disturb some existing plant communities, the disturbed areas will remain wetlands, with the exception of the area filled for berms.

To effectively lower the water surface elevations of the ponds, the outlet channel (West Fork Des Moines Creek) must also be lowered. This will require reconstruction of approximately 2,000 linear feet of existing channel and the removal of two artificial weirs within that reach. Restoration and enhancement of the stream channel will include both in-stream and habitat features, such as placement of large, woody debris and boulders, as well as buffer revegetation. As currently proposed, there will be no permanent loss of stream function or length as a result of conveyance improvements to the stream for operation of the facility. *Preliminary Design Report,* p. 54.

There are three proposed Alternatives for this project. Alternative 2 is the Preferred Alternative.

Alternative 1 impounds the Northwest Ponds by constructing a berm at the existing outlet release control. A second berm would be constructed at the Approach Light Road with flow release of discharge in the range of 10-year to 25-year return interval flow rate. The South End Sea-Tac storm drainage (existing concrete pipe) would be rerouted to the Northwest Ponds. The Flow Bypass System would be connected to Northwest Ponds at the existing outlet.

Alternative 2 impounds the Northwest Ponds by constructing a berm at the existing outlet. A second berm would be constructed at the Approach Light Road with a flow release control of discharge in the range of 10-year to 25-year return interval flow rate. The existing culverts at South 200th Street would be modified to perform flow rate control for 25-year to 500-year return interval flow rates. East Fork Des Moines Creek at the Tyee Pond would be diverted to Northwest Pond. The South End Sea-Tac storm drainage (existing concrete pipe) would be rerouted to the Northwest Ponds, and the Flow Bypass System would be connected to the existing outlet. *Preliminary Design Report,* p. 16.

The berm design for Alternative 2 could require filling up to 1 acre of wetland within the golf course, depending on the final berm design and location. *Preliminary Design Report,* p. 53. This Alternative would also require reconstruction of approximately 2,000 linear feet of existing channel and the removal of two artificial weirs that are located within that reach. Restoration and enhancement of the stream channel would include both instream habitat features, such as large woody debris and boulders, as well as buffer revegetation. There would be no permanent loss of stream function or length as a result of the stream conveyance improvements.

Alternative 3 would not require construction of a berm at the outlet. Instead, the outlet would be excavated to provide an open conveyance from Northwest Ponds to hydraulic control at the Approach Light Road. As with the other alternatives, a berm would be constructed at the Approach Light Road with flow release control of discharge for the storm events up to the 100-year return interval. The culverts at South 200th Street would be modified to perform flow rate control for 100-year to 500-year return interval flow rates. *See Preliminary Design Report,* p. 27.

Mitigation for wetland and stream impacts includes reducing water level fluctuations in adjacent forested wetlands, creating 1.8 acres of new wetland, enhancement of 5 acres of wetland, and improved aquatic habitat (due to reduced peak flow) in over 2 miles of Des Moines Creek. The City of SeaTac hearing examiner (File No. CZ00-00001) found that the RDF project would result in no net loss of wetland function and area, enhance the hydrologic functions of the affected stream, and increase diversity in wetland plant species.

The Des Moines Basin Planning Committee identified a preferred alternative for the RDF in November of 1999. This alternative proposes construction of a berm and hydrologic controls west of the Port's proposed wetland mitigation site on the Tyee Valley Golf Course. The proposal also includes channel reconstruction south of the Port's wetland mitigation. The Port's mitigation project has been designed to avoid areas needed for construction of the RDF, including the western edge of the mitigation project where the RDF berm is proposed, and the area along Des Moines Creek where channel excavation, grade control, and riparian restoration are planned. Furthermore, during construction of the RDF, the Port will protect the western and southern edges of the mitigation site with ecology blocks to prevent construction machinery from impacting the mitigation site. The Port will also install orange barrier fencing and TESC measures during any construction adjacent to the mitigation site to ensure that any potential impacts from construction are avoided.

The Port's proposed mitigation on Tyee golf course is over 500 ft from the preferred alternative for SR 509. The mitigation is also over 500 ft from the preferred alternative for the South Access Freeway. In addition to this substantial distance, the drainage conditions adjacent to each proposed roadway would prevent construction runoff to enter the mitigation area. Construction noise from machinery more than 500 ft away is likely to be less than noise generated from aircraft, and is thus unlikely to affect any wildlife using the mitigation site. Therefore, these projects would not affect the hydrologic or riparian functions desired for the mitigation site

The FAA and USDA Wildlife Services staff have evaluated the mitigation proposed for the Tyee Valley Golf Course for potential wildlife hazards to aviation. These agencies have determined that the mitigation results in a *decrease* in wildlife hazards near the airfield. Highway construction and operations typically reduced habitat for and use by wildlife, and therefore new roads near the mitigation site are not expected to increase wildlife hazards. New roads will not create new habitat; they are unlikely to substantially affect bird movements in the area as most birds of concern habituate to vehicle and air traffic. Overall, modification of waterfowl habitat through the Port's mitigation and the proposed RDF, as well as removal of habitat through conversion of undeveloped land to roadway, should reduce wildlife hazards on the golf course.

There is no conflict between the South Access Freeway and the access bridge to SASA. The SASA access bridge will be located at airfield elevation (approximately 340 ft). The South Access road will be located near existing grades (280 ft). Thus, the South Access road will pass beneath the SASA bridge in an underpass.

The Port's proposed wetland mitigation is located outside the proposed RDF facility, and wetland hydrology of the mitigation site would not be affected by operation of the RDF facility. The 100-year floodplain of Des Moines Creek (under existing conditions) is entirely within the mitigation site, and within the boundaries of Wetland 28 (See Implementation Addendum, Appendix C, Sheet C3). With the RDF in operation, the 100-year flood elevations in the mitigation site will be slightly lower than under existing conditions. Thus, increased flooding would not impact wetland vegetation. The relation of the mitigation to the 100-year floodplain, with and without the RDF is summarized below:

	With RDF	Without RDF
100-year floodplain elevation	249.5 ft	250.5 ft
Area within 100-year floodplain	2.1 acres	3.1 acres

Regardless of whether the RDF is built or not, most of the area in the mitigation site is existing wetland that is maintained by high groundwater and by precipitation during the winter months. Observations made during wetland delineations found high groundwater in the wetland, with water at or near the surface. This water apparently perches on a low permeability soil layer consisting of diatomaceous earth and/or volcanic ash.

Site constraints preclude the installation of extensive buffers around the mitigation site. Within the mitigation site itself, there are shrub buffers on the north side between the enhanced wetland edge and the surrounding golf course. The mitigation site will be buffered to the west by the extensive area of existing wetland (Wetland 28). On the south side, 100-ft buffers associated with Des Moines Creek will be enhanced and the mitigation site will function ecologically as a part of this important system. Wetland buffers cannot be enhanced east of the mitigation site because the land east of the site is within designated safety areas and runway embankment. In these runway safety areas, emergency and non-emergency access, flexibility to maintain or modify vegetation, and flexibility to maintain or supplement navigation equipment or other airfield facilities must be retained. However, airport operations described above will preclude high impact uses near the east site of the mitigation site, thereby providing an effective land use buffer.

4.4.3 City of SeaTac Development Planning

As a condition of the 1997 Interlocal Agreement between the Port of Seattle and the City of SeaTac, both agencies have agreed to coordinate development in and around the airport. The proposed Master Plan Update improvements are consistent with the City's comprehensive plan adopted pursuant to the state Growth Management Act.

While final designs for these projects are not available, each of these projects may have direct or indirect impacts to wetlands near the airport and without mitigation may result in some impact to wetland area and ecological functions. SEPA, NEPA, and Section 404 review for these projects will require evaluation of options that avoid and minimize impacts to wetlands and the aquatic environment. For unavoidable impacts to wetlands, mitigation must be provided. Mitigation provided by these projects for unavoidable wetland and stream impacts is likely to require protection of water quality conditions in streams and wetlands, replacement of wetland functions on-site, and restoration of aquatic habitat. Thus, significant cumulative impacts to wetlands are not anticipated.

Westside Plan: In November 1997, the City published the *City of SeaTac Comprehensive Plan Amendments and Zoning Changes Final Supplemental Environmental Impact Statement* (SeaTac 1997). This document addresses zoning classifications and development alternatives for the Westside Subarea and modifications to the City's Comp Plan to be consistent with the regional Metropolitan Transportation Plan.

The *SeaTac Comp Plan/Zoning FSEIS* found that there would be no significant impact to water resources. Water impacts would be limited to the possible mitigatable increases in stormwater runoff in Miller Creek. King County, the City of SeaTac, and the Port have already coordinated their efforts in the Des Moines and Miller Creek watersheds to control water quantity and enhance water quality. Des Moines Creek would be unaffected by the proposed project actions.

City Center Plan: In November 1999, the City adopted the SeaTac City Center Plan as a Subarea plan to SeaTac's comprehensive plan. The primary objectives of the City Center Plan include support for integrated development in the City Center area, creation of a central business district, changes to land use designations, and location of a Sound Transit light rail station (SeaTac 1999).

The City and the Port of Seattle have also entered into a Joint Transportation Study that will include development of multi-modal travel simulation models to test various combinations of regional Airport and City-wide development and access alternatives.

The *SeaTac City Plan FEIS* did not identify any unavoidable impacts that affect the environmental analysis provided for the Port's 404 application. For example, the *SeaTac City Plan FEIS* did not identify any additional wetland impacts, and water impacts were limited to additional stormwater runoff that will be mitigated through compliance with applicable surface water design regulations, stormwater filtration, and additional landscaping requirements. See *SeaTac City Plan FEIS,* pp. 1-7 to 1-13.

4.4.4 STIA Projects

The Port has a number of airport improvement projects at various stages of design and implementation. These projects are not expected to cause significant adverse cumulative impacts that, when considered in relation to the potential impacts of the Master Plan Update projects, would necessitate preparation of another SEIS.

4.4.4.1 South SeaTac Electrical Substation Upgrade

This project expands the capacity of the existing South SeaTac Substation by constructing a new substation next to the existing one and installing approximately 1.2 miles of 115kV high transmission lines on segments of South 188th Street and 28th Avenue South. See *SEPA Determination of Non-Significance*: POS SEPA File No. 99-02 (March 1, 1999).

Two shrub and forested wetlands are located 50 feet south and 50 feet east of the proposed substation site. The wetlands south of the site contain both forested and emergent wetland habitats. Groundwater seepage into the wetlands during the wet season maintains the area as a wetland. The wetlands lack any distinct surface water inlet or outlet features. The wetlands are considered Category IV using the WSDOE wetland rating system because of small size, recent disturbance, and limited biological diversity. The wetlands are rated Class II under the City of SeaTac's sensitive areas code. *Substation SEPA Checklist*, pp. 7-8. The proposed project will be designed and constructed in accordance with City of SeaTac requirements for projects near wetlands. No structures will be constructed within 65 feet of the wetlands, and measures to minimize erosion, and off-site sediment transport will be implemented.

4.4.4.2 South Terminal Expansion

Much of this project was analyzed under the Master Plan Update FEIS and FSEIS. Changes to the proposal were discussed in the July 19, 1999 *South Terminal Expansion SEPA Checklist*, Table 1, pp. 3-11 and considered in a Mitigated Determination of Non-Significance dated July 19, 1999. The project will be constructed on a previously developed portion of airport property and is expected to include the following elements: Concourse A Extension, Office Tower Building, Supply Distribution Center on Concourse A, South Ground Transportation Lot, Public Transit Curb, Gate B Outbound Baggage Facility, Concourse B Operations Office, relocation of Concourse A tenants and South Satellite Office, Remain Overnight Aircraft Parking, apron paving, demolition of existing Delta Airlines hanger and construction of a new Northwest Airlines hanger on the site, Northwest Airlines flight kitchen, aircraft lavatory dump station replacement, and construction staging area. The project changes do not substantially alter the Master Plan EIS analysis of potential environmental impacts. See July 19, 1999 *South Terminal Expansion SEPA Checklist*, pp. 13-31.

4.4.4.3 Upgrade of Airport Satellite Transit System

This proposal was analyzed in the May 13, 1997 Master Plan FSEIS. The upgrade entails relocation of the existing north security checkpoint, construction of a new vertical circulation core, improvements to the satellite transit system, interior remodeling, and extension of the north end of the main terminal by approximately 75 feet. Project modifications are discussed in the August 23, 1999 SEPA Addendum. The modifications do not substantially alter the analysis of significant impacts described in the Master Plan FSEIS. August 23, 1999 SEPA Addendum, p. 3.

4.4.4.4 Upgrade and Expansion of Industrial Wastewater System Lagoon #3

This proposal is to clean, line, expand and upgrade an existing wastewater system lagoon. The expanded lagoon will provide greater industrial wastewater storage capacity prior to treatment in the Port's Industrial Wastewater System Treatment Plant (Kennedy Jenks 2000) and allow for controlled discharge to the King County Metro Sewer line. The proposal received a SEPA Determination of Non-Significance on December 22, 1999.

Two wetland complexes and a stream are located in the immediate site vicinity. Wetland 28, also know as the Northwest Ponds, is a large diverse Class I wetland located mostly south of Lagoon #3. The wetland is approximately 35 acres in size and consists of open water, and emergent and scrub-shrub vegetation. Two arms of Wetland 28 extend north to border both the east and west sides of Lagoon #3. The west branch of Des Moines Creek originates in Wetland 28 and flows south and west into Puget Sound. Another wetland complex (IWSA/IWSB) is located north of Lagoon #3. This forested wetland is approximately 0.67 acres and is divided by a gravel access road.

The project will not involve work in the waters of Wetland 28 (see Section 4.3.2.18) or IWSA/IWSB. Work will occur adjacent to the northern arms of Wetland 28 and IWSA/IWSB. Buffer impacts resulting from the project would be reviewed by the appropriate regulatory agencies and may require mitigation such as buffer averaging or replacement. *IWS Lagoon #3 Upgrade SEPA Checklist*, p. 10. Some groundwater dewatering is expected during construction with a maximum dry weather pumping rate of 450 gallons per minute. This groundwater is not expected to require treatment prior to discharge into the Des Moines Creek tributary east of the site. If water quality testing indicates high levels of turbidity, the water may be treated on site prior to discharge. As part of the proposed lagoon improvement, a permanent underdrain and pumping system would be installed to prevent accumulation of groundwater under the lagoon liner system. The collected water would be discharged into Des Moines Creek. *IWS Lagoon #3 Upgrade SEPA Checklist*, p. 11.

4.4.4.5 Air Cargo Development Plan (ACDP)

This is a programmatic action. The ACDP is a 10-year development plan for facilities and actions recommended to meet the needs of existing air cargo customers at Sea-Tac Airport. Actions tentatively planned through 2004 include purchasing of airport leases to allow redevelopment in the north cargo area, constructing four aircraft hardstands in the north cargo area, constructing freight warehousing in the north cargo area, preparing a site development plan for property north of SR 518 (the "L-shaped parcel"), and redeveloping Port building 313 for air cargo. Actions tentatively planned from 2005 through 2010 include construction of five aircraft hardstands in the north cargo area, construction of mail processing and transfer facilities, constructing a non-public bridge across SR 518 (adjacent to the existing 24th Avenue South bridge), and constructing a ground support equipment storage area. Air Cargo Development Plan SEPA Checklist, p. 3.

Redevelopment of airport property will have little effect on impervious surface area. Development of the "L-shaped parcel" north of SR 518 will increase impervious surface area because the parcel is currently undeveloped. Site development of this parcel and the bridge will include stormwater collection and detention facilities.

There are no water bodies in the immediate vicinity of the northeast corner of the Airport where the air cargo facilities recommended in the Plan would be located. The majority of the area is paved and already developed for airport uses. Preliminary information indicates that wetlands exist on the "L-shaped parcel." Portions of this property would be developed if all of the Plan recommendations are implemented. As the project is still in the project definition phase, no wetland delineation or environmental analysis has been undertaken. Air Cargo Development Plan SEPA Checklist, pp. 7-10.

4.4.4.6 Aircraft Hydrant Fueling System ("AHFS")

The AHFS proposal is to install a Jet A underground fuel line concurrent with the planned improvements to Concourse A. The AHFS would provide single source fuel delivery of Jet A fuel at the airport and a common infrastructure that would be used by all airlines. The AHFS would replace the current fueling operations (primarily truck deliveries) for most commercial passenger aircraft at the Airport. The AHFS would include cathodic corrosion protection for the underground pipes and a state-of-the-art leak detection system.

A SEPA determination of non-significance was issued for the project on October 6, 2000. Previously, the Port had analyzed the need to replace the existing fueling equipment in the Master Plan FEIS. Other environmental documents that discuss the proposal are listed on page three of the SEPA environmental checklist for the proposal.

4.4.4.7 Part 150 Noise Compatibility Plan

The Port issued a SEPA Determination of Non-Significance for the Part 150 Noise Compatibility Plan on October 20, 2000. The Part 150 plan consists of a series of actions to reduce noise from ground and flight operations at the airport. The Plan includes conducting additional studies including a siting study for the Ground Run-up Enclosure, a siting study for noise walls and recommended changes to in runway use and flight tracks. The Plan also includes descriptions of existing conditions, aircraft operations forecasts, existing and future noise environment, facilities, operational and land use alternatives, technical reports, and a community involvement plan.

The Plan is part of the Port's Noise Remedy program, the goal of which is to reduce aircraft and ground noise at the Airport, reduce noise impacts on the greater Seattle area, and encourage land uses that are compatible with anticipated aircraft noise exposure.

The plan is anticipated to include the following components:

- Construction of noise barriers in the north cargo area
- Construction of a ground runup enclosure
- Modifying existing maintenance regulations and noise fines
- Implementing a ground power and pre-conditioned air system
- Working with the FAA to develop noise-reducing aircraft arrival patterns, runway use, and glide slopes.
- Sound insulation of schools in the 65 DNL zone
- Acquisition of mobile home parks in the 70 DNL zone
- Working with local governments on airport noise compatible land use and building codes

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APPENDIX A

APPENDIX A

THIRD RUNWAY EMBANKMENT CONSTRUCTION

EVALUATION OF:

TEMPORARY CONSTRUCTION IMPACTS TO WETLANDS

AND

EROSION AND SEDIMENTATION CONTROL DURING THIRD RUNWAY EMBANKMENT CONSTRUCTION

Technical Memorandum

TEMPORARY IMPACTS TO WETLANDS DURING THIRD RUNWAY EMBANKMENT CONSTRUCTION

Seattle-Tacoma International Airport
Third Runway Project

June 15, 1999

Prepared For:
The Port of Seattle, and
Parametrix, Inc.

Prepared By:
HNTB Corporation

Temporary Impacts to Wetlands during Third Runway Embankment Construction

Introduction

Construction of the Third Runway will require filling low areas west of the current airfield to raise the existing grade to approximately 400 feet MSL. This construction will require unavoidable placement of fill in existing wetlands. Temporary impacts to wetlands will result from facilities needed to meet water quality standards for construction runoff, construction dewatering, construction access, and construction staging. The facilities and activities that will result in temporary impacts to wetlands and streams are discussed below and summarized in Table 1.

Temporary construction in some of the wetlands west of the toe of the runway embankment is unavoidable because certain construction activities must occur outside (west of), but in close proximity to the footprint of the embankment where wetlands are located. Construction impacts to wetlands west of the embankment are considered temporary because following completion of construction, these impacts will be removed and the wetland areas restored to pre-construction conditions. Where feasible and consistent with FAA requirements regarding wildlife attractants, existing wetlands will be enhanced (i.e. wetlands dominated by non-native vegetation will be replanted with native species). Permanent facilities west of the runway embankment, such as storm water detention facilities, will generally be constructed outside of existing wetlands.

Storm water runoff from construction areas requires water quality treatment facilities to prevent water quality impacts to Miller Creek due to potential sedimentation. The proposed storm water treatment facilities must be constructed in low areas (which are often wetlands) and parallel to the embankment footprint (which requires crossing wetlands) to intercept construction runoff prior to entering Miller Creek. Specific storm water facilities that must be placed at the toe of the embankment slope include:

- erosion control fencing
- collection and conveyance swales
- sedimentation ponds
- pumping facilities (including power generators)
- treatment facilities (including pumps and power generators).

Additional facilities required to monitor and maintain the storm water facilities include the following. These facilities will be sited to avoid wetlands as much as possible:

- support facilities (including a trailer, parking, and material storage)
- access driveways.

In addition, the following construction activities may occur near the proposed toe of slope. These activities will also be sited to avoid wetlands, however, minor wetland impacts may occur due to temporary access roads and drainage features to support these facilities:

- contractor office space
- construction material storage
- materials testing laboratory
- concrete batch plant
- construction equipment parking and servicing

These temporary construction facilities will be removed following completion and stabilization of the embankment. Following project completion, the wetlands will be restored by:

- replacing or amending fill material with topsoil
- restoring drainage patterns and directing surface water to the wetlands
- hydroseeding disturbed areas
- replanting areas with native trees and shrubs.

Storm Water Management During Construction

This section describes the temporary drainage facilities required to meet water quality standards for the project during construction. Runoff from the embankment construction area generally flows south and west, eventually draining to one of three drainage basins. The three drainage basins within the third runway project area are:

- Miller Creek Drainage (MC)
- Walker Creek Drainage (WC) (a sub-drainage basin of Miller Creek)
- Des Moines Creek Drainage (DC)

The existing varying terrain and the proposed grading limits within the Miller Creek drainage basin require that the basin be divided into two sub-basins: Miller Creek North (MCN) and Miller Creek South (MCS). In order to manage construction runoff, temporary sedimentation ponds and treatment facilities will be constructed to serve each of the drainage basins. Plan views of the drainage basins and the conceptual construction storm water management system are depicted in Figure 1 through Figure 4.

Storm water runoff will generally be collected and conveyed to the sedimentation ponds by gravity-flow rock- or grass-lined swales. However, the lowest portions of the Miller Creek basin and the Walker Creek basin are wetlands (Wetland 37 and 44 respectively). To reduce impacts to these wetlands, construction runoff draining to these low areas will be collected in small collection ponds (sumps) and pumped to larger sedimentation ponds located upslope. The larger, upslope facilities are located in non-wetland areas to reduce wetland impacts and reduce the risk of potential encroachment into wetlands. The sumps needed to collect runoff were sized and located to reduce wetland impacts, yet provide an adequate margin of safety to prevent unauthorized storm water discharge to wetlands during emergency conditions (i.e., extreme storm events or power failures).

In order to collect runoff from the outer edge of the embankment and beyond the proposed Security Road, a temporary outer collection swale will be constructed (Figure 5-8). The swale is intended to have dual uses. First, it will collect construction runoff from the outermost portion of the embankment during the initial phases of construction and route the water to a sedimentation and treatment facility until the ground surface is established. Secondly, after establishment of the new embankment side slopes, the swale may be used as a distribution channel to direct clean runoff water to specific wetlands. Water may be distributed to wetlands using a variety of techniques, including point discharges, perforated pipe, porous rock berms, or infiltration swales. Portions of the outer swale will remain following construction to replace the conveyance functions of drainage channels filled by the project.

To service the outer collection channel during construction, as well as to provide construction access along the silt fence and the outermost fill slope, a temporary access road will be constructed (Figures 5-8). The access road will generally be constructed at or very near existing grade to minimize ground disturbance. It will not be paved and it is not intended to be used as a construction haul road.

Table 1. Temporary Construction Impacts to Wetlands Resulting From Construction of the Third Runway Embankment.

Wetland Number	Description of Facility	Purpose and Need
R2	Pond outlet pipe.	Outlet pipe from MCN-a detention pond must discharge to Miller Creek to maintain drainage basin boundary. Construction access to install pipe is required.
A5	Temporary access drive, outer collection swale, silt fence.	A swale at the edge of the construction area is necessary to collect and convey runoff to the MCN-b pond. A temporary access road will allow service and maintenance in the swale and allow installation and maintenance of a silt fence. The road, swale and fence will be removed following construction and soil stabilization.
35d	Temporary access drive, outer collection swale, silt fence, pumping facility.	A swale at the edge of the construction area is necessary to collect and convey runoff to the MCN-c holding pond. Water from the MCN-c pond will be pumped to the MCN-b pond for treatment if necessary. A temporary access road will allow service and maintenance in the swale and allow installation and maintenance of the silt fence. The road, swale and fence will be removed following construction and soil stabilization.
18	Temporary access drive, outer collection swale, holding pond (MCN-c), silt fence.	A swale at the toe of the proposed slope is necessary to collect and convey runoff to the MCN-c holding pond. The holding pond will collect construction runoff up to approximately elevation 350. Water from the pond will be pumped to the MCN-b pond for treatment if necessary. A temporary access road will allow service and maintenance in the swale and the pond, and will allow installation and maintenance of the silt fence. The road, swale, pond, and fence will be removed following construction and soil stabilization.
37a	Temporary access drive, Interim sump (MCN-d), pumping facility, silt fence.	A swale at the toe of the proposed slope is necessary to collect and convey runoff to the MCN-d sump. The sump will only collect construction runoff originating from the lowest portion of the embankment, up to approximately elevation 250. Water from the sump will be pumped to the MCN-b pond for treatment. After construction of the adjacent embankment (during the first 1-2 years of construction,) the sump will be removed and the wetland restored. A temporary access road will allow service and maintenance in the swale and the sump, and will allow installation and maintenance of the silt fence. To reduce wetland impacts, no access road will be provided in the extreme lowest portion of the embankment. The road, swale, sump, and fence will be removed following construction and soil stabilization.
Water B	Temporary access drive, outer collection swale, silt fence.	A swale at the edge of the construction area is necessary to collect and convey runoff to the MCN-c pond. A temporary access road will allow service and maintenance in the swale and allow installation and maintenance of the silt fence. The road, swale and fence will be removed following construction and soil stabilization.

Table 1. Temporary Construction Impacts to Wetlands Resulting From Construction of the Third Runway Embankment (continued).

Wetland Number	Description of Facility	Purpose and Need
A12	Temporary access drive, outer collection swale, silt fence.	A swale at the edge of the construction area is necessary to collect and convey runoff to the MCN-c pond. A temporary access road will allow service and maintenance in the swale and allow installation and maintenance of the silt fence. The road, swale and fence will be removed following construction and soil stabilization.
A13	Temporary access drive, outer collection swale, silt fence.	A swale at the toe of the proposed slope is necessary to collect and convey runoff to the MCN-c pond. A temporary access road will allow service and maintenance in the swale and allow installation and maintenance of the silt fence. The road, swale and fence will be removed following construction and soil stabilization.
41a	Temporary access drive, outer collection swale, Miller Creek South pond (MCS), silt fence.	A swale at the toe of the proposed slope is necessary to collect and convey runoff to the MCS pond. A temporary access road will allow service and maintenance in the swale and the pond and allow installation and maintenance of the silt fence. The pond is necessary for sedimentation and treatment of runoff from the southern portion of the Miller Creek drainage basin. The pond is located in the lowest area so it will collect runoff from the embankment to the east as well as staging areas to the north, west, and south.[1]
41b	Temporary access drive, outer collection swale, silt fence.	A swale at the edge of the construction area is necessary to collect and convey runoff to the MCS pond. A temporary access road will allow service and maintenance in the swale and the pond and allow installation and maintenance of the silt fence. The road, swale, pond and fence will be removed following construction and soil stabilization.
44a	Temporary access drive, outer collection swale, interim sump pond (WC-b), silt fence.	A swale at the edge of the construction area is necessary to collect and convey runoff to the WC-b sump. A temporary access road will allow service and maintenance in the swale and the pond and allow installation and maintenance of the silt fence. Access to the extreme lowest portion of the Walker Creek basin will be provided only from the south to reduce impacts to the wetland. The sump will collect water from outside the toe of the retaining wall where it will be pumped to the Walker Creek sedimentation pond (WC-a.) After the retaining wall is constructed and the surrounding ground reestablished, the sump will be removed and the ground restored.

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[1] Because this wetland will be impacted throughout the duration of runway construction (4 - 5 years, the impact is considered permanent and included in on-site and off-site mitigation plans. This wetland will not be restored following construction.

Construction Dewatering

Two types of construction dewatering will occur during construction of the runway embankment. The first involves interception of existing ground water flow and the second involves localized drawdowns of the shallow water table.

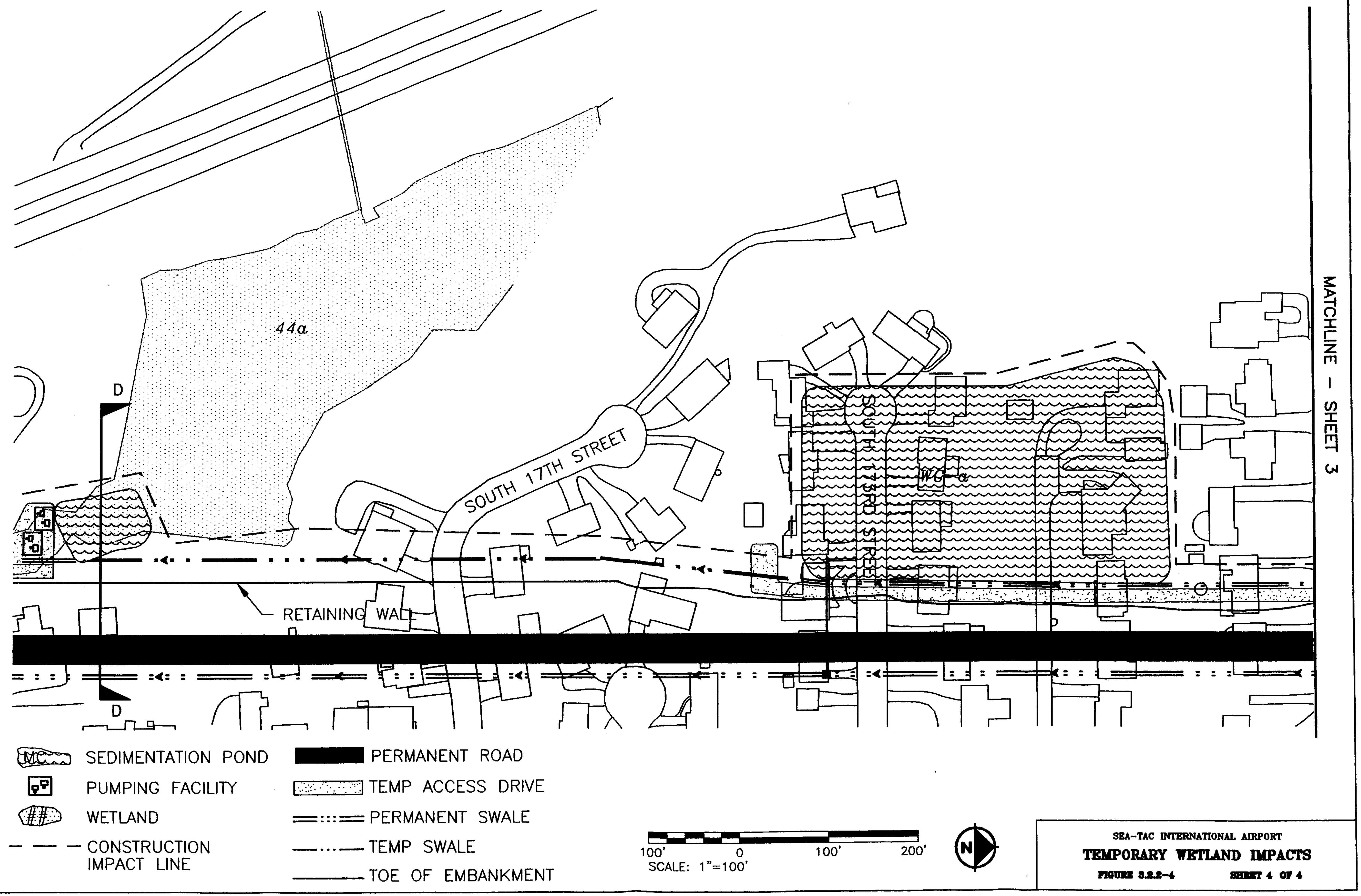
Prior to beginning construction, any existing surface flows through the work area will be routed through or around work areas via temporary piping. This will allow clean runoff water to be intercepted and discharged to the creek or wetlands and will reduce the amount of construction runoff needing water quality treatment.

Dewatering of ground water in isolated areas within the embankment will be necessary in areas where excavation of existing unsuitable material is needed. Based on preliminary geotechnical investigations, excavation of unsuitable material will be necessary for structural and seismic stability beneath the proposed retaining walls and in areas where existing soils may cause stability or settlement problems in the constructed embankment.

Removal of soft sub-soils (unsuitable material) will consist of excavating the unsuitable materials to depths where firm bearing soils are present. The excavation areas will be backfilled with structural fill or foundation material suitable for supporting the anticipated loads. Prior to excavating and backfilling, temporary wells or well points will be bored to draw down the surrounding water table. The draw down area will be localized by strategic placement of the wells, adjustment of the pump rates from the wells, or installation of temporary sheet piling. Water from the wells will be discharged to the surrounding wetlands or creek outside of the construction area as long as water quality is maintained. Hoses, sprinklers, spreaders or other methods will be utilized to distribute the water as necessary to adjacent wetlands.

The dewatering wells will be in operation at specific work areas (such as at the retaining wall areas) for as long as necessary to allow completion of any excavation of unsuitable material, foundation construction and embankment placement. The wells will be removed after the foundation is completed or the embankment grade is sufficiently above the natural ground water table that further construction activities will not be adversely affected by ground water. After removal of the wells, the ground water will be allowed to return to its natural elevation.

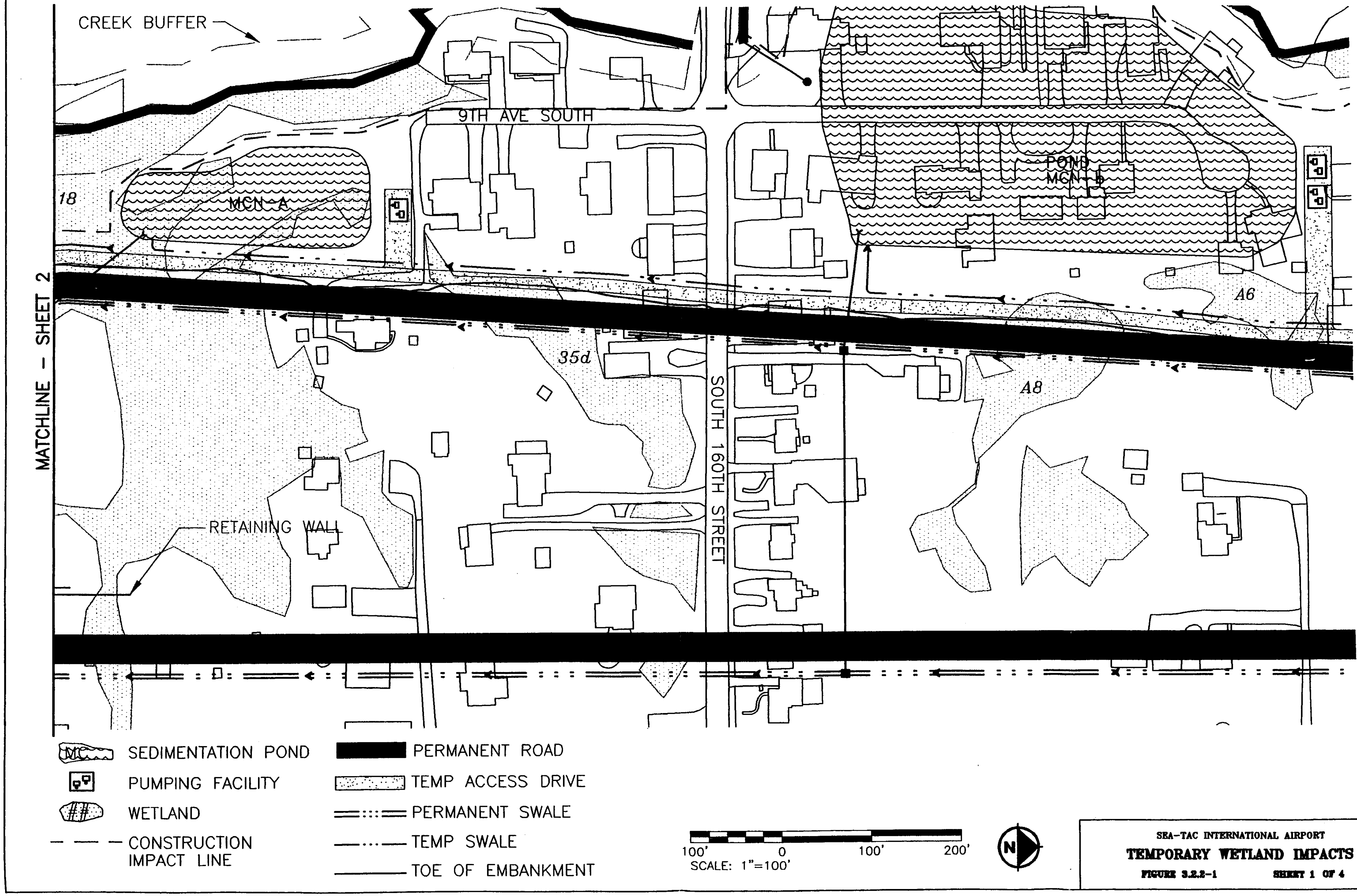
Due to the short duration of the dewatering operations coupled with the mitigating measures, significant adverse impacts to wetlands are not expected. The localization of the drawdown areas to the minimum size needed for construction, the re-distribution of groundwater to adjacent wetlands, and the routing of water from upslope areas to wetlands downslope of the construction will prevent significant dewatering impacts from occurring in downslope wetlands.



SEA-TAC INTERNATIONAL AIRPORT

TEMPORARY WETLAND IMPACTS

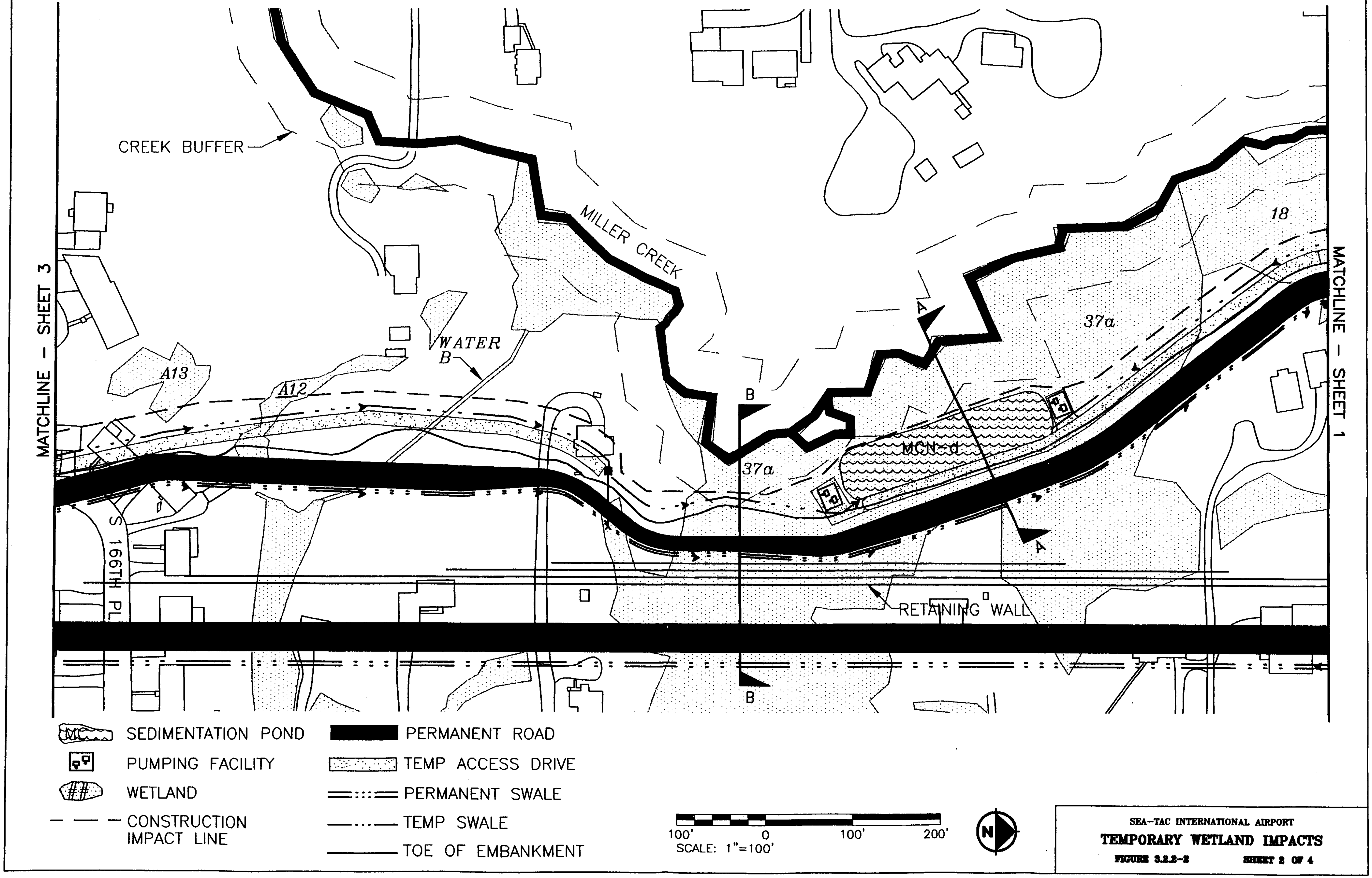
FIGURE 3.2.2-4 SHEET 4 OF 4



SEA-TAC INTERNATIONAL AIRPORT

TEMPORARY WETLAND IMPACTS

FIGURE 3.2.2-1 SHEET 1 OF 4



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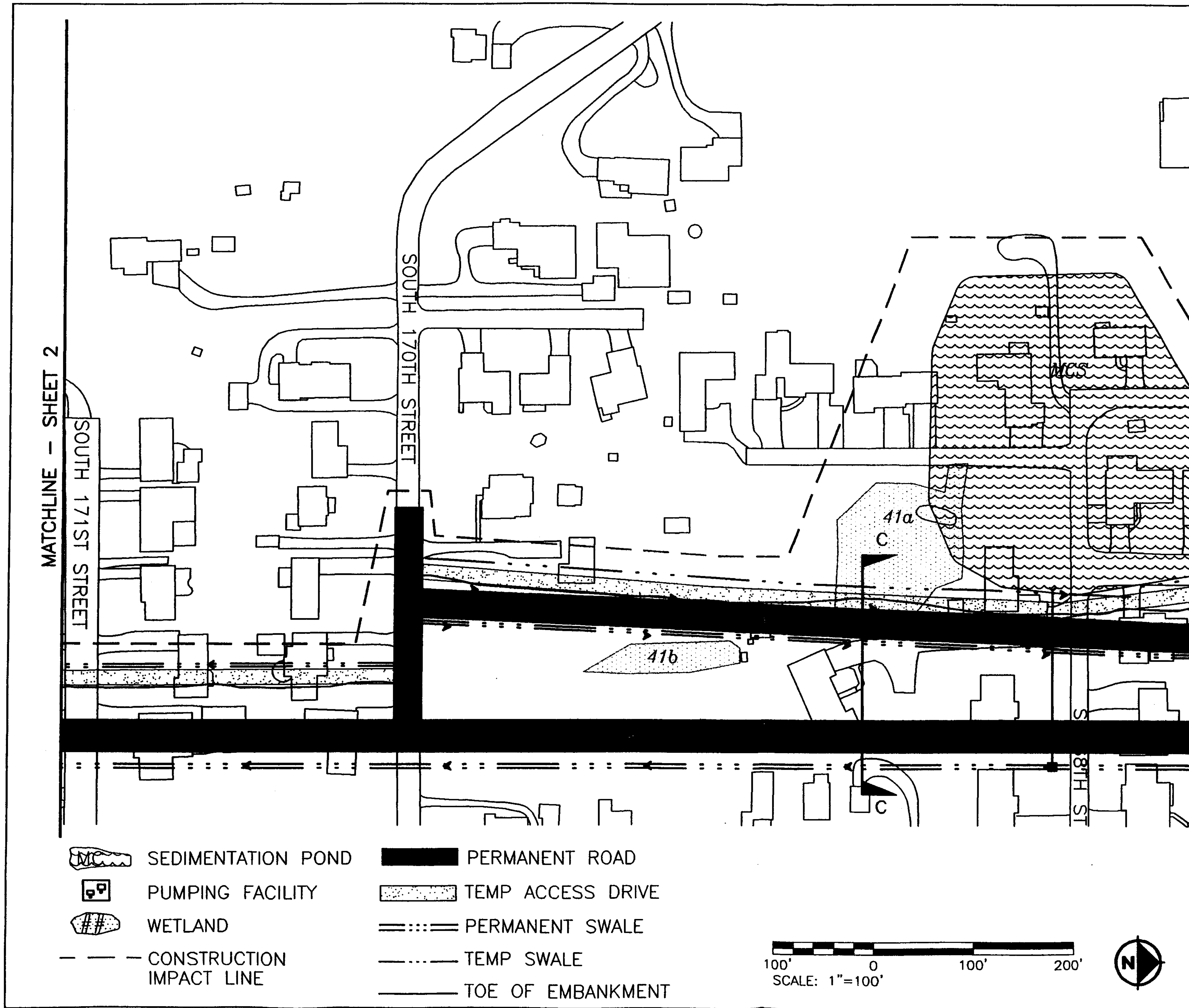
TEMPORARY WETLAND IMPACTS

FIGURE 3.2.2-2 SHEET 2 OF 4



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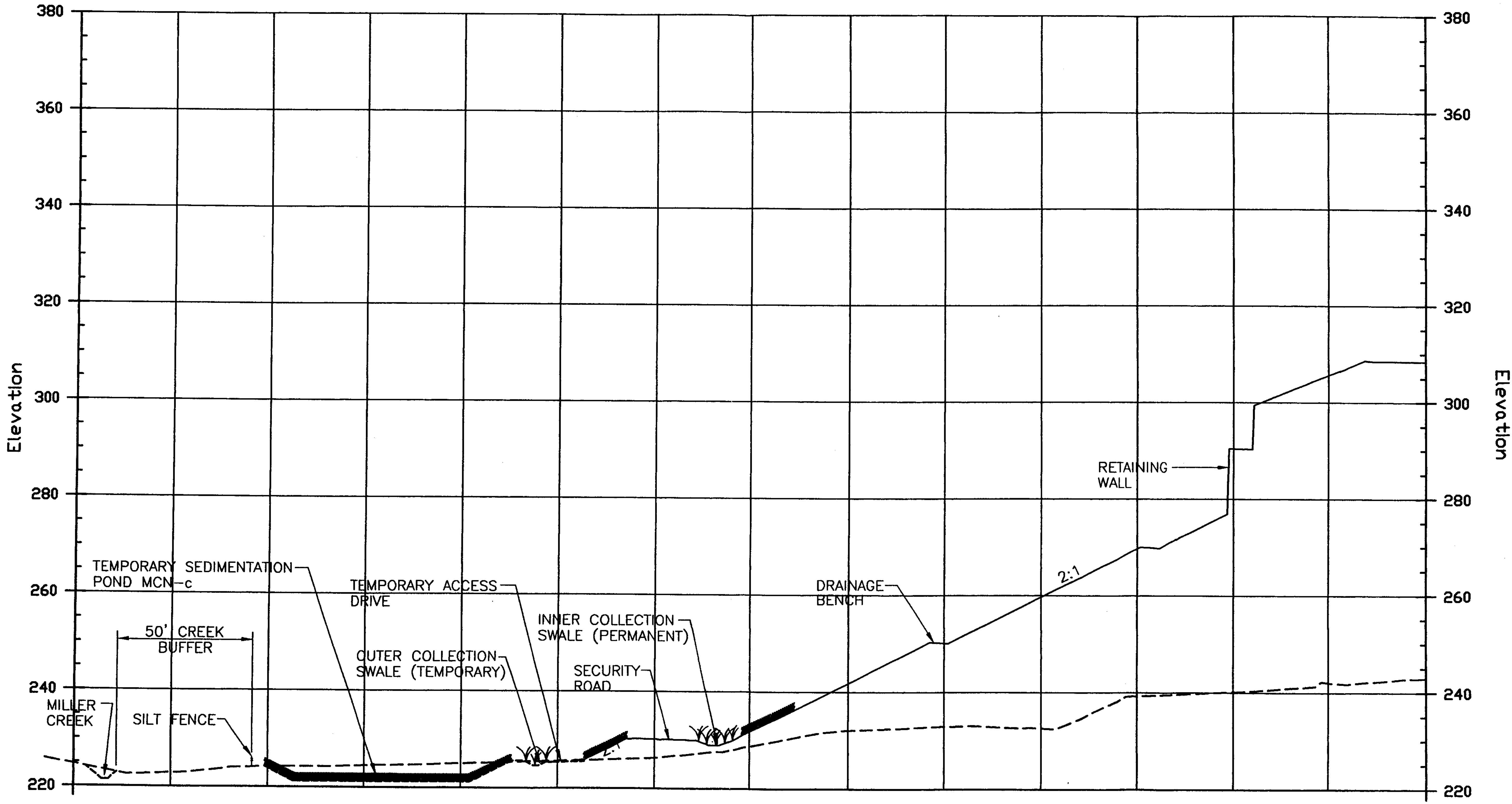
TEMPORARY WETLAND IMPACTS

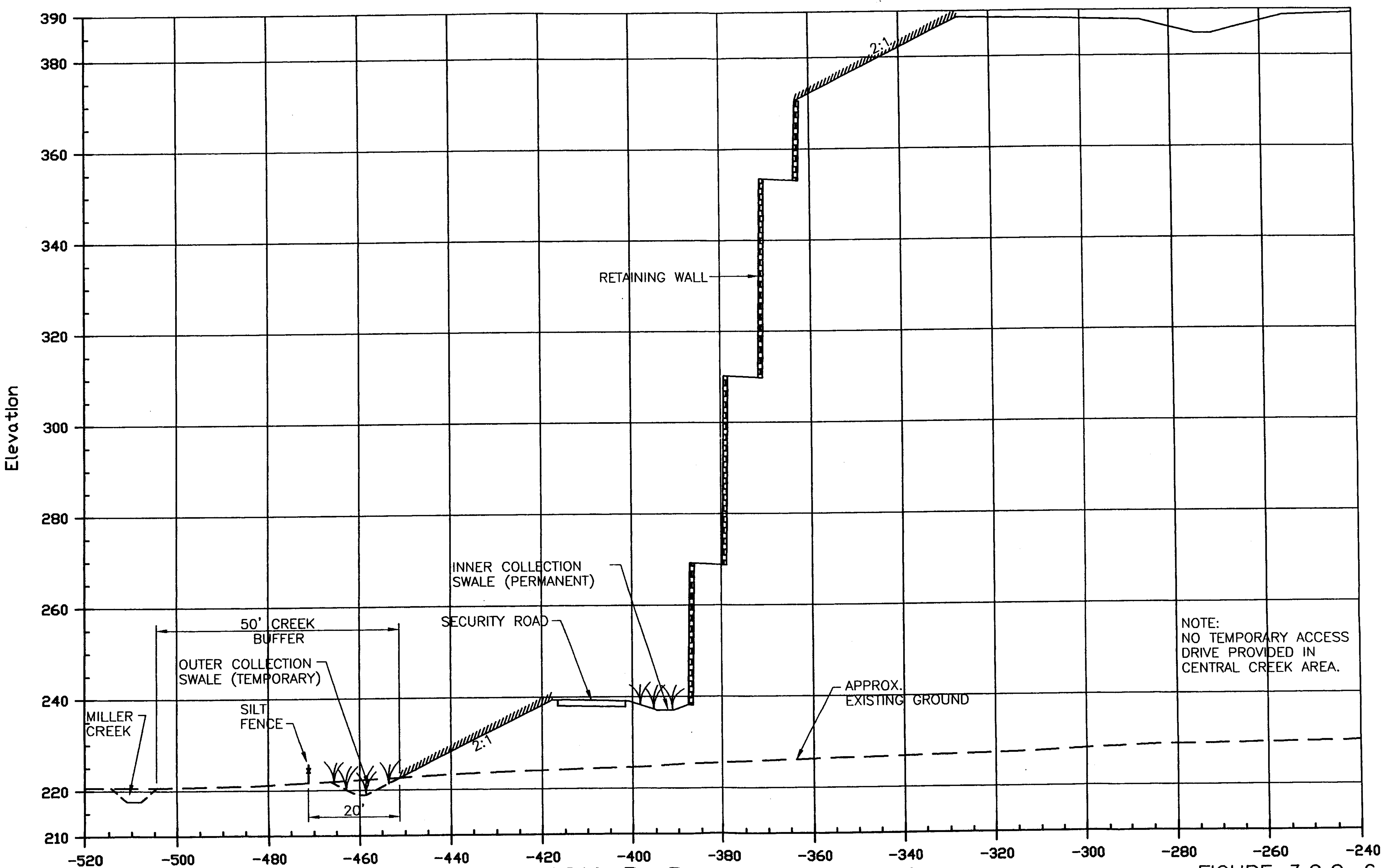
FIGURE 3.2.2-3 SHEET 3 OF 4



SECTION A–A

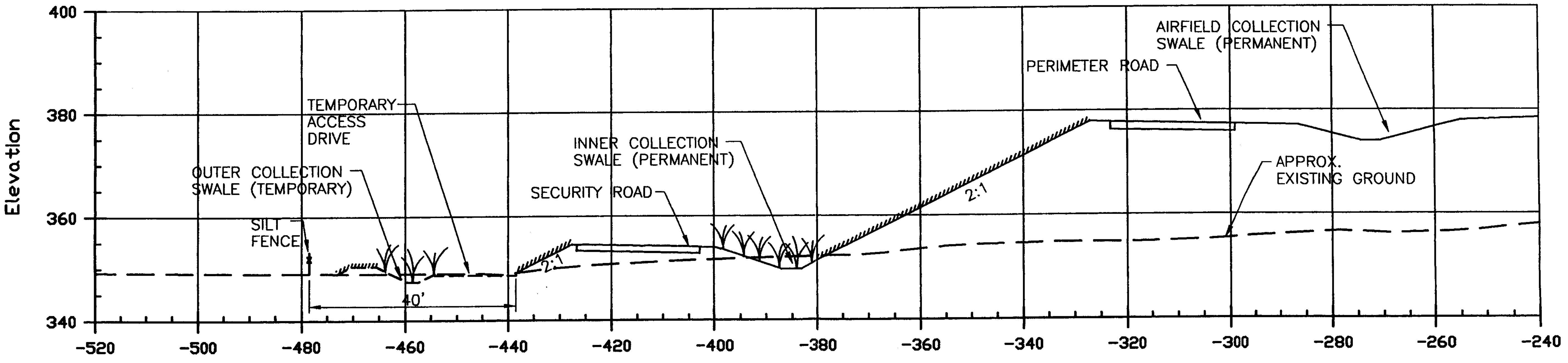
STATION 184+00 (PERPENDICULAR TO FILL SLOPE)

FIGURE 3.2.2–5



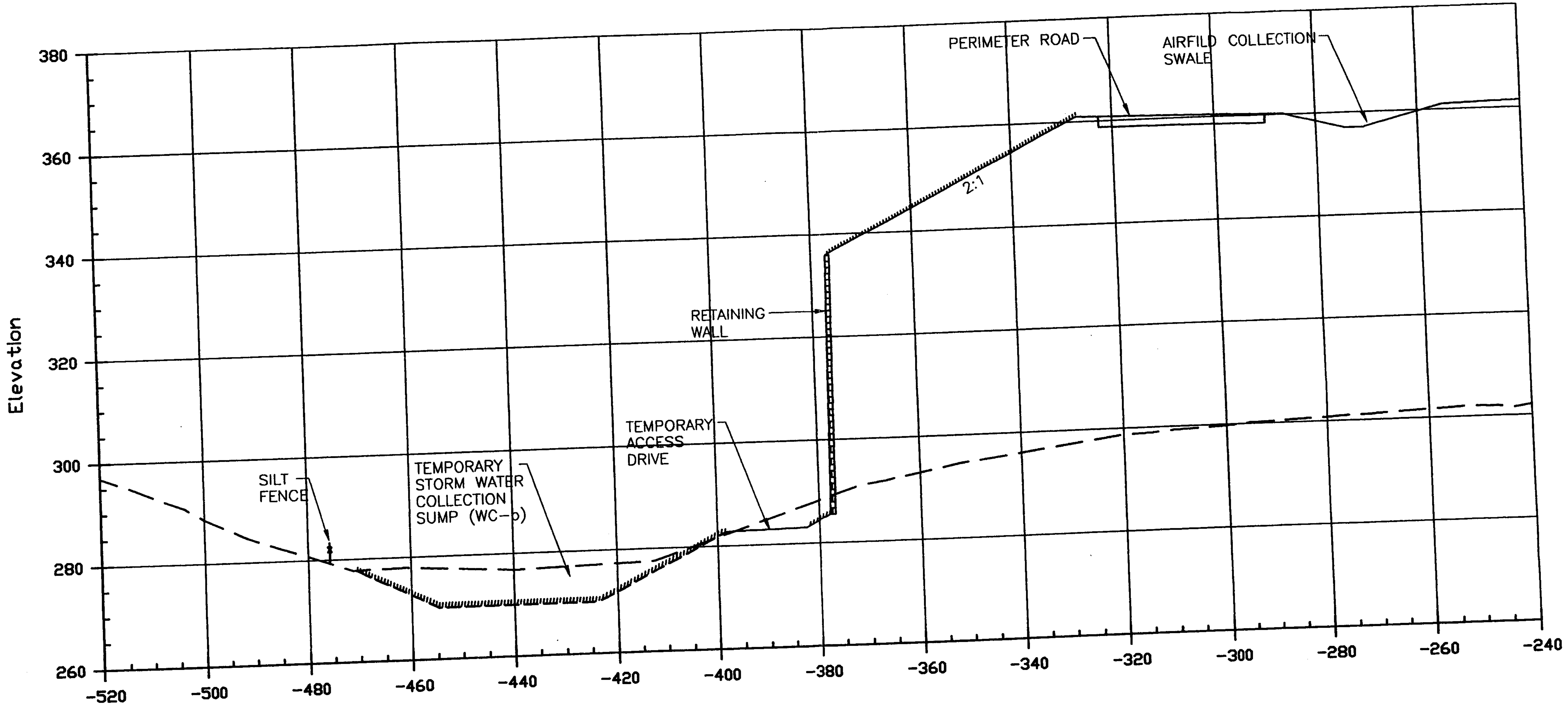
SECTION B–B STATION 179+00

FIGURE 3.2.2–6



SECTION C–C
STATION 165+00

FIGURE 3.2.2–7



SECTION D–D
STATION 143+00

FIGURE 3.2.2–8

Technical Memorandum

EROSION AND SEDIMENTATION CONTROL DURING THIRD RUNWAY EMBANKMENT CONSTRUCTION

Seattle-Tacoma International Airport
Third Runway Project

November 12, 1999

Prepared For:
The Port of Seattle

Prepared By:
HNTB Corporation

Erosion and Sedimentation Control During Third Runway Embankment Construction

I. Introduction

Placement of earth and gravel fill material necessary for the proposed Third Runway embankment and other construction projects associated the Seattle-Tacoma International Airport Master Plan Update will be completed over several years. During the multi-year embankment project, material placement will be completed over much of the annual periods, including the wetter months, in order meet the project schedule. Embankment construction during the wetter times of the year could generate stormwater runoff containing silt, sand, or other suspended solids in excess of permit requirements. This technical memorandum describes the approach for collection, storage, treatment, and discharge stormwater runoff during embankment construction in order to meet required water-quality standards. These or similar methods were successfully implemented during the 1998-1999 construction period. Despite wet weather construction during record periods of heavy rain, all storm water discharges were achieved.

II. Construction Stormwater Standards

The Washington State Water Quality Standards (WAC 173-201A) requires that runoff from construction projects not increase receiving stream turbidity by more than 5 NTU (Nephelometric Turbidity Units). To meet those requirements, standard BMPs will be constructed and maintained as necessary in and around the embankment construction areas. Standard BMPs can be utilized to remove most of the suspended solids in the stormwater while also providing conveyance and retention. However, due to the large scale of the proposed third runway project, combined with the proximity of the construction sites to Miller Creek, Walker Creek, and Des Moines Creek, standard BMPs alone will likely not satisfy water quality requirements for turbidity. The standard BMPs have not historically provided adequate removal of very small (colloidal) suspended particles from the embankment runoff. Even with liberal application of standard BMPs throughout the project site, experience on previous projects indicates that additional treatment of construction stormwater runoff may be necessary to meet water quality standards for turbidity.

Standard BMPs alone will not provide the level of safety desired by the Port to assure that water quality requirements will be achieved during Third Runway Embankment construction. Therefore, additional or supplemental stormwater treatment is proposed as part of the Third Runway Embankment Construction Erosion and Sedimentation Control Plan (CESCP) to provide assurance that water quality requirements will be met and wet weather construction will be allowed. Specific supplemental stormwater treatment systems are described in the 1999 Draft Ecology Stormwater Management Manual. It is anticipated that the type of supplemental stormwater treatment system described in the draft Ecology Manual will be utilized during embankment construction to control erosion and sediment. The following section summarizes the anticipated overall Third Runway

Embankment CESCP, including the use of standard and experimental BMPs during construction. Development of the Third Runway Embankment CESCP is based on experience gained on wet-weather embankment projects completed in 1998 and 1999, as well as other projects in the region.

III. 1998 and 1999 Embankment Projects

During the spring, summer, and fall of 1998 and 1999, approximately 1.8 million cubic yards of embankment was placed in the northwest corner of the existing airfield. Standard construction erosion and sedimentation controls for the 1998 and 1999 projects included the following standard BMPs:

- silt fence
- grass and rock-lined swales,
- check dams,
- sediment traps,
- a large sedimentation pond,
- a truck wheel wash,
- soil coverings (bonded fiber matrix)
- hydroseeding

In addition to the above BMPs, the top of the embankment was sloped away from the embankment face at all times during fill placement. This reduced erosion by preventing runoff from the top of the fill from flowing down the embankment face. Collection of runoff from the top at the back of the embankment also allowed flexibility in routing the runoff to gain the most benefit from the standard BMPs. In addition, only fill material containing a lower percentage of very fine particles was placed during periods of wet weather to reduce the amount of sedimentation generated in the construction stormwater runoff.

Even with the above-described controls, it was determined early in the 1998 project that standard BMPs alone would not provide the treatment necessary to consistently meet DOE stormwater quality requirements for turbidity. Potential supplemental treatment systems were evaluated to ensure that water quality discharge standards would be achieved throughout construction.

A polymer stormwater batch treatment system was selected to provide supplemental stormwater treatment prior to discharge. The treatment system developed for these embankment projects was approved as an experimental BMP by the Department of Ecology. A brief summary of the supplemental treatment system constructed for the 1998/1999 embankment projects follows.

IV. 1998/1999 Supplemental Treatment Summary

Construction runoff containing suspended solids (silt and/or sand) was intercepted in collection swales and collected in a large sedimentation pond. Under standard Department of Ecology design criteria, stormwater would normally be discharged from the sediment pond after a pre-determined "residence time" which, in theory, would result in satisfactory water quality conditions. The pond and standard BMPs helped remove the larger particles, but the polymer treatment system further cleaned the runoff water by removing the smaller suspended fine particles (colloidal particles) that the standard BMPs could not adequately remove. The polymer treatment system developed for this project involved pumping of stormwater runoff from the sedimentation pond into one of several lined treatment cells constructed adjacent to the sedimentation pond. Each treatment cell acted as an individual mixing tank/settling pond in which liquid flocculents were added at closely monitored rates. The flocculents, when properly mixed with silt-laden water, cause the suspended particles to "bind". to each other creating a heavier particle. Eventually gravity causes the flocculents and silt particles to settle to the bottom of the cell (precipitation). After testing of the water in the cell to verify quality parameters, it is pumped to a roadside storm drainage system that ultimately discharges to Miller Creek. The cell is then refilled with silt-laden water and the process started again. The sludge that accumulates at the bottom of the cells is removed with vacuum trucks as needed and disposed of at approved disposal areas off Port property.

The process was extremely successful, with stormwater discharges from the 1998 embankment site exceeding water quality standards throughout the winter of 1998/1999, a record setting season for precipitation. Much of the treated water discharge was at or below creek turbidity, and at no time was the discharge greater than 5 NTU above the creek background turbidity. The treatment system resulted in construction storm water discharges far exceeding water quality standards, which call for no *increase* of background creek turbidity greater than 5 NTU.

In accordance with the approved BMP request, water quality monitoring and testing were regularly preformed on the treated water prior to discharge. The monitoring included tests for pH, turbidity, and settleable solids, as well as bioassays to assess treated water toxicity. The bioassays were performed by a Department of Ecology accredited laboratory and test results indicated 100% conformance to Department of Ecology construction stormwater quality criteria, including toxicity, pH, and turbidity. Approximately 15 million gallons of construction stormwater were treated without incident during the winter of 1998/1999.

A similar treatment system has been used for a private development project in Redmond, WA. Through November 1997, approximately 40 million gallons of storm water had been treated and discharged without incident.

Although effective, the batch treatment process used is labor intensive. Ongoing research is being conducted to evaluate other potential supplemental treatment systems that will improve on the batch treatment system used in 1998 and 1999.

Chemical treatment of construction stormwater runoff is a relatively new application of technology that is used extensively by municipalities for drinking water and wastewater treatment. The application of this technology is fostered by increasing standards for environmental protection and the need for extended construction seasons for large projects. The Puget Sound region, in particular the Cities of Redmond and Issaquah, Washington, are national leaders in the development of chemical treatment for construction stormwater management. Chemical treatment of construction stormwater runoff is being used for a number of both public and private development projects in those cities. It is anticipated that chemical treatment of construction stormwater runoff will become more widely used due to increased scrutiny of the effectiveness of current BMPs and greater enforcement of water quality standards to protect fish and fish habitat protected under the Endangered Species Act.

V. Future Embankment Projects

This section describes a general sequence of embankment construction and the associated erosion and sedimentation control facilities anticipated for use during future construction. Contract specifications for future embankment projects will include detailed construction phasing and sequencing plans with associated stormwater runoff controls necessary for each phase of construction. The contract documents may allow the construction sequencing plan contained in the contract documents to be tailored to best suit the operations of a general contractor. However, the stormwater runoff standards and treatment approach cannot be modified by any contractor-proposed revision to the sequence of construction contained in the plans.

Conceptual Construction Sequencing & Associated Storm Water Treatment

Generally, Third Runway embankment placement is anticipated to begin in the lowest portions of the area to be filled. The lowest portion of the topography also corresponds to one of the more environmentally sensitive areas within the project boundaries (due to adjacent wetlands and proximity to Miller Creek).

Stormwater runoff naturally flows to this low point of the site. In order to reduce the impacts to wetlands in this low area, no large sedimentation pond will be constructed in this area as would typically be necessary for stormwater control. One or more collection "sumps" or small ponds will be constructed. These "sumps" are intended to collect construction runoff that flows to this low area, but are not intended to hold the runoff water for settling or supplemental treatment. Instead, runoff collected by these sumps will be pumped to larger sedimentation ponds and supplemental treatment facilities located upstream of the low point and outside of wetlands. The larger, upslope sedimentation pond and treatment facilities will be located in non-wetland areas to reduce wetland impacts and reduce the risk of potential encroachment into wetlands.

The sumps needed for runoff collection will be sized to reduce wetland impacts, yet provide an adequate margin of safety to prevent unauthorized stormwater discharge during emergency conditions (i.e. extreme storm events or power failures). The capacity of the combined sumps and pump systems will be sized to accommodate at least twice the required stormwater runoff volume.

Runoff water will be diverted directly to the upstream sedimentation pond and treatment facilities once embankment construction reaches a height that will allow runoff to gravity flow directly to the sedimentation pond(s). After settling in the sedimentation ponds and supplemental treatment as necessary, runoff water will be released to Miller Creek.

Standard BMPs will be constructed and maintained throughout the work area, including the low-point construction area. The BMPs may include, but will not be limited to, silt fence, cutoff swales, rock check dams, truck wheel washes, and fabric erosion control matting. Embankment side slopes will be covered with bonded fiber matrix, hydroseeding, and/or erosion matting as necessary as soon as possible following finish grading. Runoff water flowing into the sumps in the low portions of the site will continue to be pumped to sedimentation ponds and treatment facilities as needed ensure water quality standards are met. When the side slopes in the area have been established with vegetative growth (hydoseeding) and the runoff meets water quality standards without additional settling or treatment, pumping will cease. Water flowing into the sumps will then be allowed to flow into drainage channels and eventually to Miller Creek or the adjacent wetlands via point discharges, perforated pipe, porous rock berms, or infiltration swales as appropriate.

Runoff from construction areas outside the lowest topographical areas will be routed directly to sedimentation ponds and supplemental treatment facilities (as needed) located west of the construction zone and outside of wetlands. In general, a temporary cutoff swale will be constructed just outside (west) of the toe of the embankment prior to any site preparation or material placement. The cutoff swale will intercept construction runoff from the work area and divert it to previously constructed sedimentation ponds/treatment facilities.

To protect the outer fill slopes from erosion throughout the embankment program, fill will be placed to always slope back from the toe of the slope (to the east) as was successfully accomplished during the 1998 Embankment. A collection channel at the back of the embankment will collect stormwater runoff from the top of the fill and flow to the sedimentation ponds/treatment facilities, similar to the collection method used for the 1998 Embankment. The exposed face of the fill slope will be stabilized with hydroseeding and/or erosion matting as soon as possible following finish grading.

A conceptual storm drainage plan is shown in Figure 1, and sequential cross sections of the embankment during construction are depicted in Figures 2 and 3. Embankment will be placed in phases over several years. The exposed surface area at any given time during construction will be limited to an area equal to or less than the area of exposed surface that would generate turbid runoff in excess of the capacity of the stormwater treatment systems, less an appropriate factor of safety. Capacity of the various treatment systems (including ponds and supplemental treatment) is dependent on several varying factors and that will also influence the area of allowable exposed surface. The factors include existing soils type, fill material type, season of construction activity, and type of supplemental treatment system. On-going planning and research is being conducted to determine the construction phasing schedule and combination of treatment systems that will best meet project needs, including water quality requirements.

Special Considerations

- Pond Sizing and Overflow:
  The sedimentation ponds, sump ponds, swales, pumps, and supplemental treatment facilities necessary for a particular work area will be constructed and operational prior to fill placement. The facilities will be designed to accommodate the runoff flow that can be expected, in accordance King County and Ecology Requirements. In the unlikely event stormwater runoff volume in the ponds exceeds the design storm, pond overflow structures will be provided to allow controlled overflow discharges to minimize potential damage from the overflow. Backup power supply sources will be available for the pumping and treatment systems that require power to operate, and at least one-foot of freeboard will be provided in sedimentation ponds.

- Supplemental Treatment:
  As with the previous projects, supplemental stormwater treatment in addition to standard BMPs may be provided to ensure water quality standards are met throughout the embankment construction program. Potential supplemental treatment systems include:

  - Chemical batch treatment cells (i.e.: 1998/1999 system)
  - High-volume mechanical filtering devices, with or without chemical treatment
  - Flow-through clairifiers, with or without chemical treatment
  - Flow-through ponds, with chemical treatment

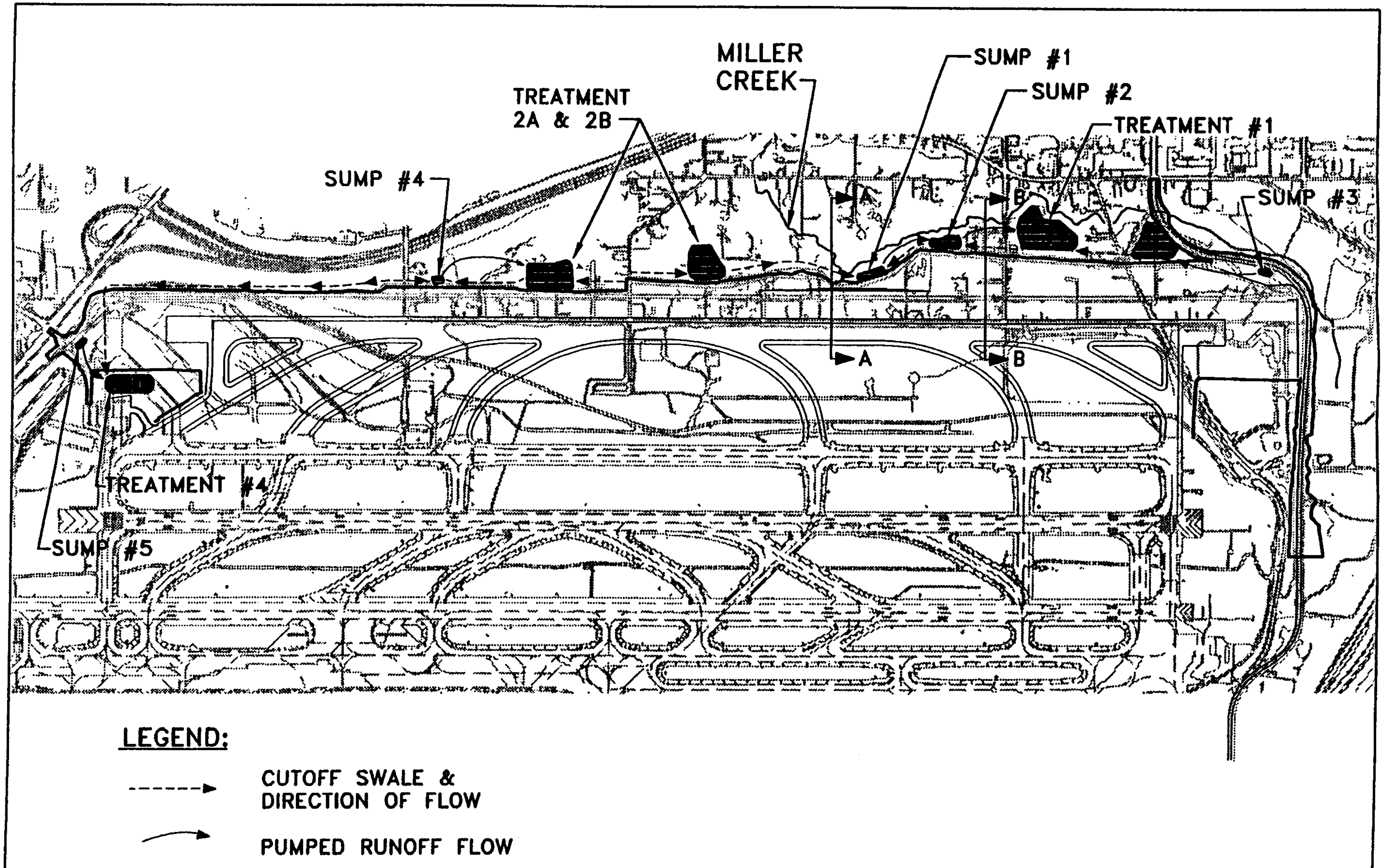
  On-going research is being conducted to develop the experimental BMPs that will achieve water quality standards and best fit the needs of the Third Runway Embankment projects. It is expected that the approved experimental BMPs will utilize one or more of the above supplemental treatment systems.

  Supplemental treatment will be provided as necessary to meet runoff water quality requirements throughout future embankment programs. The supplemental treatment system(s) will be approved for use by the Department of Ecology prior to operation. The BMP request will also include detailed description of the water testing and quality assurance program, similar to the testing program developed for the 1998/1999 batch treatment system. The specific treatment systems to be utilized for the future embankment programs will be chosen based on past experience, the ability to fulfill project requirements for performance and reliability, and DOE approval.

- Pumping:
  Pumping of stormwater runoff will allow flexibility in locating sedimentation ponds and thereby reduce wetland impacts. Pumping of stormwater was a key component of the successful 1998/1999 Embankment project. Pumping in 1998/1999 was achieved utilizing trailer-mounted portable pumps. Similar pumps are anticipated to be used during future embankment programs.

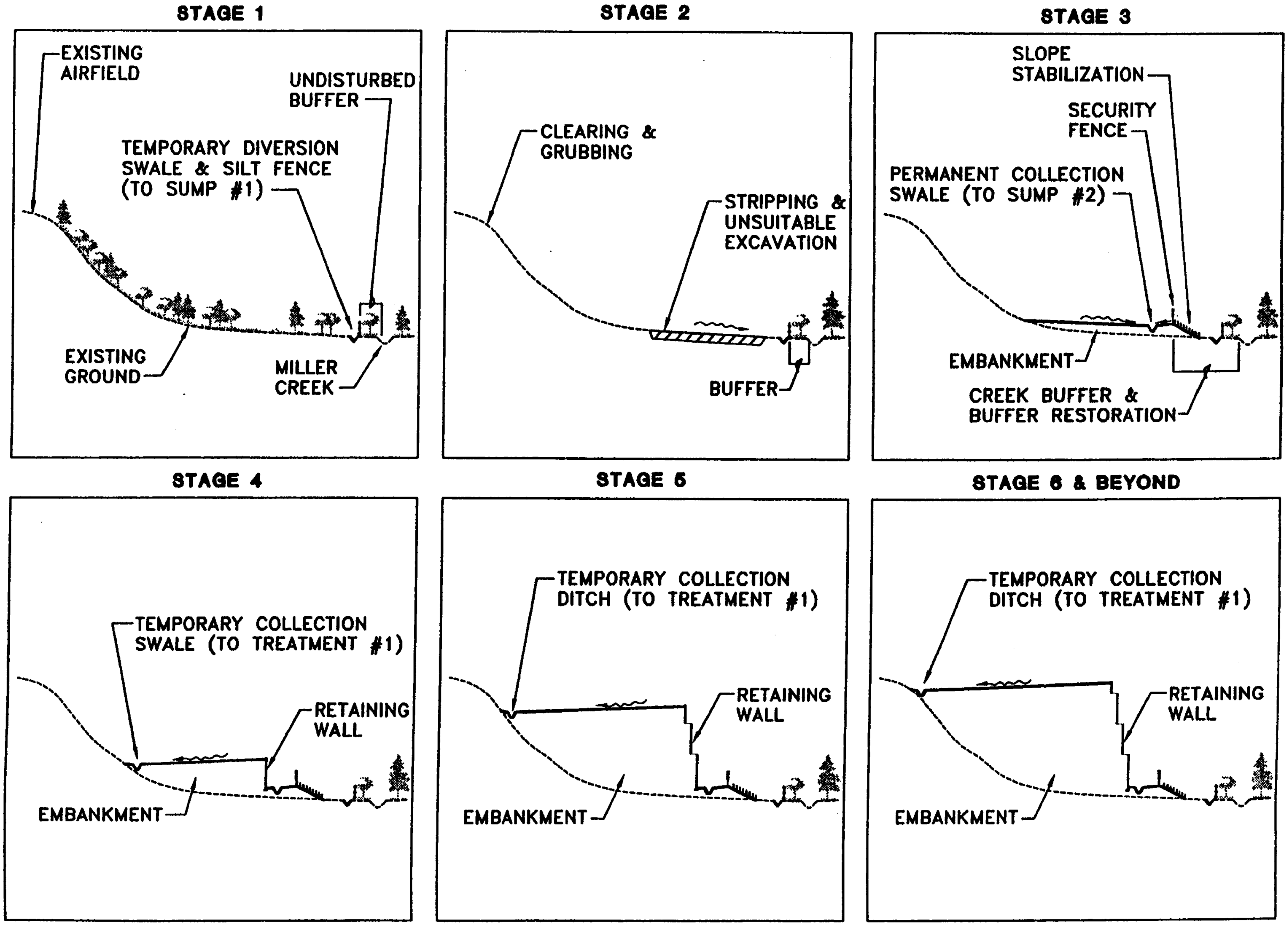
- Clean Runoff Diversion:
  During construction, runoff from undisturbed areas will be routed, as much as possible, around disturbed areas. This will reduce runoff quantities from exposed surfaces to further assure water quality standards can be met. Diversion will be accomplished using diversion swales and/or temporary piping around construction areas. Pipe outlets, level spreaders, swales, or other devices may be used to reduce erosion at the discharges of these diverted clean water flows.

- Maintenance:
  The stormwater management facilities will be regularly maintained throughout the multi-year construction period. Maintenance may include soil and turf repair as necessary, removal of sediment accumulation from the swales and ponds, and restoration of silt fencing, pipe inlets and outfalls.



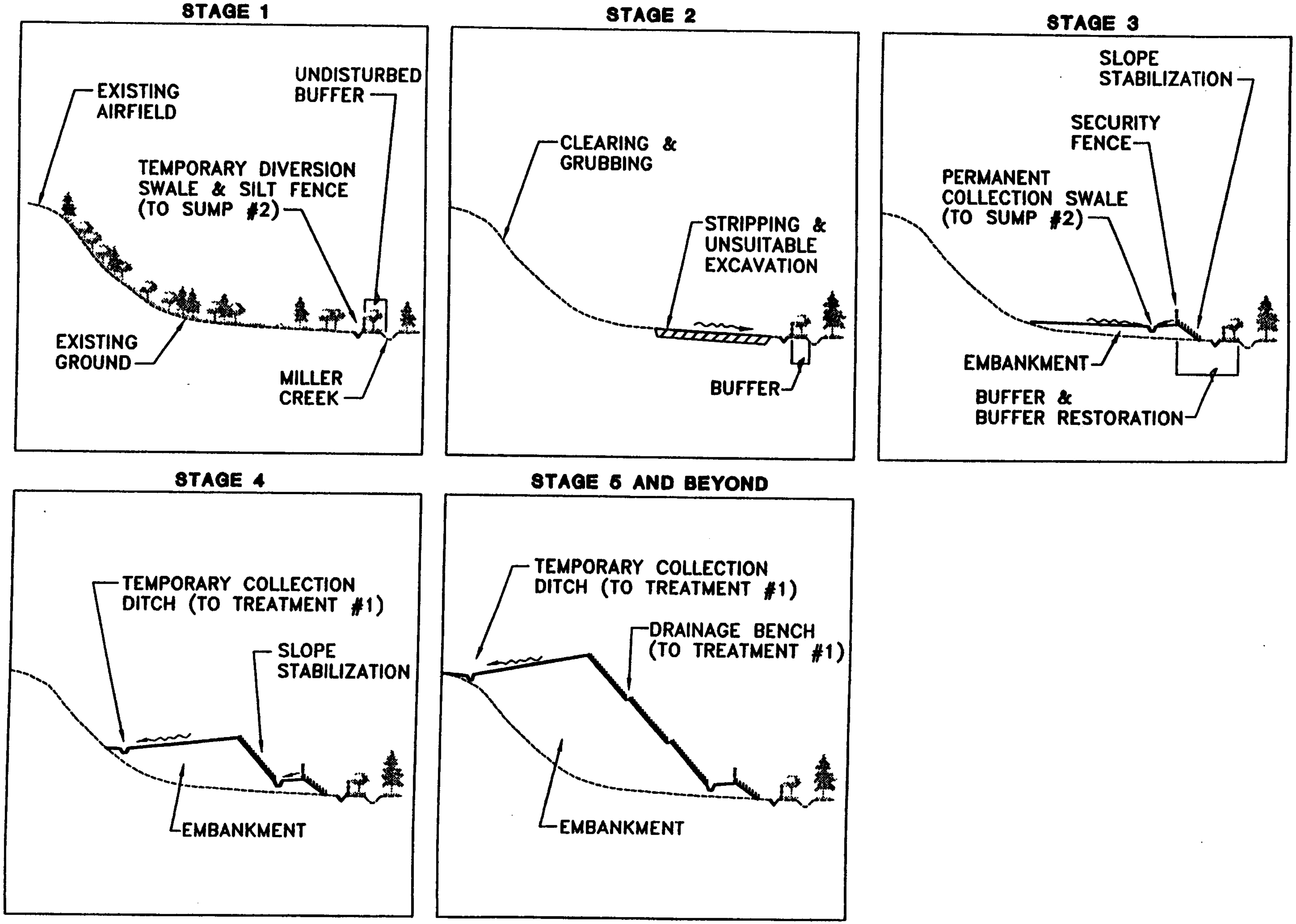
PRELIMINARY THIRD RUNWAY
CESCP

FIGURE 1



SECTION A-A

FIGURE 2
NOT TO SCALE



SECTION B-B

FIGURE 3
NOT TO SCALE

APPENDIX B

APPENDIX B

GEOTECHNICAL ENGINEERING REPORT FOR THE THIRD RUNWAY EMBANKMENT CONSTRUCTION

(Includes July 1999 Original Report and December 2000 Update Memorandum)

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MEMORANDUM

MICHAEL J. BAILEY
22484
EXPIRES 12/13/01

DATE: December 8, 2000

TO: Ms. Elizabeth Leavitt, Port of Seattle

FROM: Michael Bailey, P.E., Hart Crowser, Inc.

RE: **Proposed MSE Wall Subgrade Improvements**
Seattle-Tacoma International Airport
J-4978-06

CC: Jim Thomson, P.E., HNTB

In response to your request, this memo provides an update on design of the subgrade improvements to support the mechanically stabilized earth (MSE) retaining walls for the Third Runway embankment at Sea-Tac.

This memo describes why the proposed construction below existing ground level will have no adverse impact to groundwater flow below the proposed MSE walls.

The basic design concept, construction approach, and subsurface conditions below the proposed MSE walls are generally discussed in Appendix B in the Wetland Functional Assessment and Impact Analysis document for the project, which includes Hart Crowser's July 9, 1999, report entitled "Geotechnical Engineering Report, 404 Permit Support, Third Runway Embankment." This memo provides additional detail based on subsurface explorations and design work completed since July 1999. This memo provides a description of the components used in the MSE wall foundation and the proposed subgrade soil improvements, and why these constructed features will not impede shallow groundwater flow that recharges Miller Creek and adjacent wetlands.

MSE Wall and Foundation Components

Figure 1 shows a schematic cross section of the proposed MSE wall that will be constructed to avoid relocating Miller Creek. The cross section, located at runway Station 178+60, is a good section to use for illustration because it includes wetland soils and is near the

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maximum height of the proposed wall. Figure 2 shows location of the cross section as well as the extent of the proposed subgrade improvements in plan view for the west wall.

Figure 1 shows elements of the reinforced wall backfill zone and subgrade improvement zone that are discussed in this memo. Construction elements that are related to groundwater flow include the following:

Native Surficial Soils. This soft or loose to medium dense surficial soil unit consists of silty sand with organics, interbedded silty sand, gravelly sand, and sandy silt, and occasional sandy clay. The surficial soils contain the shallow aquifer that recharges Miller Creek and the adjacent wetlands. The seasonal groundwater level is near to, and locally slightly above the ground surface in this area, as indicated by Hart Crowser's monitoring wells and observations of shallow puddles in the wetland and overland flow from the east during the late spring. The surficial soils vary from about 10 to 20 feet in depth in this area. These surficial soils are not suitable to provide structural support of the proposed MSE wall.

Glacial Till. Underlying the surficial soils is glacial till or other hard glacially overridden soils that consist of very dense silty sand and hard sandy silt, with varying amounts of gravel. This soil unit will provide very good foundation support for the proposed MSE walls.

Reinforced Fill Zone. The proposed MSE wall is constructed of concrete facing panels connected to strips of steel reinforcing that extend back into the wall backfill behind the wall. Both the panels and the reinforced backfill are embedded below the surface of the new fill in front of the wall, to provide support for the wall. Depth of embedment is depends on the wall height and ground slope; in this area, it will be about 8 feet.

Subgrade Improvement Zone. The reinforced fill and MSE wall facing will be supported on soils which are adequately strong and non-compressible, to transfer the weight of the wall to the underlying glacial till. There are two types of subgrade improvement that may be used where the existing surficial soils need to be "improved" to provide this support;

- In areas where the depth of subgrade improvement is relatively shallow, existing soils in the subgrade improvement zone can be removed and replaced with compacted structural fill.
- In areas where the soils that need improvement are more than a few feet thick, subgrade improvement may be accomplished by installing stone columns to reinforce the existing native soils.

Both types of subgrade improvement are discussed later in this memo.

As shown on Figure 1, the eastern part of the reinforced fill extends a few feet below the existing ground surface at the cross section (Station 178+60). The depth of this embedment for the reinforced zone varies, for instance at Station 177+75, the reinforced zone will extend below the ground surface about 9 feet.

The remainder of the memo describes the construction sequence and why shallow groundwater recharge to Miller Creek and the wetlands west of the MSE wall will not be impeded by either the reinforced fill extending below the ground surface, or either type of subgrade improvement.

Shallow Groundwater Seepage through Subgrade Improvements

Subgrade improvements will be constructed by either 1) overexcavation and replacement with compacted fill, or 2) use of stone columns. In some areas, the reinforced fill may also extend below the groundwater level.

Removal and Replacement for Subgrade Improvement

Where unsuitable soils are excavated as part of subgrade improvement, backfill will consist of relatively free-draining structural fill of the type used for wet weather construction or for the embankment underdrain. This fill will be well-graded and have a maximum fines content (percentage of silt and clay), limited by the construction specifications to not more than 8 percent. Figures 3 and 4 show gradation of the fill materials that may be used for this purpose. Permeability of this fill will be greater than the existing surficial soils it replaces, because of its overall gradation and the limited percent fines.

Stone Columns

Where stone columns will be used for subgrade improvement, design calls for them to have a nominal diameter of 42 inches and be spaced in a triangular pattern 8 feet apart. Figure 5 shows the method of constructing stone columns, and Figure 6 shows the spacing. The design calls for the stone columns to be constructed of coarse gravel with a maximum of 10 percent passing the no. 4 size sieve with little or no fines (silt and clay sized particles). The coarse gravel columns will occupy about 17 percent of the native soil volume based on the design spacing and diameter. Figure 7 shows gradation of the gravel specified for use in the stone columns.

Some densification of the native surficial soils will occur during stone column construction. However, the degree of densification is less in silty or clayey soils of the type that exist at the

Third Runway site, compared to non-silty soils. There are no reports in the engineering literature of stone columns impeding groundwater flow. In fact there are many case studies that show that stone columns actually improve site drainage by enhancing vertical seepage between granular soils that are separated by more silty interbeds.

Reinforced Zone

The MSE wall consists of concrete facing panels that are separated vertically by elastomeric bearing pads that maintain a ¾-inch gap completely around the perimeter of each concrete panel. The gap in the joint between MSE panels enables the face of the wall to be free-draining, including the portion embedded below the ground surface. Where the wall extends above the ground surface, this joint is so free-draining that it is typically protected with filter fabric to prevent soil erosion. Figure 8 shows the joint between MSE panels.

The bottom of the wall bears on a 6-inch-high concrete pad. This concrete pad will not impede shallow groundwater flow through the area where the wall is embedded because of its small height relative to the thickness of the aquifer.

The reinforced zone behind the wall facing has steel strips laid horizontally in the soil, to provide the MSE soil reinforcing. These strips are typically about a quarter-inch thick by four inches wide, and they are spaced a minimum of 9 inches on center both horizontally and vertically. The reinforcing will not impede shallow groundwater flow, for the same reason noted above, because of the small area occupied by the reinforcing strips relative to the overall height of the aquifer.

Please call if you have any questions.

F:\docs\jobs\497806\SubgradeMSE(mem)Final.doc

Attachments:
Figure 1 - West MSE Wall Cross Section Station 178 + 60
Figure 2 - West MSE Wall Subgrade Improvement Plan
Figure 3 - Grain Size Envelope for Group 1A Fill Material
Figure 4 - Grain Size Envelope for Group 1B Fill Material
Figure 5 - Stone Column Installation for Subgrade Improvement
Figure 6 - Stone Column Layout Plan
Figure 7 - Grain Size Envelope for Gravel Used in Stone Columns
Figure 8 - Joint Details between MSE Wall Panels

West MSE Wall Cross Section

Station 178+60

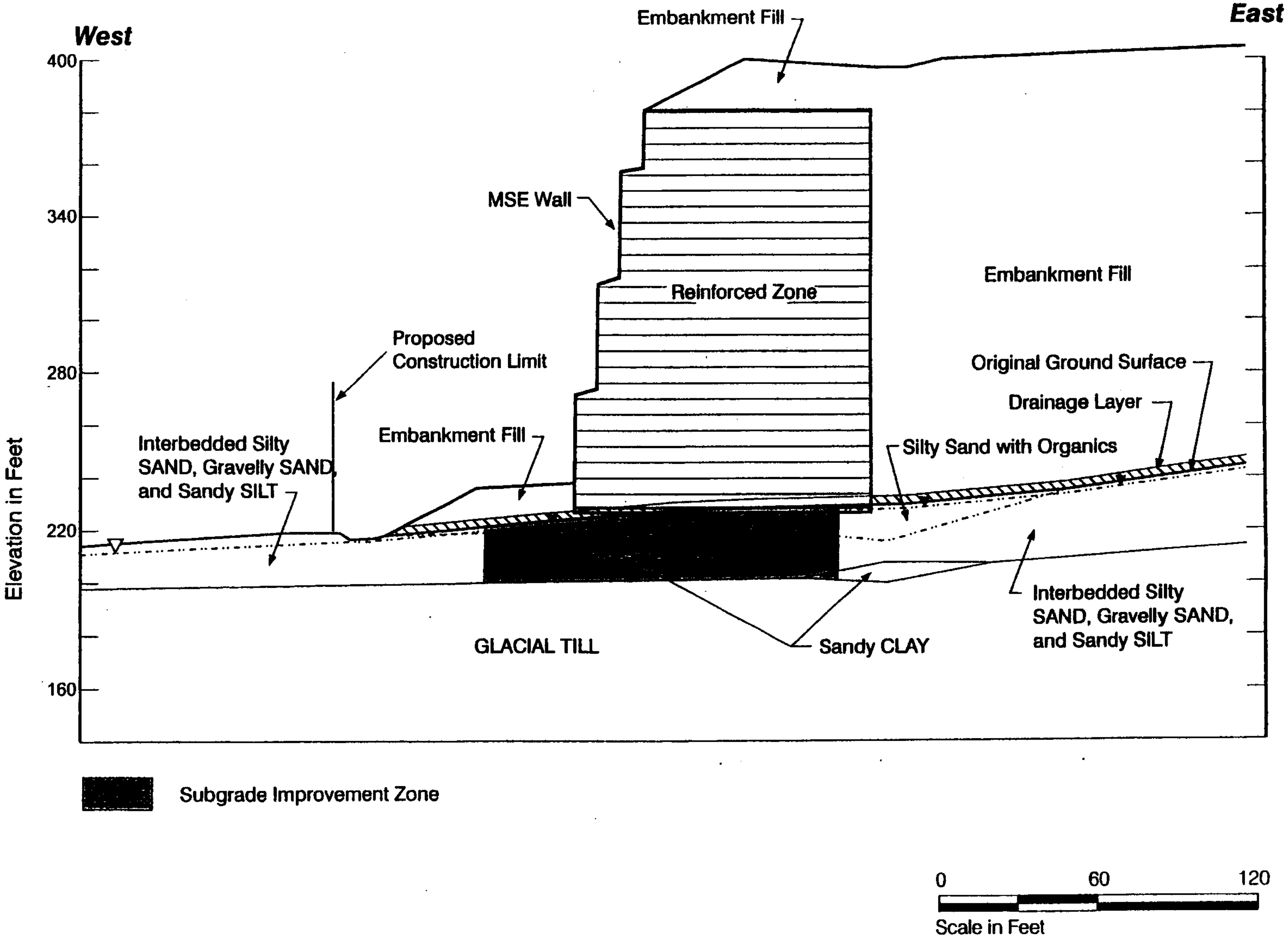

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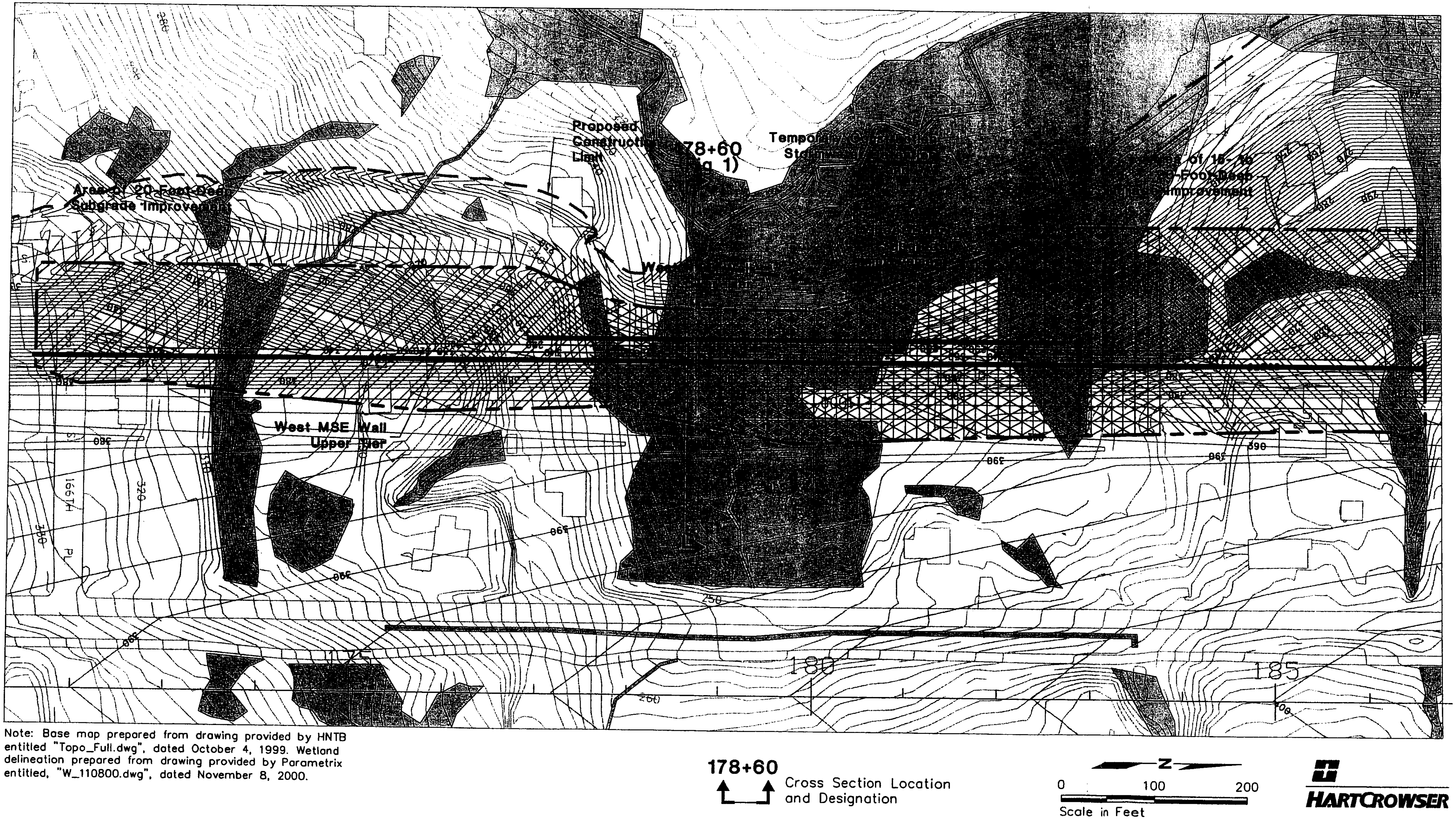
Figure 1

West MSE Wall Subgrade Improvement Plan



Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_110800.dwg", dated November 8, 2000.

RC 11/14/00 1=100 (xref)see drawing file/charlie.pc2
49780643.dwg

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Figure 2

Grain Size Envelope for Group 1A Fill Material

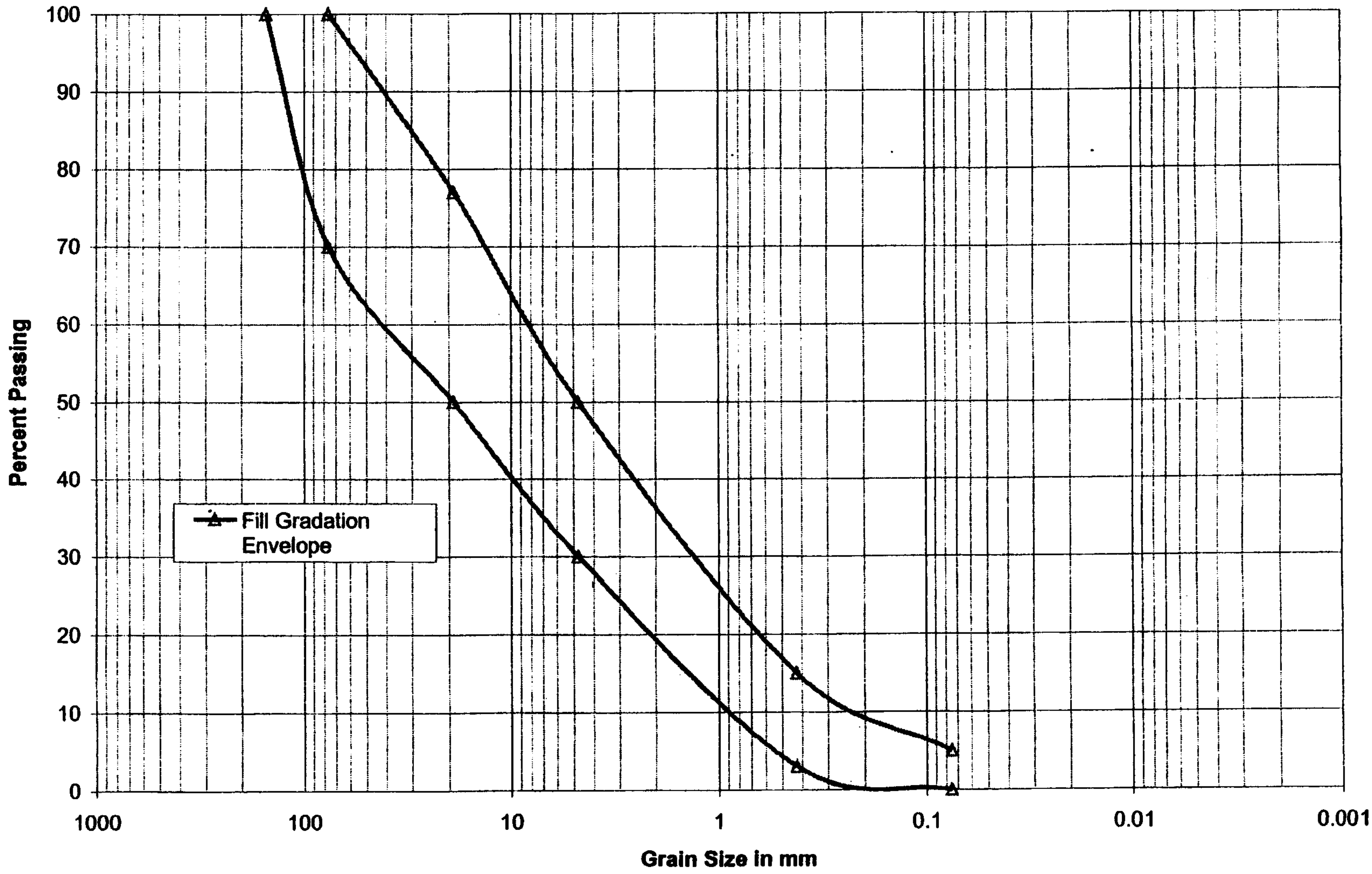

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Figure 3

Grain Size Envelope for Group 1B Fill Material

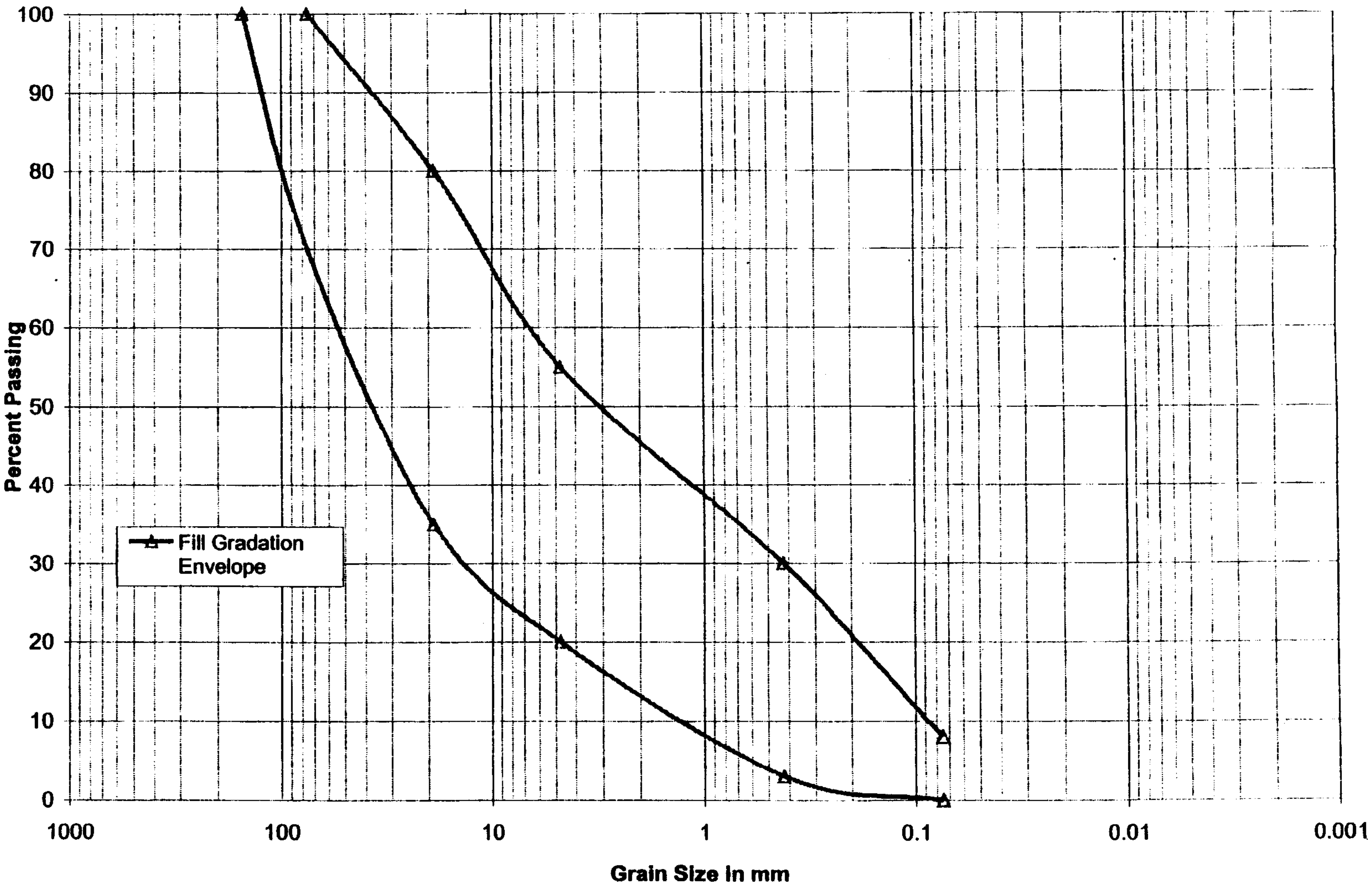

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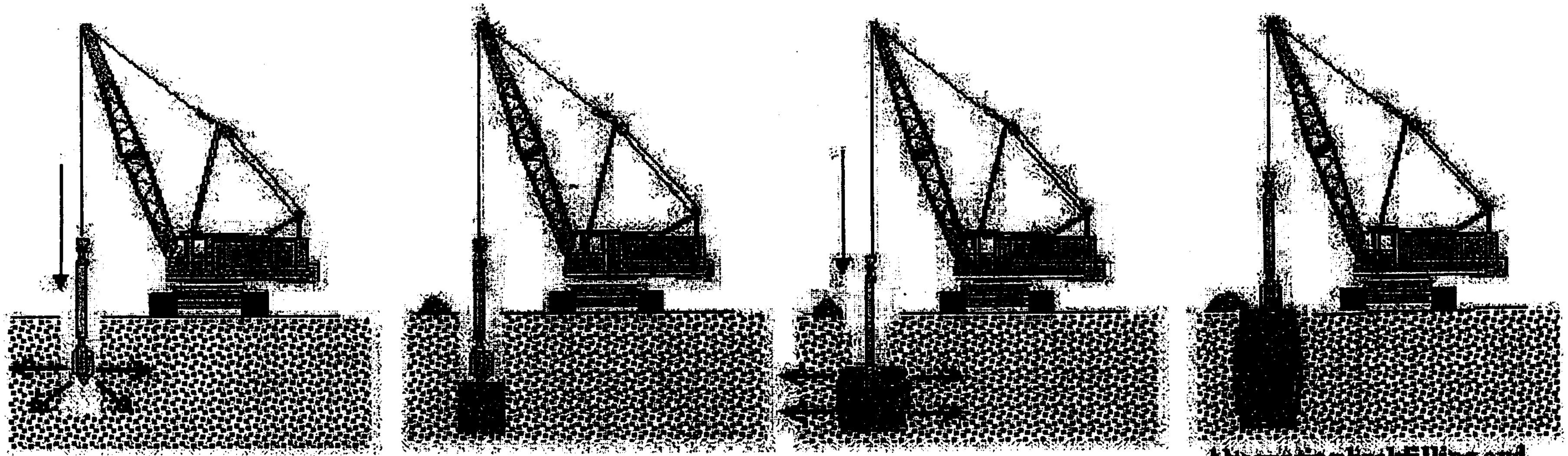
Figure 4

Stone Column Installation for Subgrade Improvement



Borehole is formed by sinking vibrator into the ground

Backfill material is placed into the borehole in stages and compacted

Alternating backfilling and compacting form continuous stone column

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Figure 5

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Stone Column Layout Plan

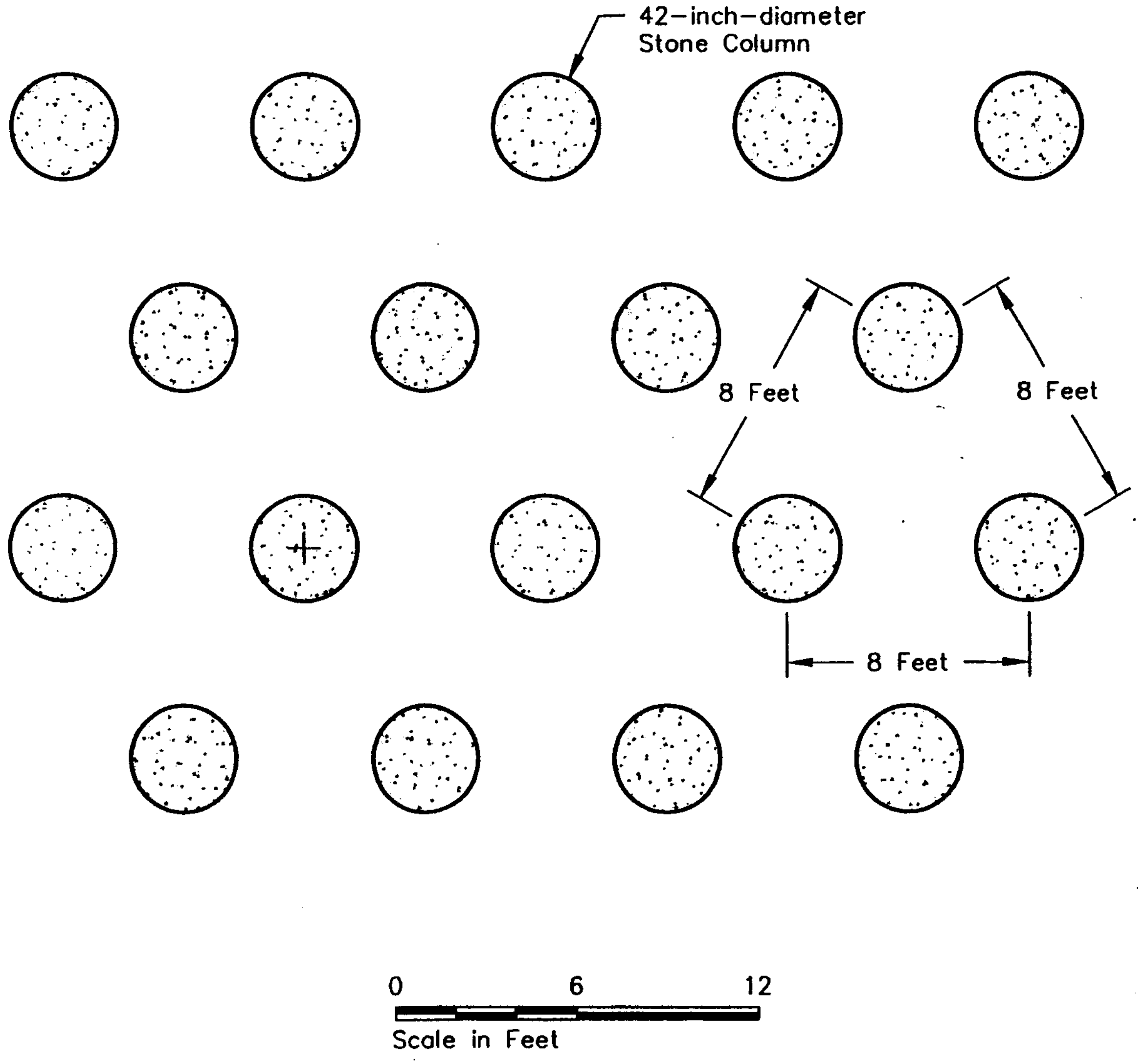

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Figure 6

Grain Size Envelope for Gravel Used in Stone Columns

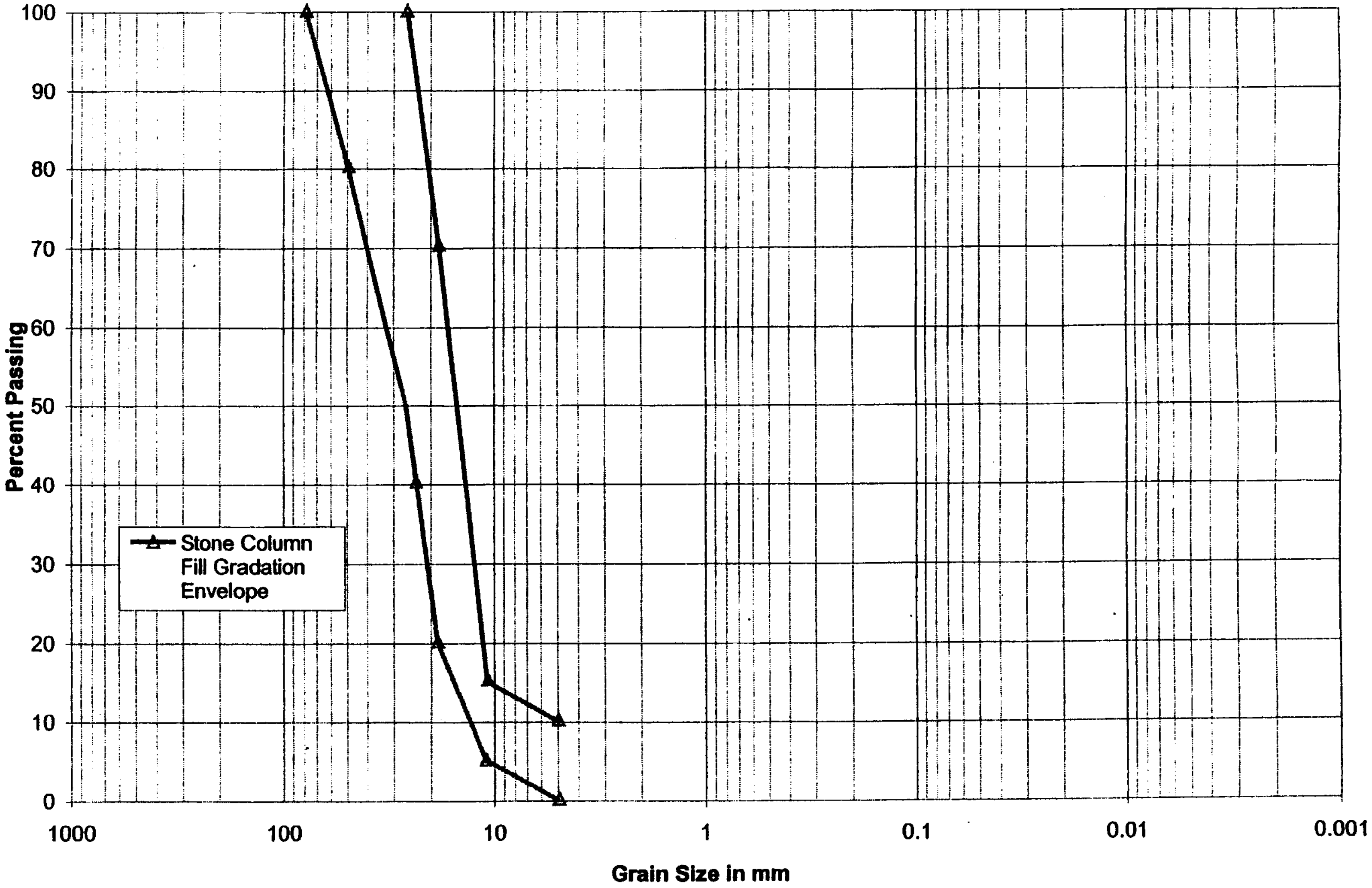

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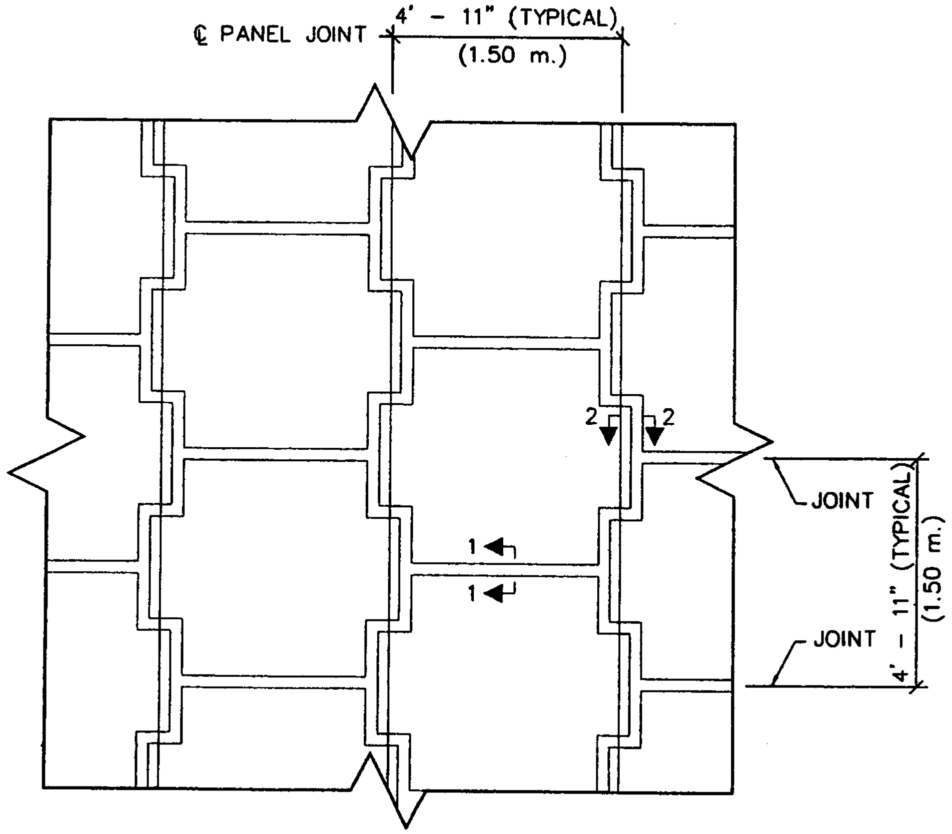
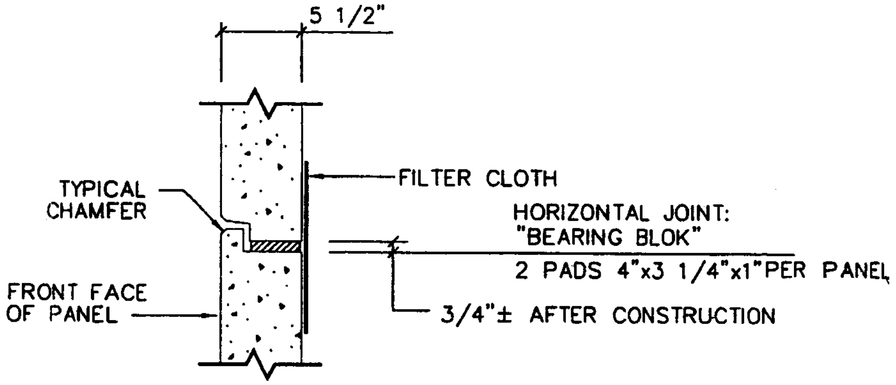
Figure 7

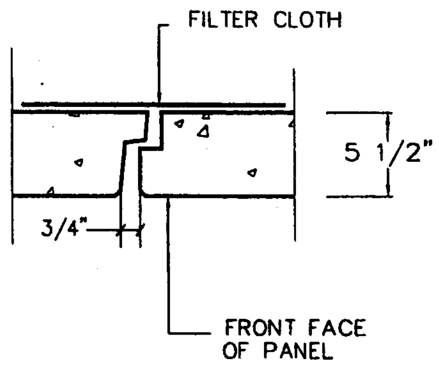
Joint Details Between MSE Wall Panels



TYPICAL MSE PANEL LAYOUT
PARTIAL ELEVATION - FRONT FACE
SCALE: 1/4" = 1'-0"



SECTION 1-1
SCALE : 1" = 1'-0"



SECTION 2-2
SCALE : 1" = 1'-0"

RC 11/14/00 1=20 charlie.pc2
49780644

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J-4978-06 11/00
Figure 8

Geotechnical Engineering Report
404 Permit Support
Third Runway Embankment
Sea-Tac International Airport

Prepared for
HNTB Corporation and
The Port of Seattle

July 9, 1999
J-4978-06

CONTENTS

CONTENTS (Continued)

Page

TABLE

FIGURES

APPENDIX A
SUBSURFACE CONDITIONS IN SELECTED REPRESENTATIVE WETLAND AREAS

APPENDIX B
WATER BALANCE MODEL

FIGURES

GEOTECHNICAL ENGINEERING REPORT
404 PERMIT SUPPORT
THIRD RUNWAY EMBANKMENT
SEA-TAC INTERNATIONAL AIRPORT

INTRODUCTION

This report evaluates subsurface conditions and geotechnical engineering aspects of the proposed Third Runway embankment construction in the Miller Creek drainage basin. This evaluation includes determining potential indirect impacts to wetlands downgradient of the Third Runway embankment, resulting from project construction. Design and construction measures to avoid indirect adverse impacts to wetlands during and after construction are also identified.

Avoidance of potential indirect impacts includes:

- Providing engineered measures to maintain or enhance existing infiltration on non-paved portions of the airfield and groundwater recharge to support wetlands and baseflow to Miller Creek downgradient of the embankment;
- Verifying construction of the embankment will not impair existing subsurface groundwater movement; and
- Designing the embankment to be stable during anticipated seismic events.

Figure 1 shows the project vicinity. The main areas of focus in this report are the north end and mid-west side of the proposed embankment, where retaining walls will be used to reduce the amount of wetlands filled by construction. Figures 2 and 3 provide additional detail for these areas, including the wetlands of potential concern, Miller Creek, and limits of the proposed embankment and related construction. Related construction includes relocation of South 154th Street around the north end of the embankment, and a new airport security road around the embankment perimeter.

SUMMARY

Information in this report is based in part on exploratory borings in representative wetland areas, accomplished under a Nationwide 6 Permit from the Corps of Engineers (Hart Crowser, 1999, see reference list following the main text of this report). Additional information was obtained from test pits excavated in representative areas outside the wetlands, as well as previous explorations by others for a variety of purposes.

General findings of this report are:

- Soil conditions in the embankment footprint area will generally provide good (better than required) foundation support, assuring long-term stability.
- Construction will locally include subgrade improvements (removal and replacement or *in situ* improvement of soils, as needed) to improve foundation support.
- Satisfactory embankment and retaining wall seismic stability will result from conventional construction practices (including the subgrade improvements).
- Existing shallow groundwater seepage rates will be relatively unchanged because construction will include engineering measures to maintain flow from existing seeps, and transmit this flow downgradient to recharge wetlands west of the embankment.
- Infiltration through the embankment will reach Miller Creek later due to a longer seepage path compared to existing infiltration, producing a beneficial impact on late summer stream flow.
- Overall, recharge to shallow groundwater will continue during and after construction, much as it does at the present time.

This report identifies geotechnical design and construction measures to avoid or mitigate temporary (construction-related) impacts to wetlands, such as re-infiltration and/or re-injection of groundwater from dewatering, limiting the extent of soil disturbance, and subgrade improvements. Information on the wetlands, extent of impacts, and other mitigation are discussed in separate reports (Parametrix Inc., 1999a and 1999b).

This report also discusses geotechnical design and construction measures to avoid or mitigate indirect permanent impacts to wetlands. Mitigation measures that minimize direct impacts include engineering design to:

- Limit disturbance of groundwater discharge zones;
- Maintain groundwater seepage to Miller Creek, and adjacent wetlands; and
- Permanently protect undisturbed wetlands with approved buffers.

GEOTECHNICAL OVERVIEW RELATED TO WETLANDS

Construction of the Third Runway will require filling topographic low areas west of the existing airfield to an elevation of about 400 feet MSL. Construction will require filling some existing wetlands and temporary construction impacts to additional wetlands as discussed by Parametrix (1999b). Geotechnical design and construction planning to protect wetlands focused on the following main areas:

- Use of retaining walls (referred to as MSE walls) to avoid relocating a portion of Miller Creek and to avoid filling adjacent wetlands;
- Use of appropriate embankment construction techniques and materials to minimize indirect wetland impacts during and after construction;
- Design for embankment and retaining wall stability to avoid indirect post-construction impacts to wetlands; and
- Design of subsurface embankment drainage to preserve flow to wetlands and augment groundwater recharge that becomes baseflow to wetlands and Miller Creek.

Storm water management during construction and temporary erosion and sediment control (TESC) to avoid construction impacts to wetlands are discussed by HNTB (1999) and Parametrix (1999a and 1999c).

SUMMARY OF EXISTING SUBSURFACE CONDITIONS

Subsurface conditions at the site have been explored by drilling and sampling test pits, various types of infiltration tests, and use of cone penetrometer soundings, as discussed in several reports (Hart Crowser, 1999; AGI 1998; CivilTech, 1997). These reports document information on subsurface conditions that has been primarily developed subsequent to completion of the 1996 Final Environmental Impact Statement (FEIS) and the 1997 Final Supplemental EIS (FSEIS). This new geotechnical information provides more detail, at specific locations, to provide the basis for detailed project design. The findings from this work are consistent with geotechnical information used for evaluation of the project design and impacts in the FEIS and FSEIS.

Soil Conditions

Most of the proposed embankment is anticipated to be built on recessional outwash soils, typically consisting of 5 to 10 feet of medium dense, moist, silty, slightly gravelly to gravelly sand, overlying dense to very dense glacial till (typically silty, gravelly sand) and advance outwash soils of similar gradation. Where the surficial soils have been locally disturbed by previous site development, they are referred to as "fill" on the exploration logs (Hart Crowser, 1999).

Within the wetland areas, generally similar soils are encountered at relatively shallow depths, with additional surficial soil layers of soft to medium stiff, low plasticity, sandy clay and silt, which varies to loose to medium dense, non-silty to clayey sand, and may contain organic material (peat). Borings completed under the Nationwide 6 Permit indicate these soils range up to about 20 feet in thickness (Hart Crowser, 1999).

Available information on soils within wetlands in the north safety area (Wetlands 9, FW6, and FW3) as well as on the west side of the Third Runway (Wetlands 18, 37, and 44) are discussed in Appendix A to this report. This information is based on detailed geotechnical explorations accomplished by subsurface borings under a Corps of Engineers Nationwide 6 Permit. Other wetlands not explored are anticipated to include similar limited thicknesses of soft to medium stiff , wet and organic soils, based on comparison to conditions encountered in explorations to date in the north end and west wall areas.

Soil conditions observed in the specific project areas addressed in this report are summarized in Appendix A, based on boring and test results presented in the Subsurface Conditions Data Report (Hart Crowser, 1999).

Surface Water Conditions

In the project area, pre-construction baseflow to Miller Creek is comprised primarily of groundwater discharge from the Shallow Regional Aquifer, from both the airport (east) side of Miller Creek, and from the area on the western side of the creek basin. Additional discharges to Miller Creek are in the form of surface runoff and near-surface interflow (Parametrix, 1999c).

Precipitation onto the airfield becomes runoff, is intercepted by the storm water management system, is lost to evapotranspiration, or is available for infiltration (see Parametrix 1999c). The amount of infiltration available as recharge depends on soil characteristics, slope, and engineered measures.

Groundwater Conditions

Hydrologic assessments completed by Parametrix (1999c) and AGI Technologies (1996) show completion of the Third Runway will increase total area of impervious surface and storm water runoff within the embankment footprint. This will result in a slight decrease in baseflow to Miller Creek due to the net reduction in infiltration in this part of the Miller Creek basin. Mitigation for this effect is provided by the hydraulic lag of seepage from the infiltration which does occur, resulting in a net increase in recharge and baseflow in the late summer, as discussed in this report.

Existing shallow groundwater in the project area includes:

- Infiltration from the ground surface;
- The surficial interflow zone;
- Discontinuous perched water zones; and
- The Shallow Regional Aquifer.

This report discusses potential local impacts and mitigation for these near-surface groundwater components, shown diagrammatically on Figure 4. The shallow groundwater components are discussed in more detail below.

Infiltration. Hydrologic measurements conducted for the study on which the airport's Stormwater Management Plan is based (Parametrix, 1999c) were used to calculate infiltration characteristics for existing airfield fill soils, to provide information on effects of constructing the Third Runway embankment. Infiltration to the underlying groundwater system is able to occur over the existing large areas of the airport and adjacent land areas which are not paved. Similarly, infiltration is anticipated over the unpaved areas (~80 acres) on top of the new embankment.

Surficial Interflow. The surficial interflow zone exists in the upper few feet of the soil profile. Flow in this zone is essentially subsurface stormflow that is usually associated with periods of substantial rainfall. The near-surface soils become saturated and allow flow to move laterally from the upper to lower parts of the watershed catchment area. Interflow tends to last for at most a few days after major storms, but may persist through the winter months when storms occur frequently. Interflow could be a factor in sustaining some of the wetland areas that are not fed by perched groundwater or by the Shallow Regional Aquifer.

Discontinuous Perched Water. Zones of perched groundwater appear to exist in the sloping hillside that forms portions of the western flank of the existing airfield, east of 12th Avenue. The forested slope is formed of a mixture of glacial till and outwash soils, which allow differing amounts of runoff, infiltration, and evaporation to occur.

- The glacial till and hard silt soils (where present) are typically at a depth of 5 to 10 feet below ground level, overlain by outwash soils.
- The outwash soils facilitate more infiltration, allowing perched zones to develop in places on the glacial till, or on other silty (i.e., less-permeable) layers above the Shallow Regional Aquifer (see Figure 4).

The lateral continuity of such perched zones depends on extent and stratigraphic position of the perching layers. Test pit observations (Hart Crowser, 1999) indicate limited continuity and frequent gradational transitions in the silt content of on-site soils. These variations affect shallow seepage in two ways:

- Along the margins of silty soil zones, perched groundwater tends to percolate downward to the Shallow Regional Aquifer; and
- Surface seeps can form where the perching layers crop out at the ground surface. Locally these seeps may be important sources of water to wetlands.

Shallow Regional Aquifer. Figure 5 shows groundwater elevation contours for the Shallow Regional Aquifer. These contours generally mimic the surface topography, with higher groundwater levels occurring beneath the airfield. The elevated groundwater levels reflect groundwater recharge that occurs beneath the existing airfield and discharges as baseflow to Miller Creek. Recharge is derived from part of the infiltration through the extensive areas of flat grassland that flank the paved runways and taxiways.

The potential area for groundwater recharge to the Shallow Regional Aquifer that discharges to Miller Creek extends from Miller Creek to the eastern side of the existing airfield based on the location of the groundwater divide in this aquifer (Hart Crowser, 1985). Much of this area is underlain by glacial till, a dense relatively less-permeable soil unit (an aquitard) that ranges up to 50 feet in thickness below the airfield. A portion of the infiltration likely recharges shallow perched water zones above the glacial till aquitard, rather than directly recharging the Shallow Regional Aquifer, see Figure 4.

Recharge to the Shallow Regional Aquifer creates elevated groundwater levels beneath and east of the airport, and generates lateral groundwater flow toward the adjacent drainages (Miller Creek, Des Moines Creek, and their tributaries).

A portion of the groundwater recharge that enters the Shallow Regional Aquifer passes through that groundwater body and percolates deeper. Eventually this seepage becomes part of the regional recharge to the Intermediate and Deep Regional Aquifers that are located at depth. The Intermediate Regional Aquifer and Deep Regional Aquifer, are not anticipated to be impacted by development at Sea-Tac. Regional groundwater movement including relationship of the Third Runway project to the Seattle Public Utility wells in the Intermediate Aquifer and the Highline Water District Wells in the Deep Aquifer, is well-documented in the Third Runway FEIS/FSEIS and studies by others (Federal Aviation Administration, 1997; AGI Technologies, 1996; Hart Crowser, 1985).

GEOTECHNICAL DESIGN CONSIDERATIONS

Geotechnical design to avoid and/or mitigate construction impacts to wetlands has been refined from the initial analysis presented in the FEIS, to include several specific elements. These include the following:

- Use of retaining walls to reduce filling some wetlands and limit creek relocation;
- Use of soil zones to provide a stable embankment that can be constructed cost-effectively with the least impact possible to local groundwater recharge;
- Exploration and analysis of the local soils to design a stable foundation for the embankment and retaining walls; and
- Design of the embankment to avoid or mitigate long-term, indirect impacts to groundwater, adjacent wetlands, and Miller Creek.

Embankment Design Refinements Accomplished since the FSEIS

Subsequent to completion of the FSEIS (Federal Aviation Administration, 1997) and in response to requests for information to support the Corps of Engineers' 404 Permit, the Port completed an extensive analysis of alternatives for construction to avoid impacts to wetlands. A major component of this was selection of embankment slope and retaining wall configurations to minimize the extent of wetland impacts.

Geotechnical engineering aspects of the analysis of wall and slope alternatives were subjected to peer review, conducted by the firm Shannon & Wilson, Inc. Shannon & Wilson found the analysis to be both appropriate and consistent with conventional engineering practices. Details of the analysis are presented in a

1999 report by HNTB, Hart Crowser, and Parametrix, which includes the peer review report as an attachment.

As part of evaluating alternatives to filling wetlands, Port operations staff (security, fire and rescue, and maintenance) identified alternatives to reduce the area of impact related to roads on and around the runway embankment. This included elimination of an intermediate access road along much of the embankment, and revising the security road alignment and profile, to reduce the extent of construction impacts to wetlands.

Another design refinement has focused on surface water and groundwater drainage from the embankment. After completion of construction, runoff from the new embankment will be detained and otherwise managed to reduce storm water impacts to Miller Creek (see Parametrix, 1999b). Designs to promote storm water infiltration and maintenance of groundwater recharge are discussed in this report.

Use of MSE Walls to Avoid Filling Key Wetlands and Creek Relocation

During the past two years, Port staff and consultants have completed geotechnical, hydrologic and wetland studies, to identify alternatives and verify that existing MSE (mechanically stabilized earth) technology can provide safe and relatively cost-effective construction of retaining walls for soil conditions at the site.

The Port of Seattle reviewed a large number of embankment slope and retaining wall alternatives to avoid or reduce impacts to Miller Creek and adjacent wetlands. MSE retaining walls were selected as the recommended alternative, (HNTB, Hart Crowser, and Parametrix, 1999).

Where retaining wall height exceeds about 60 feet, MSE retaining walls will typically be used in combination with narrow, relatively horizontal terraces and conventional or reinforced 2H:1V embankment sections, to limit the area of filled wetlands.

- At the north end of the embankment, MSE walls will be used to limit the impact to Miller Creek and the extent of filling Wetlands A-1 and 9;

- Near the middle of the west side of the embankment (approximately runway stations 174+00 to 186+00), an MSE wall will be used to avoid filling a significant part of Wetland 37a, and to avoid relocating part of Miller Creek; and

- Near the south end of the new runway, an MSE wall will be built to limit the extent of filling Wetland 44a.

Specific design and construction considerations for the embankment and MSE walls in these areas are discussed later in this report.

What are MSE Walls?

MSE is a method of constructing earth embankments using a combination of compacted soil and reinforcing elements. MSE technology includes a range of steel and polymer (plastic) products (mesh, strips, and grids) used to retain and reinforce soil, and provides a number of advantages over other types of retaining walls. The MSE technology improves soil strength through incorporation of reinforcing strips or sheets (geogrids or geotextiles) within the soil embankment during construction. There are a number of proprietary products used for this purpose.

Some, but not all, MSE products include a means to secure a retaining wall facing to the reinforced soil mass, permitting a range of embankment slopes up to and including vertical walls. MSE walls may be faced with wire mesh, geotextile, or concrete facing elements. Concrete facings are typically used for permanent installations of the type contemplated for the Third Runway, and may consist of pre-fabricated concrete wall facing components installed during or after construction, or cast-in-place/shotcrete facings applied after construction.

MSE walls can be designed to accommodate a considerable range in site drainage conditions. Typically the reinforced zone includes relatively non-silty, free-draining soil, which would enhance infiltration near the face of the wall. The reinforced zone would be hydraulically connected to the embankment underdrain, to enable infiltration from above the wall to seep beyond the toe of the wall. Also, MSE walls do not require a structural concrete key below ground for stability; thus unlike some other types of wall, MSE walls do not impede subsurface seepage.

MSE walls are relatively economical to construct compared to other types of retaining structures, particularly at heights in excess of about 25 feet. MSE walls have been successfully used to retain embankment fills well over 100 feet in height, including both tiered walls and single "flat faced" wall configurations. MSE embankments and retaining walls can be designed to be highly stable under both static and seismic loads.

Figure 6 shows a schematic cross section of an MSE retaining wall.

Geotechnical Design to Accommodate Site Conditions

Foundation Soil Conditions in Wetlands and Upland Slopes

Native soils capable of providing a suitable foundation to support the embankment have been observed at depths ranging from zero to around 20 feet below the existing ground surface across the site. Available information indicates very little subgrade preparation will be needed across most of the site. Wetland soils and soils in some other specific areas will need to be improved or replaced to support parts of the fill and MSE walls. This subgrade improvement will be accomplished without reducing subsurface groundwater movement as discussed below.

Existing subgrade soils which are unsuitable to provide structural support for the embankment (because they are soft, wet, or contain organic materials), will be removed and replaced with compacted structural fill, or improved *in situ* (i.e., in-place or without removal), as discussed below. The unsuitable subgrade material that is removed will be reused where possible in non-structural areas of the embankment.

Following excavation of unsuitable soils, stable subgrade will be prepared by either:

- Placing structural fill that is free-draining and non-silty. The relatively high permeability of this fill will not decrease the soil capacity to transmit groundwater flow through these areas; or
- Making *in situ* improvements to existing subgrade soils, including "stone columns," soil mixing, or similar technologies, as described later in this report. These techniques increase subgrade strength with some corresponding reduction in permeability in the immediate vicinity of application.

Designs will address mitigation for the potential change in permeability where *in situ* soil improvement is used. Mitigation would typically include thickening the embankment underdrain layer (discussed below) or installation of "french drains" through areas of soil improvement, to compensate for any reductions in soil permeability within the zone of improvement.

Embankment Drainage Layer

At the base of the proposed embankment, a drainage layer will be constructed that extends over the existing soil surface (after clearing and grubbing). The drainage layer will be constructed of select non-silty material that is significantly more permeable than the typical fill soils used in the body of the embankment. A minimum thickness of the drainage layer will be maintained throughout the area covered, which may be locally increased within areas of subgrade improvement, and filled wetlands, seeps, or springs. The embankment drainage layer, referred to as an underdrain, is commonly used for earth dams and other embankments.

The underdrain enables beneficial discharge of water that infiltrates into the embankment from above or below, to be conveyed downgradient to discharge into wetlands between the embankment and Miller Creek. The underdrain will:

- Prevent excess pore pressures and associated stability problems;
- Prevent erosion where seepage is discharged near the toe of the embankment; and
- Provide perennial seepage to recharge groundwater and wetlands beyond the toe of the embankment.

The primary purpose of the underdrain is as a stability-enhancement measure to prevent the build-up of pore water pressures within the soils at the base of the embankment, and to prevent subsurface erosion, a condition known as "piping." Piping can have serious consequences in constructed embankments if inadequate consideration is given to the movement and discharge of seepage or other groundwater within the embankment.

The underdrain provides a controlled seepage path below the embankment. Gradation of the drain layer is designed to prevent piping and clogging or sedimentation within the drain. The hydraulic lag resulting from seepage through the embankment and underdrain increases the relative amount of late-summer recharge downgradient of the embankment, to mitigate indirect impacts on wetlands and Miller Creek.

The underdrain will collect seepage, intercepting water that percolates down from the surface of the new embankment, as well as collecting subsurface seeps and springs that currently occur on the existing ground surface. Collecting this water in the underdrain will allow it to be beneficially managed for the long-term protection of downslope wetlands, and to maintain groundwater baseflows to Miller Creek.

The completed underdrain will be separated from the surface of the airfield by the full thickness of the embankment. In the event of a contaminant release (such as an airfield fuel spill), the long flow path through the new fill would provide substantial opportunity to accomplish source control and remediation before any contaminants could reach wetlands, Miller Creek, or the underlying aquifers.

Characteristics of Proposed Embankment Fill Soils

The proposed embankment will be constructed with varying fill materials as needed to satisfy specific design requirements in specific zones.

1. **Type 1 Fill.** About 40 percent (roughly 6.5 million cubic yards) of the embankment would be constructed of relatively silt-free sand and gravel soils, referred to as "Type 1" fill.

2. **Type 2 Fill.** About 60 percent (roughly 10 million cubic yards) of the embankment would be constructed of more or less silty sand (glacial till and outwash soils). These "Type 2" fill soils are similar in particle size gradation but will be less densely compacted than the existing glacially overridden soils below the embankment (resulting in the fill having corresponding higher soil porosity compared to the native soils).

Relative proportions of these predominant soil types may vary depending on final design and availability at the time of construction. The descriptions above refer to general soil characteristics; construction contract documents will utilize fill specifications that are more precise and may add variations to the types shown to accommodate construction.

Within each of the two general fill types, there will be variations for specific construction requirements.

- Typically the relatively silt-free Type 1 fill would be used below pavements, the embankment underdrain, MSE wall reinforcement zones as wet weather fill, and elsewhere as needed to accommodate construction.

- Generally the more silty Type 2 fill will be used to the maximum extent possible, balancing relatively high availability (low cost) with limitations of trying to compact such material in wet weather. (Typically as the silt content of a soil increases, it becomes increasingly difficult to compact it to a uniformly dense condition in wet weather.)

Comparison of Native Soils to Embankment Fill Soils

Typical near-surface soils in the area to be filled are more or less silty (Hart Crowser, 1999; AGI, 1999), and are generally similar in gradation to the Type 2 fill that will be predominantly used as embankment fill. While the Type 1 fill is anticipated to have significantly better infiltration and seepage characteristics compared to existing site soils, they will not have much influence on overall infiltration into the embankment because of location (i.e., predominantly under pavement, within the underdrain, and within specific zones. Where infiltration seeps through both Type 1 and Type 2 soils, it will seep relatively faster through Type 1 and relatively slower through the Type 2 soils.

Type 2 fill compacted in the embankment will be less dense than existing glacially overridden on site soils, but will probably be more dense than the relatively looser near-surface soils (upper 5 to 10 feet). The embankment fill is anticipated to store and transmit groundwater in a manner intermediate between the existing loose to medium dense near-surface soils (upper 5 to 10 feet), and the deeper glacially overridden soils which dominate the site. Generally the new embankment is expected to have infiltration characteristics similar to the existing airfield.

Because of the similarity in gradation and contrast in density noted above, Type 2 fill will typically retain surface infiltration longer than existing native soils. The embankment will therefore release water to Miller Creek and wetlands later into the summer compared to native soils in the area to be filled.

Changes in the relative proportions of these two predominant soil types in the embankment are unlikely to have a significant impact on drainage characteristics of the embankment as a whole, because the arrangement of the fill zones within the embankment will allow for interconnection and free drainage of the relatively more permeable soils.

Fill Zones within the Embankment

The Third Runway embankment will be designed as a zoned embankment, with different fill types and/or different compaction requirements used in specific areas to accommodate strength, compressibility and drainage requirements, see Figure 6. These zones include:

A-1. Pavement Subgrade. High-strength, low-compressibility granular soil used in the upper few feet immediately below airfield pavements (Type 1).

A-2. Drainage Material. Free-draining soil used in the underdrain and in areas of overexcavation to improve foundation support (Type 1).

B-1. Pavement Support Fill. Low-compressibility soil used below the pavement subgrade zone A-1 (may be Type 1 or Type 2 fill).

B-2. MSE Reinforced Backfill. High strength granular soil used in the reinforced zone behind retaining walls (Type 1).

C-1. Common Embankment Fill. Moderate strength compacted soil (may be Type 1 or Type 2 fill).

C-2. Common Embankment Fill. Compacted soil used adjacent to slope faces. This fill (which may be Type 1 or Type 2) may be more select and/or have somewhat higher compaction requirements compared to C-1, depending on where it is used.

D. Non-structural Fill. Soil removed from foundation areas because it is unsuitable for foundation support (Type 2).

Construction of a zoned embankment in this manner provides significant environmental benefits, including:

- Seasonal limitations on use of relatively silty soils in wet weather will reduce erosion and sediment control problems;
- Use of relatively silty soils as "fair-weather fill" for common embankment construction will increase the hydraulic log (late summer recharge volume) compared to non-silty soils;
- Reduction in truck haulage for the embankment by enabling use of local borrow materials and elimination of "export" haulage to dispose of unsuitable subgrade soils; and
- Ability to construct an embankment underdrain which collects infiltration and seepage, for controlled discharge to promote infiltration, and preserve groundwater recharge to downgradient wetlands and Miller Creek.

Embankment and MSE Wall Stability Analyses

Engineering analyses of embankment slope stability were completed for a typical embankment fill cross section (nominal 2H:1V), as well as for representative

MSE wall cross sections in or adjacent to wetlands for both the north and west areas. These analyses were conducted to:

- Verify suitability of the proposed geometry of embankment slopes and retaining walls;
- Assess base preparation required to avoid instability; and
- Assess sensitivity of embankment fill parameters.

The analyses incorporated specific subsurface information developed through explorations accomplished under a Nationwide 6 Permit for drilling in wetlands at the site. Soil conditions in these area are summarized in Appendix A based on data presented in Hart Crowser (1999). The stability analyses considered various combinations of wall/slope geometry and subsurface soil and groundwater conditions. Cross sections were analyzed for the Wetland 37 Wall (the retaining wall which will be used to reduce filling wetlands and to avoid relocating a portion of Miller Creek), and wall-slope combinations for the north end of the embankment (in and adjacent to Wetlands 9, FW6, and FW3) that will be used to limit wetland fill.

Embankment stability was evaluated using computer analyses that employ the conventional limit equilibrium methods developed by Janbu, and more rigorous procedures developed by Spencer (Wright, 1991; Sharma, 1994). Search routines were conducted using the Janbu method of analysis to identify the most plausible potential failure surfaces for the given combination of slope/wall geometry and subsurface conditions. The potentially critical failure surfaces selected by the computer program were then reanalyzed using Spencer's method to more accurately determine the factor of safety.

Stability Analysis Parameters

Soils. Table 1 provides a summary of the engineering and strength parameters used in the analyses for the soils in the project area. Strength parameters for on-site soils were developed using laboratory test results developed for the Third Runway project (Hart Crowser, 1999; AGI, 1998) and through published correlation of field and laboratory test results (Hart Crowser, 1998b and 1998c).

For these analyses, MSE walls were assumed to include reinforcing elements with lengths equal to 80 percent of the wall height. Base stability was analyzed for potential failure surfaces below the reinforced zone.

Groundwater. Groundwater levels were modeled using an assumed piezometric surface concurrent with the present ground surface and/or partial saturation of the underdrain below the embankment soils and retaining wall backfill. Sensitivity analyses were performed to measure the effect of raising the water level within the underdrain. This is a conservative approach because it assumes that all the soils below the underdrain will be saturated and subject to buoyant forces.

Seismic Input. Two types of seismic analysis were completed to verify both overall stability of the embankment and to estimate anticipated deformation under seismic loads.

The combined result of the two types of stability analysis show the embankment including the MSE retained wall sections, in and adjacent to the wetlands, can be constructed to have comparable stability as for other parts of the embankment, and with the same low risk of catastrophic failure, accepted for other major transportation facilities.

Stability analyses used standard geotechnical methods that are widely accepted for embankment design. Seismic (pseudostatic) stability analyses were performed on the most critical failure surfaces that were found during searches for minimum *static* factors of safety. The seismic analysis incorporated a horizontal acceleration component into the computer model to account for the effects of an earthquake. The acceleration term used in the preliminary analysis is based on the peak ground acceleration (PGA) that would be expected in the SeaTac area during an earthquake with a 475-year return interval (10 percent probability of exceedence in 50 years). This corresponds to a somewhat larger seismic event than both the 1965 SeaTac earthquake (Richter magnitude 6.5) and the 1949 Olympia earthquake (Richter magnitude 7.1).

Additional seismic analysis of the Wetland 37 Wall was accomplished to estimate the magnitude of potential embankment movements, using the Newmark procedure (Kramer, 1996). This analysis used a much larger seismic event, corresponding to the maximum probable earthquake with a nominal return period of 3,000 years, a so-called "great earthquake." The Newmark analysis calculates deformation of the reinforced soil mass as a sliding block.

Sensitivity. The sensitivity of the stability analyses was checked by varying the following:

- Shape of failure surface;
- Depth of failure surface;
- Length of reinforcement in vertical walls;

- Soil strength;
- Groundwater level;
- Backfill and base preparation strengths;
- Backfill unit weight;
- Limit equilibrium analysis method; and
- Analysis tools (i.e., different software programs and analytical methods).

Results of Stability Analyses

Static factors of safety ranged from 1.2 to 2.0, and pseudostatic seismic factors of safety ranged from 0.8 to 1.2 for critical sections. A target factor of safety of 1.3 (static) and 1.05 (seismic) was selected for these analyses, based on conventional geotechnical design for comparable embankments.

The target factors of safety were obtained for the Wetland 37 Wall, but not for some areas of existing soils under some of the wall/slope combinations analyzed for the north end of the embankment. These results demonstrate the need to, and provide some of the basis for, designing subgrade improvements to the native soils in these areas.

Failure to obtain the target factors of safety in the north area resulted from insufficient existing strength in the medium stiff silt and clay below part of the proposed embankment, particularly under seismic loading. Subsequent analyses to show improved stability can result from improving subgrade strength during construction after overexcavating the unsuitable soils and replacement with compacted soil fill (possibly MSE reinforced) or *in situ* soil improvement.

The results are referred to as "proof of concept" because they demonstrate satisfactory stability will result from conventional construction procedures. Final design of the subgrade improvements will be based on further analyses accomplished following additional subsurface explorations. *In situ* measurements accomplished by cone penetrometer, test pits, and test trenches in the wetlands (which are not covered under the existing Nationwide 6 Permit program) will provide the specific input for design of subgrade improvements in the wetlands.

Results of the initial Newmark deformation analysis indicated that movement of the maximum height MSE retained fill, the Wetland 37 Wall, will be less than about 10 feet during a maximum probable earthquake. This analysis indicates that MSE reinforced fills designed for the site would have acceptable deformations during the maximum credible seismic event. Much smaller deformations would result from more likely earthquakes (i.e., an earthquake with a 475-year return interval (10 percent probability of exceedence in 50 years) compared to this "great earthquake." More detailed strain analyses to complete design of the MSE reinforced zone will be accomplished using finite difference methods.

Post-Construction Infiltration and Baseflow to Miller Creek

Hart Crowser analyzed post-construction effects of the Third Runway embankment on the Miller Creek drainage. These include the effect of infiltration into the new embankment that becomes groundwater recharge, and the effect of the new embankment on groundwater that infiltrates below the existing airfield and discharges to wetlands and Miller Creek west of the airfield. While the relative amount of runoff will increase in new paved areas and embankment slopes, infiltration is anticipated to increase over about 80 acres of relatively flat grassed areas that will be created between the new and existing runways and taxiway pavements.

In the area of construction, specific groundwater recharge contributions to Miller Creek will include:

- Infiltration into the top surface of the new embankment;
- Infiltration into the side slopes of the new embankment;
- Management of runoff from the side slopes;
- Maintenance of existing shallow interflow below the embankment; and
- Flow from the Shallow Regional Aquifer into Miller Creek.

These are discussed below individually. Appendix B provides additional detail on water balance calculations before and after construction.

Infiltration into the Top Surface of the New Embankment. Infiltration into the unpaved portion of the new embankment top surface exceeds existing on-site infiltration in the same area for the following reasons:

- Large area (about 80 acres) of relatively flat grassed land between runway and taxiway pavements permits greater infiltration compared to pre-construction sloping ground in the same areas;

- Post-construction grassed area between pavements will have less evapotranspiration (ET) compared to forest vegetation on the pre-construction slopes; and

- Soil conditions within the embankment will promote infiltration in some areas and overall have better average groundwater transmission rates compared with the underlying native soils (glacial till, glacially overridden silty advance sand, and hard silt units).

The large embankment thickness (up to 165 feet) provides significant buffering of storm water infiltration, increasing the available groundwater recharge and short-term storage before seepage eventually reaches Miller Creek or downslope wetlands.

Seasonal infiltration into the embankment soil mass will fill near-surface soil pore space until the soil reaches a condition referred to by soil scientists as "field capacity." Field capacity is the threshold moisture content above which a soil will drain freely. Additional infiltration will then percolate downward into the embankment. This percolating water will eventually intercept the embankment underdrain at the base of the fill, and most of this seepage will then flow to the west to Miller Creek or adjacent wetlands. The amount of deep percolation into soils directly underlying the new embankment will therefore be reduced relative to existing conditions. Recharge of seepage from the underdrain downgradient of the embankment is designed to mitigate this reduced deep percolation (adjacent to, rather than below, the embankment).

Infiltration into the Side Slopes of the New Embankment. Infiltration into the new embankment side slopes (nominal 2 horizontal to 1 vertical) is anticipated to be slightly less than existing infiltration over the "foot print" area of the side slopes (38 percent of rainfall post-construction, versus 50 percent for pre-construction infiltration). The reduction is mainly the result of the increased slope causing increased runoff. The potential for increased runoff is mitigated by improved infiltration capacity of the embankment fill relative to the existing glacially overridden soils, reduced evapotranspiration, and increased storage of water within the fill.

Infiltration into the new embankment side slopes will percolate downward until it is also intercepted by the underdrain discussed above. Benches on the slope face also mitigate the runoff and provide more opportunity for infiltration. This seepage will be increased slightly by additional infiltration along storm water swales which collect runoff from the embankment slopes.

Maintenance of Existing Shallow Interflow below the Embankment. In addition to intercepting seepage infiltration from the top of the embankment, the embankment underdrain also provides a means for existing seepage in the filled area to continue to flow downgradient to the west.

The existing ground surface below the embankment will largely be left undisturbed prior to fill placement, as discussed later in this report. Shallow interflow seeps, expressed where perching layers outcrop on the slope, will continue to discharge into the underdrain, or will continue to flow downslope below the underdrain.

Areas of soft soils that need to be removed to provide embankment foundation support will be backfilled with free-draining sand and gravel hydraulically connected to the underdrain. In this way existing seepage into wetlands that are filled will continue to be available as seepage through the underdrain. This water will flow downgradient to the west, and eventually reach downslope wetlands and Miller Creek.

Flow from the Shallow Regional Aquifer into Miller Creek. A geotechnical analysis was used to assess whether the weight of the embankment would significantly reduce the amount of existing baseflow from the Shallow Regional Aquifer to Miller Creek (Hart Crowser, 1998a).

Experience with earth dams shows seepage under an embankment is typically not reduced by the weight of the fill, and grout curtains or sheet pile cutoffs are typically constructed where control of seepage is necessary below embankments (Terzaghi & Peck, 1967). None the less, Hart Crowser calculated the effect of the embankment on seepage below the new fill.

These calculations indicate that volume of soil pore space, expressed as the void ratio (volume of voids relative to volume of solids) within the Shallow, Intermediate, and Deep Aquifers within the area immediately underlying and adjacent to the embankment would be reduced by roughly 1 to 3 percent due to the maximum weight of the embankment. For perspective, this corresponds to about a 4-inch maximum change in thickness for the 50-foot-thick Shallow Aquifer. The magnitude of the change in void ratio would diminish rapidly both laterally and as a function of depth. There would be no effect in the Shallow Aquifer more than 50 feet from the edge of the embankment, and no effect in the Deep Aquifer more than about 500 feet from the edge of the embankment.

Reductions in permeability on the order of 2 to 5 percent corresponding to the change in void ratio are estimated immediately below the embankment, with the effects decreasing with depth. The estimated 2 to 5 percent change is insignificant, given that differences in permeability are usually evaluated in terms of orders of magnitude (powers of 10).

Effects of the magnitude estimated could conceivably produce a slight groundwater mounding in the Shallow Regional Aquifer on the upgradient side of the embankment (i.e., below the existing airport), but this would probably not be measurable. Baseflow to Miller Creek located west of the embankment is not likely to be impacted, since the effect of the mounding would be to locally increase the groundwater flow gradient resulting in no net loss of baseflow.

No impacts are anticipated to drinking water resources in the Intermediate and Deep Aquifers. The effect of the embankment weight diminishes with increasing depth and distance from the fill. There are no wells within the affected area (maximum about 500 feet from the edge of the embankment).

GEOTECHNICAL OVERVIEW OF PROPOSED CONSTRUCTION

This section of the report discusses the general sequence of construction from a geotechnical perspective, focused on avoidance or mitigation of sediment-loading impacts to Miller Creek and wetlands. Each of the areas outlined below should be addressed in the construction plans and specifications, but may need to be modified as additional information is obtained.

Installation of TESC

Temporary erosion and sediment controls (TESCs) will be installed prior to any other land disturbance for construction. TESC will be installed upgradient of Miller Creek and the undisturbed portions of wetlands.

All construction and related activities such as access and staging, will be accomplished in specific areas with appropriate TESC measures.

TESC measures will be designed prior to construction. Installation and maintenance will be specified as part of construction contract documents. TESC measures will conform to the Port's NPDES permit, including best management practices (BMPs), (Parametrix, 1999a).

Temporary Construction Access Road to Maintain TESC

Temporary construction access roads will be installed along the perimeter of disturbed areas to enable regular inspection and maintenance of TESC facilities. Wood chip mulch (tub grindings) from other site clearing can be used seasonally to limit generation of dust and improve roadbed trafficability along such roads in wet conditions.

After completion of construction and permanent erosion controls, temporary construction roads not needed for permanent airport operations would be removed from wetland and stream buffer areas. Restoration of temporary road areas would include:

- Removing any rock fill or quarry spalls;

- Grading to permanent slopes designed for erosion control;

- Ripping or plowing to loosen surficial soils compacted by traffic; and

- Revegetating with appropriate plant materials (identified in the Natural Resource Mitigation Plan; Parametrix, 1999b).

Clearing—Topsoil Removal Limited to Specific Areas

Prior to placement of any embankment fill, the site will be cleared, including close-cutting all vegetation to within a few inches of the ground surface and removal of existing structures.

Specified site clearing shall be limited within the construction area to reduce potential erosion and sedimentation.

Topsoils will not be stripped within most of the construction area.

- Based on experience with fill construction in 1998, the Port does not plan to strip topsoil or grub (remove) root masses within most of the area to be filled; and

- Stability analyses and the 1998 fill experience indicate the effect of surficial topsoil on stability of the fill is limited to the toe of the embankment. The extent of topsoil stripping was found to have little influence on stability as embankment height increases. Topsoil removal and grubbing will typically be limited to a zone about 50 feet wide along the toe of the embankment.

Limiting the extent of grubbing and topsoil stripping in this manner will significantly reduce potential for erosion to occur in the period between clearing and fill placement.

Existing structures will be removed down to the foundation level, along with removal of any existing underground fuel (home heating oil) tanks.

Subgrade Preparation

Following site clearing, heavy compaction equipment will be used to "proof roll" the subgrade, to aid in identifying local areas of soft, loose, or otherwise unsuitable foundation soils. These areas will be compacted in place, or otherwise improved as discussed later.

During subgrade preparation, visible seepage may be collected in gravel and perforated pipe "french drains" for conveyance and reinfiltration outside the immediate construction area. This may be done for instance to avoid mixing clean groundwater with potentially more turbid storm water, or to improve drainage/reduce mud in work areas.

Limited Construction Dewatering

Temporary construction dewatering may be accomplished in limited areas so that structural fill can be compacted below grade in areas where existing soils need to be replaced, or to enable construction of subgrade drainage.

Shallow excavations in stable soils would typically be excavated with internal sumps to remove any accumulated seepage or precipitation. Construction dewatering to depths of around 10 to 15 feet would typically be accomplished with well points around the perimeter of the area to be dewatered. Dewatering to the maximum anticipated depth of soil removal or improvement, on the order of up to about 20 feet, would probably be accomplished with staged well point systems.

Discharge from individual well points or sump pumps would be discharged in a controlled manner.

- Pumping from open sumps and initial discharge of well development water, which may be somewhat silty, would be pumped to the TESC sediment ponds for treatment as needed prior to discharge to Miller Creek; and

- During operation, clean water from the wells would be discharged through land application adjacent to Miller Creek. Typically this involves low velocity discharge through perforated pipe laid along the ground surface in grassed or forested uplands adjacent to the creek buffer.

Well points rather than pumped well systems are anticipated to be used. Pumped well systems, which cause groundwater drawdown over extensive areas, are not anticipated to be used because:

- Dewatering is needed only in limited areas and depths;

- The soils that need to be dewatered are relatively silty or include stratified zones of relatively silty and non-silty soils; and

- Dewatering will be of short duration (a few weeks in each location)

Temporary construction dewatering systems would be designed to avoid adverse impacts to Miller Creek and Walker Creek. Lateral extent of drawdown adjacent to dewatered areas likely will be very limited (on the order of tens of feet) due to the typically silty nature of soils to be dewatered. Where more extensive impacts may occur (i.e., based on possible findings of future explorations), construction can incorporate reinjection wells and/or temporary use of sheet pile cutoffs to control the area of drawdown.

Rates of dewatering will depend on the sequence of construction, excavation geometry, and specific local soil conditions. Relatively low flow rates for dewatering are anticipated based on results of slug tests and an attempted pumping test (Hart Crowser, 1999). Total magnitude of discharge in any area will depend on the size of the dewatered zone (to be determined during final design of subgrade improvements).

Local Overexcavation and Removal of Unsuitable Soils

Existing soils in the area below the Wetland 37 Wall, below portions of the embankment, and below portions of walls in the North Safety Area, are unsuitable to support load of the new fill and/or retaining walls. Engineering measures to improve subgrade support during construction, will typically consist of local overexcavation and removal of unsuitable soils.

Typically, soils are unsuitable foundation material because they have one or more of the following characteristics:

- Excessive amounts of organic material (peat);
- Relatively compressible or low strength (medium stiff) silt or clay; and/or
- Loose to medium dense relatively non-silty sands which may be subject to liquefaction.

Typically depth of such overexcavation is anticipated to be on the order of about 15 feet or less, based on wetland exploratory borings accomplished under the Nationwide 6 Permit. Specification of the final extent and depth of overexcavation to remove unsuitable soils will require additional explorations, which will need to include test trenches and test pits, to be completed after construction access is permitted in the wetland areas to be filled.

Overexcavation would typically be accomplished with open cut slopes averaging 2H:1V or flatter. Temporary sheet pile would be used as needed to limit the extent of disturbance in wetlands along the edge of the embankment fill, such as Wetlands 44a, 41a, 11, 37a, A6, and A1 (see Figure 8).

Where unsuitable soils are removed, they will be replaced with compacted free-draining granular fill (Type 1). This structural fill may be MSE reinforced as needed for stability. The MSE reinforcement will not impede infiltration, thus new subgrade fill in wetland areas will typically have better infiltration characteristics relative to existing (relatively silty) wetland soils.

The free-draining structural fill in overexcavated areas would be hydraulically connected to the embankment underdrain to promote infiltration and permit dissipation of accumulated seepage (see Figures 8 and 9).

- For filled areas below the main embankment, the hydraulic connection with the underdrain enables any natural seepage into the overexcavated area to be conveyed to the edge of the embankment with no adverse impact on stability. Beyond the edge of the embankment, this seepage is available as recharge to downgradient wetlands

- For wetlands along the edge of the embankment, the hydraulic connection with the underdrain enables infiltration (recharge) of seepage from below the embankment to the remaining wetland.

Local in situ Improvement of Unsuitable Soils

In situ soil improvement may be used where depth of unsuitable soils or other circumstances makes overexcavation and replacement infeasible. Alternative approaches, such as stone columns, soil mixing, jet grouting, etc. may be used along with appropriate seepage mitigation to improve shear strength and reduce compressibility of existing soils below the MSE reinforced zones behind retaining walls.

Earthwork details will be developed as needed for subgrade improvement areas to preserve transmission of seepage beyond the embankment. There are a number of proprietary techniques to accomplish foundation improvement. As an example, stone columns are created by placement of compacted gravel zones in the existing soil through vibratory densification, see Figure 10.

Selection of specific construction method(s) for soil improvement will be completed prior to construction, when subsurface explorations and test trenches are completed in wetland areas to be filled.

Embankment Drainage Layer

The first layer of embankment fill will consist of free-draining sand and gravel to form the embankment underdrain. The underdrain will range from 2 to 4 feet thick depending on the overlying fill, and locally the thickness would be increased to include fill in overexcavated areas.

In addition to assuring good subsurface drainage for the embankment fill that is subsequently placed, the underdrain will provide an initial working surface that can be sloped to reduce subsequent runoff and erosion.

The underdrain material would be placed in lifts and densely compacted. Typically it would be constructed working up from the lowest part of a given fill area and in from the edges of the fill. Graded granular filters, a combination of filter fabric and soil, and/or rock riprap would be used to prevent erosion in areas of active seepage, such as along the drainage swale at the downgradient edge of the underdrain, see Figure 8.

MSE Retaining Wall Construction

Construction of the MSE retaining walls would be accomplished by constructing an initial strip footing along the alignment of the wall facing, and then placing the reinforced backfill behind the wall in lifts, working upward. In some areas, the wall(s) would be constructed on top of densely compacted fill rather than directly on the subgrade.

Typically the foundation for the wall elements consists of a strip of below-grade MSE reinforced soil, and a compacted gravel pad or concrete strip footing. Placement of the reinforcing and backfill soil is accomplished from behind the wall. Temporary road access along the face of the wall may be provided to install a final wall facing, such as pre-cast concrete panels. Other than this temporary road and required TESC facilities, construction of the walls would not need to intrude into the wetlands in front of the wall.

During construction, the top of the fill would be sloped gently downward behind and away from the face of the wall (about 2 percent) to facilitate storm water runoff away from the wetlands, and to help control alignment of the wall facing. Runoff would be collected in temporary swales on the back of the fill (away from the wetlands) and conveyed to sediment ponds in the same manner as was successfully used during the 1998 embankment construction.

Placement and Compaction of Embankment Fill

Earth fill for the Third Runway embankment would be placed in layers and compacted. Soil would be moisture-conditioned as needed to improve compaction. Typically the conditioning could include:

- Spreading and aeration by disking to reduce soil moisture;
- Light sprinkling to increase soil moisture; or
- Use of soil blending or use of a more select soil, in wet weather.

During construction, the top of the fill would be sloped gently (about 2 percent) to the east, away from the face of the wall to direct storm water runoff away from the wetlands. Runoff would be collected in temporary swales on the back of the fill (away from the wetlands) and conveyed to sediment ponds such as were used successfully for the 1998 embankment construction.

Construction specifications would include provisions for maintaining runoff and erosion protection during any construction shut-downs.

Embankment Slope Protection

As embankment construction phases are completed, permanent erosion protection would be installed. Typically this would include planting vegetation on the embankment slopes and monitoring to assure it becomes well-established and self-sustaining (Parametrix, 1999a).

The Port has had good success with hydroseeding to provide temporary erosion protection on the 1998 fill. This experience demonstrates:

- Hydroseeding is a viable means of controlling erosion in the winter immediately following fill placement; and
- The resultant cover can be relied on until permanent vegetation is established and/or completion of other construction phases.

MITIGATION OF POST-CONSTRUCTION HYDROGEOLOGIC IMPACTS

Management of Storm Water Runoff

Storm water runoff from the embankment will be collected and handled as discussed by Parametrix (1999a and 1999c).

Storm water runoff from the sloping face of the embankment will be collected in a permanent swale alongside the security road (see Figure 9) and conducted to detention facilities below the toe of the slope.

The swales provide some opportunity for infiltration. These swales will be rock-lined where necessary or otherwise protected against erosion along the toe of MSE walls, see Figure 8. Infiltration in this area will recharge to the Shallow Regional Aquifer and contribute to groundwater discharge to wetlands and Miller Creek.

Discharge of Seepage from the Embankment Underdrain

Most seepage collected from the embankment via the underdrain will discharge to a collection swale at the toe of the slope or below the toe of the MSE wall, the remainder will infiltrate directly into the Shallow Regional Aquifer under the embankment footprint. Seepage into the swale is likely to occur discontinuously along the length of the embankment, with flow concentrating at topographic low spots or in areas where there are pre-existing seeps.

The purpose of the swale is to collect seepage from the underdrain and conduct it laterally along the toe of the embankment for surface discharge to wetlands. Additional infiltration to recharge shallow interflow and the Shallow Regional Aquifer, will occur along the swale.

Facilities to enhance infiltration can be constructed at specific locations to augment water supplies for existing wetlands that are left undisturbed beyond the area of impact for the project. Facilities will be designed to infiltrate water from the drainage layer into the shallow subsurface soils that form the delineated wetlands. These can include:

- Locally increasing the swale width to reduce velocity and provide increased infiltration area;
- Overexcavating the side of the swale and replacing the existing soil with a sandy gravel berm to promote side wall seepage;
- Overexcavating the bottom of the swale to provide small check dams to hold water for continued infiltration in low flow times; and/or
- Construction of lateral gravel-filled finger-trenches

Post-Construction Baseflow to Miller Creek and Riparian Wetlands

The embankment underdrain plays a key role in collecting percolating water that has infiltrated into the surface and facing slopes of the embankment. The underdrain intercepts percolation and enables some control of groundwater recharge for the Shallow Regional Aquifer beneath the embankment:

- All of the water in the underdrain is available as direct recharge, by vertical seepage into the underlying soil; and
- Water which infiltrates through the embankment at a rate faster than it can infiltrate into the native soil will seep laterally downgradient within the underdrain, to swales which convey it to wetlands beyond the embankment.

By collecting and re-infiltrating seepage from the underdrain as described above, the impact of runway construction on baseflow to Miller Creek will be substantially mitigated.

Typical MSE Wall Section

Impacts to recharge in the vicinity of the Wetland 37 Wall between Station 175+00 and 185+00 are summarized in Appendix B. The water-balance model is based on average conditions and 40 inches of annual rainfall. The variation of pre-project and mitigated post-construction recharge to groundwater during an average year is depicted on Figure 11.

In this analysis, the impact of infiltration to baseflow is proportional to monthly rainfall, with the major impacts occurring in the winter months. The embankment will provide increased storage and a corresponding delay in discharge of infiltration, caused by groundwater travel time through the embankment subsurface. The effect of these factors is to delay the groundwater recharge by one or two months, providing higher flow than at present in the early summer months.

Typical 2:1 Embankment Section

Impacts to recharge along the main embankment between Station 185+00 and 215+00 are summarized in Appendix B. The variation of pre-project, impacted, and mitigated baseflows through an average year is depicted on Figure 12.

PREPARATION OF THIS REPORT

This report has been prepared for the exclusive use of HNTB Corporation and the Port of Seattle for specific application to the site and project discussed herein. Hart Crowser, Inc., accomplished this work in general accordance with our proposal dated January 28, 1999. We completed this work in accordance with conventionally accepted geotechnical engineering practices for the nature and conditions of work completed in the same or similar localities at the time the work was accomplished. We make no other warranties, express or implied.

We appreciate the opportunity to assist you on this project. Please call if you have any questions.

Sincerely,

HART CROWSER, INC.

22484

7/9/99

EXPIRES 12/13/99

MICHAEL J. BAILEY, P.E.
Principal Engineer

31229

7/9/99

EXPIRES 9/17/99

MICHAEL A.P. KENRICK, P.E.
Sr. Assoc. Hydrogeologist

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Table 1 - Soil Parameters Used for Stability Analysis

Soil Description	Moist Unit Weight in pcf	Cohesion in psf	Friction Angle in Degrees
Fill - Select Runway Fill	125	0	35
Fill - Wall Backfill	109 to 120	0	32 to 36
Glacial Till	130	250	40
Peat	90	0	19
Sand - Advance Outwash	125	0	35
Sand - Base Preparation	130	0	32 to 40
Sand - Dense to Very Dense	125	0	39
Sand - Drainage Layer	140	0	40
Sand - Medium Dense to Dense	120	0	35 to 37
Sand - Recessional Outwash	120	0	35
Silt - Hard, Sandy	120	4000	0
Silt - Medium Stiff	120	400	20 to 24
Topsoil	90	0	23

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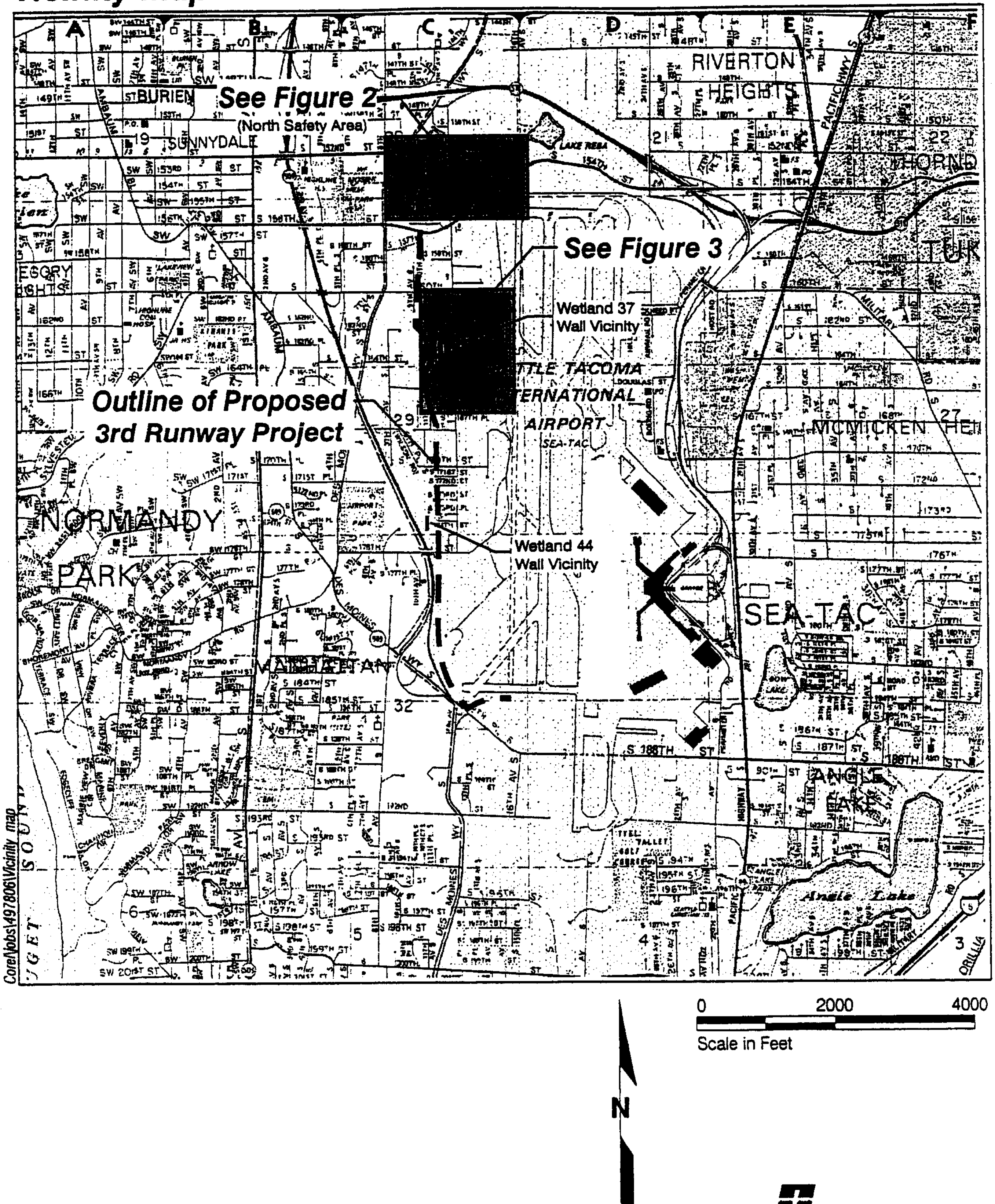
Vicinity Map



CoreVobs\497806\Vicinity map

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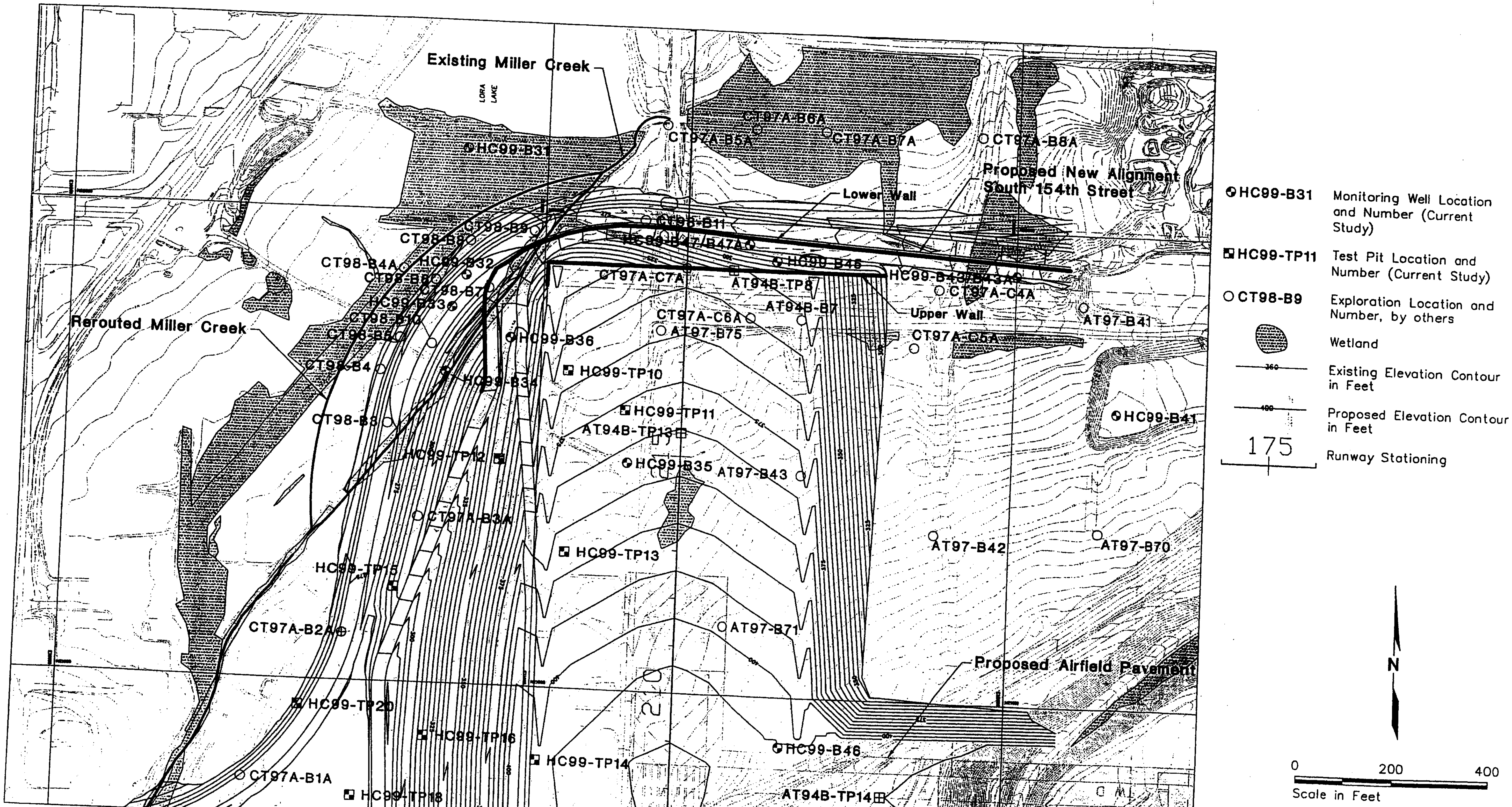
Figure 1

Site and Exploration Plan - 1 of 2

North Study Area



Note: Base map prepared from drawing provided by HNTB entitled "Sthbase.dwg", dated August, 1998. Wetland locations based on drawing provided by Parametrix entitled "w_050799.dwg", dated May 7, 1999.

RC 6/10/99 1=200 (xref)see drawing file/woodstock.pcp
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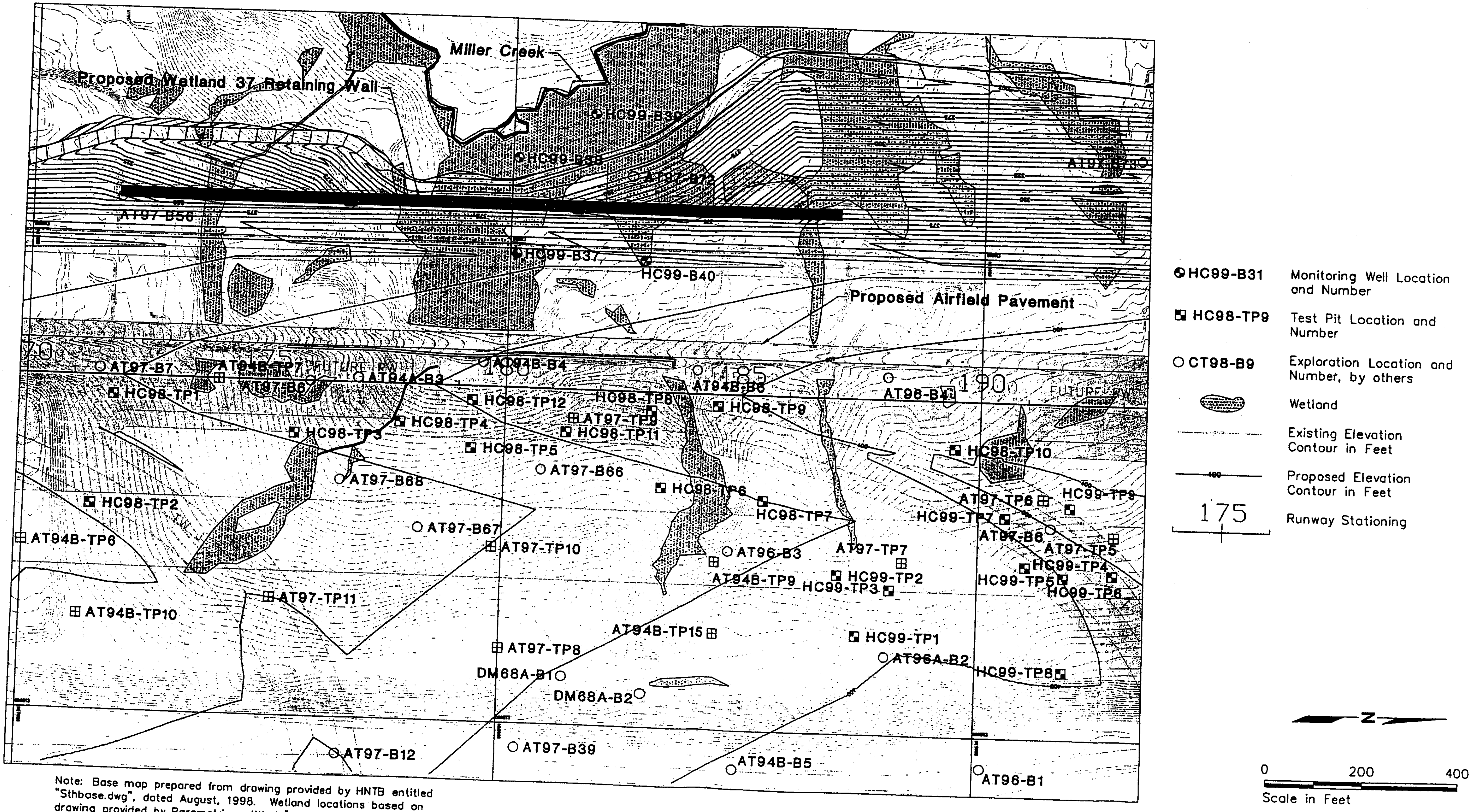
Figure 2

Site and Exploration Plan - 2 of 2

West Study Area



Note: Base map prepared from drawing provided by HNTB entitled "Sthbase.dwg", dated August, 1998. Wetland locations based on drawing provided by Parametrix entitled "w_050799.dwg", dated May 7, 1999.

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Figure 3

HC 7/8/99 1=1 wdstck-8.pcp 49780624

Elements of Shallow Groundwater Movement

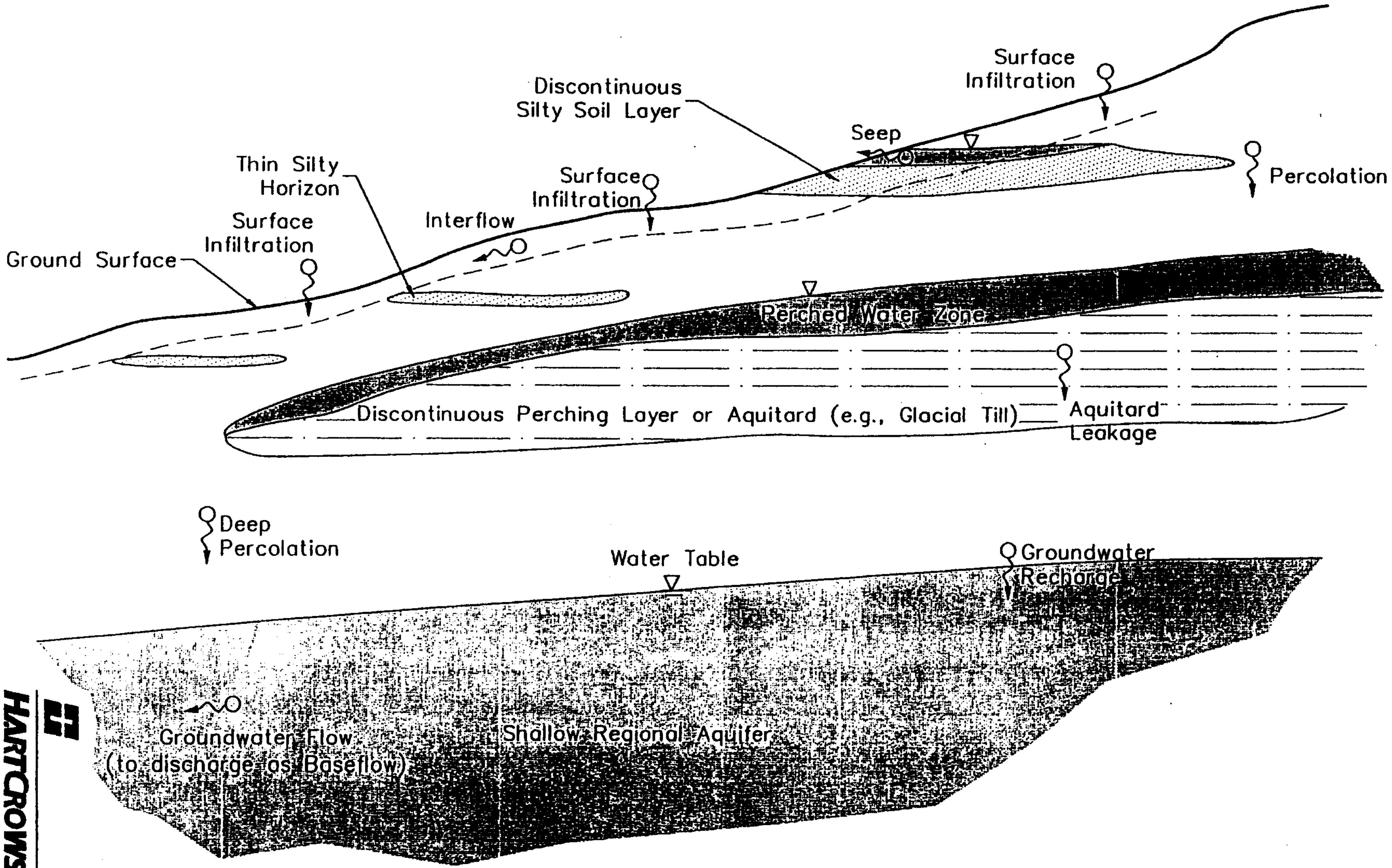

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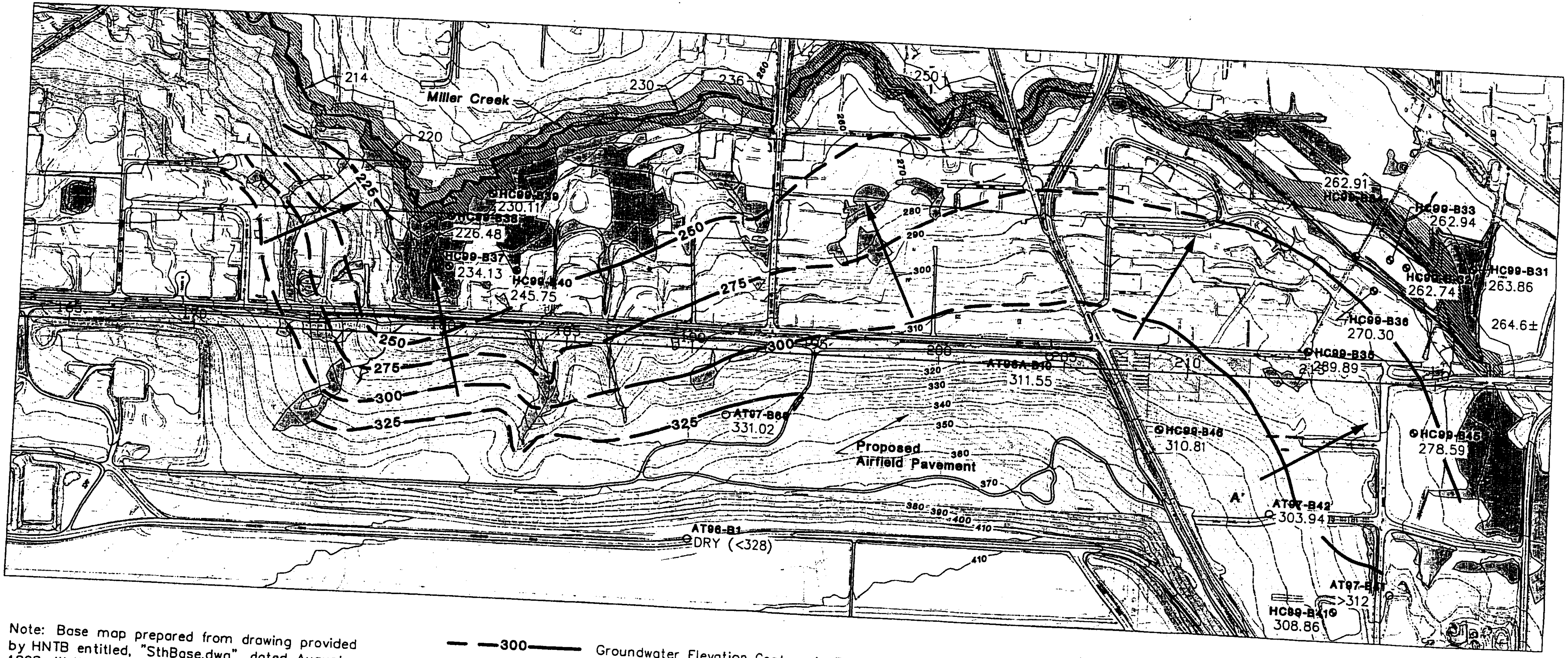
Figure 4

Shallow Regional Aquifer Groundwater Elevation Contour Map



Note: Base map prepared from drawing provided by HNTB entitled, "SthBase.dwg", dated August, 1998. Wetland locations based on drawing provided by Parametrix entitled, "w_050799.dwg," dated May 7, 1999.

— —300——	Groundwater Elevation Contour in Feet
---------410----------	Existing Elevation Contour in Feet
⊕HC99-B35	Monitoring Well Location and Number
278.59	Groundwater Elevation in Feet
←	Inferred Groundwater Flow Direction
175	Runway Stationing
▨	Wetland

N

0 400 800

Scale in Feet

RC 7/8/99 1=400 (wref)see drawing file/woodstck.pcp
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RC 7/8/99 1=1 wdslck-8.pcp 49780618

MSE Wall Schematic

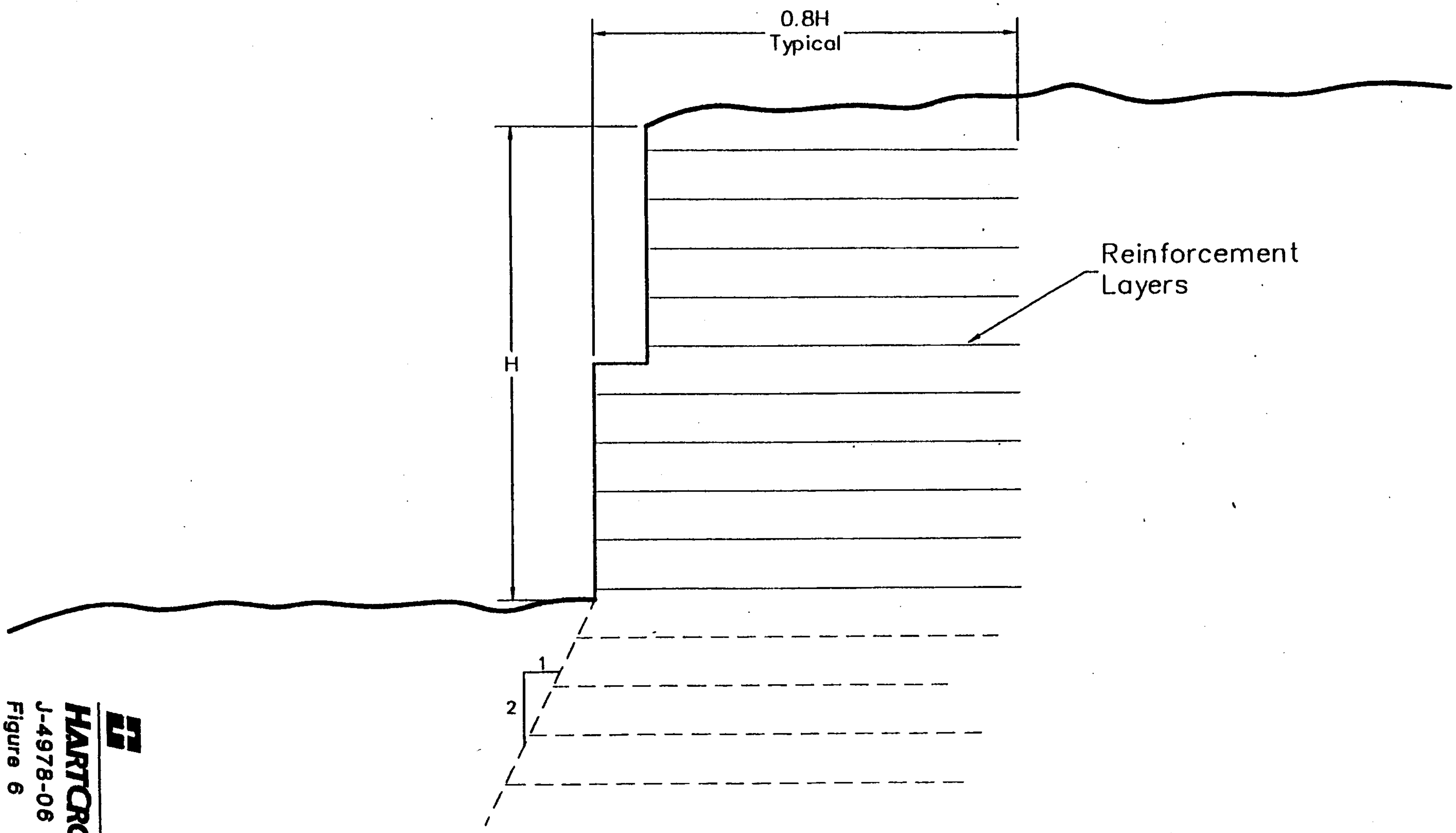

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Figure 6

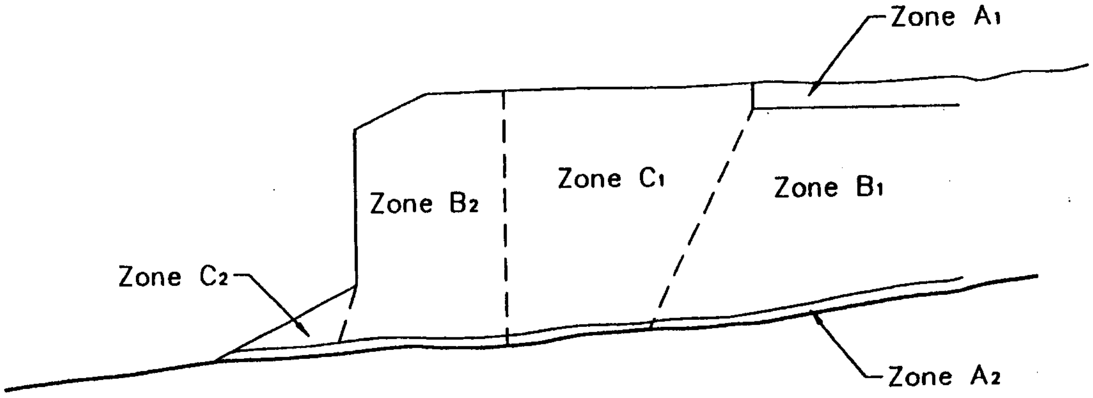
RC 7/8/99 1=1 woodstck.pcp 49780615

Conceptual Zoned Embankment Cross Sections

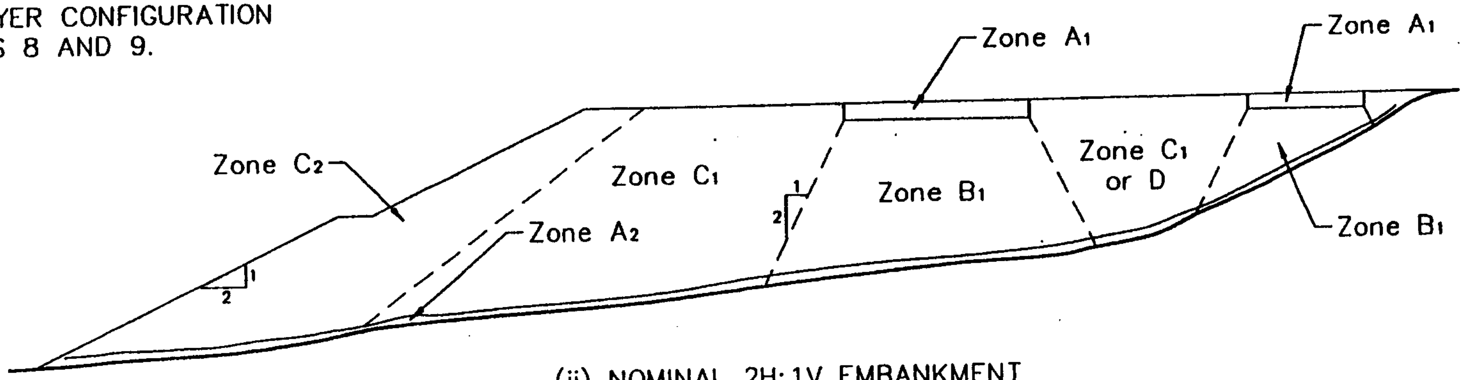
EMBANKMENT ZONES

- A_1 PAVEMENT SUBGRADE
- A_2 DRAINAGE
- B_1 PAVEMENT SUPPORT
- B_2 MSE REINFORCING
- C_1 COMMON EMBANKMENT
- C_2 COMMON EMBANKMENT, SLOPE FACE
- D NON-STRUCTURAL FILL

NOTE: DRAINAGE LAYER CONFIGURATION VARIES, SEE FIGURES 8 AND 9.



(i) MSE RETAINED EMBANKMENT



(ii) NOMINAL 2H:1V EMBANKMENT

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Figure 7

RC 7/8/99 1=1 wdalck-8.pcp 49780617

Extent of Overexcavation for Replacement of Foundation Soils

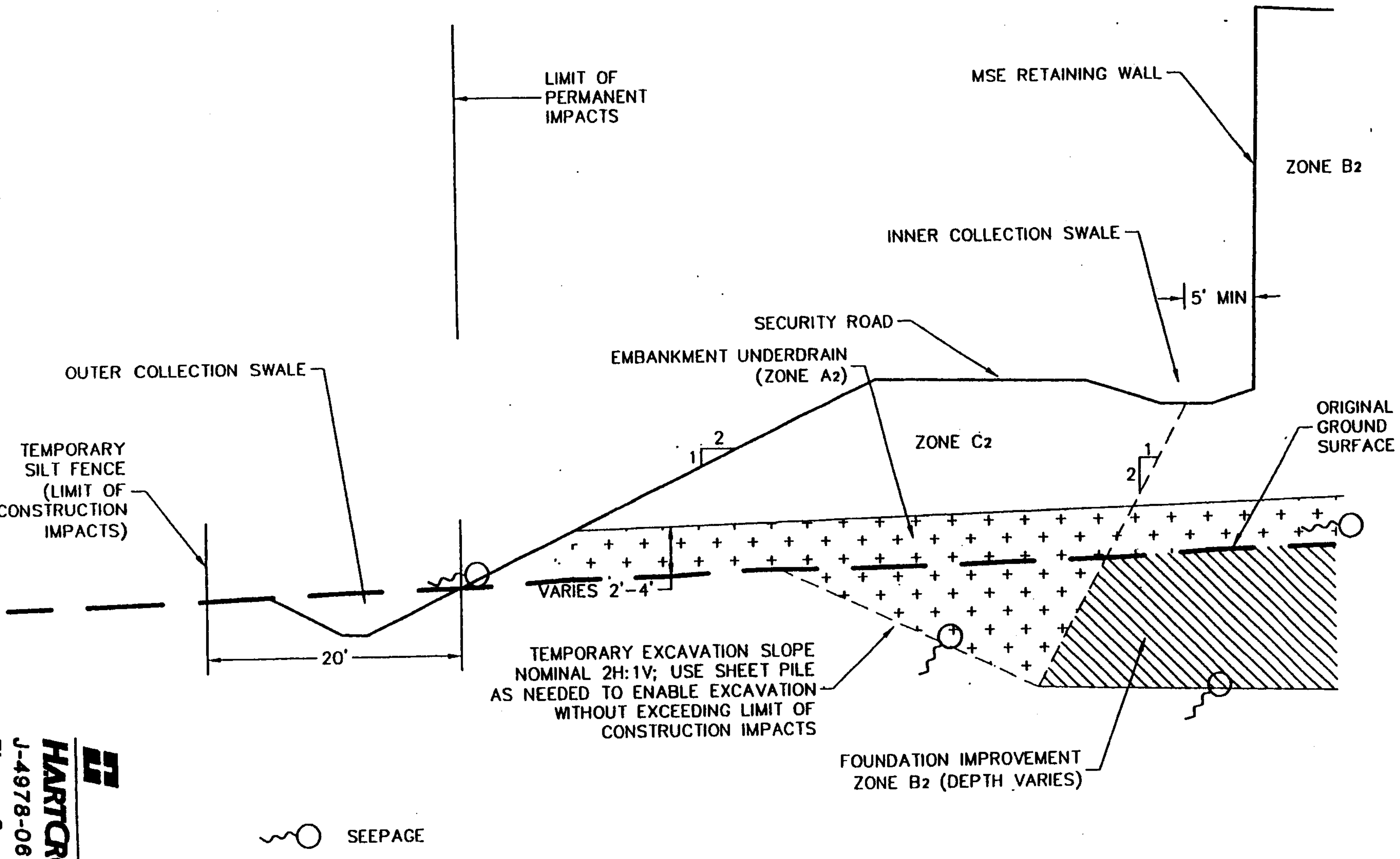

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Figure 8

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Hydraulic Connection between Wetland Fill and Embankment Underdrain

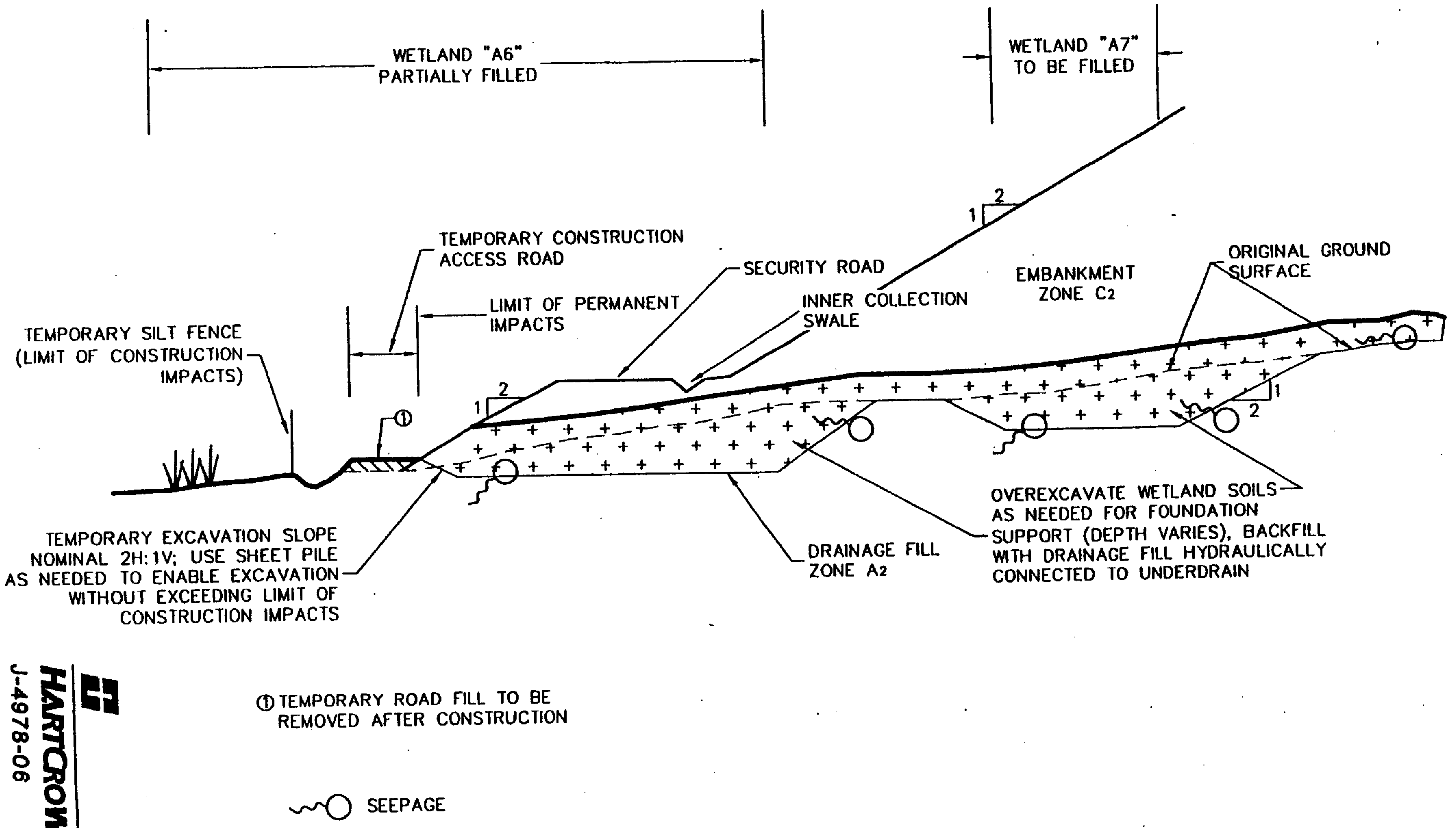

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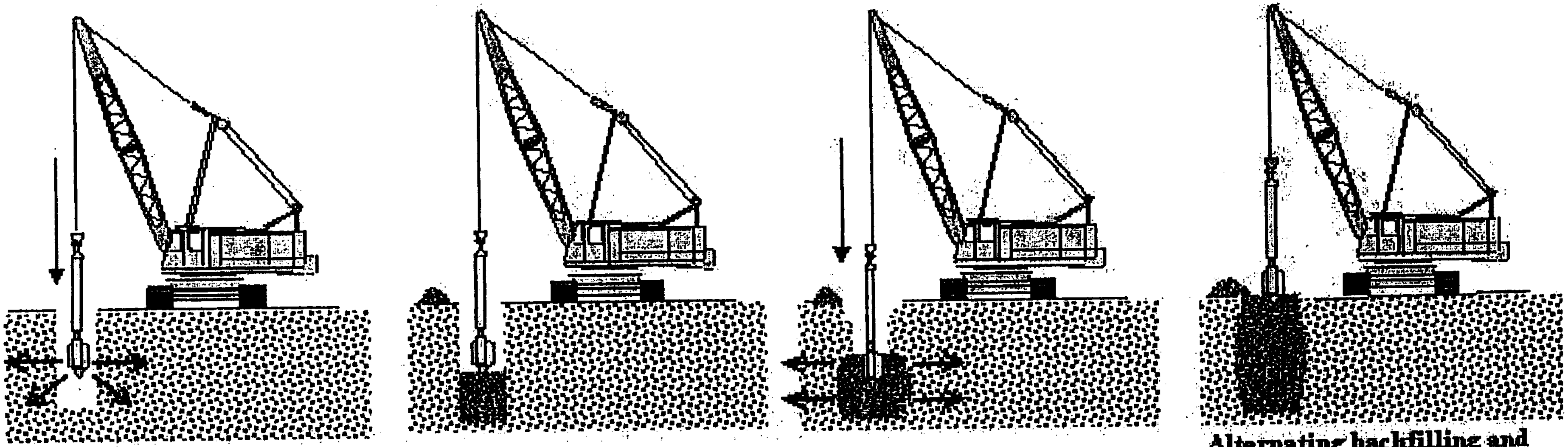
Figure 9

Stone Column Installation for Subgrade Improvement



Borehole is formed by sinking vibrator into the ground

Backfill material is placed into the borehole in stages and compacted

Alternating backfilling and compacting form continuous stone column

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Figure 10

Comparison of Pre- and Post-Construction Groundwater Recharge

Runway Stations 175+00 to 185+00 (Typical MSE Wall)

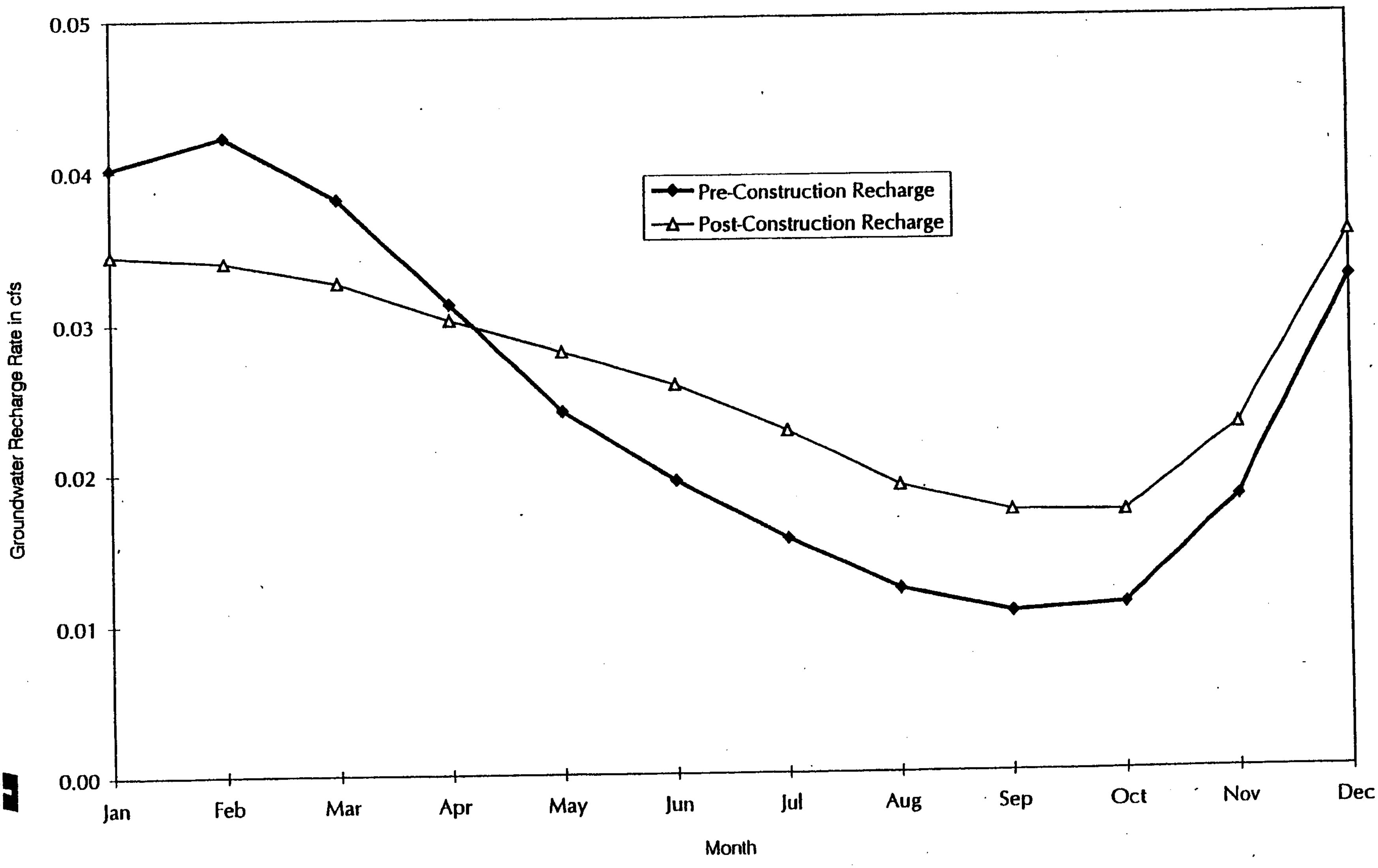

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Figure 11

Comparison of Pre- and Post-Construction Groundwater Recharge Runway Stations 185+00 to 215+00 (Typical 2H:1V Embankment)

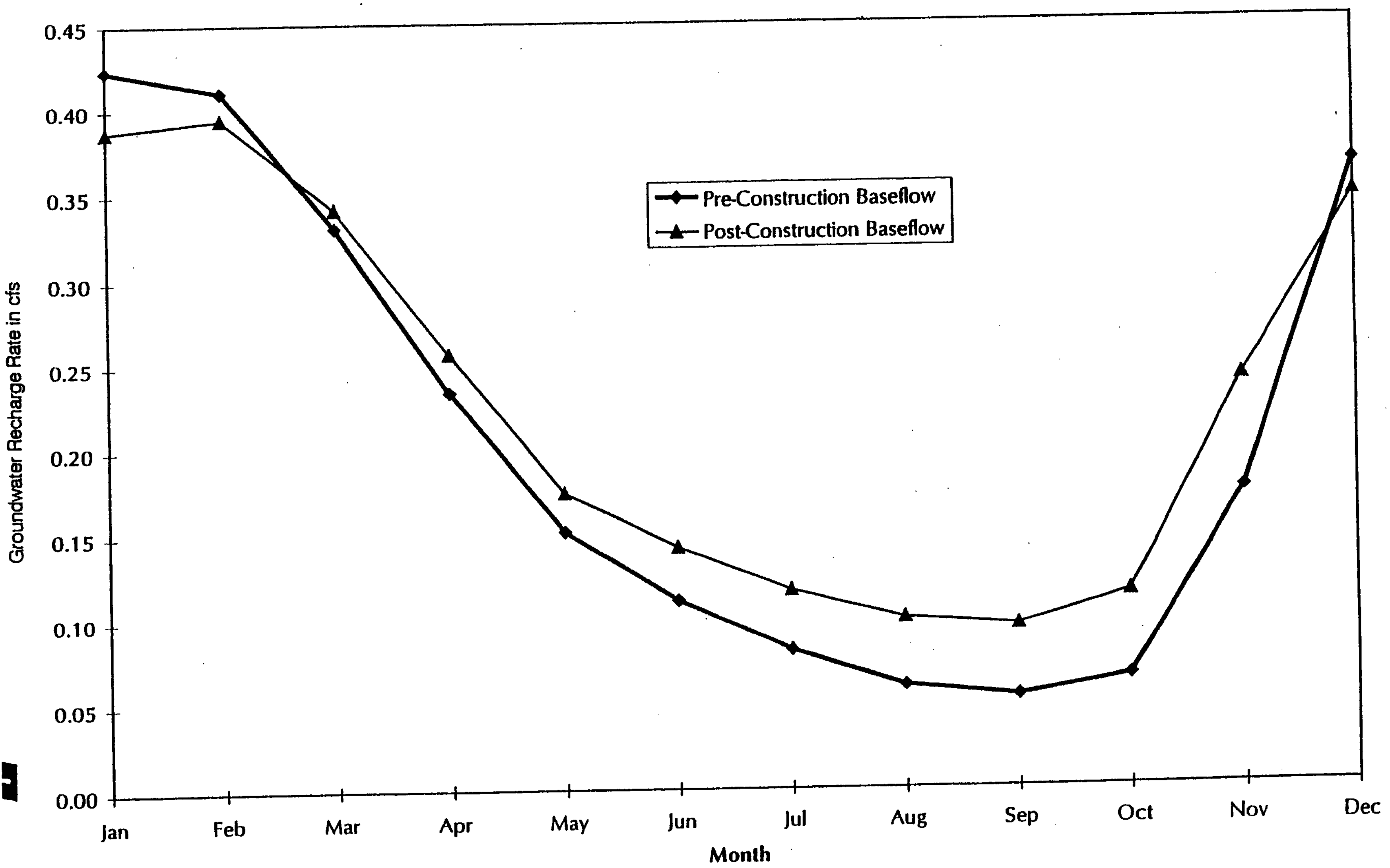

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Figure 12

APPENDIX A
SUBSURFACE CONDITIONS IN SELECTED REPRESENTATIVE WETLAND AREAS

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SUBSURFACE CONDITIONS IN SELECTED REPRESENTATIVE WETLAND AREAS

This appendix summarizes geotechnical soil conditions encountered in exploratory borings accomplished within representative wetland areas. Boring logs and test results, along with additional information are presented in Hart Crowser (1999). The selected wetlands were identified as being representative based on review of existing information, or as significant based on anticipated location of MSE walls to retain the fill. Available information indicates other wetlands to be filled are likely to have similar geotechnical characteristics.

North Safety Area (Combination of Slopes and Walls)

Near-surface soils in the vicinity of the north end of the embankment including Wetlands 9, FW6 and FW3, generally consist of:

- Loose to medium dense, moist, silty, gravelly sand;
- Sand with occasional gravel and occasional thin layers of silt;
- Occasional peat and soft, organic silt; and
- Medium stiff to hard, sandy silt.

These soils are predominantly recessional outwash deposits which comprise the majority of surficial materials in the embankment footprint (AGI, 1996). Some recent alluvium is also present. The recessional outwash soils and alluvium combined are typically less than about 10 to 20 feet in thickness, and overlie dense to very dense glacial till and advance outwash deposits.

Soils at the north end of the embankment are relatively variable in gradation compared to soil conditions under most of the embankment footprint. Soil conditions affecting embankment design include the following significant units:

- In the area upslope of Wetland 9, the near-surface soils consist of medium stiff to very stiff, sandy silt, underlain by a laterally consistent layer of medium stiff to hard, moist to wet, fine sandy silt. Laboratory testing indicates this soil has low plasticity, low cohesion, and potential to consolidate (gain strength) under the embankment load. This fine sandy silt is anticipated to be relatively well-drained due to the presence of thin layers of silty fine sand which are wet and relatively more permeable than the fine sandy silt.

- An area of very soft to soft peat and organic silt was encountered in Wetland FW6, in the northwest area of the embankment, during explorations for the 154th Avenue relocation alignment study (CivilTech, 1997). HC99-B36, which is slightly upslope of the soft peat soils, encountered 8 feet of loose, very silty sand over stiff to hard silt. The soft, moist to wet, peat and silt soils vary from a single layer generally less than 15 to 20 feet in thickness, to peat interbedded with loose to medium dense silty sand or stiff silt.

West Side of Embankment

Wetland 37 Wall

Surficial soils were evaluated on the west side of the embankment within and adjacent to Wetland 37a as part of evaluating retaining wall and slope alternatives (to avoid relocating Miller Creek and reduce the filling of wetlands) in this area.

Near-surface soils within the topographically low-lying areas generally consist of interlayered:

- Loose to medium dense, moist to wet, silty to very silty, fine sand, which is occasionally slightly gravelly;
- Soft to stiff, moist peat and organic silt; and
- Soft to stiff, moist, sandy silt.

Dense to very dense glacial till soils are generally encountered at 5 to 17 feet in depth (i.e., below the loose or soft soils identified above). Typically the thicker deposits of soft and loose materials appear to be in the topographic lower portions of the wetland. As the ground surface topography rises, the surficial soils transition from the recently deposited peat, silt, and fine sand into medium dense, moist, silty, slightly gravelly to gravelly sand, identified as recessional outwash soils. The depth to glacial till in the upland areas typically appears to be 5 to 10 feet, somewhat less than in the low lying areas.

Wetland 44a Wall

A third area where construction impacts to wetlands can be significantly reduced by retaining wall construction is Wetland 44a. Subsurface explorations have not been completed to date within Wetland 44a, because of property access constraints and because drill-rig access is likely to require cutting and filling within the ravine which would disturb wetland and buffer habitat. Review of available soil and groundwater information adjacent to Wetland 44a suggests subsurface conditions will likely be similar to those discussed above for Wetland 37a.

Upslope of the ravine, exploration borings AT97-B53, AT97-B59, and AT97-B60 have been accomplished on South 176th and South 174th Streets. These explorations indicate that very dense, glacially overridden soils are close to the surface around the upslope perimeter of Wetland 44a. Surficial soils generally consist of about 5 to 10 feet of medium dense, silty sand with occasional gravel over very dense, silty sand to slightly gravelly, silty sand.

Boring AT97-B60, which is located further south and west of the anticipated wall area, encountered 9 feet of very dense, silty sand with cobbles, over very dense sand with occasional gravel.

Visual reconnaissance suggests that the topographically lower portions of the ravine likely include loose to medium dense silty sand (colluvium) and possibly soft to medium stiff silt and/or peat.

Test pit and trench explorations, along with fill construction to enable access for cone penetrometer explorations, will be completed for final design, after completion of 404 Permit process.

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APPENDIX B
WATER BALANCE MODEL

APPENDIX B
WATER BALANCE MODEL

Model Objective

The objective of the water balance modeling conducted to support the geotechnical re-evaluation of wetland impacts is to examine changes in hydrologic flows (runoff, interflow, groundwater flow, and baseflow) that will occur as a result of embankment construction. The analysis is designed to include the effects of internal drainage facilities constructed within the proposed embankment, and to evaluate the ways for redistribution of flows generated from this drainage layer, to mitigate potential impacts to wetlands and baseflow.

Previous Work

Previous analyses of baseflow changes resulting from construction of the Third Runway and associated project components have considered overall changes in land use occurring within individual surface catchments or sub-basins that contribute flow to Miller Creek or Des Moines Creek, and their tributaries. The latest approach (Parametrix, 1999c) includes both HSP-F modeling of the catchments, and a water-budget analysis based on the rainfall-runoff-evapotranspiration-recharge characteristics of different soil types involved.

The results of the HSP-F catchment modeling by Parametrix show relatively small changes in groundwater recharge and consequently in baseflow, predicated on the observation that airport fill behaves hydrologically in a manner similar to outwash soils, rather than glacial till soils. Outwash soils are typically more permeable, allowing more infiltration and less runoff than glacial till soils. In this way, it is shown that Masterplan Project construction will in general allow some increase in potential groundwater recharge in areas that are not covered by impervious surfaces. However, the overall increase in impervious surfaces as a result of project development more than compensates for the increased groundwater recharge, resulting in the predicted small reductions to baseflow overall (see Parametrix 1999c, page 4-16).

Re-Evaluation Issues

One embankment design factor not considered in the previous baseflow analyses is the hydrologic effect of the internal drainage layer that is required to ensure embankment stability. The drainage layer will typically be placed as a blanket over the existing ground surface at the base of the fill soils. The primary function of the drainage layer is to control the build-up of pore water pressures within the embankment by providing a preferential drainage path for any pore water draining downward through the embankment.

The primary source of pore water in the embankment will be percolation of excess moisture from the upper soil layers following the infiltration of rainfall. In the earlier analyses of baseflow, it is assumed that such deep percolation will recharge the shallow groundwater beneath the embankment, and then discharge to the neighboring creeks as baseflow.

A portion of the groundwater recharge that enters the Shallow Regional Aquifer passes through that groundwater body and percolates deeper through the underlying aquitards. Most of this deep groundwater flow is removed from the shallow groundwater system that provides baseflow to local drainages including Miller Creek and Des Moines Creek.

- A portion of this deeper groundwater recharge returns to the Shallow Aquifer along valley areas where there is an upward groundwater gradient from depth.
- The remainder recharges the intermediate and deep regional aquifers that are located at depth within the Puget Sound sediments.

In the current design concept for the embankment, a substantial proportion of the infiltration will be intercepted by the drainage layer, and conducted laterally to recharge wetlands beyond the toe of the new embankment.

The analysis presented here is intended to compliment the work of Parametrix. It uses the same parameters as their water-budget analysis (Parametrix, 1999c; Appendix D) to quantify groundwater recharge before and after embankment construction, and to predict drainage-layer outflow. The management and reapplication of the drainage-layer outflow is then examined to maintain groundwater recharge and provide additional water to supplement water sources for off-site wetlands.

Model Concept

The concept used to examine the effect of the drainage layer is a water-balance model that considers inflows and outflows occurring within a representative vertical-slice through the proposed embankment. For this analysis, two representative embankment profiles are considered:

1) The Wetland 37 Wall (between Sta. 175+00 and 185+00)
2) The typical 2H:1V embankment (between Sta. 185+00 and 215+00).

Each embankment profile is divided into a series of blocks that allows the components of the water balance to be traced through the profile (see Figures B-1 and B-2).

Pre-Construction Conditions

The water balance model is initially set up to represent existing hydrologic conditions at the location of the typical embankment profiles. Existing land surface profiles and soil types are assigned to each block, and values are ascribed for evapotranspiration, runoff, interflow, and deep percolation that becomes groundwater recharge, using the runoff responses developed by Parametrix (Table 3-1 in Appendix D of Parametrix 1999c). Resulting hydrologic flows are accumulated for each block, and passed to the adjacent downgradient block as appropriate. Groundwater flow within and between each block is modeled using analytical equations for one-dimensional groundwater flow.

Notes and Assumptions:

1. Surface runoff from the existing airport area (Block 1) and from new embankment construction is diverted away to separate storm water management facilities;

2. Interflow in Block 1 likely contributes to groundwater flow toward the west. The model preserves interflow as a separate component that ultimately enters Miller Creek, or is intercepted by the drainage layer.

3. The apportionment of precipitation into its component parts focuses on shallow "active" groundwater that discharges to local streams; the analysis takes account of deep basin recharge, which replenishes lower aquifers and ultimately discharges to Puget Sound.

4. Some of the groundwater recharge will be retained as storage during winter months when the water table is rising; this water is released from storage during the summer when water levels are falling.

5. Wetlands represented in Block 4 may be sustained by one or a combination of precipitation, runoff, interflow, and groundwater discharge.

The existing water balance is calculated as an average for the year, and on a month-by-month basis, using average annual and monthly precipitation data.

Post-Construction Conditions

The water balance model is adjusted to represent post-construction conditions in which the embankment has been constructed on part of the original profile (see Figure B-1 (b)). In the model, the embankment is represented as an additional sub-block consisting of airport fill, placed above the existing land surface. Precipitation on the airport fill is split into evapotranspiration, runoff, interflow, and percolation. Approximately 90 percent of the percolation enters the drainage layer and is removed as drainage outflow. Approximately 10 percent of the deep percolation through the new embankment fill is assumed to pass through the drainage layer and into the underlying groundwater system, based on the contrast in hydraulic conductivity between the drainage layer and the underlying soil.

Pre-construction interflow in the soil layers beneath the embankment fill will be replaced, as a result of construction of the embankment. The MSE wall will include a wide zone of permeable material near the wall face, allowing all interflow in the new fill to enter the drainage layer (see Figure B-1). Interflow in the 2H:1V embankment is also assumed to enter the drainage layer (see Figure B-2).

Outflow from the drainage layer is applied as recharge to Block 4 in each of the embankment profiles. This may be achieved in practice by installing a variety of different infiltration facilities near the embankment toe, as outlined in the main text of this report.

Model Results

Water balance models were prepared for two representative cross sections through the proposed embankment: the Wetland 37 MSE Wall (between Stations 175+00 and 185+00) and the typical 2H:1V embankment (between Stations 185+00 and 215+00).

Overall Water Balance

At the MSE wall location, the water balance model shows that the overall precipitation on the cross section is divided up as follows:

Flow Component	Pre-Construction	Post-Construction
Evapotranspiration:	42.0%	38.2%
Surface Runoff:	15.5%	26.7%
Interflow:	8.0%	1.5%
Shallow Groundwater Flow:	10.1%	12.6%
Deep Groundwater Recharge:	24.3%	21.0%

Evapotranspiration is reduced, the main increase is in the form of runoff. Interflow and deep percolation captured by the drainage layer is re-infiltrated to increase groundwater flow. The drainage-layer outflow represents 11.3 percent of the overall water balance for the cross section. Comparable results are obtained at the 2H:1V embankment location, where the precipitation is divided up as follows:

Flow Component	Pre-Construction	Post-Construction
Evapotranspiration:	42.1%	38.7%
Surface Runoff:	14.9%	27.0%
Interflow:	10.9%	1.2%
Shallow Groundwater Flow:	9.6%	11.7%
Deep Groundwater Recharge:	22.4%	21.3%

The increase in groundwater recharge is achieved by re-infiltration of water flowing from the drainage layer. Drainage-layer flow represents 12.8 percent of the overall water balance.

Seasonal Changes in Groundwater Recharge

Figures 11 and 12 in the main report depict the variation in groundwater recharge on a monthly basis through an average year, for the two cross sections described above. The pre-construction recharge curves reflect the seasonal changes in precipitation from winter to summer.

The best conditions for re-infiltration of drainage-layer flow to create additional groundwater recharge occur during the summer months, when groundwater levels are low. However, drain flow rates are at their lowest during this period, allowing all the drain flow to be recharged. During the winter months, when groundwater levels are higher, recharge will be less effective, but excess water will be available for recharge, due to higher rates of seepage into the underdrain. Any water that cannot be recharged will overflow the recharge system, and flow through constructed swales into the wetlands as overland flow. Depending on the levels of soil saturation in the wetland, some of the excess flow may infiltrate; some will be lost by evapotranspiration, and some will run off as overland flow to Miller Creek.

Implications for Wetlands

Wetlands located beyond the toe of the embankment (off-site wetlands) are sustained by one or a combination of water sources including:

- Precipitation;
- Runoff;
- Interflow or discharge of perched groundwater; and
- Groundwater discharge from the Shallow Regional Aquifer.

In qualitative terms, the findings of the water balance model indicate the following:

- The amount of **precipitation** falling on off-site wetlands will not be affected by embankment construction.

- The amount of **runoff** supplied to off-site wetlands will change if embankment construction occurs in the catchment area above the wetland. Existing runoff from upslope areas will be eliminated as the embankment and new storm water facilities are constructed. For the off-site wetlands, this source of water will be replaced by flow from the underdrain system during the winter months.

- Off-site wetlands supplied by **interflow** or seepage of perched groundwater may see a change due to embankment construction above the wetland. Off-site wetlands will still be recharged by this mechanism although the volume of interflow may change. Interflow to wetlands which are partially filled and interflow to off-site wetlands will be replaced by seepage through the underdrain and overflow from the swale constructed at the edge of the underdrain. During the winter months, seepage from the perimeter swale will infiltrate to create interflow to off-site wetlands.

- Off-site wetlands supplied by **groundwater discharge from the Shallow Regional Aquifer** will see an overall increase in flow as a result of increased recharge of water from the drainage layer.

The analysis is based on long-term average annual and monthly precipitation rates. Natural variation in precipitation form month to month and year to year will produce differing results.

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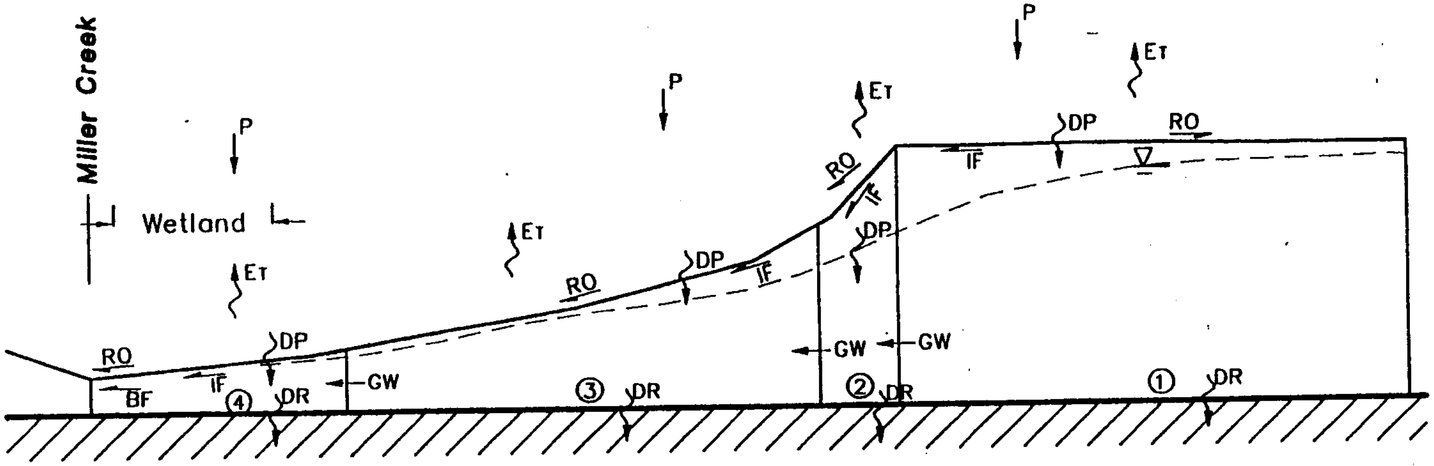
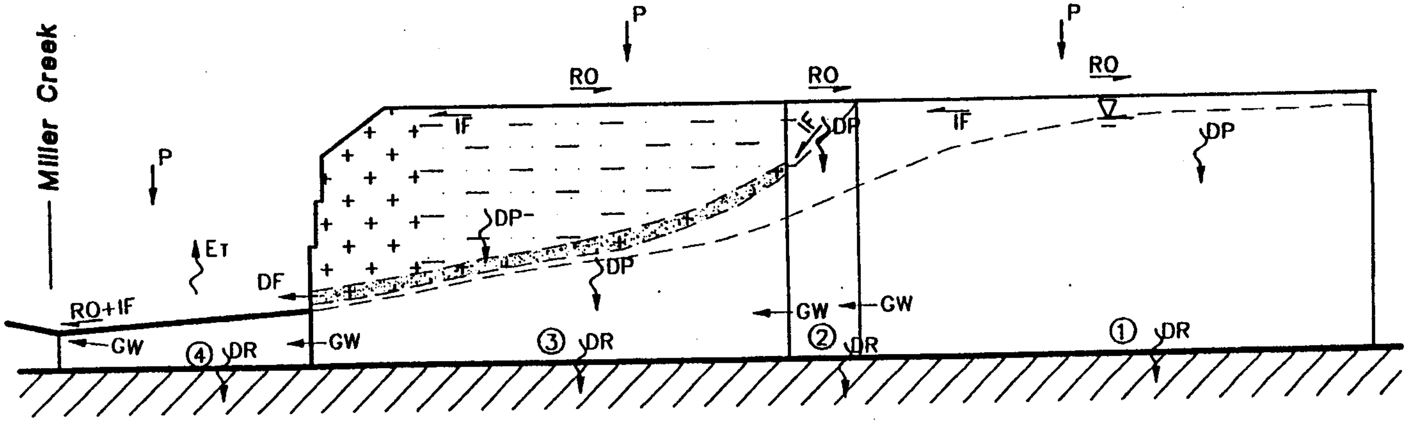
Water Balance Schematic between Stations 175+00 and 185+00 (Typical MSE Wall)

④	Block Number
P	Precipitation
E_T	Evapotranspiration
RO	Runoff
IF	Interflow
DP	Deep Percolation
GW	Groundwater Flow
DF	Drainage Flow
∇	Water Table
DR	Deep Recharge
░	Drainage Layer
— —	New Embankment
+ +	Free-draining Backfill



a) Pre-Construction



b) Post-Construction (with MSE Wall and Internal Drainage Layer)

Not to Scale

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Figure B-1

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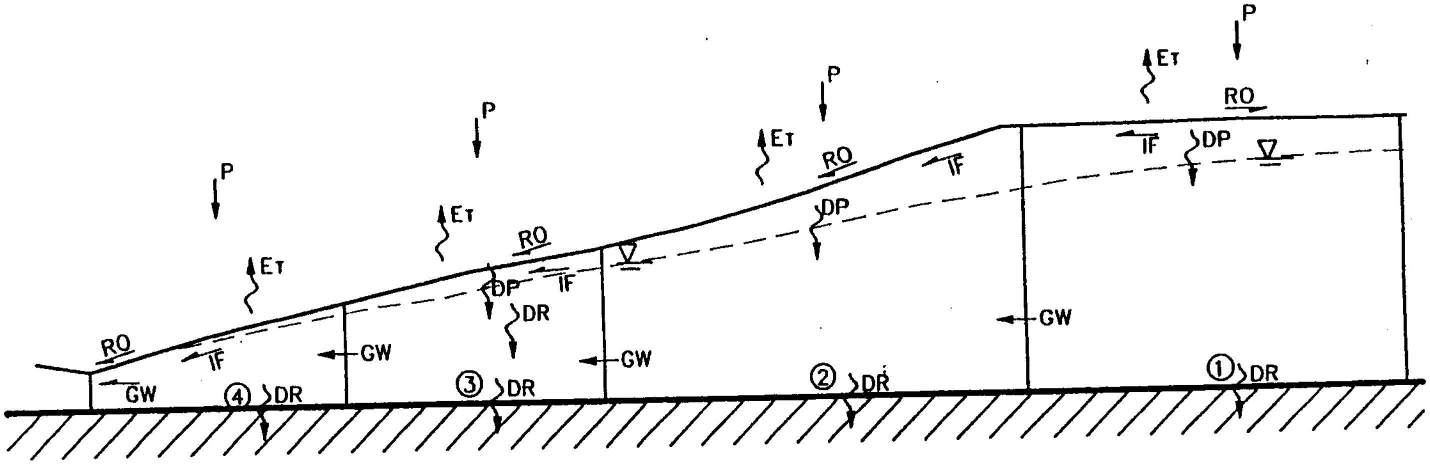
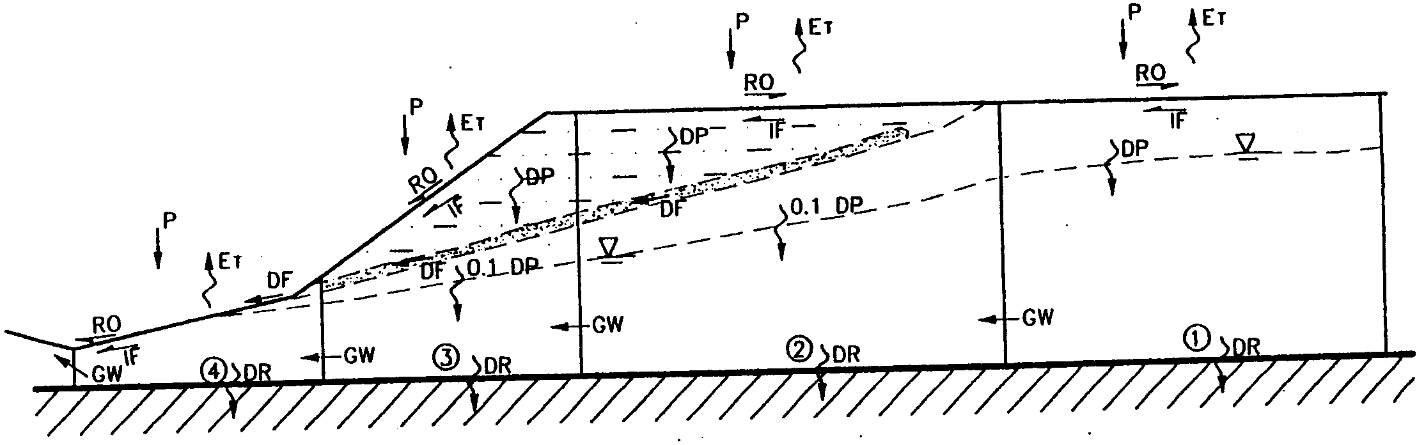
Water Balance Schematic Between Stations 185+00 and 215+00 (Typical 2H:1V Embankment)

④	Block Number
P	Precipitation
E_T	Evapotranspiration
RO	Runoff
IF	Interflow
DP	Deep Percolation
GW	Groundwater Flow
DF	Drainage Flow
∇	Water Table
DR	Deep Recharge
▨	Drainage Layer
— —	New Embankment



a) Pre-Construction



b) Post-Construction

Not to Scale

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Figure B-2

APPENDIX C

APPENDIX C

BORROW AREAS 1, 3, AND 4 – PROJECTED IMPACTS TO WETLANDS

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MEMORANDUM

DATE: December 8, 2000

TO: Ralph Wessels, Port of Seattle

FROM: Reese P. Hastings and Michael J. Bailey, P.E., Hart Crowser, Inc.

RE: **Third Runway Project, Borrow Areas 1, 3, and 4**
Projected Impacts to Wetlands
J-4978-06

CC: Marti Louther and James C. Kelley, Ph. D., Parametrix, Inc.
J. Thomson, P.E., HNTB

On-Site Borrow Activities

This memorandum quantifies the potential impacts to wetland resources resulting from development of Borrow Areas 1, 3, and 4, and an on-site haul route for use in the construction of the Third Runway embankment. Completion of the Third Runway embankment will require about 17 million cubic yards of compacted earth fill. Use of borrow sites owned by the Port of Seattle (Port) to provide this material will significantly reduce air quality and local traffic impacts associated with haulage from off-site sources.

The Final Environmental Impact Statement (FEIS) (prepared for Sea-Tac International Airport's Proposed Master Plan update development actions) discussed development of construction fill material borrow areas from eight identified sources within property controlled by the Port. Based on several factors (wetlands impacts, material types, operational costs) the Final Supplemental Environmental Impact Statement (FSEIS) indicated that four of these eight on-site resource areas could likely be used to extract a maximum quantity of 15.45 million cubic yards of fill material. Further study by the Port has focused on the Borrow Areas designated 1, 3, and 4, which are proposed to provide a combined total of 6.7 million cubic yards. Figure 1 - Site Location Map shows the location of Borrow Areas 1, 3, and 4.

Original resource estimates for two of these borrow areas have been revised in an effort to minimize the potential impacts on wetland resources delineated therein. The decrease in the potential impacts to wetland resources and the decline in the resource estimates are described below.

Borrow Area 1

Borrow Area 1 is located less than a mile south of the Airport's 34 R runway. It consists of approximately 121 acres situated northwest of South 216th Street and 24th Avenue South. The area is bounded by these streets to the south and east, respectively, and on the north and west sides by the Des Moines Creek Park and the proposed Washington State Department of Transportation (WSDOT) SR-509 extension right of way. Borrow Area 1 is located in the City of Des Moines and City of SeaTac.

Engineering estimates conducted in 1994 supporting the FEIS and FSEIS indicated that the borrow material resource consists of glacially deposited, slightly silty to silty sands and gravels. Volumetric estimates presented in the FSEIS indicated that 6.6 million bank cubic yards (BCY - volume unit of soil in place, prior to excavation) of material were available from Borrow Area 1. Changes in site development conditions and the adoption of wider buffers (perimeter, stream) have resulted in this figure being adjusted. Estimates were revised in 1998 and indicate that this area still has the potential to generate substantial quantities of fill, and if fully utilized, it would produce approximately 4.8 million BCY of borrow material. Figure 2 shows the conceptual end of mining topography for the area based on full utilization.

There are 1.83 acres of wetlands within Borrow Area 1, some of which can be avoided without significantly diminishing the available borrow resource (as discussed below). Examination of Figure 2 shows how the current full utilization development plan will avoid several perimeter wetlands, and how it will utilize a 200-foot setback to avoid the Des Moines Creek drainage system. Post-extraction topography would drain toward the creek through approved erosion, infiltration, and sediment control structures constructed along the western margins of the excavation.

Under the Port's currently proposed development alternative to avoid impacts to wetlands and enhance site infiltration and off-site drainage to Des Moines Creek within or adjacent to the western margins of Borrow Area 1, approximately 4.2 million BCY of borrow material would be available. The resource reduction from 4.8 million BCY to 4.2 million BCY was done specifically to avoid impacts to off-site wetlands. Figure 3 shows how this alternative would be contoured to infiltrate or drain precipitation naturally through existing wetlands, draws, or ravines into Des Moines Creek and adjacent wetlands.

Borrow Area 3

Borrow Area 3 is located south of the Airport's 34 L runway, in the City of SeaTac. It consists of approximately 60 acres, bounded on the north by South 200th Street, and to the east by 18th Avenue South and the WSDOT right of way. The resource consists of glacially deposited, slightly silty to silty sands and gravels. Borrow Area 3 contains 2.35 acres of wetlands. Full utilization of the available resource would produce approximately 1.5 million BCY of borrow material for use in the construction of the Third Runway embankment (see Figure 4). Under the Port's currently proposed development alternative to avoid impacts to all the wetlands in Area 3, approximately 1.0 million BCY of the borrow resource would be available (see Figure 5). The resource reduction from 1.5 million BCY to 1.0 million BCY was done specifically to avoid impacts to on-site wetlands. Material extraction would be conducted in a manner that would preserve local hydrologic seepage thought to support Borrow Area 3 wetlands (see Hart Crowser, 2000).

Borrow Area 4

Immediately north of Borrow Area 3 and approximately 1,100 feet south-southwest of the runway is Borrow Area 4 (see Figure 4). The site comprises an area of approximately 36 acres and is located west of the Tyee Golf Course. It is bounded to the south by South 200th Street, to the east by 18th Avenue South, and to the north by South 196th Street. The resource geology has been identified as being generally similar to that of Borrow Area 3. No wetlands exist in Borrow Area 4. Full utilization of the available resource will produce approximately 1.5 million BCY of borrow material for use as embankment fill.

Conceptual Truck and Conveyor Haul Routes

Transfer of borrow materials from the above-named sources will be accomplished by truck or conveyor haulage. Conceptual haul route alternatives have been laid out to avoid wetlands impacts and to avoid conflicts with future construction of the proposed regional detention facility (RDF) to be located within the existing Port-owned Tyee Golf Course.

Figure 6 shows conceptual haul routes across Port property consisting of the Tyee Golf Course and the southern airport roadway system, to transport materials from Borrow Areas 1, 3, and 4 as presented in the FSEIS.

Three conceptual haulage mechanisms were evaluated: conventional or heavy mining truck haulage using a dedicated haul road on Port property; and a material conveyor system aligned along a similar route with a dedicated service road. The truck and conveyor routes are aligned primarily to avoid wetlands and accommodate industry-standard turning radii and roadbed grades (trucks set at <8%, conveyor set at <15°) suitable for the selected haul method (see Figure 6).

Haul routes would cross existing City of SeaTac streets (18th Avenue South and South 200th Street) at grade or via grade-separated crossings depending on selection of a preferred haul method and outcome of future studies. Haulage within the City of Des Moines would utilize existing streets or dedicated routes again depending on selection of a preferred haul method. Haulage across South 188th Street is anticipated to utilize a grade separation (special purpose bridge) regardless of which haulage method is selected.

The conceptual haul routes utilize similar terrain traversing along the eastern edge of Borrow Area 3 north toward South 200th Street, crossing onto the southeastern corner of Borrow Area 4 before heading northeast across the Tyee Golf Course toward the airport. Conceptual haul route alignments across the Golf Course have been laid out to avoid wetland impacts. Once the routes reach the central portion of the golf course, they extend along the southeastern berm of the proposed Des Moines Creek RDF, cross Des Moines Creek, and then turn north in a parallel course next to the runway approach light towers. At the southern toe of the runway embankment, the routes ascend the grade to connect into the existing airport roadway system situated on the west flank of the 34 R runway embankments. The routes then follow the southern edge of South 188th Street westward to a point where a proposed new bridge crossing structure will connect the haul route to the existing airport roadway system on the north side of the street. The haul route will then follow existing roadways along the western edge of the airport to the embankment construction site.

Borrow Development - Potential Impacts to Wetland

Wetland delineation efforts conducted throughout 1998 and 1999 identified the wetland resources indicated on Figures 2 and 4 within Borrow Areas 1 and 3. Delineation efforts have not identified any wetland resources within Borrow Area 4. Of the wetlands delineated within the Tyee Golf Course, only those adjacent to the conceptual haul route are shown on Figure 6. The areal extent of wetlands in each borrow area and the golf course that could be potentially impacted by borrow material development and hauling activities are summarized in Table 1.

Borrow Area 1

Full development of construction materials from Borrow Area 1 would likely impact approximately 1.40 acres of the 1.83 acres of wetland delineated for this site. However, the proposed approach to developing Area 1 as depicted on Figure 3 would minimize these impacts to 1.03 acres or less, and facilitate on-site infiltration and free drainage of direct precipitation and surface runoff into Des Moines Creek and the adjoining wetlands located on the parcel adjacent to and west of Wetlands 15a and 48. Excavation in these five wetlands (B-1, B-4, B-15a/b, 32, and 48) will be avoided by configuring the borrow site boundary and mined slopes a minimum of 50 feet away from wetland edges.

Potential impacts to Wetland B-15a/b and 48 would be completely avoided by not having any material extraction activities from the area west of 20th Avenue South. The portion of land west of 20th Avenue South would be managed to preserve the overland flow, which contributes, in a limited manner, to the perched wetland hydrology supporting these two flat-lying wetlands. Potential impacts to Wetlands B-1, B-4, B-15a/b, 32, and 48 will also be avoided through the use of 50-foot buffers. No borrow material extraction would occur within the wetland buffer.

It will not be practicable to avoid the remaining wetlands in Borrow Area 1 because:

- The preservation of the wetlands would render the resource impracticable to mine; or
- Mining the resource would completely remove the upgradient source of water sustaining the wetland.

Borrow Area 3

Full development of Borrow Area 3 would impact the wetlands delineated within the area boundary. However, the proposed approach to developing Borrow Area 3 as depicted on Figure 5 would avoid these impacts. As explained Hart Crowser October 20, 2000, memo, hydrogeologic studies indicate the source of water feeding the Borrow Area 3 wetlands will remain intact given that surface drainage and perched seepage systems immediately upgradient will remain undisturbed and seepage adjacent to Wetland 29 will remain unimpaired. As noted above, avoiding the wetlands would still allow development of a substantial volume of construction material from Borrow Area 3. Where mining intercepts surface seepage in areas immediately to the north of these wetlands, a collection and conveyance system in the form of a drainage swale will help ensure that an adequate amount of water from these areas will supply of water to nearby wetlands Figure 5 (Hart Crowser, 2000).

The haul route has been aligned through Borrow Areas 3 and 4, and the Tyee Golf Course with the goal of avoiding or minimizing the potential for impacts to wetlands:

- Wetlands delineated in Borrow Area 3 would not be impacted by the construction and operation of the conceptual means of haulage; and
- Wetlands delineated within the confines of the Tyee Golf Course have been avoided.

Mitigation

In addition to avoidance of wetland fill or excavation, other mitigation activities that will minimize indirect wetland impacts arising from borrow development or haulage will include:

- Conduct material extraction during the summer season and maintain site drainage through use of TESC measures throughout the winter rainy season;
- Use of 50-foot-wide undisturbed buffers around delineated wetlands;
- Preservation of water recharge source areas upgradient of wetlands;
- Construction of a drainage swale to maintain seepage flows to wetlands in Borrow Area 3;
- Use of berms or other erosion protection to prevent overland flow away from wetlands into excavated areas;
- Implementation of TESC measures (berms, silt, fencing, hay bales, drainage control swales, ponds, recontouring, etc.) within the borrow and haul areas to protect wetlands from storm water impacts; and
- Modification of mining methods (borrow area bench layout, slope stability, recontouring), and re-alignment of preferred construction material haul routes (side-cast materials, road maintenance).

Borrow Area 1

Mitigation of potential impacts in Area 1 will include modification to the conceptual post-mining contours along portions of the southern, western, and eastern perimeter. Use of a 50-foot-wide undisturbed buffer around five wetlands (B-1, B-4, B-15a/b, 32, and 48) would insulate the wetlands from activity related to borrow material development, (see Figure 3). Borrow Area 1 operations can be completed without disrupting the upgradient source of water needed to sustain these wetlands, for example, near Wetlands B-15a/b and 48, borrow material extraction activities have been shifted over 200 feet to the east.

Mitigation will also include the use of a stream setback averaging 200 feet to protect Des Moines Creek from the potential impacts of borrow development activities. Excavation along the stream buffer areas would allow borrow area bench layout and recontouring measures to provide for adequate positive drainage or infiltration from the extraction areas to the east. This combined approach to on-site infiltration and off-site drainage is required to prevent water from accumulating in the borrow area for significant periods of time.

Borrow Area 3

Mitigation of potential impacts to wetlands in Borrow Area 3 will rely upon the combined effect of avoidance and mitigation incorporated into the alternate development scenario portrayed on Figure 5.

The preferred plan for excavating borrow materials from Borrow Area 3 (identified as Alternative 2) would preserve the wetlands by maintaining 50-foot-wide undisturbed buffer zones around the wetlands, and by not mining in any areas that directly contribute surface water or groundwater flow to the wetlands. Borrow development would include construction of a drainage swale to convey seepage and precipitation into Wetland 29 that might reach this wetland by lateral flow mechanisms from the perched seepage zone to the north. Proposed mining would not impact up gradient flows into this wetland. The water conveyed by this drainage swale into Wetland 29 would mitigate potential indirect effects of mining north of this wetland (Hart Crowser, 2000). Mining would not affect seepage draining from Wetlands B-10 and 29 south and east through Wetlands B-5, B-6, B-7, and B-9 and Wetland 30, by virtue of their locations on the slopes above the mined areas.

Mining will occur to elevations that are no more than 1 to 2 feet below the base elevations of the nearest adjacent wetlands as shown by the proposed end of mining topography on Figure 5. Given that these wetland experience significant losses by percolation through permeable soils beneath the wetlands, and that seepage from upgradient sources will remain uninterrupted, mining will not materially affect the hydrology of the wetlands. Mining will be confined to a zone north and east of the wetlands, leaving the primary wetland water source areas in the southwestern portion of the site generally undisturbed.

Haul Routes

The haul route alignment was developed to avoid wetland impacts, to the maximum extent practical. Mitigation of potential impacts arising from hauling activities would consist of TESC measures near wetlands or buffers. The routes laid out for both the truck or conveyor options will have some minor temporary impact on riparian Wetland E, where the haul route must cross Des Moines Creek (see Table 1 and Figures 6 and 7). The proposed conceptual haul route alignments go around Wetlands G-1, G-2, and G-3, entirely avoiding any impacts by utilizing existing roads. Aside from the steam crossing, the routes maintain a minimum buffer distance of 50 feet, except in the vicinity of Wetland G-3 (on the west side of the 34 R runway embankment), the routes maintain a minimum buffer distance of 50 feet, see Figure 8.

In that single location, the haul route would come within 20 to 30 feet of the northeastern tip of this wetland (see Figure 8). The potential for sedimentation or water quality impacts to this wetland from hauling activity in this area would be avoided by the installation of silt fencing, berm and a drainage ditch along the outside shoulder of the road, and other appropriate TESC measures (storm water management ponds, etc.).

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Attachments:
Table 1 - Summary of Potential Wetland Impacts for Borrow Areas 1, 3, and 4 and Conceptual Haul Routes
Figure 1 - Site Location Map
Figure 2 - Conceptual End of Mining Topographic Map for Borrow Area 1 Alternative 1 - Full Utilization
Figure 3 - Conceptual End of Mining Topographic Map for Borrow Area 1 Alternative 2 - Avoidance of Wetland Impacts
Figure 4 - Conceptual End of Mining Topographic Map for Borrow Areas 3 and 4 Alternative 1 - Full Utilization of Borrow Area 3
Figure 5 - Conceptual End of Mining Topographic Map for Borrow Areas 3 and 4 Alternative 2 - Avoidance of Wetland Impacts
Figure 6 - Proposed Haulage Routes Map
Figure 7 – Details of Proposed Haulage Routes
Figure 8 - Borrow Area Haul Route Representative Cross Section At Closest Encroachment Wetland (Sta H+59.5)

References:
Hart Crowser, 2000. Memo, Sea-Tac Third Runaway – Borrow Area 3, Preservation of Wetlands.
J-4978-06, October 20, 2000.

Table 1 - Summary of Potential Wetland Impacts for Borrow Areas 1, 3, and 4 and Conceptual Haul Routes

BORROW AREA 1

Wetland	Area in Acres	Impacted Area in Acres	Comments
B-1	0.27	0	Impacts avoided
B-4	0.07	0	
32	0.09	0	
B-15a	0.19	0.19	Mining will temporarily alter buffers, wetland, and surface water sources
48	0.14	0.14	
B-11	0.18	0.18	Impacts unavoidable, mining will eliminate upgradient sources of water
B-12	0.07	0	
B-14	0.78	0.78	
B-15b	0.02	0.02	
TOTAL	**1.81**	**1.31**	

BORROW AREA 3

Wetland	Area in Acres	Impacted Area in Acres	Comments
B-1	0.02	0	Impacts completely avoided with Mining Alternative 2
B-5	0.08	0	
B-6	0.55	0	
B-7	0.03	0	
B-9	0.05	0	
29	0.74	0	
30	0.88	0	
TOTAL	**2.35**	**0**	

CONCEPTUAL HAUL ROUTES (DES MOINES CREEK CROSSING)

Wetland	Area in Acres	Impacted Area in Acres	Comments
		Truck/Conveyor	
E	0.07	0.03/0.01	Impact depends on selected haulage method
TOTAL	**0.07**	**0.03/0.01**	

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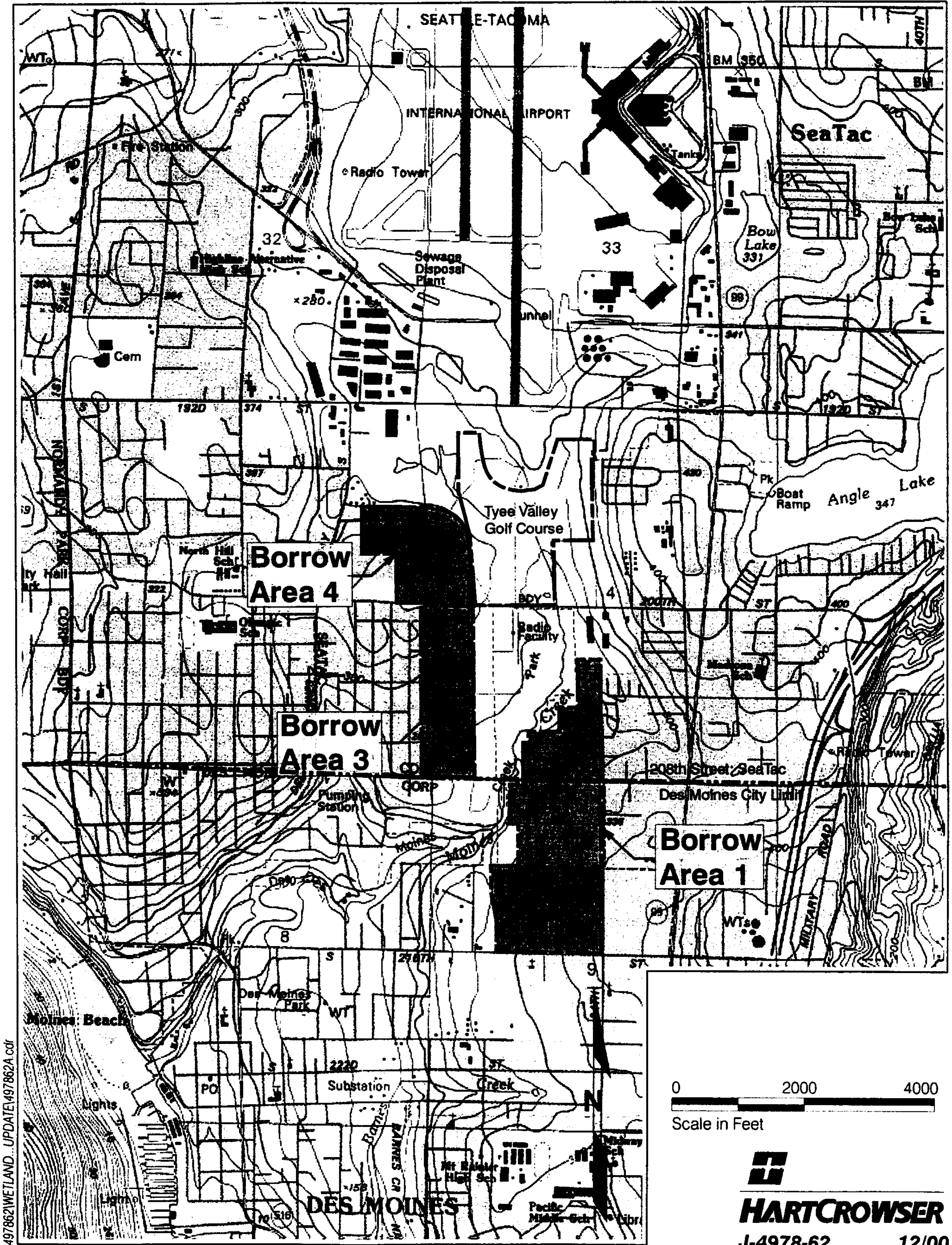
Site Location Map



Note: Base map prepared from USGS 7.5 minute quadrangle maps of Seattle South, Washington, revised 1995.

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Figure 1

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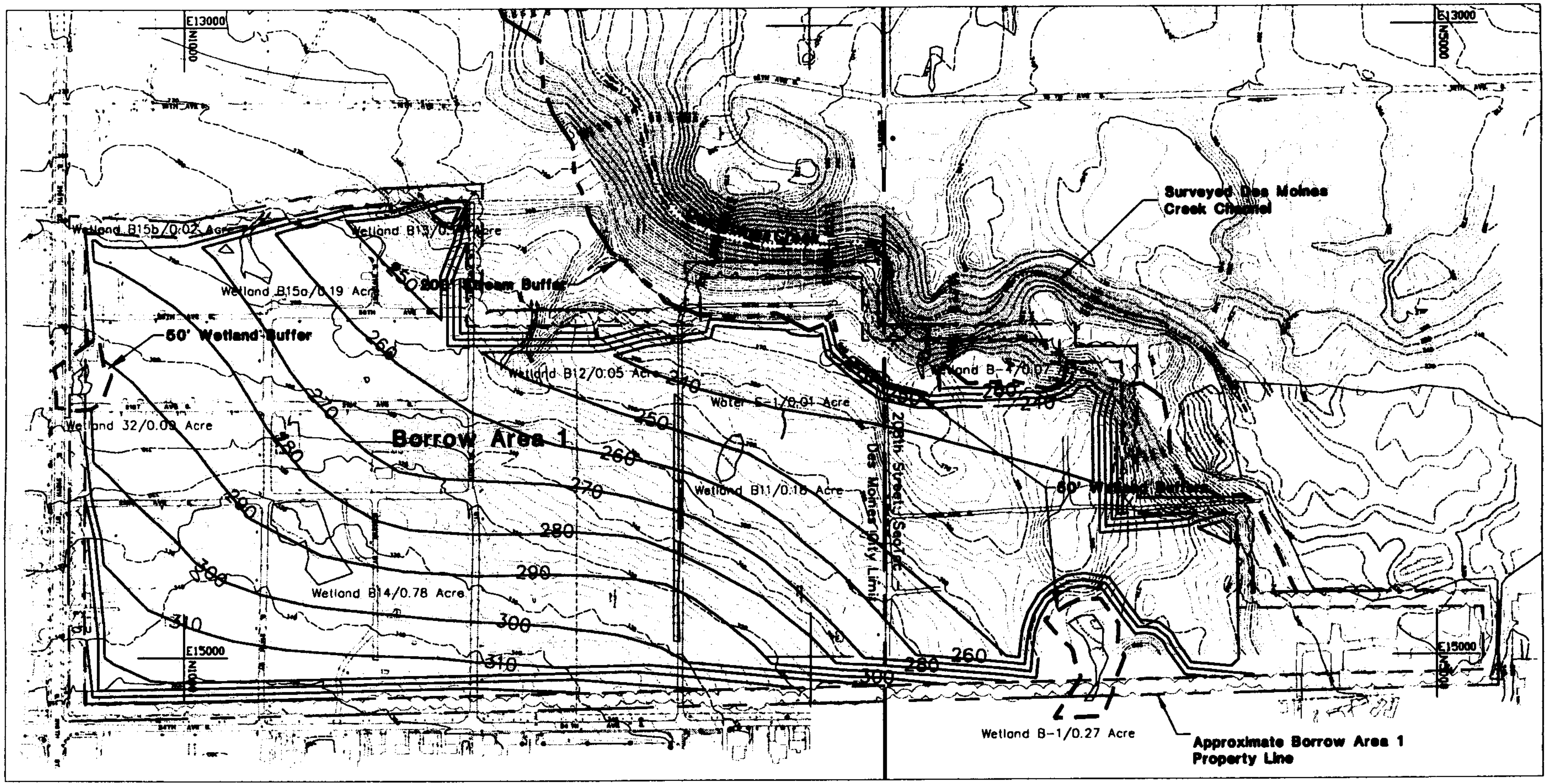
Conceptual End of Mining Topographic Map for Borrow Area 1

Alternative 1 - Full Utilization



——300—— Conceptual End of Mining Elevation Contour in Feet

-------------- Existing Elevation Contour in Feet

— — — — Reclamation Setback

Wetlands Delineated by Parametrix (11/00)

— — — — 50-Foot Wetland Buffer

—— - - —— 200-Foot Stream Buffer

Notes: Base map prepared from drawing provided by HNTB entitled "Base03", dated October 6, 1998. Wetland and stream channel survey data provided by Parametrix drawing entitled "w052899," dated May 28, 1999.

N

0 500 1000
Scale in Feet

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J-4978-62 12/00
Figure 2

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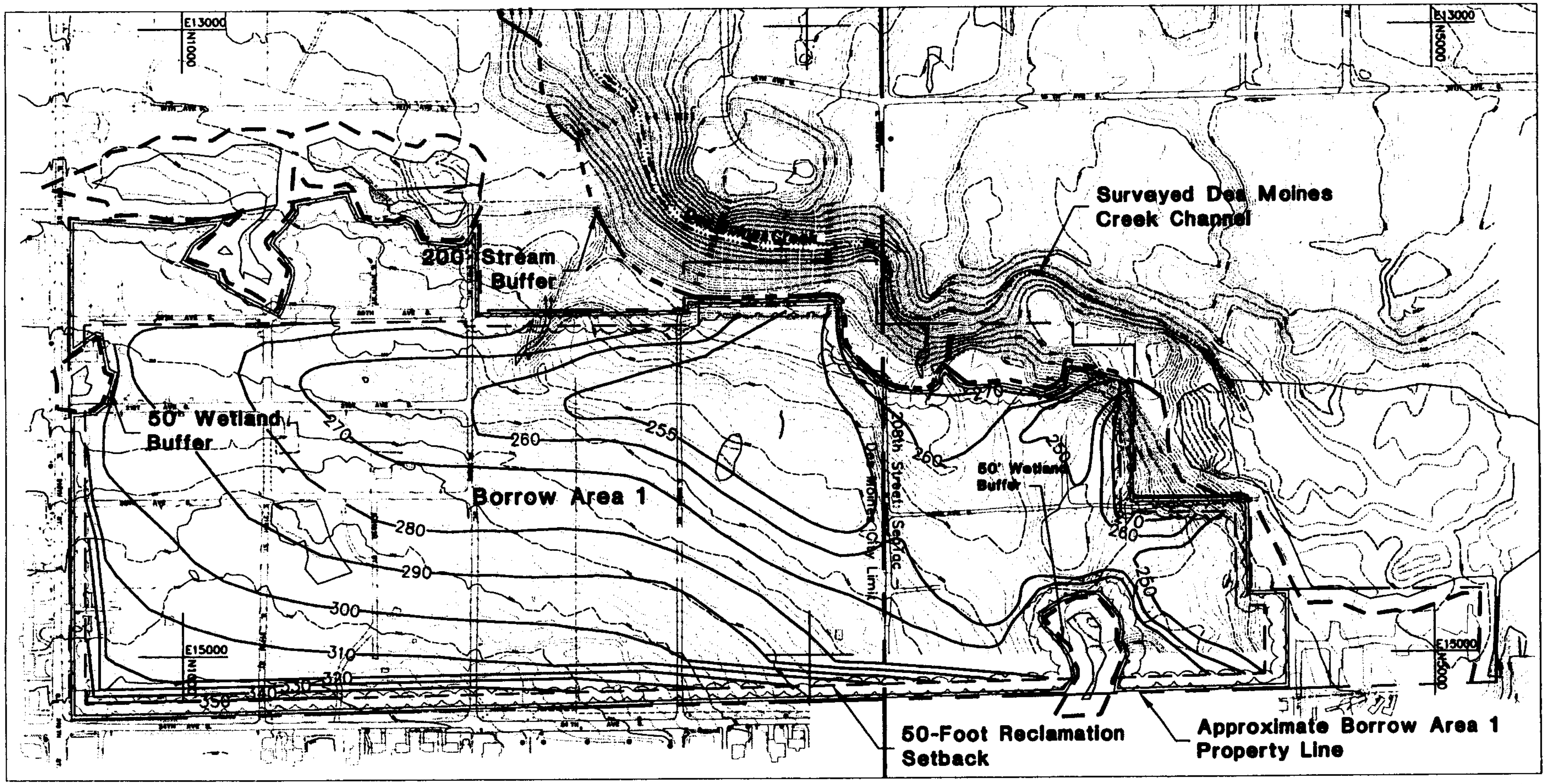
Conceptual End of Mining Topographic Map - Borrow Area 1

Alternative 2 - Avoidance of Wetland Impacts



——300—— Conceptual End of Mining Elevation Contour in Feet

- - - - - - - - Existing Elevation Contour in Feet

— — — — Reclamation Setback

═══════ Borrow Area Development Boundary

⬭ Wetlands Delineated by Parametrix (11/00)

— — — — 50-Foot Wetland Buffer

——- - -—— 200-Foot Stream Buffer

Note: Base map prepared from drawing provided by HNTB entitled "Base03", dated October 6, 1998. Wetland and stream channel survey data provided by Parametrix drawing entitled "W_110800," dated November 8, 2000.

N

0 500 1000

Scale in Feet

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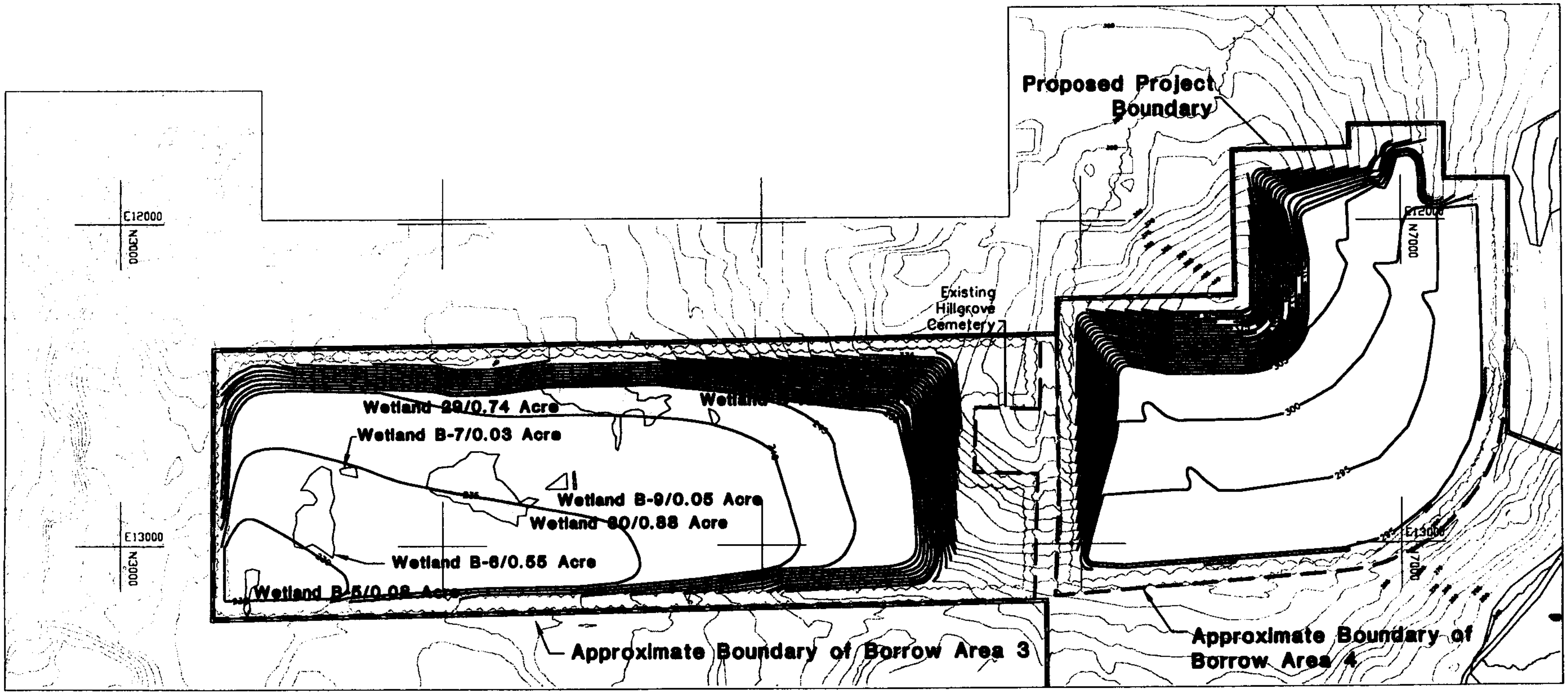
J-4978-62 12/00

Figure 3

RC 12/4/00 1=500 (xref) w052899.dwg/woodstck.pcp 8.5x11
Wetland...Update\49786235

Conceptual End of Mining Topographic Map for Borrow Areas 3 and 4

Alternative 1 - Full Utilization of Borrow Area 3



Note: Base map prepared from drawing provided by HNTB entitled "Borrow Site Areas 3 & 4 Grading Plan," dated April 13, 1998.

—250— Proposed End of Mining Elevation Contour in Feet

Existing Elevation Contour in Feet

Wetlands Delineated by Parametrix (8/98)

Proposed Borrow Development Project Boundary

N

0 500 1000

Scale in Feet

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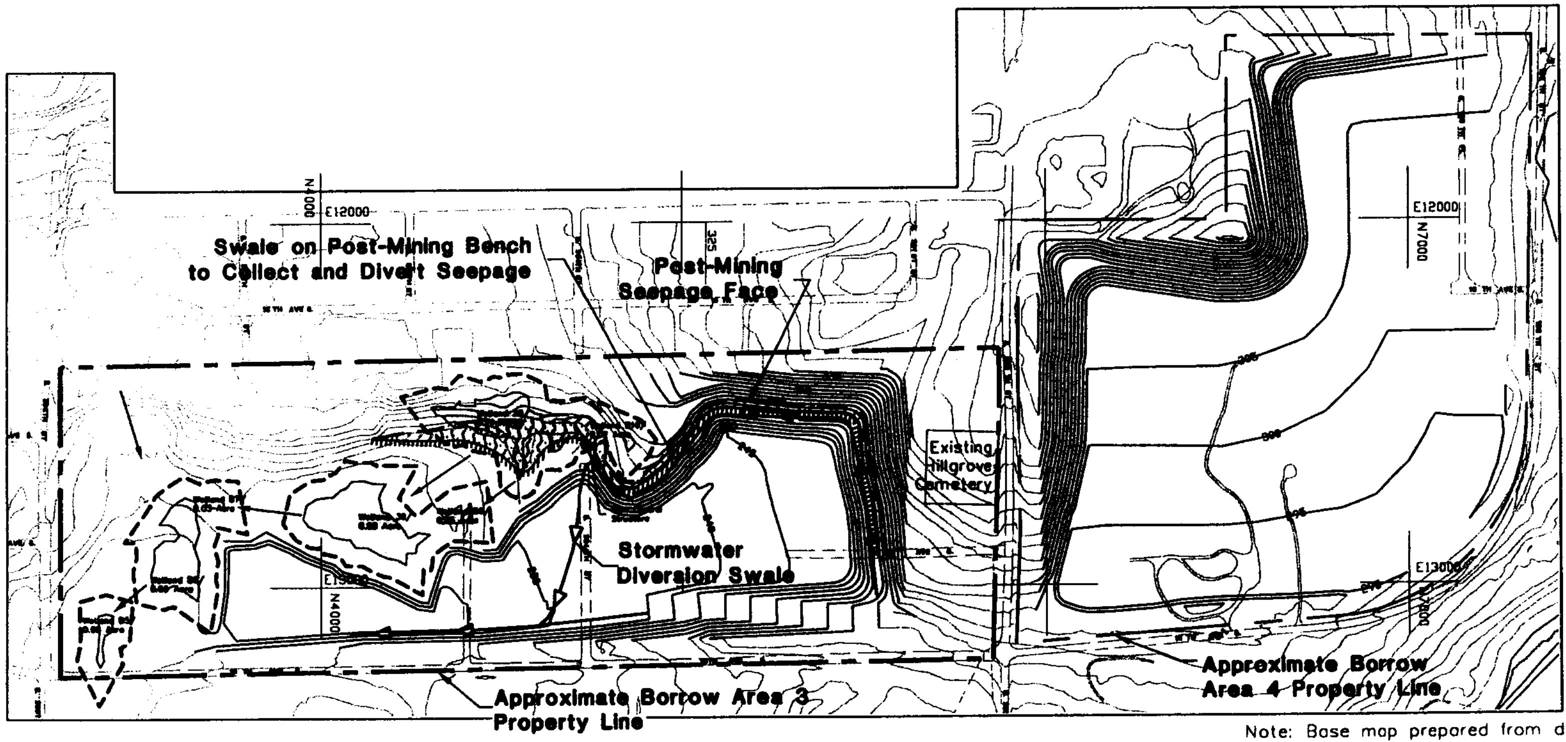
J-4978-62 12/00

Figure 4

RC 12/4/00 1=500 (xref)grid.dwg, wet040799.dwg, seepage.dwg, base-newA4.dwg/woodstock.pcp 8.5x11
Wetland...Update\49786236

Conceptual End of Mining Topographic Map for Borrow Areas 3 and 4

Alternative 2 - Avoidance of Wetlands Impacts & Drainage Swale



Note: Base map prepared from drawing provided by HNTB entitled "Borrow Site Areas 3 & 4 Grading Plan", dated April 13, 1998.

250 Proposed End of Mining Contour

300 Existing Contour

Wetlands Delineated by Parametrix (8/98)

Wetland and Stream Buffer

Inferred Seepage Face above Outcrop of Perching Layer

Direction of Surface/Shallow Subsurface Drainage

N

0 500 1000
Scale in Feet

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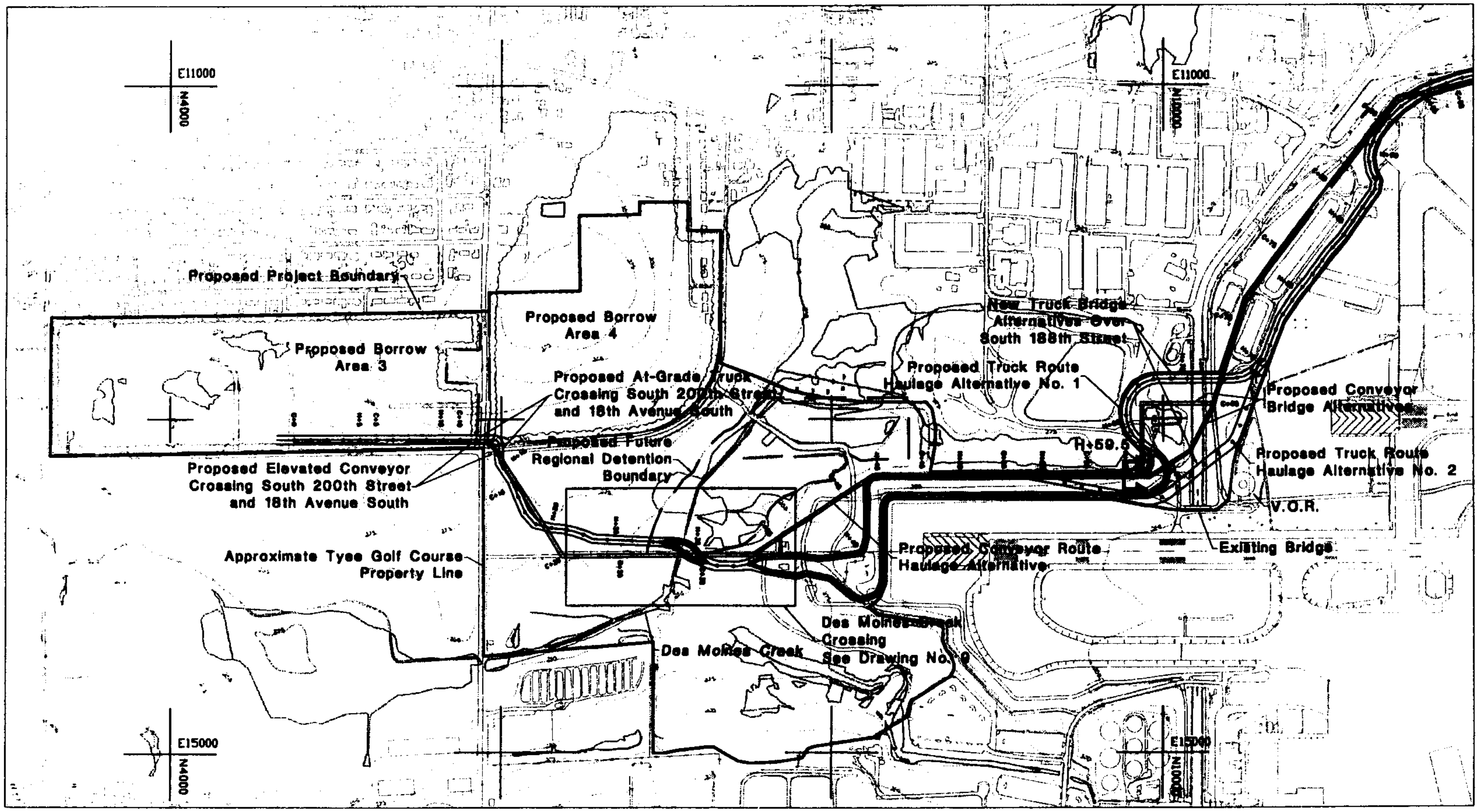
J-4978-62 12/00
Figure 5

RC 12/5/00 1=1 (xref)see drawing file/charlie-8.pc2
49786239

Proposed Haulage Routes Map



Note:
1) 25-foot elevation contours generated from drawing provided by HNTB entitled "Borrow Areas 3 & 4 Grading Plan", dated April 13, 1998.
2) Wetland delineation prepared from drawing provided by Parametrix entitled, "W_062700.dwg", dated June 27, 2000.

◯ Wetland Delineated by Parametrix and King County

— — RDF Boundary (Flooding extends beyond boundary shown)

H+59.5 Cross Section Location (See Figure 7)

N

0 1000 2000
Scale in Feet

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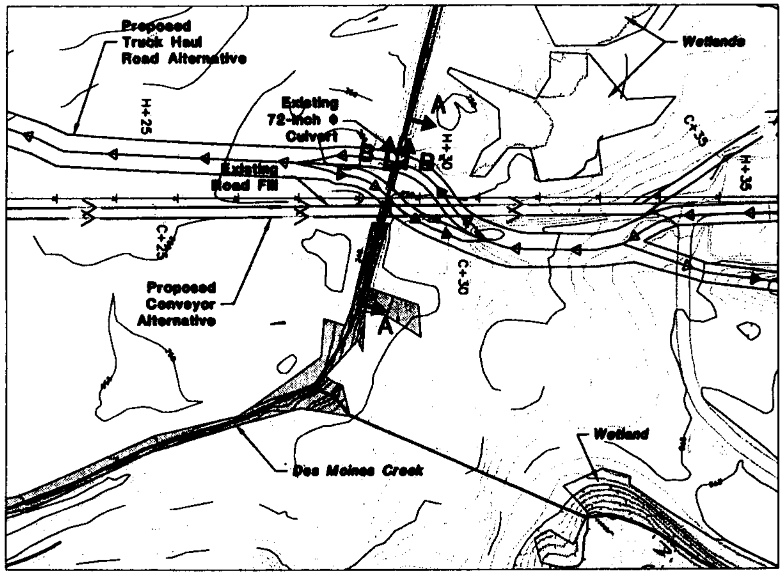
Figure 6

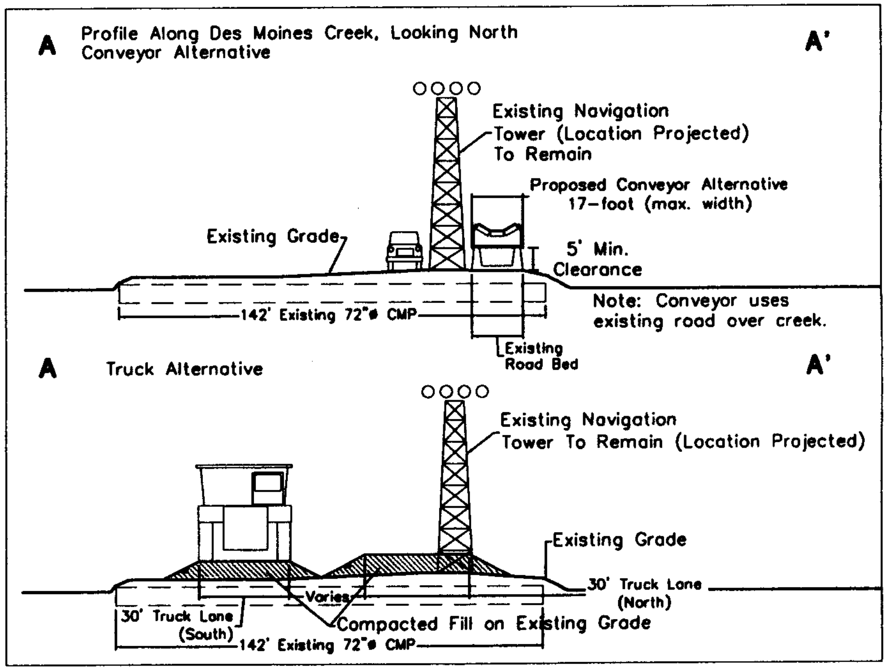
RC 12/5/00 1=1 (xref)see drawing file/charlie.pc2
49786240

Representative Conceptual Des Moines Creek - Borrow Area Haul Road Crossing Map and Cross Sections



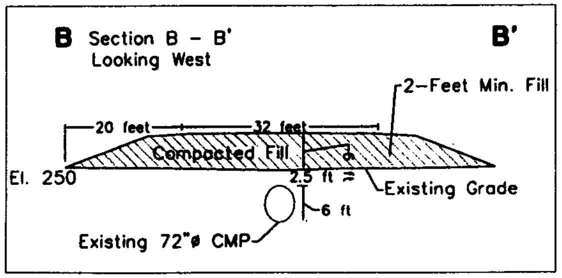
Conceptual Des Moines Creek - Haul Road Crossing Map

Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_062700.dwg", dated June 27, 2000.



Conceptual Haul Road Crossing of Des Moines Creek

0 60 120
Scale in Feet



Conceptual Fill Section at Haul Road Crossing Des Moines Creek

0 30 60
Scale in Feet

Note: Culvert will be replaced in accordance with "Fish Passage Design at Road Culverts," published March 3, 1999, by Washington Department of Fish and Wildlife.

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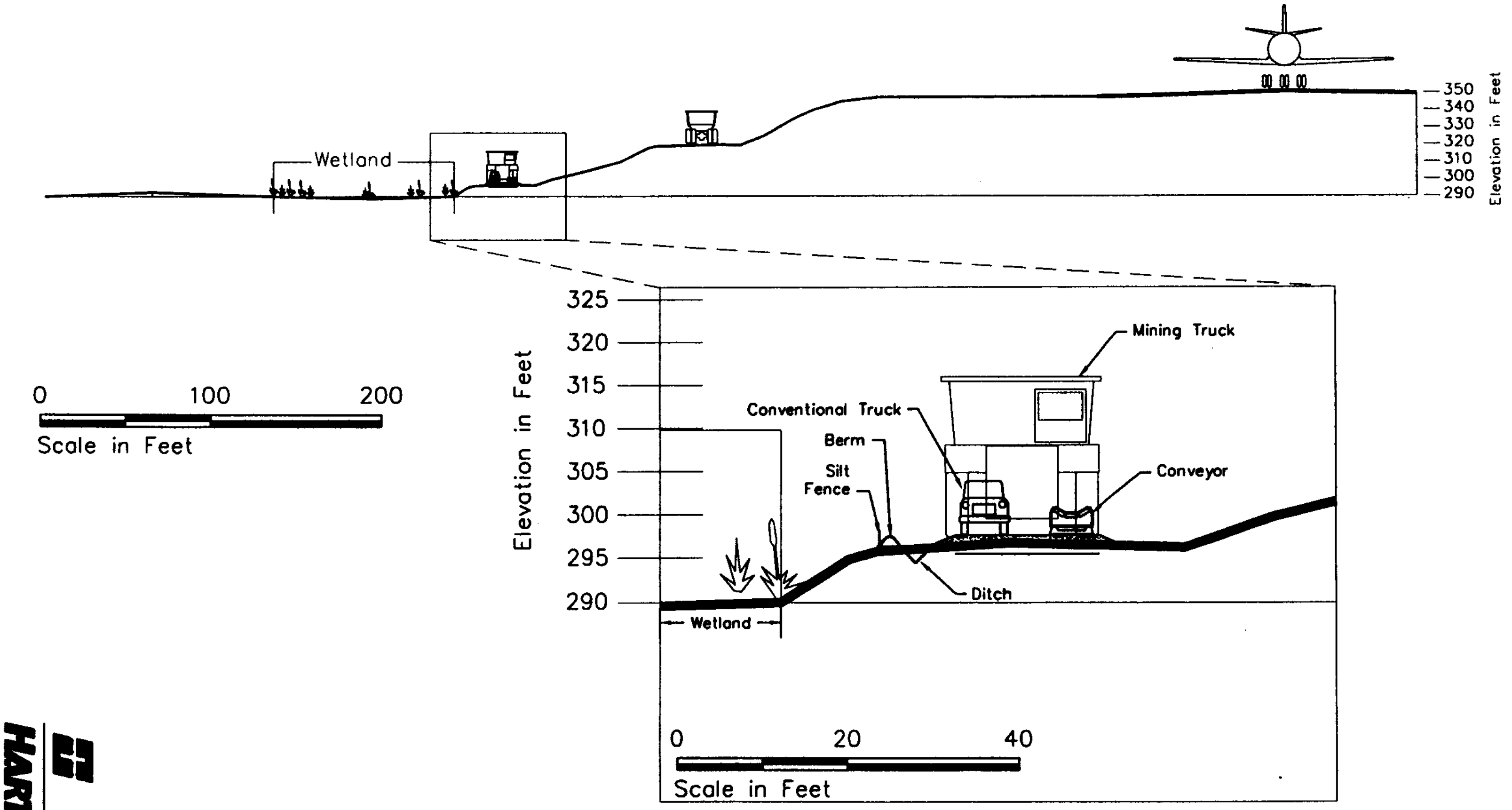
Figure 7

RC 12/4/00 1=100 8.5x11 woodstock.pc2 49786241

Borrow Area Haul Route Representative Cross Section

At Closest Encroachment to Wetland (Sta H+59.5)



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J-4978-62 12/00
Figure 8

APPENDIX D

APPENDIX D

PRESERVATION OF WETLANDS IN BORROW AREA 3

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MEMORANDUM

DATE: October 20, 2000

TO: Jim Thomson, HNTB

FROM: Michael A.P. Kenrick, P.E., and Michael J. Bailey, P.E., Hart Crowser

RE: **Sea-Tac Third Runway – Borrow Area 3**
Preservation of Wetlands
J-4978-06

As requested by the Port of Seattle, this memo and the attached figures provide conceptual design and supporting information for the proposed drainage swale to protect wetlands in Borrow Area 3. We also provide a brief explanation of the hydrology that supports the wetlands, including why excavation of Borrow Area 3 will not drain these wetlands. Figure 1 shows the location of Borrow Area 3 to the south of Sea-Tac Airport.

REVIEW OF BORROW AREA 3 WETLAND HYDROLOGY

The first section of this memo provides a review and explanation of the hydrology that currently supports and sustains wetlands in Borrow Area 3. Understanding these hydrologic factors is important in ensuring the long-term preservation of the wetlands during and after excavation of the fill materials contained in Borrow Area 3.

Factors Promoting Preservation of the Wetlands

Existing wetlands and current topography in Borrow Area 3 are shown on Figure 2; the proposed area of mining and resulting contours for final excavation are shown on Figure 3.

The series of wetlands mapped in Borrow Area 3 follow a line of shallow depressions in the southcentral part of the site, extending to the southeast from Wetland 29 through Wetlands B9, 30, B7, B6, and B5. These wetlands exist in an area of relatively permeable subsoils where the main groundwater table is at a depth of 10 to 15 feet below the wetlands. Depth of the water table indicates the wetlands are supported by other sources of water. The sources of water appear to include surficial runoff and shallow interflow, as well as

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groundwater seepage occurring from a perched zone above the main water table that discharges in the area of Wetland 29. Observation wells in the area indicate the perched zone does not contribute flow directly to the other wetlands but, by extension, flow from Wetland 29 appears to pass along the line of wetlands, to each wetland in turn.

The key factors for sustaining wetland hydrology in Borrow Area 3 are (1) ensuring the continued supply of water and (2) preventing the undue loss of water from the wetlands. Wetland hydrology is typically sustained by a combination of hydrologic processes, as shown schematically on Figure 4. The processes supporting wetland hydrology include precipitation (P), groundwater flow (GW) and spring seepage (Sp), runoff (RO), and interflow (IF). Other processes such as evapotranspiration (Et) and deep percolation (DP) lead to the potential loss of water from wetlands. Where wetlands exist, it can be assumed that the sources of water exceed the losses, for at least a large part of the year. Maintenance of the water sources, without increasing the losses, should ensure preservation of the wetlands in perpetuity.

One of the main constraints on wetland development in the area is the relatively high permeability of the surficial soils. In agricultural terms, the surficial soils are identified to be part of the Indianola series (USDA, 1973) and are characterized as being "excessively drained" with "rapid permeability." This is consistent with the predominant soil material in Borrow Area 3 being stratified glacial drift, which is primarily sand and gravel outwash with varying amounts of silt in a predominantly granular matrix.

The overall approach for maintaining wetlands in Borrow Area 3 focuses on preserving or enhancing the existing sources of water, and ensuring that no additional loss pathways are created.

Wetland 29

Wetland 29 is unique in that it occurs on a hillside (see Figure 3). Its existence is attributable primarily to a continuous supply of groundwater that seeps from the hillside at this point. Investigation of subsurface conditions at Borrow Area 3 links this area of seepage with a laterally continuous zone of perched groundwater that extends to the north and west, behind Wetland 29 (Hart Crowser, 1999, see reference list following the text of this memo). In hydrologic terms, the wetland occupies part of a surface seepage discharge area for groundwater flowing through the perched zone, as illustrated in the cross section on Figure 4. Part of the seepage from the perched zone flows into Wetland 29, the rest of the seepage from the perched layer does not appear elsewhere on the surface, so is assumed to percolate down into the shallow regional aquifer in the eastern part of the site where the perching layer has been removed by erosion.

The proposed borrow area excavation to the east of Wetland 29 (Figures 3 and 4) will not interfere with the perching layer behind or beneath the wetland and will, therefore, have no direct effect on the continued discharge of groundwater from the west. An analysis of groundwater flow potentially diverted from Wetland 29 (Hart Crowser, 2000) indicates that excavation could change the seepage gradient and result in a decrease in flow to Wetland 29. Mitigation to address this potential change is discussed below.

Although the base of the Borrow Area 3 excavation will be lower in elevation than most of Wetland 29, excavation will occur in predominantly permeable soils that are above the water table. These existing permeable soils already provide a drainage pathway for seepage losses from the wetlands. The persistence of the wetlands despite the presence of permeable soils and a relatively deep water table demonstrates that wetlands will not be drained by the adjacent excavations.

Other Wetlands

Water in Wetland 29 is primarily lost by percolation to the underlying aquifer and evapotranspiration. A portion of the water flowing through Wetland 29 is inferred to move downslope as interflow or shallow subsurface flow to feed successive wetlands that trend southeastward from Wetland 29, occupying a series of shallow depressions (see Figure 3 - note that this flow is out of the plane of the cross section on Figure 4). This inference is based on the topographic position of the adjacent wetlands and the absence of other sources of water. Flow appears to move from one wetland to the next, and some water is likely lost as deep percolation into the permeable subsurface soils that underlie most of the site, including the wetlands. Some additional water probably comes as surface runoff or interflow from the surface catchments feeding each wetland.

According to the Wetland Delineation Report (Parametrix, 1999) and supporting Field Data Sheets, the wetlands in Borrow Area 3 typically feature 10 to 12 inches of "black muck" - a fine-grained richly organic soil that appears to help the ponding of water in the wetland, and likely retains saturation of the root zone rather than allowing much of the water to percolate downward. The concept is illustrated on Figure 5, which is a cross section through Wetland 30.

Note that Wetlands 30, B7, B6, and B5 appear to exist beyond the main perching layer. It is possible that these wetlands formed on locally silty (less permeable) zones in the predominantly granular soil, promoting shallow perched conditions that sustain the wetland hydrology. As evidence of this, Wetland B7 is reported to have a seasonally high water table that would be 10 to 15 feet above the main groundwater table in the underlying relatively permeable shallow regional aquifer. As a result, excavation of the perching layer northeast of Wetland 29 would not have any direct impact on the other wetlands in Borrow Area 3 provided flow into Wetland 29 is maintained as described below.

Proximity of Excavations

The Port proposes that excavations of Borrow Area 3 (see Figure 3) will leave at least a 50-foot buffer around the wetlands. Excavation to the east of the wetlands will proceed to approximate elevation 233 to 235 feet, whereas the wetlands themselves are at approximate elevations 236 feet (Wetland 30) and 235 to 238 feet (Wetlands B6 and B7), see Figures 5 and 6. The hydrology of these wetlands will not be adversely impacted by the excavations because:

- The wetlands already exist over permeable subsoils;
- The buffer will be retained, preventing any lateral "short circuit" flowpath that could divert water from the wetlands and into the borrow site excavation; and
- Base elevations of the proposed excavations are at most only a foot or two lower than the lowest point in these adjacent wetlands.

Wetland B5 is at about elevation 230 feet, well below the proposed excavation. Wetlands B9 and 29 are upslope of the proposed excavation and would be protected against any potential loss of water by the proposed mitigation discussed herein. Wetland B10 is upslope of the perched zone and, therefore, would not be impacted by changes in perched zone flow.

Potential Loss of Surface Flows

In some areas of the buffer zone between the wetlands and the proposed excavation, there may be localized low spots that provide a potential pathway for overland flow to occur from the wetland into the excavation at periods of exceptionally high water levels. If erosion occurs during periods of high water in the wetlands, formation of gullies could divert increased surface flows from the wetlands into the excavations. Erosion will be prevented by preserving existing vegetation in the wetland buffer areas and revegetating the excavated area in accordance with Washington Department of Natural Resources reclamation criteria. However, if erosion threatens the wetland floor, mitigation could easily be accomplished. The Port has proposed a period of wetland monitoring following excavation of the borrow site. If necessary during or after excavations, berms or other erosion protection will be constructed outside the wetland buffer and on the edge of the excavations to prevent overland flow occurring from the wetland depressions into the adjacent excavation. This element of the mine plan will depend on field surveying for elevation control of the land-surface profile along the buffer zone, reclamation of the site to a stable condition, and monitoring after reclamation, which the Port has already committed to.

DRAINAGE SWALE DESIGN

The remainder of this memo addresses the design of a drainage swale that will provide additional water to Wetland 29 to replace the potential loss of seepage from the perched zone.

As described in Hart Crowser (2000), groundwater modeling suggests the possibility that mining will produce a small change in the groundwater flow regime within the perched zone that feeds Wetland 29. Modeling suggests increased drawdown in the perched zone due to excavation in the Borrow Area 3 (see Figure 3) could cause a shift in the seepage gradient. This change in gradient could reduce groundwater flow by a maximum of about 20 percent of the current flow to Wetland 29, or about 400 ft^3/day (roughly 2 gallons per minute). The Port proposes to mitigate this potential indirect impact by collecting groundwater seepage in a swale along the western slope face of the excavation (see Figure 3) and diverting this to Wetland 29.

Overall Concept for Drainage Swale

The proposed drainage swale is designed to collect groundwater seepage from the excavated slope face on the north and west sides of Borrow Area 3, as depicted on Figure 3. The groundwater seepage represents natural flow from the perched zone that is forced to discharge at the cut slope face, as described in detail in Hart Crowser (2000). The flow will be collected and conducted southward in a swale that drains into Wetland 29. Grades along the swale are expected to be between about 1 and 2 percent. A schematic profile along the drainage swale is shown on Figure 7. Modeling shows there is about 2,400 ft^3/day of groundwater flow available compared to projected maximum loss to Wetland 29 of 400 ft^3/day (Hart Crowser, 2000). There is more than enough seepage flow available to make up any loss in the natural perched zone groundwater flow to Wetland 29.

Adaptive Design Approach

The detailed design and construction of the drainage swale will be modified as needed to take account of field conditions revealed during the excavation of Borrow Area 3. For example, the swale could be lined with HDPE (see Figure 6) if needed to prevent loss of flow in the event soils encountered during construction are more permeable than indicated by the borings. Design, construction, operation, and maintenance issues are described under the following headings.

Typical Cross Section

The typical cross section for the proposed drainage swale is shown on Figure 6(a). This cross section presupposes that a sufficient thickness of natural low-permeability soils (the lateral extension of the perching layer) will be present in the upper part of the bench holding the swale.

Prevention of Leakage

To allow for potential variability in the surface elevation or thickness of the perching zone, the design assumes the invert of the swale may extend below the base of the perching horizon in places, in order to maintain the design slope of 1 to 2 percent. If the perching horizon is thin or even be eroded away in places, this will be revealed as excavation of Borrow Area 3 occurs and the intersection of the perching layer with the final cut slope becomes visible. In the event that field mapping during excavation shows insufficient low-permeability soil is present to form the required subgrade for the unlined drainage swale, the swale grade or alignment could be modified, and/or an impermeable lining (protected by gravel) would be used in the base of the swale to prevent seepage loss, as shown on Figure 6(b).

Control of Excess Flows

The position of the drainage swale at mid-slope around the northern and western sides of Borrow Area 3 will cause the swale to collect surface water runoff during high precipitation. Some precipitation upslope of the swale is likely to infiltrate but may appear as shallow interflow or perched water and contribute to seepage in the swale. Also, if constructed to its full length as shown on Figure 3, the swale is expected to collect more than enough groundwater seepage to make up for the projected maximum loss in flow from Wetland 29.

Two measures are available to deal with these anticipated excess flows:

1) A flow-control structure will be constructed in the course of the swale before it enters Wetland 29 (see Figure 9); and
2) The length of the swale can also be modified (at time of construction, or after some period of post-construction monitoring) to control the amount of seepage (and runoff) that is collected and diverted to Wetland 29.

The proposed flow control weir or diversion structure will be designed to provide a consistent low flow of seepage into Wetland 29 and enable diversion of excess flow in the drainage swale away from Wetland 29. The excess flow will be diverted along a channel and into the base of Borrow Area 3, where it will infiltrate and/or be handled by the stormwater facilities for managing runoff from the remainder of the borrow area.

The flow control structure will be constructed of reinforced concrete. As illustrated on Figure 9, it will include a narrow flow slot at the lower elevation to enable a continuous low flow from the drainage swale into Wetland 29. The second part of the flow control structure will include a broad overflow weir that will allow water to spill over into a diversion channel during periods of higher flow in the swale. Flow through both the narrow slot and the broad weir will be controlled with adjustable boards as shown on Figure 9. Flow to Wetland 29 will be fine-tuned during the initial maintenance period (following construction) by adjusting the height of the boards placed in each part of the structure. Final flow levels may then be fixed by replacing the boards with masonry at the end of the monitoring period.

Construction

Construction of the drainage swale will be integrated with the mining and reclamation plan for the excavation of Borrow Area 3. This will prevent over-mining of the perching layer in close proximity to the final slope contours for the excavation. Mining will progress from the highest area of the site in the northwest part of Borrow Area 3, working down the slope and reclaiming the upper part of the final cut slope as excavation proceeds. The perched zone will be encountered as wet areas at the base of the working slope. Mining will then step in approximately 20 feet to allow the bench for the drainage swale to be formed in the perching layer beneath the perched zone.

The next stage will be to excavate within the bench width to cut the swale into the perched zone and underlying perching layer. The bench will be cleaned off and graded to form the swale, which will be constructed per the typical cross section. This will provide the opportunity to determine from field surveying the elevation, profile, and thickness of the perching layer in the area of the final slope. The final design of the swale invert elevations and cross sections will then be adjusted as required to best match subsurface conditions and topography, facilitating final construction the swale at the required elevation on the bench. Mining will then proceed into the lower part of the slope below the drainage swale.

Surface Protection and Reclamation

Reclamation of the borrow area will be accomplished in accordance with Washington Department of Natural Resources criteria and the Port of Seattle landscape plans. Once final grades have been established, the drainage swale and adjacent slopes will be protected from erosion using the same techniques demonstrated to be effective by the embankment construction to date. The excavation slopes will be dressed and hydroseeded with a bonded fiber matrix. The swale will be protected with erosion control matting until grass is established as part of the post-excavation site reclamation.

Operation and Maintenance

Operation of the swale, and particularly the flow control structure, will require monitoring and recordkeeping for an initial period of about two to five years. During this period, the amount of seepage and operation of the flow control weir will be monitored. The weir height may be adjusted to ensure stable and appropriate flows to Wetland 29, which are consistent with plant and ecological requirements of the wetlands.

Long-term operation and maintenance of the swale will be restricted to periodic (annual) inspections of the facility to check the basic integrity of the swale and look for signs of erosion or blockage that could require remedial work by Port grounds maintenance staff.

F:\docs\jobs\497806\DraftWetlandPreservationSwale.doc

Attachments:
References
Figure 1 - Site Location Map
Figure 2 - Pre-Excavation Topography and Wetlands – Borrow Area 3 Perched Zone
Figure 3 - Post-Excavation Topography and Drainage Facilities - Borrow Area 3 Drainage Swale
Figure 4 - Cross Section A - A′ through Wetland 29
Figure 5 - Cross Section B - B′ through Wetland 30
Figure 6 - Cross Section C - C′ through Wetland B6
Figure 7 - Drainage Swale – Profile D-D′
Figure 8 - Typical Cross Sections E-E′ - Borrow Area 3 Drainage Swale
Figure 9 - Flow Control Structure Schematic - Borrow Area 3 Drainage Swale

REFERENCES

Hart Crowser, Inc., 1999. Subsurface Conditions Data Report, Borrow Areas 1, 3, and 4, Sea-Tac Airport Third Runway. Prepared for HNTB and the Port of Seattle, September 24, 1999 (J-4978-02).

Hart Crowser, Inc., 2000. Evaluation of Perched Zone Interception and Possible Impacts to Wetland Hydrology, Borrow Areas 3, Sea-Tac Airport Third Runway. Prepared for HNTB and the Port of Seattle, September 12, 2000 (J-4978-13).

Parametrix, Inc., 1999. Wetland Delineation Report, Seattle-Tacoma International Airport, Master Plan Update Improvements. Prepared for Port of Seattle, August 1999.

USDA, 1973. Soil Survey, King County Area, Washington. United States Department of Agriculture, Soil Conservation Service, 100 pp. November 1973.

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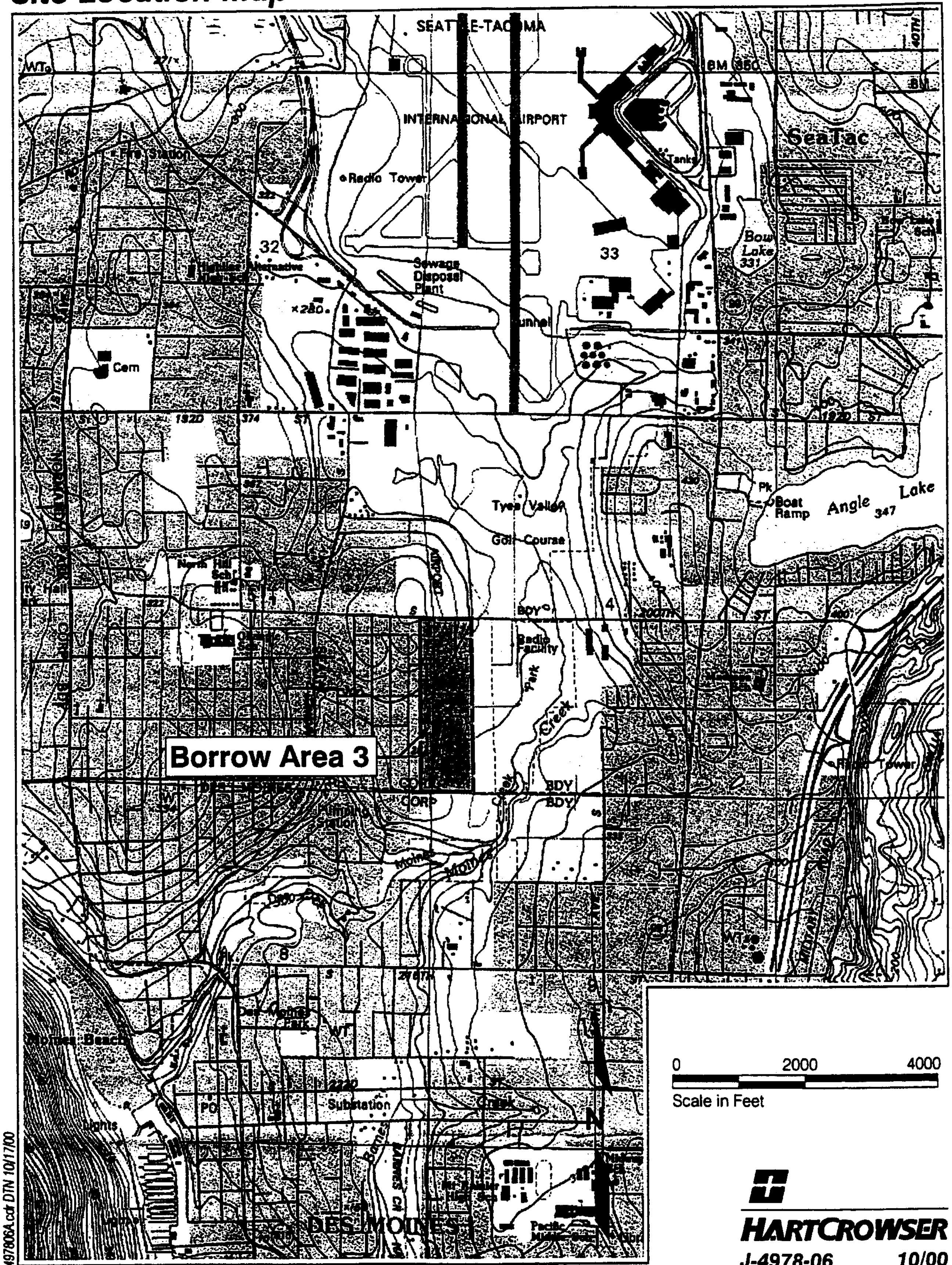
Site Location Map



Note: Base map prepared from USGS 7.5 minute quadrangle maps of Seattle South, Washington, revised 1995.

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Figure 1

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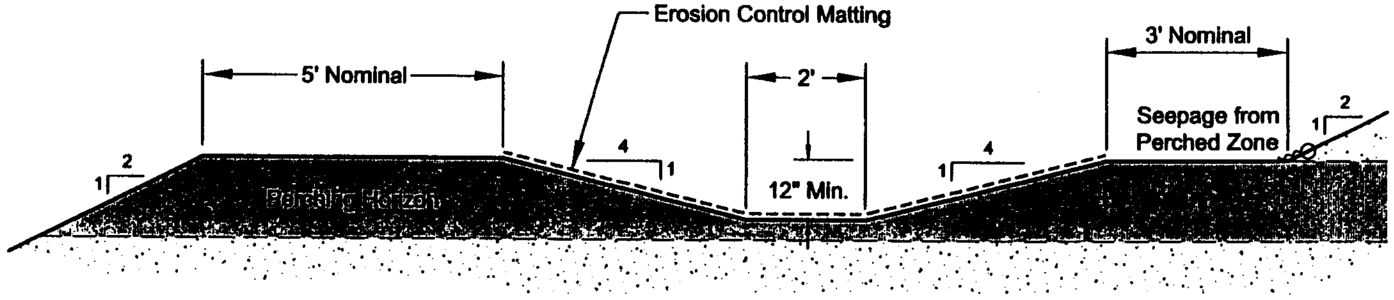
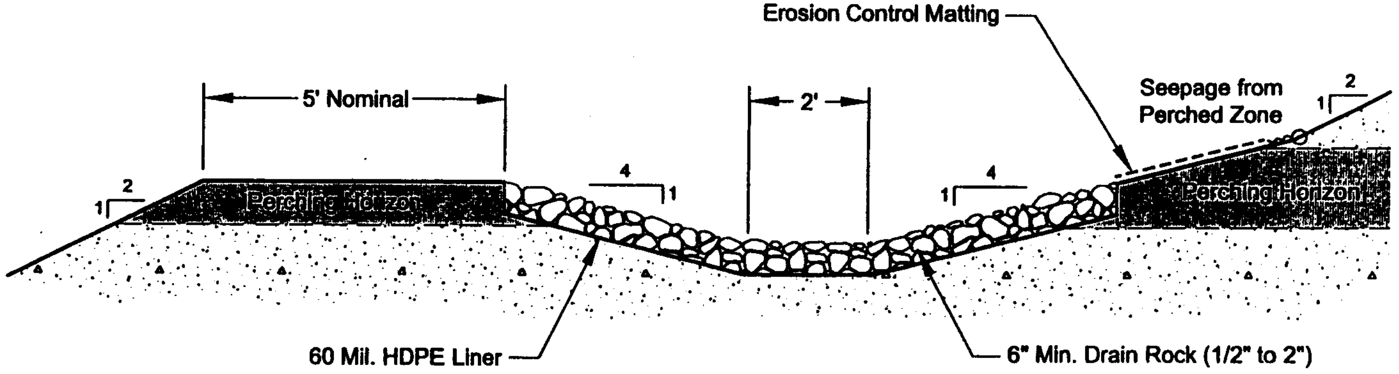
Typical Cross Sections E-E'

Borrow Area 3 Drainage Swale



(a) DRAINAGE SWALE (TYPICAL)

Not to Scale



(b) LINED DRAINAGE SWALE (AS NEEDED)

Not to Scale

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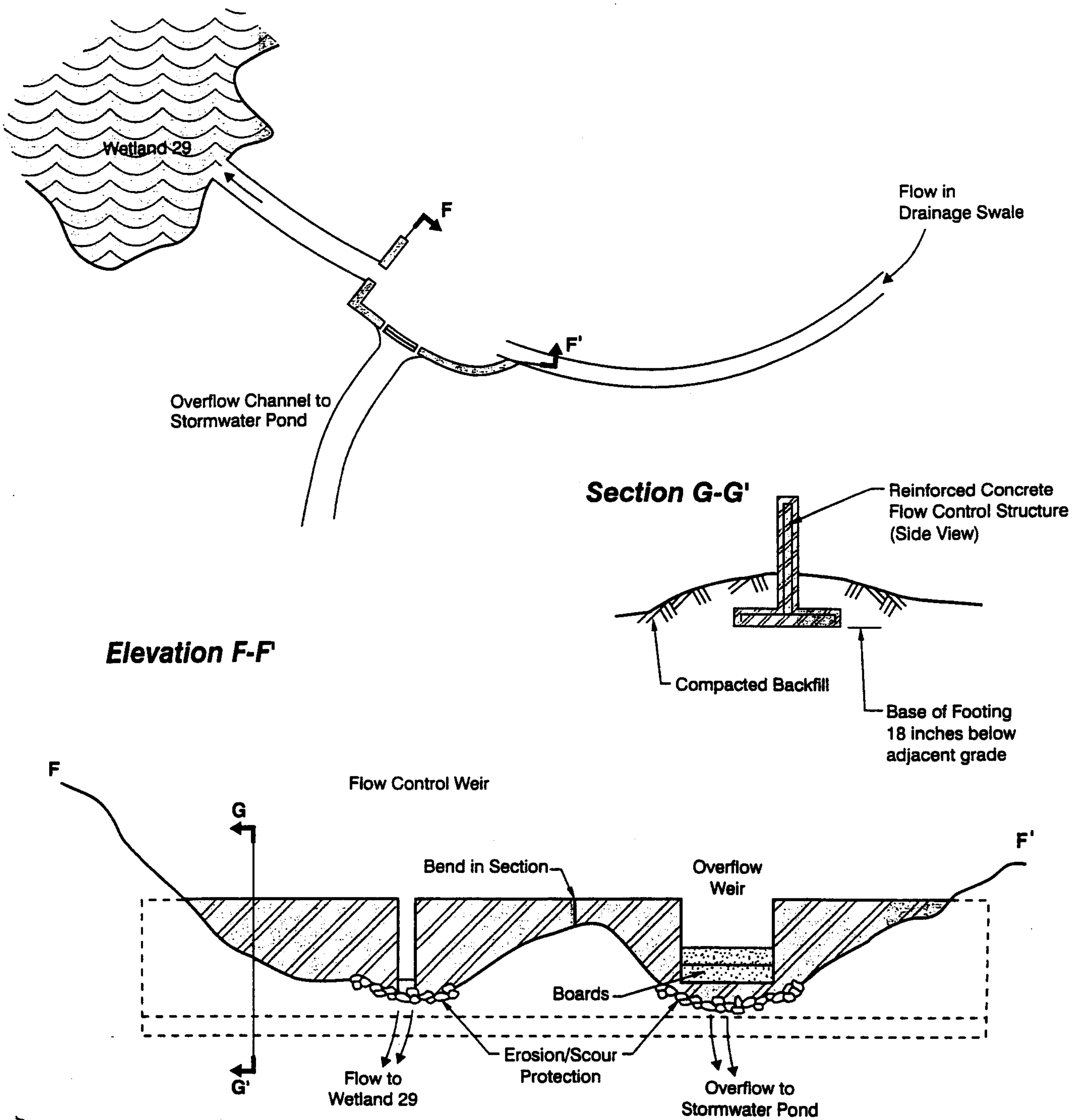
J-4978-06 10/00
Figure 8

Flow Control Structure Schematic

Borrow Area 3 Drainage Swale



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J-4978-06 *10/00*

Figure 9

APPENDIX E

APPENDIX E

THIRD RUNWAY MSE WALL SUBGRADE IMPROVEMENTS

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MEMORANDUM

DATE: December 8, 2000

TO: Ms. Elizabeth Leavitt, Port of Seattle

FROM: Michael Bailey, P.E., Hart Crowser, Inc.

RE: **Proposed MSE Wall Subgrade Improvements**
Seattle-Tacoma International Airport
J-4978-06

CC: Jim Thomson, P.E., HNTB

MICHAEL J. BAILEY
22484
EXPIRES 12/13/01

In response to your request, this memo provides an update on design of the subgrade improvements to support the mechanically stabilized earth (MSE) retaining walls for the Third Runway embankment at Sea-Tac.

This memo describes why the proposed construction below existing ground level will have no adverse impact to groundwater flow below the proposed MSE walls.

The basic design concept, construction approach, and subsurface conditions below the proposed MSE walls are generally discussed in Appendix B in the Wetland Functional Assessment and Impact Analysis document for the project, which includes Hart Crowser's July 9, 1999, report entitled "Geotechnical Engineering Report, 404 Permit Support, Third Runway Embankment." This memo provides additional detail based on subsurface explorations and design work completed since July 1999. This memo provides a description of the components used in the MSE wall foundation and the proposed subgrade soil improvements, and why these constructed features will not impede shallow groundwater flow that recharges Miller Creek and adjacent wetlands.

MSE Wall and Foundation Components

Figure 1 shows a schematic cross section of the proposed MSE wall that will be constructed to avoid relocating Miller Creek. The cross section, located at runway Station 178+60, is a good section to use for illustration because it includes wetland soils and is near the

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maximum height of the proposed wall. Figure 2 shows location of the cross section as well as the extent of the proposed subgrade improvements in plan view for the west wall.

Figure 1 shows elements of the reinforced wall backfill zone and subgrade improvement zone that are discussed in this memo. Construction elements that are related to groundwater flow include the following:

Native Surficial Soils. This soft or loose to medium dense surficial soil unit consists of silty sand with organics, interbedded silty sand, gravelly sand, and sandy silt, and occasional sandy clay. The surficial soils contain the shallow aquifer that recharges Miller Creek and the adjacent wetlands. The seasonal groundwater level is near to, and locally slightly above the ground surface in this area, as indicated by Hart Crowser's monitoring wells and observations of shallow puddles in the wetland and overland flow from the east during the late spring. The surficial soils vary from about 10 to 20 feet in depth in this area. These surficial soils are not suitable to provide structural support of the proposed MSE wall.

Glacial Till. Underlying the surficial soils is glacial till or other hard glacially overridden soils that consist of very dense silty sand and hard sandy silt, with varying amounts of gravel. This soil unit will provide very good foundation support for the proposed MSE walls.

Reinforced Fill Zone. The proposed MSE wall is constructed of concrete facing panels connected to strips of steel reinforcing that extend back into the wall backfill behind the wall. Both the panels and the reinforced backfill are embedded below the surface of the new fill in front of the wall, to provide support for the wall. Depth of embedment is depends on the wall height and ground slope; in this area, it will be about 8 feet.

Subgrade Improvement Zone. The reinforced fill and MSE wall facing will be supported on soils which are adequately strong and non-compressible, to transfer the weight of the wall to the underlying glacial till. There are two types of subgrade improvement that may be used where the existing surficial soils need to be "improved" to provide this support;

- In areas where the depth of subgrade improvement is relatively shallow, existing soils in the subgrade improvement zone can be removed and replaced with compacted structural fill.
- In areas where the soils that need improvement are more than a few feet thick, subgrade improvement may be accomplished by installing stone columns to reinforce the existing native soils.

Both types of subgrade improvement are discussed later in this memo.

As shown on Figure 1, the eastern part of the reinforced fill extends a few feet below the existing ground surface at the cross section (Station 178+60). The depth of this embedment for the reinforced zone varies; for instance at Station 177+75, the reinforced zone will extend below the ground surface about 9 feet.

The remainder of the memo describes the construction sequence and why shallow groundwater recharge to Miller Creek and the wetlands west of the MSE wall will not be impeded by either the reinforced fill extending below the ground surface, or either type of subgrade improvement.

Shallow Groundwater Seepage through Subgrade Improvements

Subgrade improvements will be constructed by either 1) overexcavation and replacement with compacted fill, or 2) use of stone columns. In some areas, the reinforced fill may also extend below the groundwater level.

Removal and Replacement for Subgrade Improvement

Where unsuitable soils are excavated as part of subgrade improvement, backfill will consist of relatively free-draining structural fill of the type used for wet weather construction or for the embankment underdrain. This fill will be well-graded and have a maximum fines content (percentage of silt and clay), limited by the construction specifications to not more than 8 percent. Figures 3 and 4 show gradation of the fill materials that may be used for this purpose. Permeability of this fill will be greater than the existing surficial soils it replaces, because of its overall gradation and the limited percent fines.

Stone Columns

Where stone columns will be used for subgrade improvement, design calls for them to have a nominal diameter of 42 inches and be spaced in a triangular pattern 8 feet apart. Figure 5 shows the method of constructing stone columns, and Figure 6 shows the spacing. The design calls for the stone columns to be constructed of coarse gravel with a maximum of 10 percent passing the no. 4 size sieve with little or no fines (silt and clay sized particles). The coarse gravel columns will occupy about 17 percent of the native soil volume based on the design spacing and diameter. Figure 7 shows gradation of the gravel specified for use in the stone columns.

Some densification of the native surficial soils will occur during stone column construction. However, the degree of densification is less in silty or clayey soils of the type that exist at the

Third Runway site, compared to non-silty soils. There are no reports in the engineering literature of stone columns impeding groundwater flow. In fact there are many case studies that show that stone columns actually improve site drainage by enhancing vertical seepage between granular soils that are separated by more silty interbeds.

Reinforced Zone

The MSE wall consists of concrete facing panels that are separated vertically by elastomeric bearing pads that maintain a ¾-inch gap completely around the perimeter of each concrete panel. The gap in the joint between MSE panels enables the face of the wall to be free-draining, including the portion embedded below the ground surface. Where the wall extends above the ground surface, this joint is so free-draining that it is typically protected with filter fabric to prevent soil erosion. Figure 8 shows the joint between MSE panels.

The bottom of the wall bears on a 6-inch-high concrete pad. This concrete pad will not impede shallow groundwater flow through the area where the wall is embedded because of its small height relative to the thickness of the aquifer.

The reinforced zone behind the wall facing has steel strips laid horizontally in the soil, to provide the MSE soil reinforcing. These strips are typically about a quarter-inch thick by four inches wide, and they are spaced a minimum of 9 inches on center both horizontally and vertically. The reinforcing will not impede shallow groundwater flow, for the same reason noted above, because of the small area occupied by the reinforcing strips relative to the overall height of the aquifer.

Please call if you have any questions.

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Attachments:
Figure 1 - West MSE Wall Cross Section Station 178 + 60
Figure 2 - West MSE Wall Subgrade Improvement Plan
Figure 3 - Grain Size Envelope for Group 1A Fill Material
Figure 4 - Grain Size Envelope for Group 1B Fill Material
Figure 5 - Stone Column Installation for Subgrade Improvement
Figure 6 - Stone Column Layout Plan
Figure 7 - Grain Size Envelope for Gravel Used in Stone Columns
Figure 8 - Joint Details between MSE Wall Panels

West MSE Wall Cross Section

Station 178+60

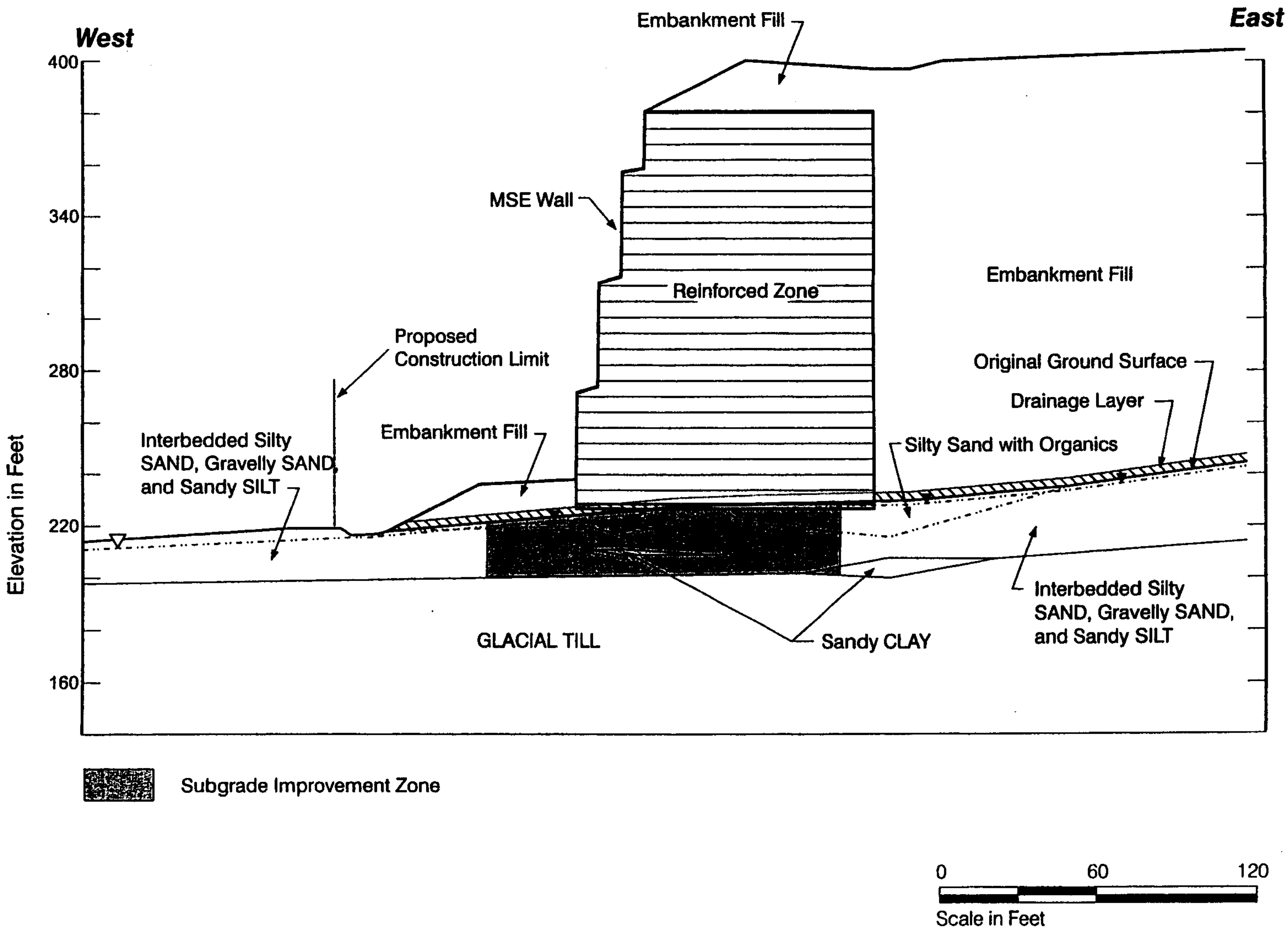

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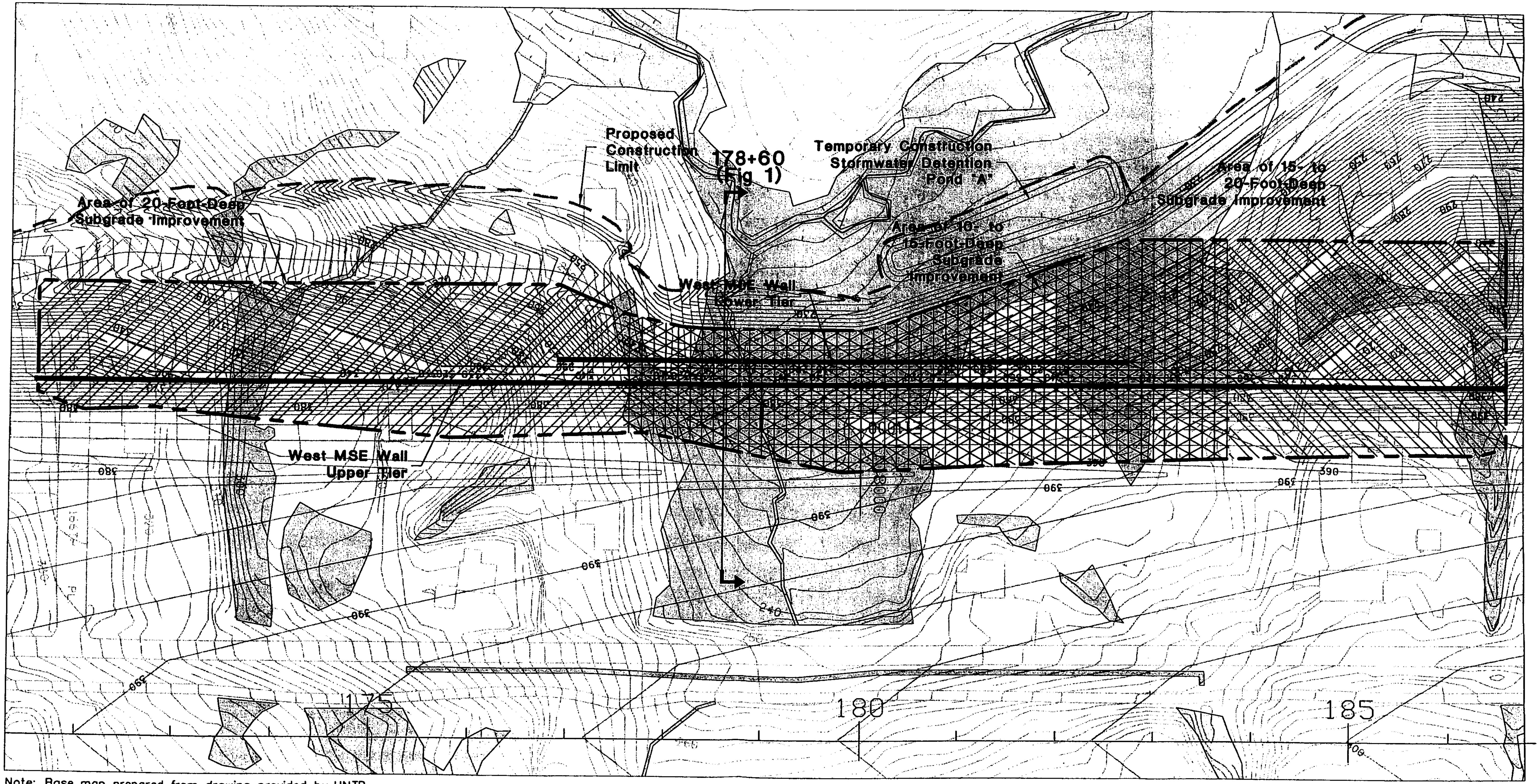
Figure 1

West MSE Wall Subgrade Improvement Plan



Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_110800.dwg", dated November 8, 2000.

178+60 Cross Section Location and Designation

Z

0 100 200

Scale in Feet

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Figure 2

RC 11/14/00 1=100 (xref)see drawing file/charlie.pc2
49780643.dwg

Grain Size Envelope for Group 1A Fill Material

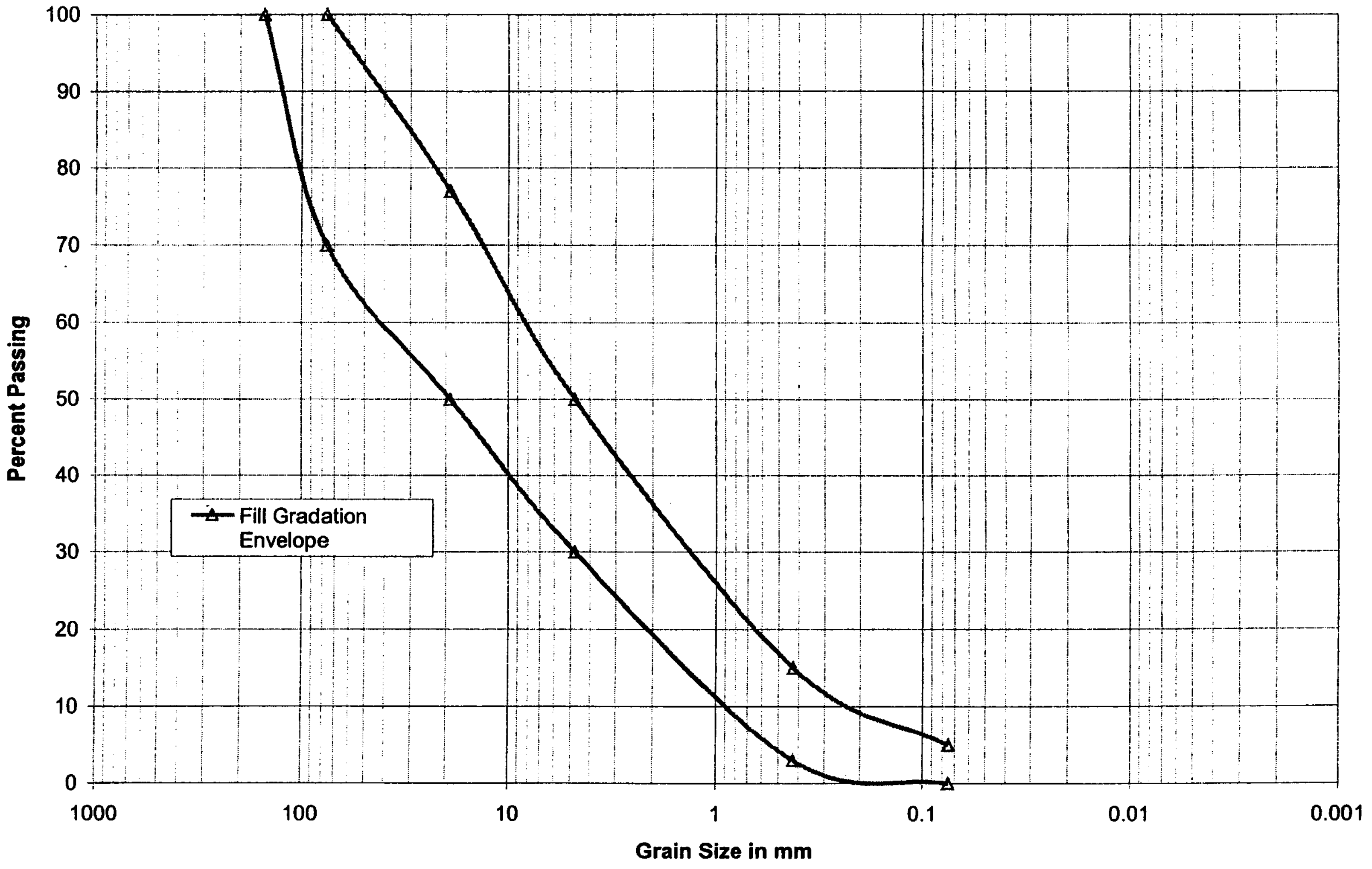

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Figure 3

Grain Size Envelope for Group 1B Fill Material

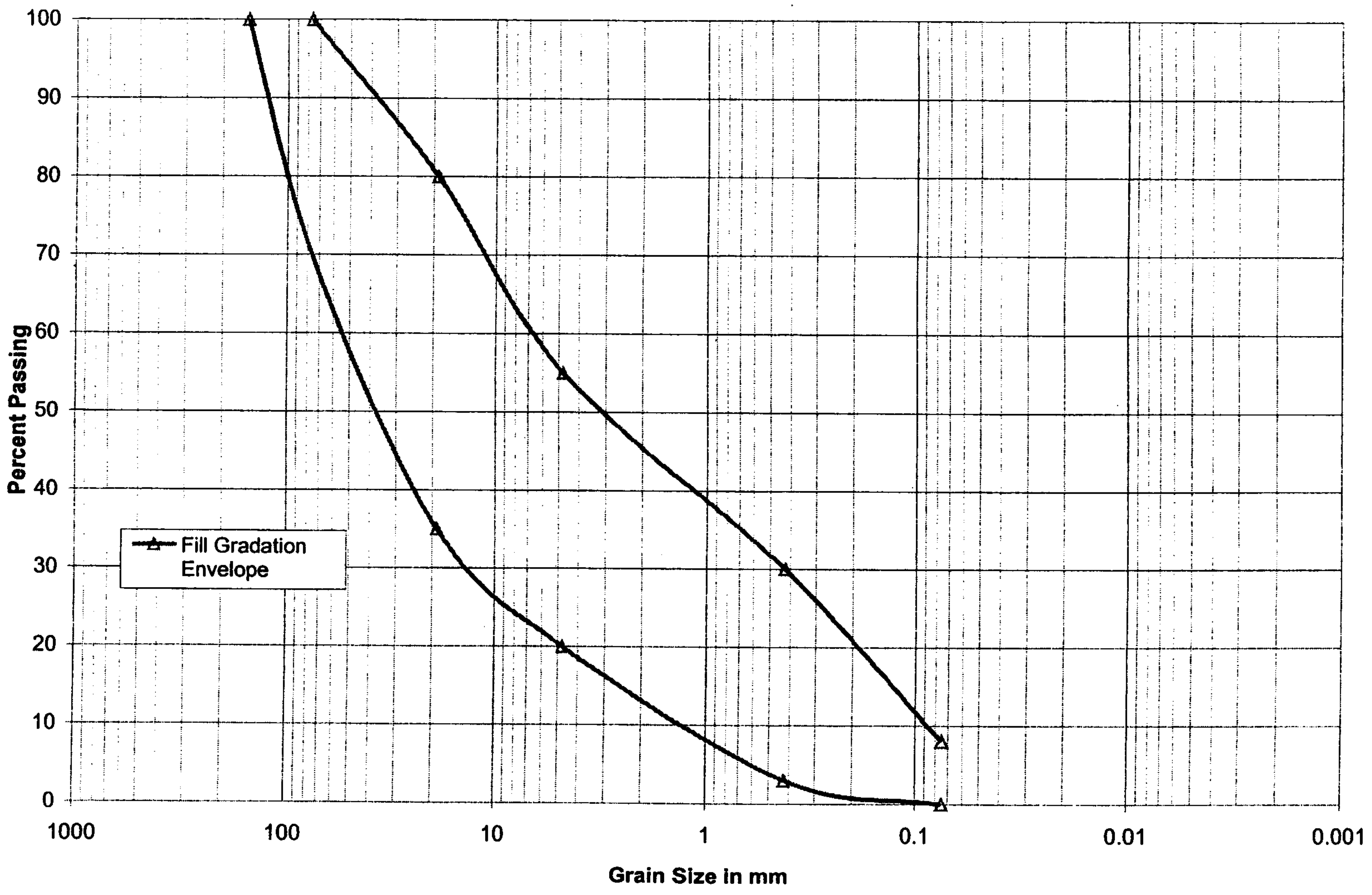

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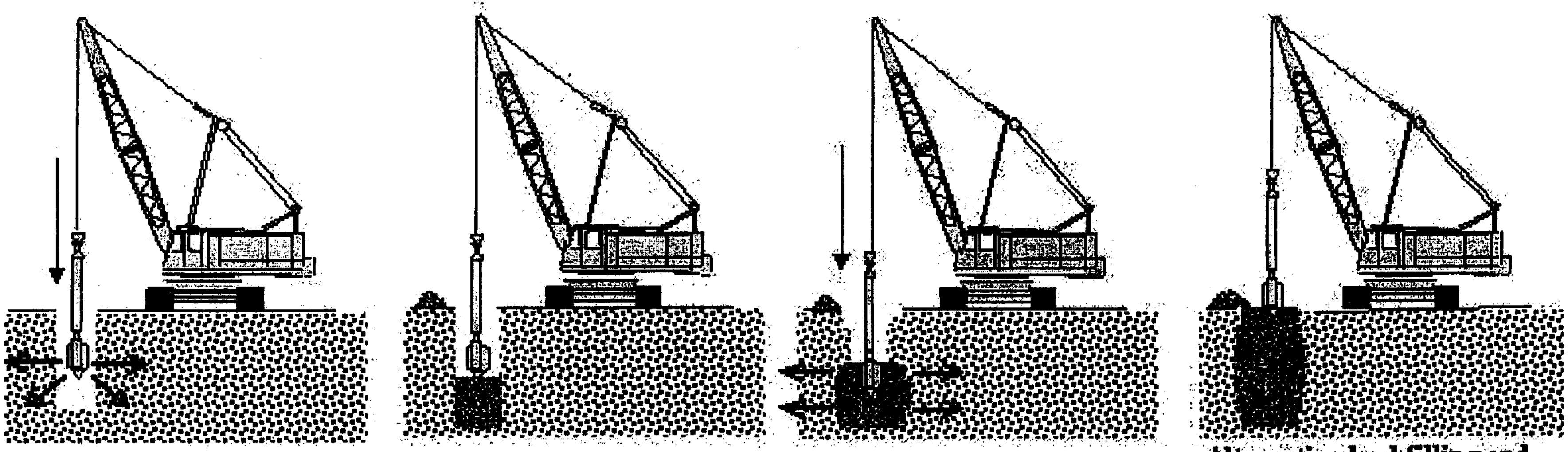
Figure 4

Stone Column Installation for Subgrade Improvement



Borehole is formed by sinking vibrator into the ground

Backfill material is placed into the borehole in stages and compacted

Alternating backfilling and compacting form continuous stone column

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Figure 5

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Stone Column Layout Plan

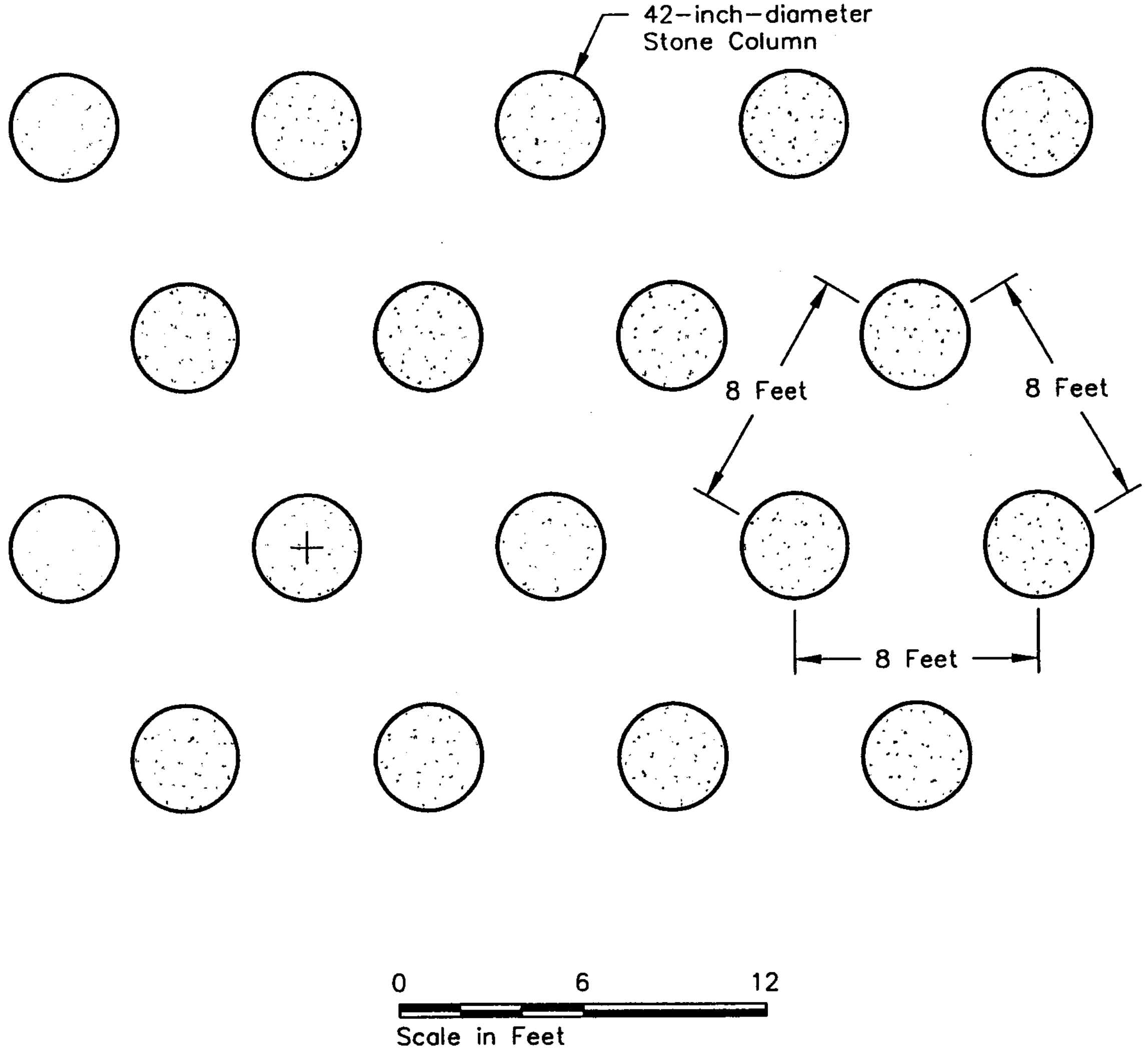

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Figure 6

Grain Size Envelope for Gravel Used in Stone Columns

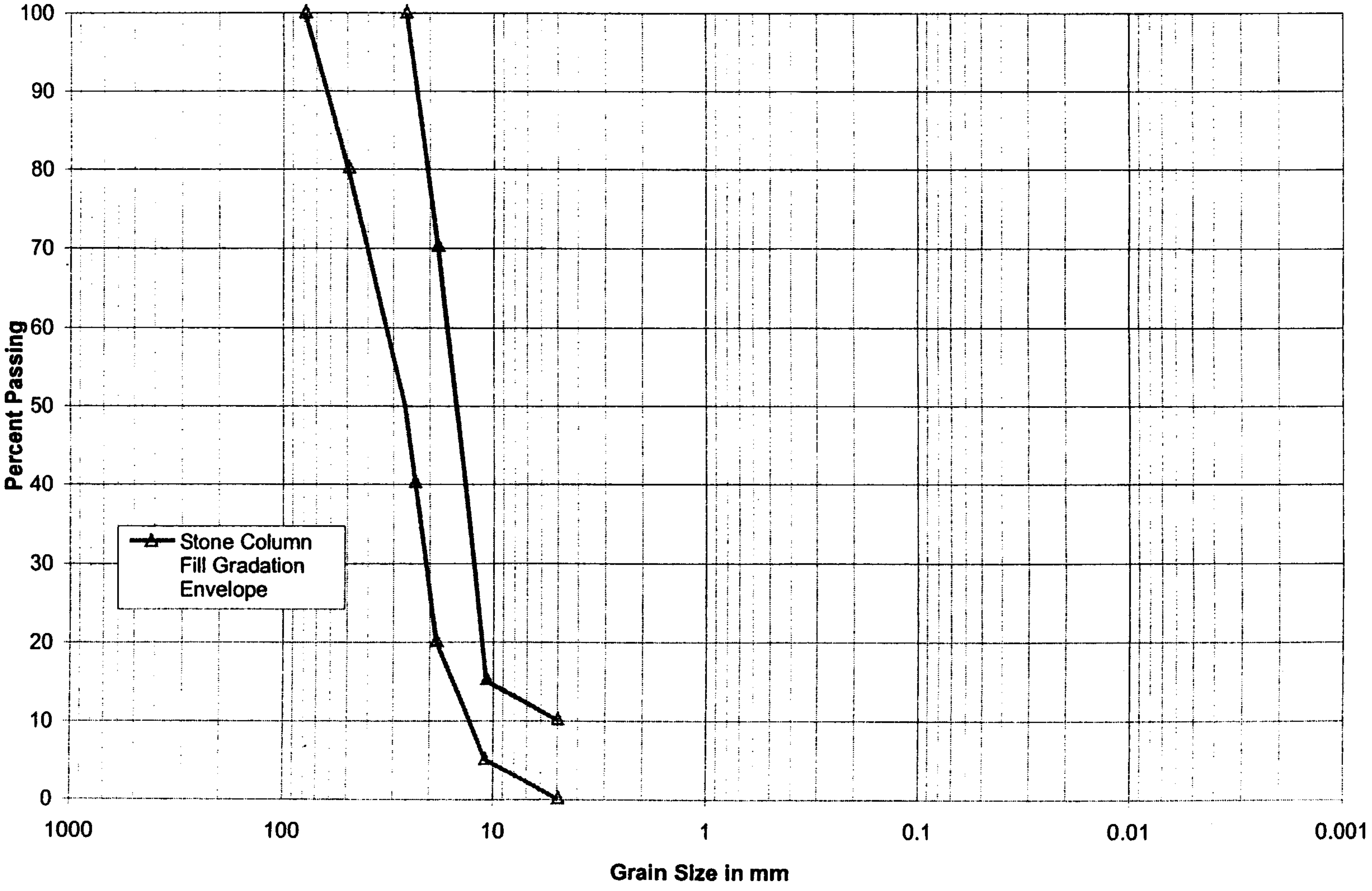

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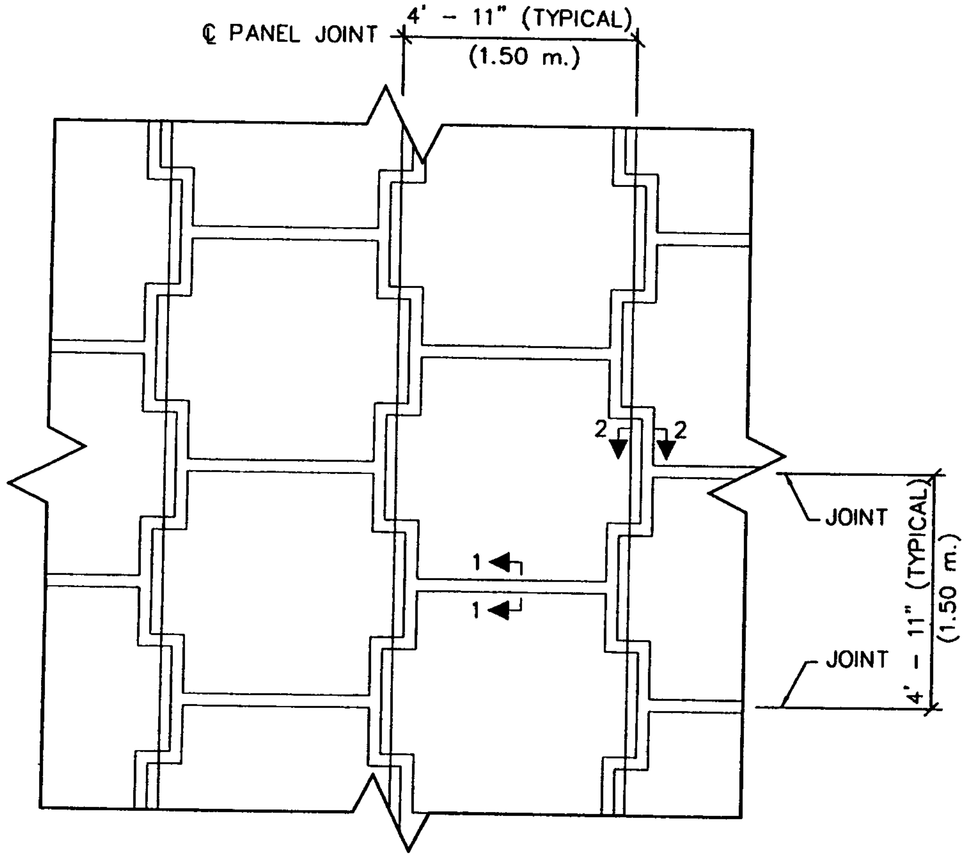
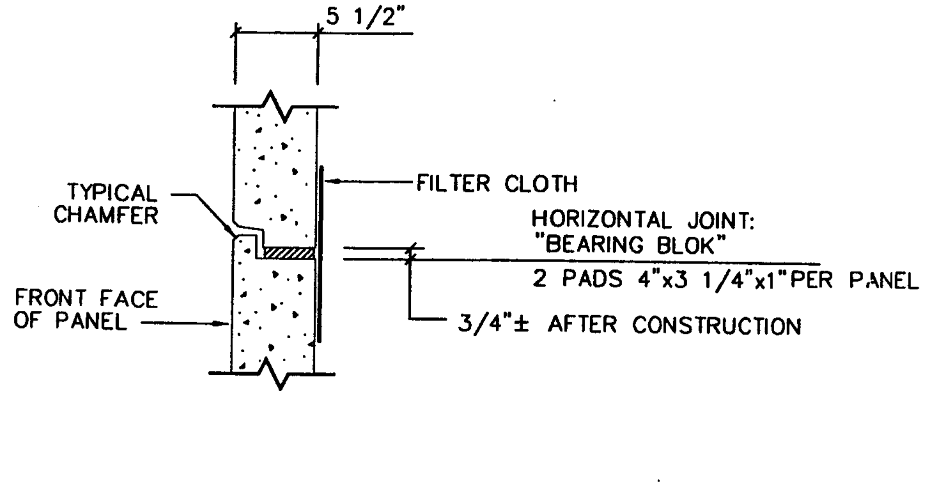
Figure 7

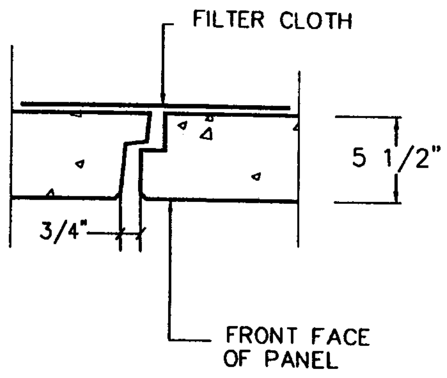
Joint Details Between MSE Wall Panels



TYPICAL MSE PANEL LAYOUT
PARTIAL ELEVATION - FRONT FACE
SCALE: 1/4" = 1'-0"



SECTION 1-1
SCALE : 1" = 1'-0"



SECTION 2-2
SCALE : 1" = 1'-0"

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49780644

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Figure 8

APPENDIX F

APPENDIX F

THIRD RUNWAY EMBANKMENT – EFFECTS OF INFILTRATION ON BASE FLOW

Feasibility of Stormwater Infiltration
Third Runway Project
Sea-Tac International Airport
SeaTac, Washington

Prepared for
Port of Seattle

December 14, 2000
J-4978-06

CONTENTS

TABLES

FIGURES

APPENDIX A
EXPLORATION LOGS

FIGURES

FEASIBILITY OF STORMWATER INFILTRATION
THIRD RUNWAY PROJECT,
SEA-TAC INTERNATIONAL AIRPORT
SEATAC, WASHINGTON

SUMMARY

Infiltration tests have been performed for selected sites on the west side of the proposed runway embankment to evaluate the feasibility of infiltration as part of the Stormwater Management Plan (SMP) for the Sea-Tac Third Runway project. The testing performed to date shows infiltration is feasible in two of the areas tested (Areas 1 and 3). Preliminary design infiltration rates have been developed from the field tests using methods stipulated by King County (1998) as listed in Table 1. Based on these results, potential infiltration capacities (in cubic feet per second [cfs]) at the individual sites have been developed for nominal 8-foot-wide infiltration trenches totaling 400 feet in length:

- Infiltration Area 1 can accommodate stormwater disposal at an average rate of 0.30 cfs; and
- Infiltration Area 3 can accommodate stormwater disposal at an average rate of 0.15 cfs.

Additional trenches may be located in these areas to increase infiltration capacity, depending on site logistics.

These data are suitable for conceptual infiltration facility design. The infiltration capacity of any site will depend on the detailed design and layout (i.e., area and elevation) of the infiltration facility, and the degree of variability in soil conditions beneath the facility. Additional infiltration tests and soil borings will be needed to meet all the requirements of the King County Surface Water Design Manual (1998) and should be completed once provisional footprints of the facilities are established.

This report summarizes design requirements for infiltration facilities, field data collection performed by Hart Crowser, and results of our work to date for Infiltration Areas 1 and 3.

INTRODUCTION

As a result of increased stormwater storage capacity requirements in the SMP, Hart Crowser was tasked to investigate potential sites for infiltration of detained stormwater on the west side of the proposed Third Runway project area (see Figure 1 for general location). Based on the location of detention ponds C, D, and G, three sites were identified as potential sites for infiltration of water discharged from detention ponds and/or vaults on the airfield. Additionally, the footprint of detention ponds C, D, and G were also considered for potential infiltration capacity. Locations of the detention ponds and Infiltration Areas 1, 2, and 3 are shown on Figures 2 and 3.

Infiltration testing was conducted along with the collection of soils and groundwater data that are needed to establish if infiltration can be implemented in each area in accordance with the requirements of the King County Surface Water Design Manual (KCSWDM - King County, 1998). The overall requirements for infiltration facilities are summarized in the following section.

INFILTRATION FACILITY REQUIREMENTS

The following summary outlines the General Requirements (Section 5.4.1 of the KCSWDM) for infiltration facilities (ponds, tanks, and trenches) associated with the natural site conditions. Additional requirements identified below under "Other Engineering Considerations" need to be addressed by the engineering design team.

Soils

- The basic requirement is a minimum of 3 feet of permeable soil below the bottom of the facility and at least 3 feet between the bottom of the facility and the maximum wet-season water table.
- A minimum of two test pits or soil borings per 10,000 ft^2 of infiltration area are required to characterize the site.
- Test pits or borings should extend at least 5 feet below the bottom of the infiltration facility, and at least one test hole should reach the water table.

Measured Infiltration Rates

- The measured infiltration rate should be determined using either the double-ring infiltrometer test (ASTM Method D 3385, 2000) or the EPA falling head percolation test procedure (EPA, 1980).
- Sufficient tests should be performed to determine a representative infiltration rate but at least three tests shall be performed for each proposed infiltration facility.

Design Infiltration Rate

- The design infiltration rate should be calculated by Equation 5-9 of the KCSWDM, using the correction factors listed in that Section 5.4.1.

Off-site Groundwater Impacts

- The impacts of infiltration should be considered for the potential to provide increased water to landslide areas, increased groundwater resources available, increased water levels in closed depressions, and higher groundwater levels.

Groundwater Protection

Groundwater protection requirements call for implementing one of the following actions when infiltrating water from pollution-generating surfaces:

- Provide water quality treatment prior to infiltration; or
- Demonstrate that the soil beneath the infiltration facility has properties which reduce the risk of groundwater contamination from typical stormwater runoff.

Other Engineering Considerations

- 100-Year Overflow Conveyance
- Spill Control Devices
- Pre-settling
- Protection from Upstream Erosion
- Construction Guidelines.

This report by Hart Crowser provides a preliminary assessment of the soils, infiltration rates, and hydrology of each site to establish the feasibility of infiltration. Engineering aspects and site logistics will be addressed by the design team as part of final design.

APPROACH

The type of infiltration test chosen at each location was dependent on the depth of the target soil strata or pond elevation. Generally, for tests less than 4 to 5 feet below ground surface, test pits were dug and the double-ring infiltrometer method was used. This method involved repeatedly measuring a small (< 1/4 inch) change in water level in both the inner and outer rings while consistently maintaining a head between 5.5 and 6 inches in both rings until a relatively constant rate was obtained. Pre-soaking the test area is not required; however, to limit the amount of inconsistent readings at the beginning of the test, a pre-soaking period of approximately one hour was employed.

For testing depths below 5 feet, the EPA method was used in an augered hole with a 6-inch-diameter temporary casing inserted to prevent caving of the borehole walls. This method involved repeatedly measuring the water level drop from an initial head (6 inches above the base of the hole) over a given period until a relatively constant rate was obtained. At the end time interval the water level was adjusted back to the original head level prior to starting the next measurement. A minimum of four hours or overnight pre-soaking of the test zone was performed.

The seasonal high groundwater level was estimated by measuring current groundwater levels in existing or recently installed monitoring wells at each site and comparing these with longer records from existing nearby wells in similar hydrogeologic settings. Additionally, soil profile characteristics such as low chroma mottling were also reviewed to assess the seasonal high groundwater levels.

RESULTS

We have completed infiltration tests and soil borings at one pond location and three potential infiltration areas:

- Pond G;
- Infiltration Area 1 (between Pond C and Pond G);
- Infiltration Area 2 (south of Pond G); and
- Infiltration Area 3 (northwest of Pond D).

Results of the double-ring infiltrometer tests are listed in Table 2; results of the EPA method falling head percolation tests are listed in Table 3.

Work on Pond D is still in progress. A third pond location (Pond C) was considered but the presence of groundwater seepage precluded further consideration of infiltration at Pond C. Infiltration in Pond G and Area 2 proved to be unfeasible due to low permeability soils and/or high groundwater levels. Logs of soil borings and test pits are included in Appendix A for Infiltration Areas 1 and 3.

In the following summaries, we include an estimate of the design infiltration rate for each area. This is currently based on the average values of the measured infiltration rates for each area, factored by our estimate of the appropriate correction factors, as stipulated by King County (1998). However, given the variability of the soils encountered to date, the mean value may not be appropriate for the entire facility at each location. Final design would take into account the results of additional facility-specific testing, the actual geometry of the proposed facilities, and additional design adjustments to provide an adequate "factor of safety."

Final measured infiltration values will be recommended for the design of the proposed facilities after completion of the additional borings and tests needed to fulfill KCSWDM requirements.

Infiltration Area 1

Investigative explorations show a consistent slightly silty fine to medium sand occurring across the site. The sand unit starts just below the surface and extends to depths of 8 feet (approximately 268 feet elevation) where deeper material increases in silt content.

The groundwater level measured in the new monitoring well HC00-B333, during November 2000, had an elevation of 268.5 feet. Table 4 lists the seasonal water level variations for two comparable wells east of Infiltration Area 1 with water level records that include last year's seasonal high. Based on the average seasonal fluctuation in these wells, and assuming currently observed water levels correspond to the seasonal low, the projected seasonal high water level for HC00-B333 is 273.1 feet (approximately 8 feet below ground surface).

The locations tested exhibited medium to high infiltration capacities ranging from 4.6 to 20.4 in./hr. Results are summarized in Table 1.

To illustrate the infiltration potential of this site, we have estimated the infiltration capacity of 400 lineal feet of 8-foot-wide infiltration trench(es). Using a design infiltration rate of 4.2 in./hr, such trenches in Area 1 may be expected to infiltrate 0.30 cfs of stormwater from SMP area SDW1A.

Infiltration Area 3

Three test pits revealed varying shallow soil composition. The northern two test pits (HC00-TP338 and HC00-TP339) encountered silty fine to medium sand at elevations between 297 and 308 feet. Test pit HC00-TP337 in the southern portion of the site revealed dry silt from the surface at approximate elevation 309 feet, to the bottom of the test pit (approximate elevation 301 feet). Although not determined at this time, the groundwater level in Infiltration Area 3 is expected to be at a depth of at least 10 feet, based on the absence of seepage into the test pits. Local water table mapping by AESI (2000) suggests that the groundwater elevation in the shallow regional aquifer is around 230 to 240 feet at this location.

Double-ring infiltrometer tests were conducted in test pits approximately 3 to 4 feet below the ground surface (i.e., approximately 302 to 309 feet elevation). Two were located in a silty sand deposit and provided moderate infiltration rates of 7.5 and 5.0 in./hr. The third test was performed in finer-grained silty soil and gave an infiltration rate of 0.94 in./hr.

Using an estimated design infiltration rate of 2.7 in./hr and assuming overall trench dimensions of 400 feet by 8 feet, Area 3 should infiltrate approximately 0.2 cfs of stormwater from SMP area SDW1B. Additional trenches may be an option in this area; however, the proximity of the adjacent slope (greater than 15%) may require regrading to create benches. The KCSWDM indicates that a geotechnical assessment of slope stability would likely be required for construction of an infiltration facility in Area 3.

CONCLUSIONS

The results of our soil borings and infiltration tests show that Areas 1 and 3 are suitable for infiltration of detained stormwater. The infiltration capacities quoted in this report are provisional; the appropriate design infiltration rate for each area depends on the chosen location, layout, depth, and length of infiltration trenches. The implementation of infiltration facilities will necessitate full consideration of relevant engineering requirements as outlined in the KCSWDM.

Sincerely,

HART CROWSER, INC.

ROBERT O. MIDDOUR
Project Hydrogeologist

31228

EXPIRES 9/17/01

22484

12/14/00

EXPIRES 12/13/01

MICHAEL A.P. KENRICK, P.E.
Senior Associate Hydrogeologist

MICHAEL J. BAILEY, P.E.
Project Manager

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REFERENCES

King County, 1998. King County Surface Water Design Manual, King County and Department of Natural Resources.

EPA, 1980. EPA Falling Head Percolation Test Procedure, Design Manual - Onsite Wastewater Treatment and Disposal Systems, EPA.

ASTM, 2000. Double Ring Infiltrometer Test, ASTM Method D 3385, Annual Book of ASTM Standards, Soil and Rock (1): D 420 - D 5799.

AESI, 1999. Seattle-Tacoma International Airport Ground Water Study, Associated Earth Sciences, Inc. and S. S. Papadopulos & Assoc.

Table 1 - Summary of Infiltration Testing Results; West Side of Third Runway Embankment

Location ID	Approximate Ground Surface Elevation in Feet (msl)	Measured Infiltration Rate in in./hr	Assumed Correction Factors			Design infiltration rate in in./hr	Estimated Infiltration Capacity in cfs using 200ft x 8ft trench(es) Number of Trenches		
			$F_{testing}$	$F_{plugging}$	$F_{geometry}$		1 (200 linear ft)	2 (400 linear ft)	3 (600 linear ft)
Infiltration Area 1	(SDW1A)								
HC00-B327	276.1	20.40	0.3	0.9	1	5.51	0.20	0.41	0.61
HC00-B328	275.4	4.65	0.3	0.9	1	2.06	0.08	0.15	0.23
HC00-B329	280.8	18.45	0.3	0.9	1	4.98	0.18	0.37	0.55
Infiltration Area 2									
HC00-TP301	245.6	0.00	0.5	0.8	1	NA	NA	NA	NA
HC00-TP302	244.2	0.33	0.5	0.8	1	NA			
HC00-TP303	253.5	0.43	0.5	0.8	1	NA			
Infiltration Area 3	(SDW1B)								
HC00-TP307	309.2	0.94	0.5	0.9	1	0.42	0.02	0.03	0.05
HC00-TP308	304.9	5.00	0.5	0.9	1	2.25	0.08	0.17	0.25
HC00-TP309	311.7	7.50	0.5	0.9	1	3.38	0.13	0.25	0.38
Pond G									
HC00-B310A	264.9	0.24	0.3	0.8	0.25	NA	NA	NA	NA
HC00-B313A	260.2	1.68	0.3	0.8	0.25	NA			

Notes:

(1) Infiltration rates determined by double-ring infiltrometer (ASTM method D 3385) or a modified EPA falling head percolation test procedure (Design Manual - Onsite Wastewater Treatment and Disposal Systems, EPA, 1980)

(2) Correction Factors: per King County Surface Water Design Manual (1998)

$F_{testing}$ = 0.5 for ASTM method D3385 and 0.3 for EPA method

$F_{plugging}$ = 0.8 for fine sands and loamy sands, 0.9 for medium sands

$F_{geometry}$ = 0.25 to 1.0, values for the trenches all exceeded 1.0 and Pond G was < 0.25

Design infiltration rate = measure rate x $F_{testing}$ x $F_{plugging}$ x $F_{geometry}$

Table 2 - Double Ring Infiltrometer Tests

Test ID	Final Reading from Inner Ring in Inches	Time Increment in Minutes	Infiltration Rate in in./hr	Soil Descrpition
Infiltration Area 2				
HC00-TP301A *	0.11	191	0.03	SILT
HC00-TP302A	0.25	46	0.33	Gravelly, silty SAND
HC00-TP303A	0.28	39	0.43	Slightly gravelly SAND
Infiltration Area 3				
HC00-TP307A	0.25	16	0.94	SILT
HC00-TP308A	0.50	6	5.00	Slightly silty, fine to medium SAND
HC00-TP309A	0.50	4	7.50	Slightly silty, fine to medium SAND

* water seeping into test pit and pooling outside the rings

497806/3rd_infil_tests.xls Table 2

Table 3 - Falling Head Percolation Tests

Sheet 1 of 2

Location ID	Test Number	Elapsed Time in min	Change in Head in feet	Percolation Rate in in./hr	Soil Type
Infiltration Area 1					
HC00-B327A	1	2	0.06	21.60	Slightly silty, fine to medium SAND
		5	0.15	21.60	
	2	2	0.06	21.60	
		5	0.14	20.16	
	3	2	0.06	21.60	
		5	0.14	20.16	
	4	2	0.05	18.00	
		5	0.14	20.16	
	5	2	0.05	18.00	
		5	0.14	20.16	
	6	2	0.06	21.60	
		5	0.14	20.16	
HC00-B328A	1	2	0.02	5.40	Slightly silty, fine to medium SAND
		5	0.05	7.20	
		10	0.10	7.20	
	2	2	0.02	7.20	
		5	0.06	8.64	
		10	0.11	7.92	
	3	2	0.02	7.20	
		5	0.05	7.20	
		10	0.11	7.92	
	4	2	0.03	10.80	
		5	0.06	8.64	
		10	0.11	7.92	

497806/3rd_infil_tests.xls Table 3

Table 3 - Falling Head Percolation Tests

Sheet 2 of 2

Location ID	Test Number	Elapsed Time in min	Change in Head in feet	Percolation Rate in in./hr	Soil Type
Infiltration Area 1					
HC00-B329A	1	2	0.05	16.20	Slightly silty, fine to medium SAND
		5	0.10	14.40	
		10	0.20	14.40	
		15	0.29	13.92	
		20	0.37	13.32	
		25	0.45	12.96	
	2	2	0.05	18.00	
		5	0.12	17.28	
		10	0.23	16.56	
		15	0.33	15.84	
		20	0.44	15.84	
	3	2	0.05	18.00	
		5	0.12	17.28	
		10	0.26	18.72	
		15	0.37	17.76	
		20	0.49	17.64	
	4	2	0.06	21.60	
		5	0.14	20.16	
		10	0.26	18.72	
		15	0.39	18.72	
Pond G					
HC00-B310A	1	30	0.01	0.24	Slightly silty, fine to medium SAND
	2	30	0.01	0.24	
	3	30	0.01	0.24	
HC00-B313A	1	30	0.07	1.68	Silty, gravelly SAND
	2	30	0.06	1.44	
	3	30	0.07	1.68	
	4	30	0.07	1.68	

497806/3rd_infil_tests.xls Table 3

Table 4 - Estimation of Seasonal High Water Level in Infiltration Area 1

Monitoring Well ID	Ground Surface in Feet (msl)	Top of Casing in Feet (msl)	Seasonal Water Level Range				Period of Record	Range of Fluctuation in Feet
			Minimum in Feet (msl)	Date	Maximum in Feet (msl)	Date		
HC99-B64	292	294.2	284.9	Nov-00	288.2	Jan-00	12/99 to 10/00	3.3
HC99-B73	291.7	293.80	283.42	Oct-99	289.3	Mar-00	10/99 to 10/00	5.88
HC00-B333	281	283.5	268.5	Nov-00				

Projected Seasonal High Groundwater Level in HC00-B333 = **273.09** = 268.5 + (3.3+5.88)/2

Vicinity Map

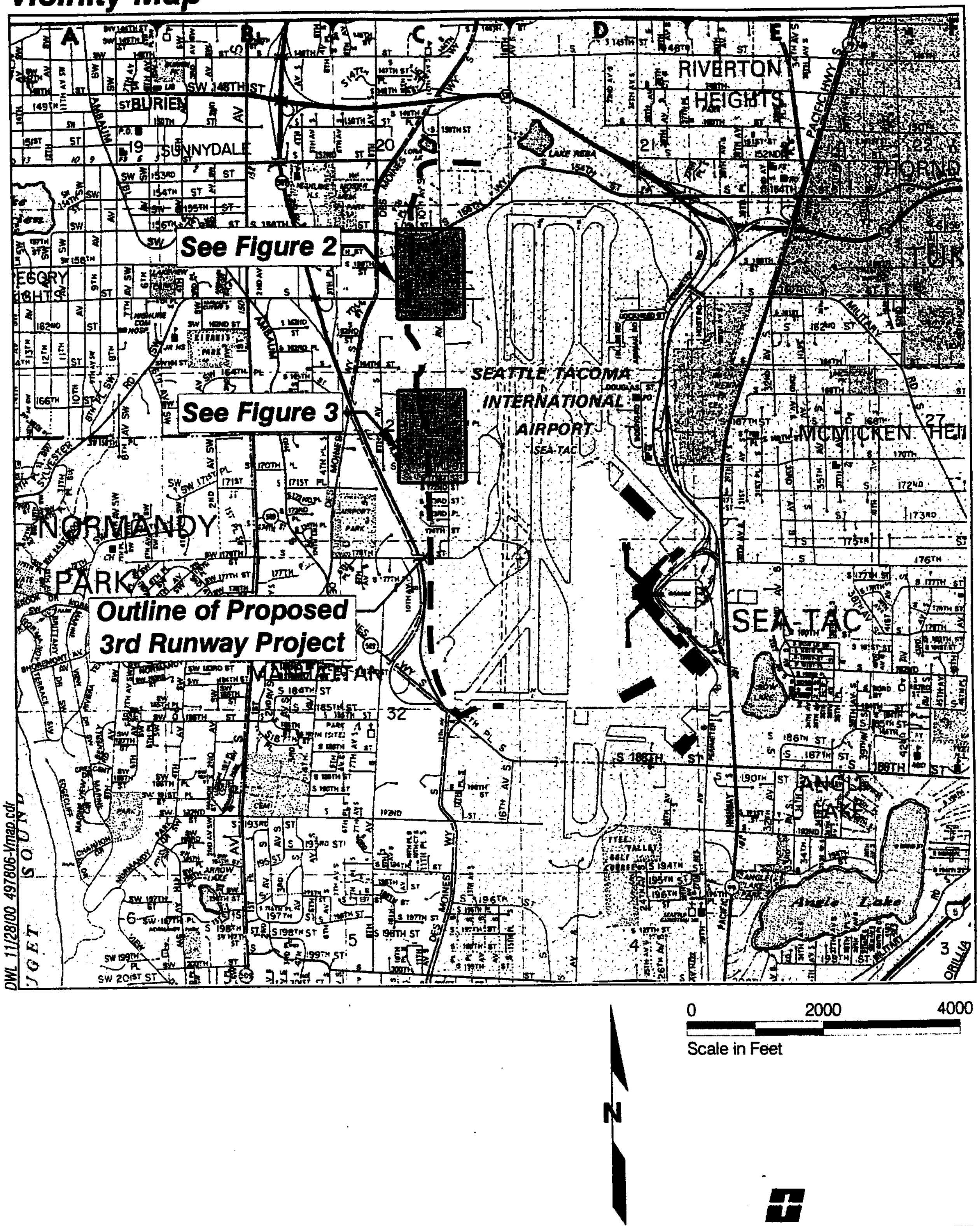

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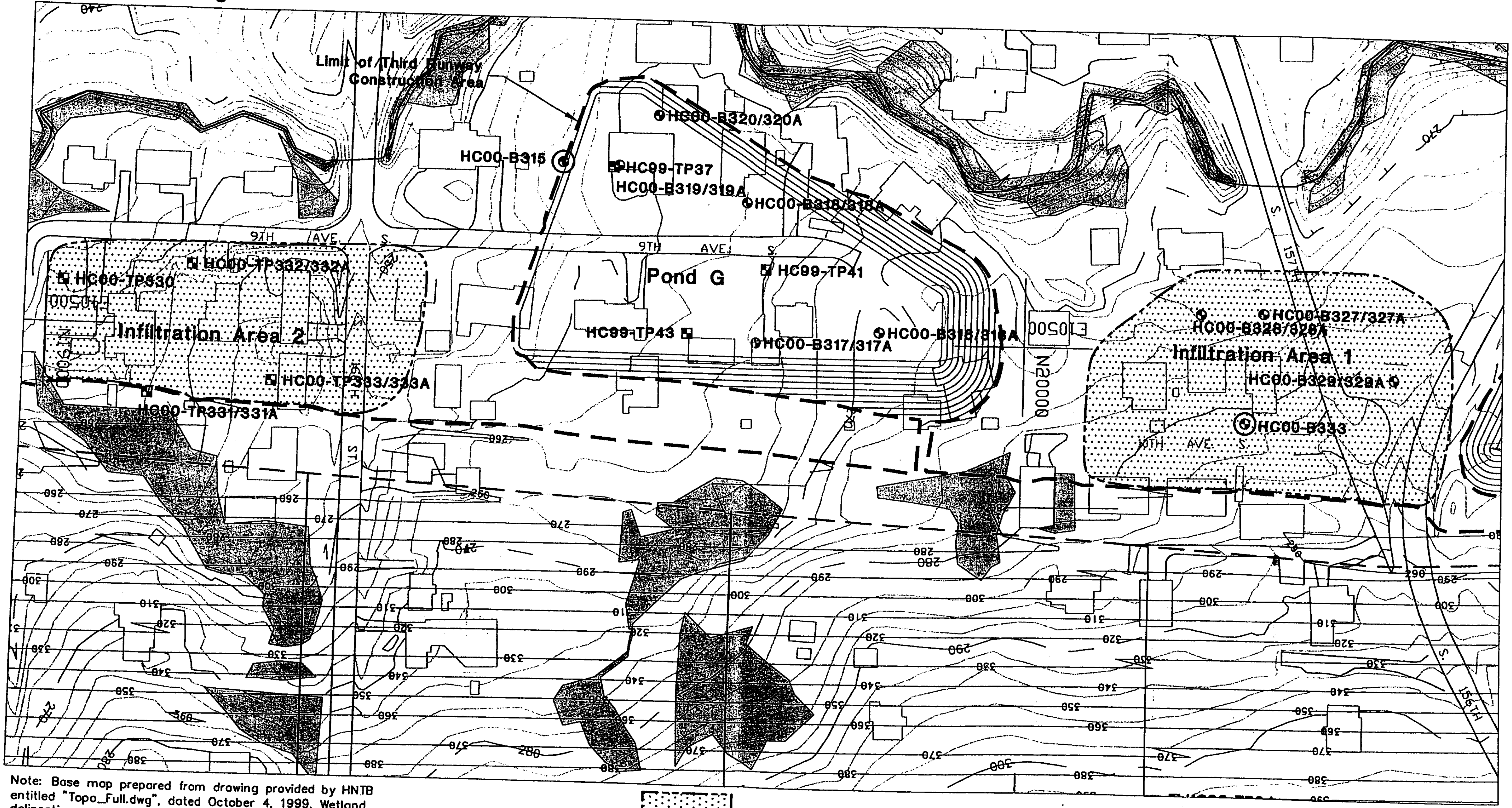
Figure 1

Site and Exploration Plan

Infiltration Testing



Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_110800.dwg", dated November 8, 2000.

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⁙	Infiltration Area

Exploration Location and Number

HC99-TP37	◪	Test Pit
HC00-B311/311A	⊕	Soil Boring
HC00-B315	⊙	Soil Boring Completed as Monitoring Well

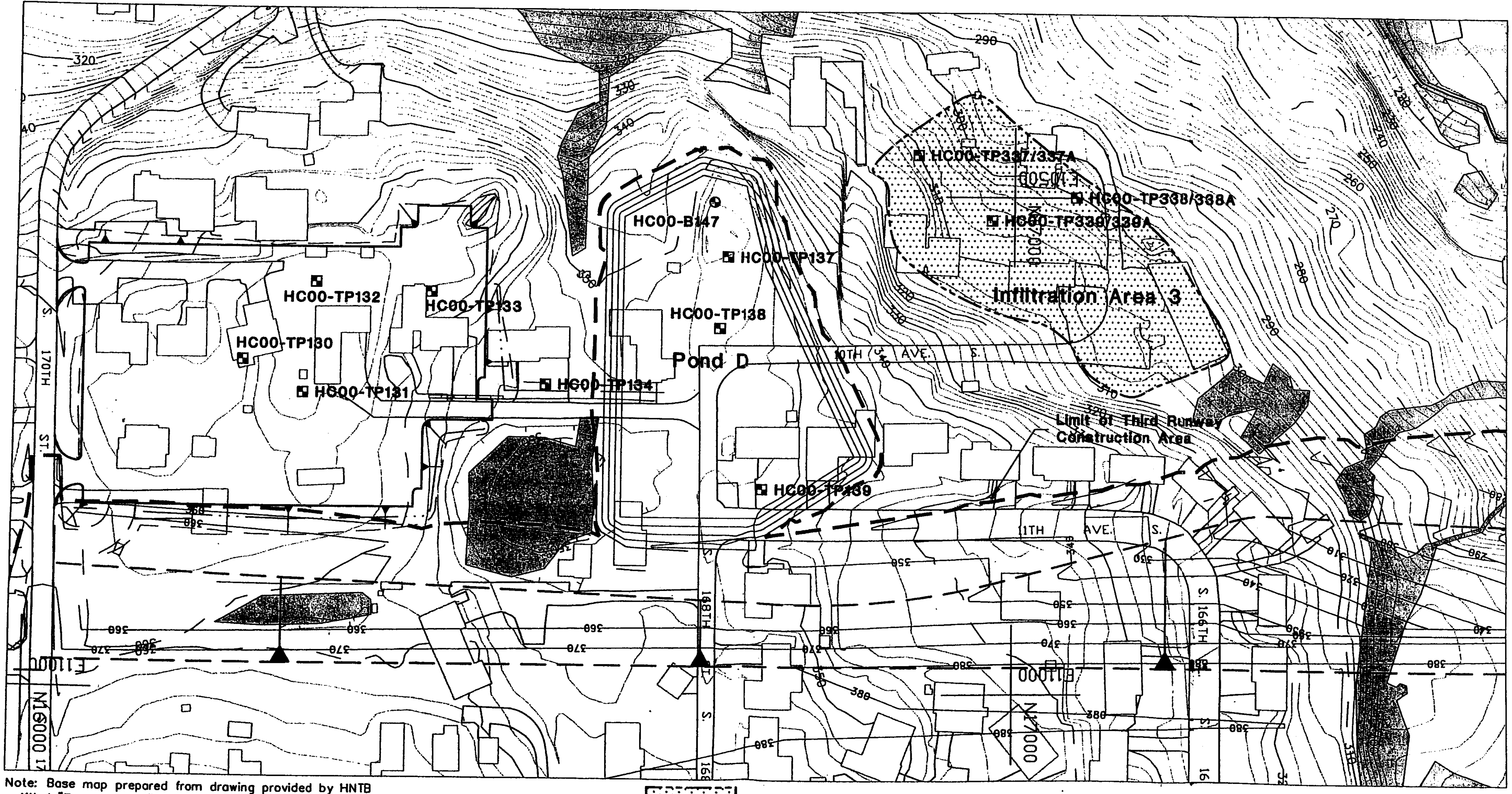
N

0 100 200
Scale in Feet

HARTCROWSER
J-4978-06 12/00
Figure 2

Site and Exploration Plan

Infiltration Testing



Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_110800.dwg", dated November 8, 2000.

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49780649

▨ Infiltration Area

Exploration Location and Number

HC99-TP37 ◪ Test Pit

HC00-B311/311A ⊕ Soil Boring

N

0 100 200

Scale in Feet

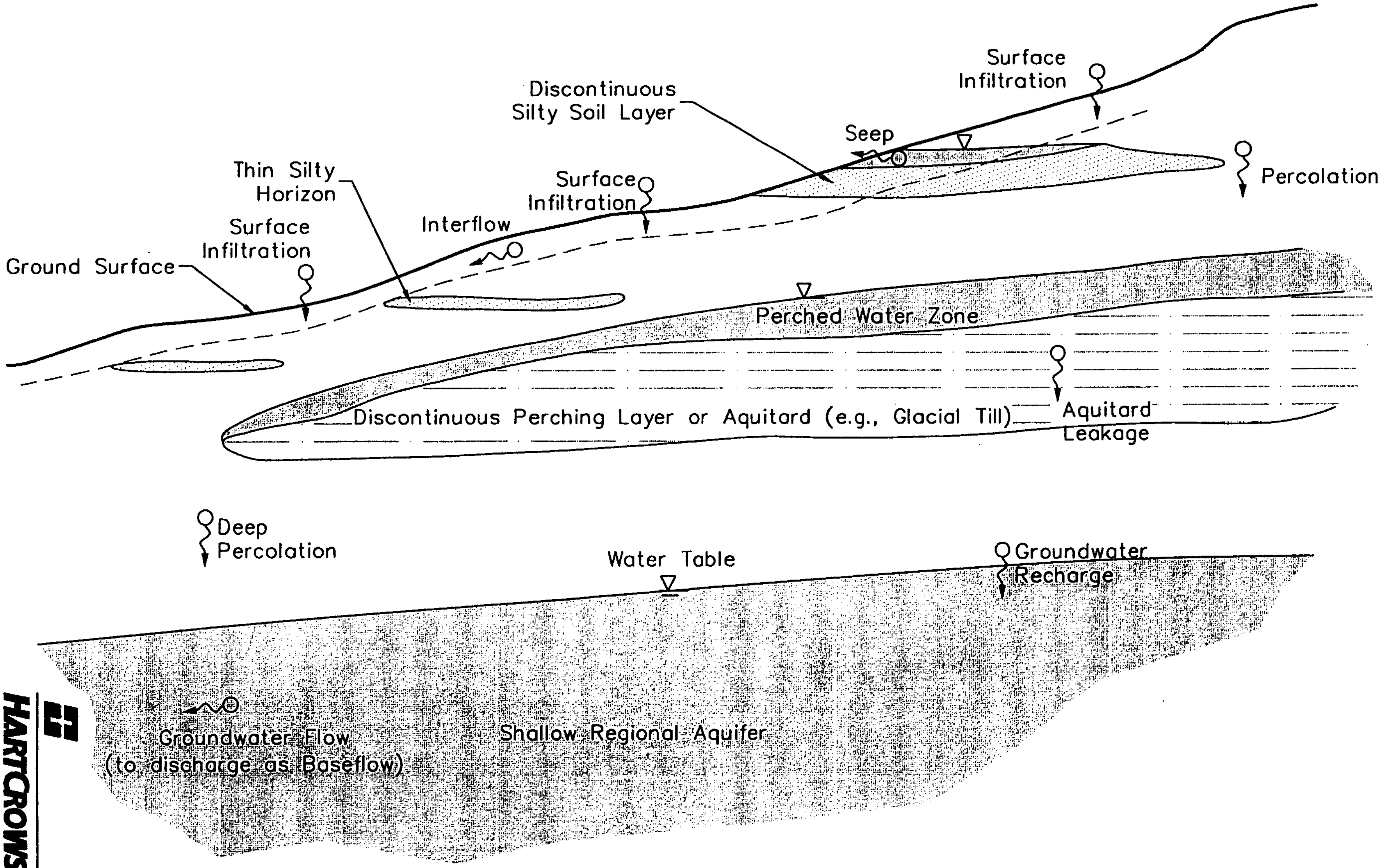
HARTCROWSER

J-4978-06 12/00

Figure 3

RC 7/8/99 1=1 wdstck-8.pcp 49780624

Elements of Shallow Groundwater Movement



HARTCROWSER
J-4978-06 7/99
Figure 4

APPENDIX A
EXPLORATION LOGS

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.
Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Test Symbols

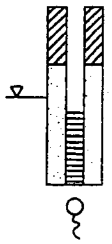
BORING SAMPLES

☒	Split Spoon
⧅	Shelby Tube
▥	Cuttings
◫	Core Run
*	No Sample Recovery
P	Tube Pushed, Not Driven

TEST PIT SAMPLES

☒	Grab (Jar)
⧄	Bag
⧅	Shelby Tube

Groundwater Observations



Surface Seal

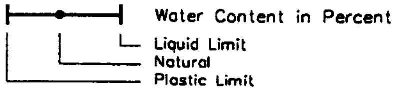
Groundwater Level on Date (ATD) At Time of Drilling

Observation Well Tip or Slotted Section

Groundwater Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits
PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	*In Situ* Density Test



BORING1.DWG 1=1

HARTCROWSER

J-4978-06 11/00

Figure A-1

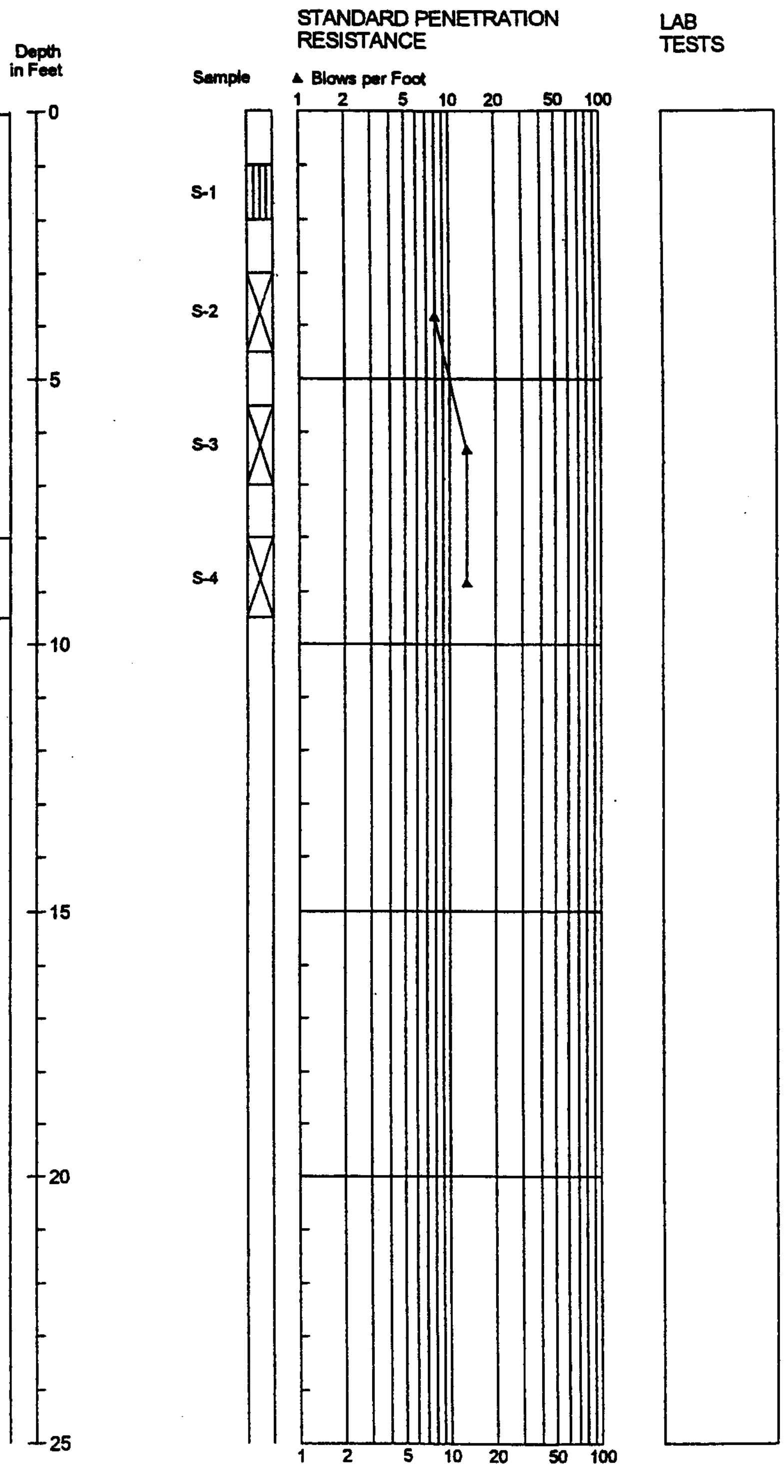
Boring Log HC00-B327

Soil Descriptions
Ground Surface Elevation in Feet: 276.1

Medium dense, moist, brown, slightly silty, fine to medium SAND, grading to slightly gravelly, fine to medium SAND.

Medium dense, moist, gray, slightly gravelly, very silty SAND.

Bottom of Boring at 9.5 Feet.
Completed 11/10/00.



BORING LOG 497806.GPJ HC_CORP.GDT 121 00

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-06 11/00
Figure A-2

Boring Log HC00-B328

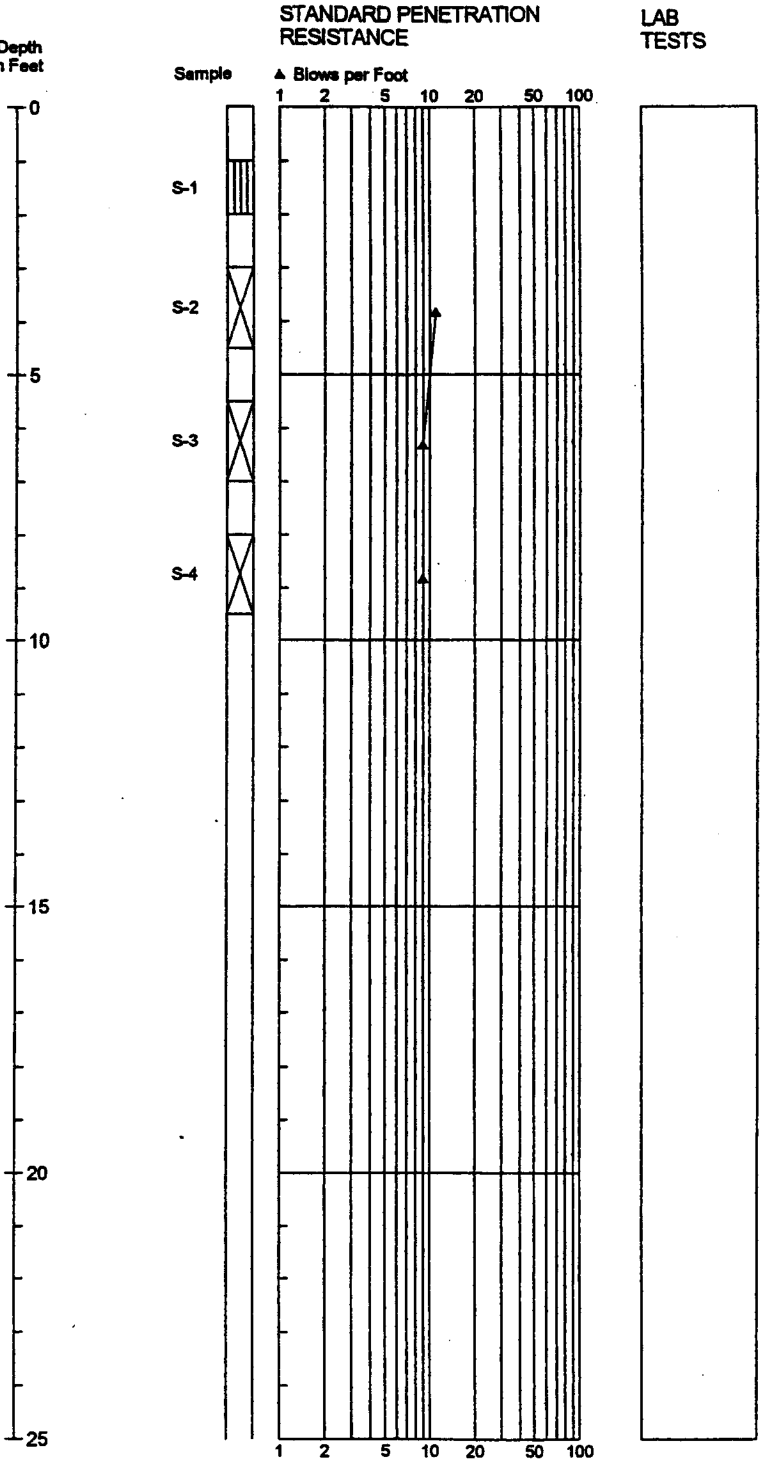
Soil Descriptions
Ground Surface Elevation in Feet: 275.4

Depth in Feet

Medium dense, moist, brown, slightly silty, fine to medium SAND.

Loose, moist, brown, slightly gravelly, very silty, medium to coarse SAND.

Bottom of Boring at 9.5 Feet.
Completed 11/10/00.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-4978-06 *11/00*
Figure A-3

Boring Log HC00-B329

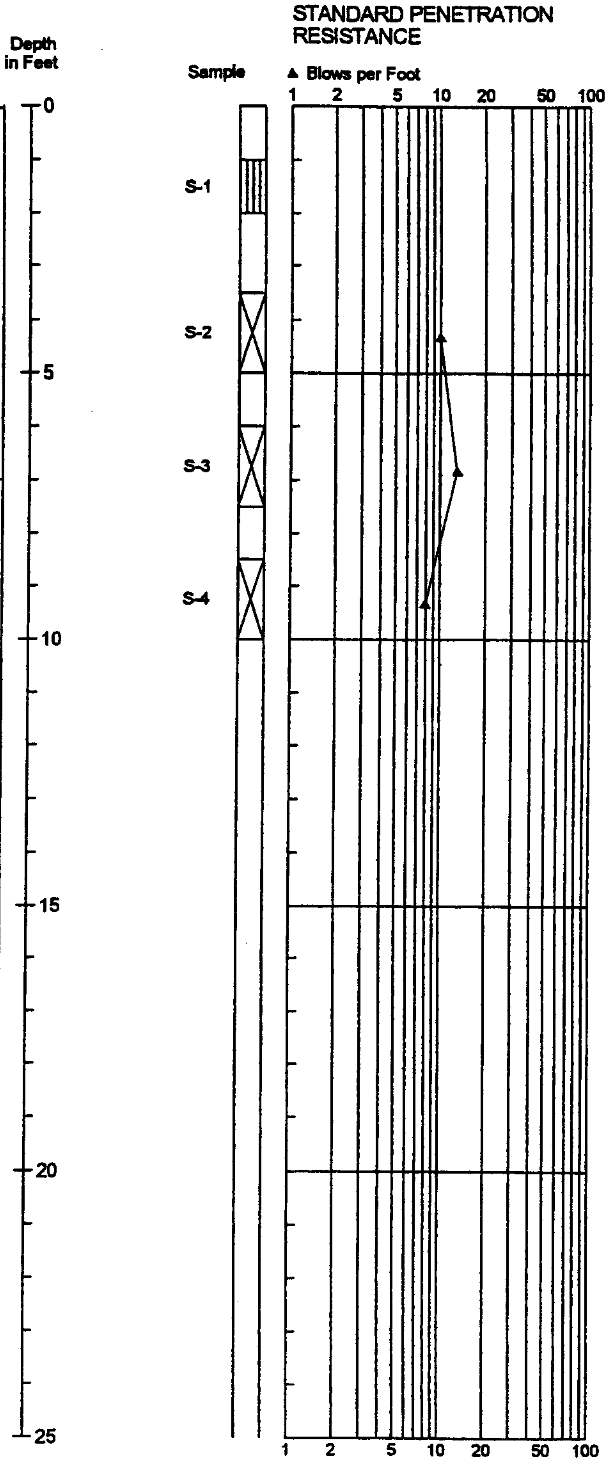
Soil Descriptions
Ground Surface Elevation in Feet: 280.1

Depth in Feet

Medium dense, moist, brown, slightly silty, fine to medium SAND.

Loose, moist, brown, slightly gravelly, very silty, fine to medium SAND.

Bottom of Boring at 10.0 Feet.
Completed 11/10/00.



LAB TESTS

BORING LOG 497806.GPJ HC_CORP.GDT 12 1 00

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-06 11/00

Figure A-4

Monitoring Well Log HC00-B333

Soil Descriptions

Ground Surface Elevation in Feet: 280.9

Loose, moist, brown, slightly gravelly, slightly silty, medium to fine SAND.

Loose, moist, brown, medium to coarse SAND grading to gray slightly gravelly, very clayey, fine to medium SAND.

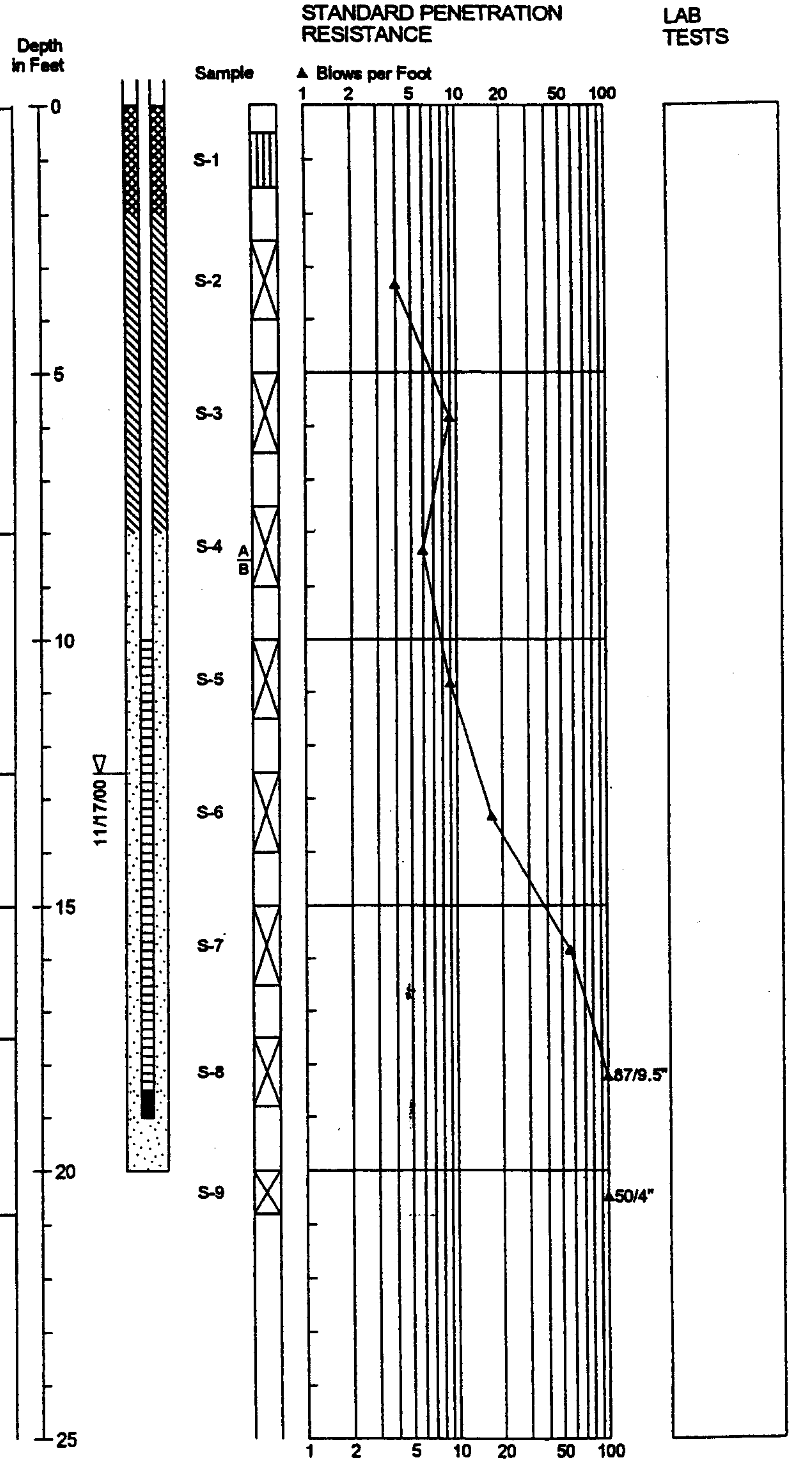
Medium dense, moist, brown, slightly gravelly, silty, fine to medium SAND.

Hard, moist, gray, very sandy SILT.

Very dense, moist, gray, very silty, fine to medium SAND.

Bottom of Boring at 20.8 Feet.
Completed 11/15/00.

Top of Casing Elevation in Feet: 283.49



BORING LOG 497808.GPJ HC CORP.GDT 12 1 00

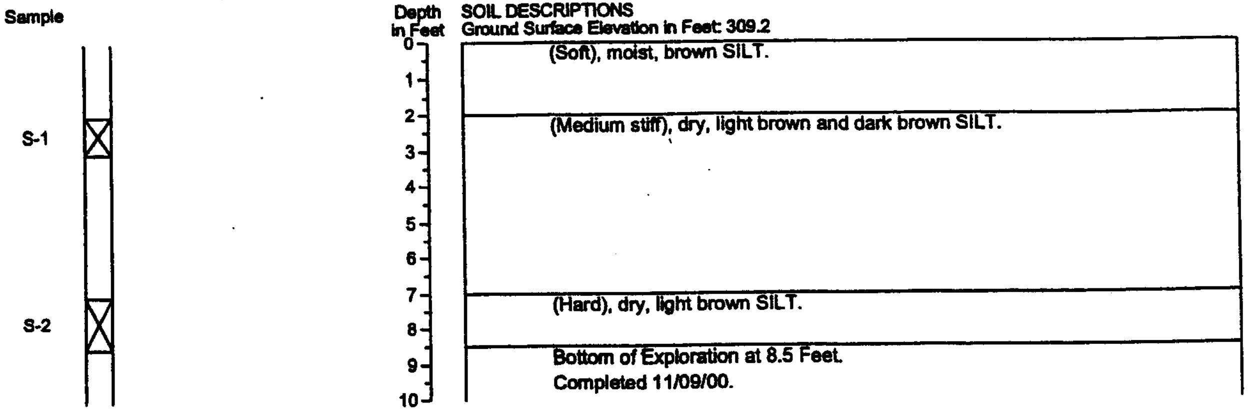
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4978-06 11/00

Figure A-5

Test Pit Log HC00-TP337



SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 309.2

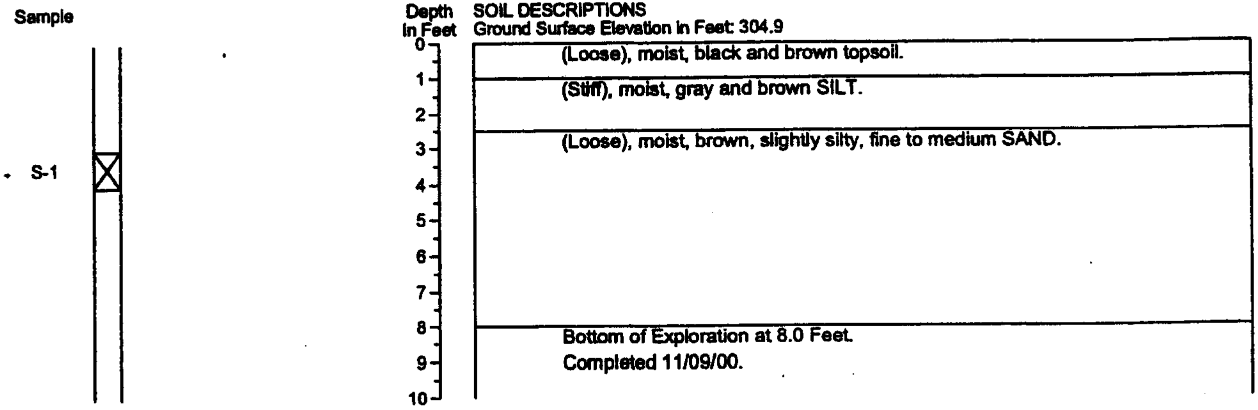
(Soft), moist, brown SILT.

(Medium stiff), dry, light brown and dark brown SILT.

(Hard), dry, light brown SILT.

Bottom of Exploration at 8.5 Feet.
Completed 11/09/00.

Test Pit Log HC00-TP338



SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 304.9

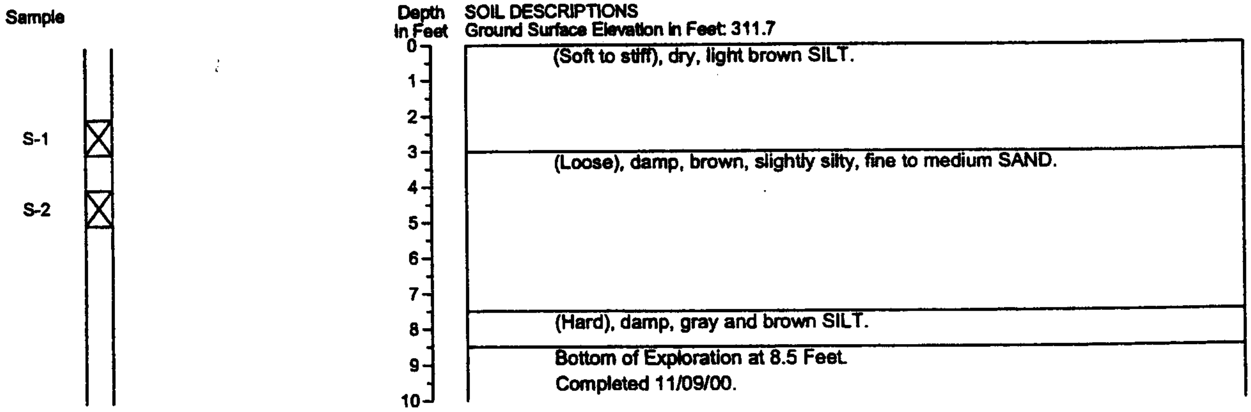
(Loose), moist, black and brown topsoil.

(Stiff), moist, gray and brown SILT.

(Loose), moist, brown, slightly silty, fine to medium SAND.

Bottom of Exploration at 8.0 Feet.
Completed 11/09/00.

Test Pit Log HC00-TP339



SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 311.7

(Soft to stiff), dry, light brown SILT.

(Loose), damp, brown, slightly silty, fine to medium SAND.

(Hard), damp, gray and brown SILT.

Bottom of Exploration at 8.5 Feet.
Completed 11/09/00.

3 LOGS PER PAGE 497806TP.GPJ HC_CORP.GDT 12/5/00

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground conditions, if indicated, are at time of excavation. Conditions may vary with time.

HARTCROWSER

J-4978-06 *11/00*

Figure A-6

APPENDIX G

APPENDIX G

LOW STREAMFLOW ANALYSIS FOR MILLER, WALKER, AND DES MOINES CREEKS

(Appendices C and D excluded)

Port of Seattle

Seattle-Tacoma Airport Master Plan Update
Low Streamflow Analysis

Prepared for:
Port of Seattle
17900 International Boulevard, Suite 402
SeaTac, Washington 98188

Prepared by:
Earth Tech, Inc.
10800 N.E. 8th Street, 7th Floor
Bellevue, WA 98004

December 2000

PORT *of* SEATTLE

Seattle-Tacoma Airport Master Plan Update Low Streamflow Analysis

TABLE *of* CONTENTS

LIST *of* TABLES

LIST *of* FIGURES

PORT *of* SEATTLE

Seattle-Tacoma Airport Master Plan Update
Low Streamflow Analysis

This report presents analyses performed to estimate the timing and volume of discharges to local receiving streams and wetlands during low flow periods from the Sea-Tac International Airport (STIA) considering proposed improvements to the STIA defined in the Port of Seattle's Master Plan Update. This report is submitted for consideration by the Department of Ecology and U.S. Army Corps of Engineers in reviewing various permit applications from the Port of Seattle related to the Third Runway project. The analyses build upon those performed in completing the *Sea-Tac Runway Fill Hydrologic Studies Report* for the Department of Ecology (Pacific Groundwater Group, 2000). The analyses presented in this report were prepared by Earth Tech, Inc., and Pacific Groundwater Group, Inc.; HSPF hydrologic model results were provided by Parametrix, Inc., in a December 2000 memorandum (Parametrix, 2000b).

For purposes of discussion in this report, the term "low streamflow" refers to total flow in a given stream reach during dry weather conditions, particularly the months of August and September. Low streamflow in this context includes water in a stream derived from groundwater, interflow and surface water discharges, including stormwater control facility discharges.

EXISTING STREAMFLOW CONDITIONS

Stream gage data available from King County at four sites in the Miller, Walker and Des Moines Creek watersheds are summarized in **Table 1** for average monthly flows in August and September.

Table 1:
Recorded Average Flows
August and September

Gauge No. and Location	Period of Record	Average August Flow (cfs)	Average September Flow (cfs)
42A – Miller Creek near mouth	1989-1996	2.35	2.03
42B – Miller Creek at RDF	1990-1996	0.48	0.41
42E – Walker Creek near mouth	1993-1996	1.56	1.24
11 F – Des Moines Creek near So. 200th St.	1996-1998	1.55	1.62

WATERSHED MODELING OF CURRENT AND PROPOSED CONDITIONS

The draft *Preliminary Comprehensive Stormwater Management Plan* (SMP) (Parametrix, August 2000a) for the Master Plan Update Improvements to STIA describes the watershed modeling prepared to define the anticipated hydrologic effects of proposed airport improvements and actions proposed to mitigate those effects on receiving waters. Watershed modeling of the Des Moines, Walker and Miller Creek basins was performed using the Hydrologic Simulation Program-Fortran (HSPF) model. This empirical watershed model is appropriate for quantifying the hydrologic effects due to changes in surface runoff conditions across the STIA area.

1994 was selected as the base year for defining pre-project hydrologic conditions for the STIA Master Plan Update (MPU). As is discussed in the SMP, the 1994 conditions represent a conservative baseline in that total impervious area in the drainage basins located within the STIA had decreased from 1974 to 1994 and that forested cover had replaced developed land coverage in some areas.

The HSPF model for each watershed produces simulations of stream flows at locations downstream of proposed STIA land modifications. The locations used to evaluate low streamflows were selected so as to be proximate to the proposed STIA construction: Miller Creek near SR 509, Walker Creek near 12th Avenue South, and Des Moines Creek near South 200th Street. The HSPF model results are included in Appendix D. The HSPF modeling results include the average monthly flows for August and September, as shown in **Table 2**, for land uses present in the watersheds in the 1994 pre-project condition.

Table 2:
HSPF Model Streamflow in August and September
for 1994 Land Use Conditions

Location	Rainfall Record Used in HSPF Simulation	Average August Flow (cfs)	Average September Flow (cfs)
Miller Creek at RDF [1]	1949-1996	0.45	0.70
Miller Creek near SR 509	1949-1996	1.27	1.50
Miller Creek near mouth [1]	1949-1996	2.70	3.23
Walker Creek near 12th Avenue So.	1949-1996	0.033	0.035
Walker Creek near mouth [1]	1949-1996	1.37	1.37
Des Moines Creek near So. 200th St.	1949-1996	1.08	1.64

[1] Included for purposes of comparison with observed flows.

Seven-day low flow rates were derived from the HSPF model results for those locations immediately downstream of the limits of proposed STIA construction activity. The low flow results are summarized in **Table 3**.

Table 3:
Seven-Day Low Flows (cfs)
Per HSPF Model of 1994 Land Use Conditions

Location	**Return Interval**			
	2 years	**5 years**	**10 years**	**20 years**
Miller Creek near SR 509	0.79	0.68	0.63	0.59
Walker Creek near 12th Avenue So.	0.021	0.019	0.017	0.016
Des Moines Creek near So. 200th St.	0.35	0.28	0.24	0.21

In constructing models of the proposed project conditions, referred to herein as the 2006 land use conditions, the 1994 conditions HSPF model was revised to reflect proposed changes in land cover, surficial soils (fill placement), and the operation of proposed stormwater flow control facilities. The memoranda in Appendix D to this report present details of the model.

The HSPF model results of low streamflows with proposed STIA construction in place are summarized in **Table 4** (average monthly flows for August and September) and **Table 5** (7-day low flows).

Table 4:
HSPF Model Streamflow in August and September
For 2006 Land Use Conditions

Location	**Rainfall Record Used in HSPF Simulation**	**Average August Flow (cfs)**	**Average September Flow (cfs)**
Miller Creek near SR 509	1949-1996	1.10	1.40
Walker Creek near 12th Avenue So.	1949-1996	0.031	0.039
Des Moines Creek near So. 200th St.	1949-1996	1.07	1.73

Table 5:
Seven-Day Low Flows (cfs)
Per HSPF Model of 2006 Land Use Conditions

Location	**Return Interval**			
	2 years	**5 years**	**10 years**	**20 years**
Miller Creek near SR 509	0.64	0.54	0.48	0.44
Walker Creek near 12th Avenue So.	0.015	0.012	0.010	0.009
Des Moines Creek near So. 200th St.	0.27	0.21	0.18	0.15

The HSPF modeling indicates that August and September streamflows (average monthly flows and 7-day low flow rates) below the STIA in Miller Creek would be reduced by an amount ranging from 0.10 to 0.17 cfs as a result of the changes proposed by the Port. In the upper reach of Walker Creek the HSPF model results indicate a decrease in average August streamflows and an increase in average September streamflows; the 7-day low flow values are predicted to decrease by 0.007 cfs in the HSPF modeling. In Des Moines Creek, the modeling indicates a decrease of 0.01 cfs in August flows, an increase of 0.08 cfs in average September flows, and a decrease of 0.06 to 0.08 cfs in 7-day low flow values.

The foregoing HSPF modeling results utilize a different approach to low flow analysis from that used in developing earlier estimates published in the 1999 draft SMP (Parametrix, 1999). The 1999 draft SMP estimated low stream flow impacts based on a model of infiltration and groundwater recharge potential, which differs from statistical comparisons of low stream flow described above. The HSPF model was used to predict the amount of precipitation available for groundwater recharge that contributes to stream flow. This water mass balance approach compared the difference of water available for stream base flow between existing (pre-project) conditions and after full construction of the MPU projects. The mass balance approach predicted flow reductions in Miller and Des Moines Creeks of 0.05 cfs and 0.13 cfs respectively for the 1 in 10 dry year. While this simplified approach does not account for other hydrologic changes, such as the construction of detention ponds or stormwater infiltration, it can provide conservative results that are representative of very small flow changes. These low stream flows are normally difficult to model precisely in watershed models.

In addition to the different approaches used to estimate low stream flow impacts, the HSPF model used for the low stream flow statistics is an updated version of the model used for the mass balance calculations. Therefore, the results are not directly comparable. Differences between the results, while on the same order of magnitude, can be explained primarily by changes in infiltration parameters in the Miller Creek model, and the influence of detention facilities and storm runoff on low streamflows.

In assessing quantitative effects on streamflow, the HSPF modeling results provide a partial characterization of the impact. As discussed in the Pacific Groundwater Group report, the HSPF model does not consider three identified factors with potential to influence summer low flows:

1. *Late summer discharge of infiltrated water stored in the proposed Third Runway embankment fill.* Precipitation that falls on pervious areas of the proposed fill infiltrates through the fill, delaying its discharge through the drainage layer to area wetlands and streams by several months.

2. *Changes in non-hydrologic flows within the buy-out area in the watersheds.* Discontinued irrigation withdrawals from within the watershed and discontinued discharges of imported water through septic system drainfields.

3. *Secondary recharge of runoff from pavement atop the proposed Third Runway embankment fill.* Runoff from runway and taxiways would traverse pervious biofiltration strips with opportunity to infiltrate into the fill, enhancing the recharge effect of the first factor identified above and reducing peak storm runoff rates from those predicted in the HSPF model.

Modifications have been made to the proposed design of stormwater control facilities in the Master Plan Update in response to review comments from the Department of Ecology. The modifications were developed in part to address low flow conditions in area streams and include:

4. *Extended duration discharge* from stormwater detention facilities through infiltration galleries that would provide input to the shallow groundwater regime adjacent to Miller Creek. The effects of these discharges were incorporated into the HSPF modeling for the 2006 proposed project condition and are reflected in the HSPF model results presented in Tables 4 and 5.

5. *Managed release of stormwater from reserved storage* to ensure that low flow discharges in streams do not fall below preproject levels. Such stormwater would be collected from winter season runoff, treated, and stored until needed during the dry season, and then aerated and released to sustain desired flow rates in streams. The effects of these discharges are not included in the HSPF modeling and must be added to the model results.

The results of the HSPF modeling should be considered together with estimates of the low streamflow impacts to accrue from each of the above factors. All five of the factors are present in the Miller Creek watershed. Walker Creek would have two of the factors present: late summer discharge from both pervious and secondary impervious recharge to the embankment fill. The buy-out area does not extend into the Des Moines Creek watershed, and the area of the runway fill within that watershed is small; therefore, the first three factors are not considered in Des Moines Creek streamflows. There also are no provisions in the Des Moines Creek drainage for proposed extended duration discharge. Discussion of the effects of extended duration discharge through infiltration is discussed in Appendix D. The remaining four factors are evaluated in the corresponding sections that follow in this report.

HYDROLOGIC BEHAVIOR OF RUNWAY FILL

In preparing the Pacific Groundwater Group (PGG) report, an analysis was conducted to model the behavior of infiltrated rainfall as it passes through the proposed fill. The analysis included modeling of a cross-section of the fill for a range of fill depths ranging from 30 feet to 150 feet. The study concluded the fill would act to store infiltrated water as it seeps through the fill and to delay the discharge of the water to wetlands and creeks. Because of the time lag through the fill, the analyses predicted that winter precipitation would be discharged through the drainage layer underlying the fill in the summer months, and this would be considered to have a generally beneficial effect on low summer flow in local streams. However, the PGG report also noted that the quantity of delayed discharge is dependent on runoff and evapotranspiration changes caused by new construction.

This section of the report applies the results of the PGG analyses to estimate the effect the delayed discharges through the embankment fill would have on August and September flows in Miller and Walker creeks.

As noted above, the HSPF model does not effectively model the mechanisms of deep percolation through the fill and subsequent discharge through the drainage layer. HSPF cannot adequately incorporate into the watershed model the effects of the fill for several reasons:

- HSPF is not designed for detailed modeling of relatively small areas with atypical geologic features such as deep fill.
- Interflow as defined in the HSPF typically has a recessional duration of 1 to 7 days, which is much shorter than the transit time expected through the fill. The interflow parameter is a "lumped" parameter that is subsequently measured downstream.
- The duration of the upper zone groundwater storage is short (approximately 1 day) prior to splitting of stored water to the lower zone storage. This is inconsistent with the behaviors of the deep fill.
- HSPF does not provide for a time delay shift to represent extended groundwater travel.
- HSPF is an empirical model intended to be calibrated against a data set. There is insufficient data available to effectively calibrate the parameter for the fill effects. One month of flow data was collected from January to February 1998 measuring discharge from the base of recently placed fill. The limited data set does not provide for an estimate of the storage within the fill volume and only extends through one short segment of time within the heart of a wet season.

Within the area of the fill, changes to the volume and timing of groundwater discharge to local wetlands and streams are predicted as a result of the proposed fill embankment. As discussed in the PGG report, the fill would provide greater storage capacity for infiltrated precipitation than exists under pre-project conditions. Infiltrated precipitation would seep through the fill to the relatively porous drainage layer underlying the fill. The water seeping to the drainage layer would then discharge from the base of the fill after a transit period of up to several months from the time it first fell on the surface of the fill. The travel time is a function of both the vertical thickness of the fill and the lateral length of travel through the drainage layer. Because the runway would create more impervious surface area than existed within the fill footprint prior to construction, the total volume of infiltration (assuming no secondary recharge of pavement runoff) would be reduced. The delayed discharge of the volume of water that does infiltrate through the fill, however, would provide increased discharge from the fill area during the critical low flow periods in area wetlands and streams.

The PGG study, conducted for the Department of Ecology, modeled the behavior of infiltrated rainfall as it passes through the proposed fill. The analysis included modeling of a cross-section of the fill that ranged from 30 feet to 150 feet thick. The analysis estimated the amount of rainfall that would percolate through the pervious areas of the fill surface (impervious surfaces were assumed to runoff to tightline systems and surface water discharges, consistent with the HSPF model) and how much of the infiltrated water would be taken up through evapotransporation. A second model (Hydrus-2D) used soil characteristics to estimate the time of vertical travel through the fill mass to the drainage layer for varying depths of fill. A third model (Slice) then summed the flows within the drainage layer over time and translated them into a discharge at the toe of the fill embankment. A repeating cycle of average monthly rainfall depths was used in the PGG model, and the model was run with this repeating rainfall cycle until the discharge pattern stabilized.

Hart Crowser later prepared an independent analysis of the behavior of infiltrated rainfall through the proposed embankment fill for the Port of Seattle. This analysis utilized the same model for estimating surface infiltration of precipitation to pervious areas. A different model was used to predict the water behavior in the fill, and some of the soil parameters and assumptions differed from those used in the PGG study. The conveyance of infiltrated water through the drainage layer was not modeled by the Hart Crowser work. The Hart Crowser analysis used a ten-year time series of daily precipitation as input to the modeling. The results of the Hart Crowser analysis support the findings of the PGG report, specifically that there would be a delayed discharge of infiltrated water and that this would provide increased discharge from the fill area during the low flow periods in area streams. Appendix A presents a comparison of various aspects of the PGG and Hart Crowser analyses. Based on this comparison it was concluded that the PGG model application was more appropriate for the modeling of the embankment fill behavior as it: (1) more accurately represents the effects of gravel within the fill; (2) simulates the variable slope and permeability of the native soil aquifer and wetland soils below the fill; and (3) models the recharge through variable thicknesses of fill.

The results of the PGG model analyses were applied across the footprint of the proposed fill within the Miller Creek watershed to derive a quantified estimate of the effects of delayed discharges through the fill on August and September flows in the creek. The model results were applied across the fill footprint for both the existing condition (year 1994) landscape and the pervious areas of the built condition (year 2006) fill. The analysis is presented in Appendix B and the results are summarized in **Table 6** along with the HSPF model results for Miller Creek.

Table 6: Estimates of Miller Creek Streamflow Effects from Fill Infiltration Discharge[1]

Period of Flow	HSPF Model Streamflow (cfs)		Increase from Fill Discharge (cfs)	2006 Condition w/ Fill Discharge (cfs)
	1994 Condition	2006 Condition		
August	1.27	1.10	0.108	1.21
September	1.50	1.40	0.065	1.47
7-Day/2-Year Low Flow	0.79	0.64	0.065[2]	0.71

[1] Miller Creek at SR 509

[2] Calculated as 75 percent of the average increase in discharge over August and September.

The analysis predicts that delayed discharge of water through the fill will have a mitigating effect on low streamflows in Miller Creek during August-September flow conditions. A similar positive effect on 7-day low flow discharges would be expected. Results from the Hart Crowser analysis provide insights into how the fill is expected to behave through periods of varying rainfall. The analysis indicates that during years with lower total precipitation, the lag between the times of minimum discharge for existing soil conditions and the fill conditions lengthens. In addition, the analysis predicts that the volume of discharge from the fill during August and September would fluctuate less with changes in precipitation than under existing soil conditions within the fill footprint. Based on the 10 years of rainfall used in the Hart Crowser analysis, the standard deviation for the differences in August and September discharge volumes between fill and existing conditions is 25 percent. This suggests that approximately 75 percent of the average increase from fill discharge could be expected during drier years when extreme low stream flows could be expected.

Applying similar techniques to the fill footprint area within Walker Creek produces the results shown in **Table** 7. The depth and shape of the fill section within the Walker Creek basin differs from that which typifies Miller Creek. Whereas the fill in Walker Creek would produce a shorter delay of infiltrated water, the discharged water must travel a greater distance in the Walker Creek basin (as shallow groundwater and surface flow) from the fill to the stream channel; therefore, comparable results are anticipated. Further, the area of proposed fill within Walker Creek is small (6.7 acres pervious fill surface) which limits the effect of differences between the fill sections on the results.

Table 7:
Estimates of Walker Creek Streamflow Effects from Fill Infiltration Discharge[1]

Period of Flow	HSPF Model Streamflow (cfs)		Increase from Fill Discharge (cfs)	2006 Condition w/ Fill Discharge (cfs)
	1994 Condition	2006 Condition		
August	0.033	0.031	0.005	0.036
September	0.035	0.039	0.003	0.042
7-Day/2-Year Low Flow	0.021	0.015	0.003[2]	0.018

[1] Walker Creek near 12th Avenue South

[2] Calculated as 75 percent of the average increase in discharge over August and September

CHANGES IN NON-HYDROLOGIC FLOWS

The November 1999 and the August 2000 drafts of the SMP identified 18 water right certificates and claims within the property buy-out area in the Miller Creek watershed. Based on assumptions regarding residential and farm property uses of these water rights, the November 1999 Plan concluded that water use from these claims during the low-flow period in August would be reduced by 0.13 cfs (SMP, Appendix G).

The PGG report identified several non-hydrologic factors with potential to affect total groundwater recharge, and hence low flows in Miller Creek. PGG included the summer irrigation quantity cited in the SMP of 0.13 cfs, or 84,000 gpd. PGG identified the following changes in water use in the buy-out area with the potential to affect streamflows:

Table 8:
Non-Hydrologic Changes In Summer Streamflow (PGG Report)

Change in Water Use	Potential Streamflow Effect (gallons per day)
Cessation of summer irrigation with local water sources	+ 84,000
Cessation of septic discharge of imported water	– 66,000
Cessation of excess lawn irrigation with imported water	– 10,000
Leakage of imported water from water supply pipes	unknown
Net Change During Irrigation Season	**~0**

Since the August 2000 draft SMP was published, Parametrix has consulted with former property owners to update estimates of historic water withdrawal under the 18 acquired water rights in Miller Creek. Based on these contacts, Parametrix concludes that historic irrigation season consumption totaled 0.079 cfs (51,000 gpd) rather than the previously cited 0.13 cfs (refer to

Appendix C). Integrating this revised estimate into the summation presented in **Table 8** would produce an estimated reduction in Miller Creek streamflow of 25,000 gpd (0.04 cfs).

EFFECTS OF SECONDARY RECHARGE

As noted earlier, the HSPF model assumes that all pavement runoff is effective impervious area, and that such runoff is completely conveyed via tightline systems to ponds or vaults and then to area streams. The PGG model of infiltration through the fill followed the same assumption for reasons of consistency with the HSPF modeling in maintaining the accounting of the hydrologic water balance. This assumption ignores the opportunity for runoff from proposed runway and taxiway pavements to infiltrate into surrounding pervious soils. The effects of this assumption on the hydrologic computations presented above are to: (1) increase the computed peak discharge rates during the majority of storm events; and (2) reduce the volume of infiltrated runoff to pass through the fill and be discharged to streams during low flow periods.

A review of the proposed runway and taxiway sections presented in the Preliminary Comprehensive Stormwater Plan suggests that substantial opportunity would be provided for pavement runoff to infiltrate into pervious ground as this runoff transits across biofiltration strips and along biofiltration swales to catch basins. Taxiways and runways are proposed to be constructed with filter strips having travel lengths of 75 feet. Shorter connecting taxiways would be constructed with filter strips 30 feet in width.

Analyses were performed to estimate the quantity of pavement runoff that would infiltrate the fill as it passes through filter strips. Infiltration within bioswales was not considered as the travel lengths within the swales varies widely and the soils within the swales are expected to be saturated a greater percentage of the year due to the concentration of flow in them. The pavement runoff that infiltrates into the filter strips is termed "secondary recharge" for purposes of this discussion. The procedure followed in the analysis is described below:

1. Compile flow exceedence probabilities for impervious surfaces from the HSPF model. The flows calculated are strictly surface runoff, as there are no interflow or groundwater flow components in impervious areas.

2. Estimate the maximum infiltration capacity of the filter strip, assuming that water can infiltrate the soil at its saturated hydraulic conductivity rate over the entire area of the filter strip. Soil conductivity is based on the matrix conductivity used for the fill in the Hydrus-2D modeling (matrix includes the silt and sand components) corrected for the presence of gravel with an empirical formula. Hydraulic gradient is assumed to be 1 (gravity). Infiltrating area is assumed to be 100 percent of total area of the filter strip.

3. For each exceedence probability range, calculate the portion of the total water input to the filter strip going to infiltration and runoff. Total water input is assumed to be expected runoff from runway/taxiway pavement (based on pavement area and HSPF flow values) plus the direct rainfall on the filter strip. If

total input exceeds total infiltration capacity, the excess water volume is considered to be runoff and the infiltrated volume is limited by the infiltration capacity. If total water input is less than the infiltration capacity, runoff is zero and infiltration equates to the total water input.

4. Plot the exceedence probability curves for: runoff from the pavement, direct rainfall to filter strip, infiltration within filter strip, and runoff from the filter strip.

5. Estimate recharge for each calendar month by summing the product of the exceedence probability range for each month and the predicted infiltration value. Because exceedence statistics never reach zero percent, there is always an upper region representing the extreme flows where there are no values. For purposes of estimating infiltration, this is not a concern because the available infiltration capacity is exceeded by the pavement runoff only in extreme event. Potential evapotranspiration (PET) values were obtained from the previous PGG analysis for grass over outwash soils, and it was conservatively assumed that actual evapotranspiration (AET) equals PET. Finally, PET was subtracted from infiltration to calculate the net recharge, which can never be less than zero.

6. Plot the monthly values of predicted infiltration, PET and recharge.

The results of the analysis indicate that nearly all runoff from the runways should infiltrate in the filter strips. Based on HSPF data provided by others, pavement runoff (and, hence, precipitation) occurs about 18 percent of the time. **Figure 1** shows the annual flow duration curves for a one-foot wide half-section of runway with a slope length of 105 feet and a 75-foot wide filter strip. The analyses indicate that runoff from the filter strips would occur less than 5 percent of the time because of the infiltration capacity of the filter strips. The runoff in the 18-to-5 percent exceedence interval completely infiltrates in the filter strips along with incident precipitation falling directly on the filter strips. When runoff does occur in the analysis, it is at lower rates than that predicted by the HSPF modeling as a result of secondary recharge.

Figure 2 presents results of a similar analysis for a taxiway having a maximum 140-foot slope length and a 75-foot wide filter strip. For this situation the infiltration capacity of the filter strip exceeds the pavement runoff and direct rainfall on the filter strip for nearly all rainfall occurrences. **Figure 3** presents results of a similar analysis for connecting taxiways having a maximum slope length of 140 feet and a 30-foot wide filter strip. In this scenario, the total water input exceeds the infiltration approximately 6 percent of the time. In all three scenarios, nearly all of the pavement runoff volume can be infiltrated in the filter strips.

Figure 1. Annual Flow Duration Curves for a One-foot Wide Half-Section of Runway (105 feet) and Adjoining Filter Strip (75 feet)

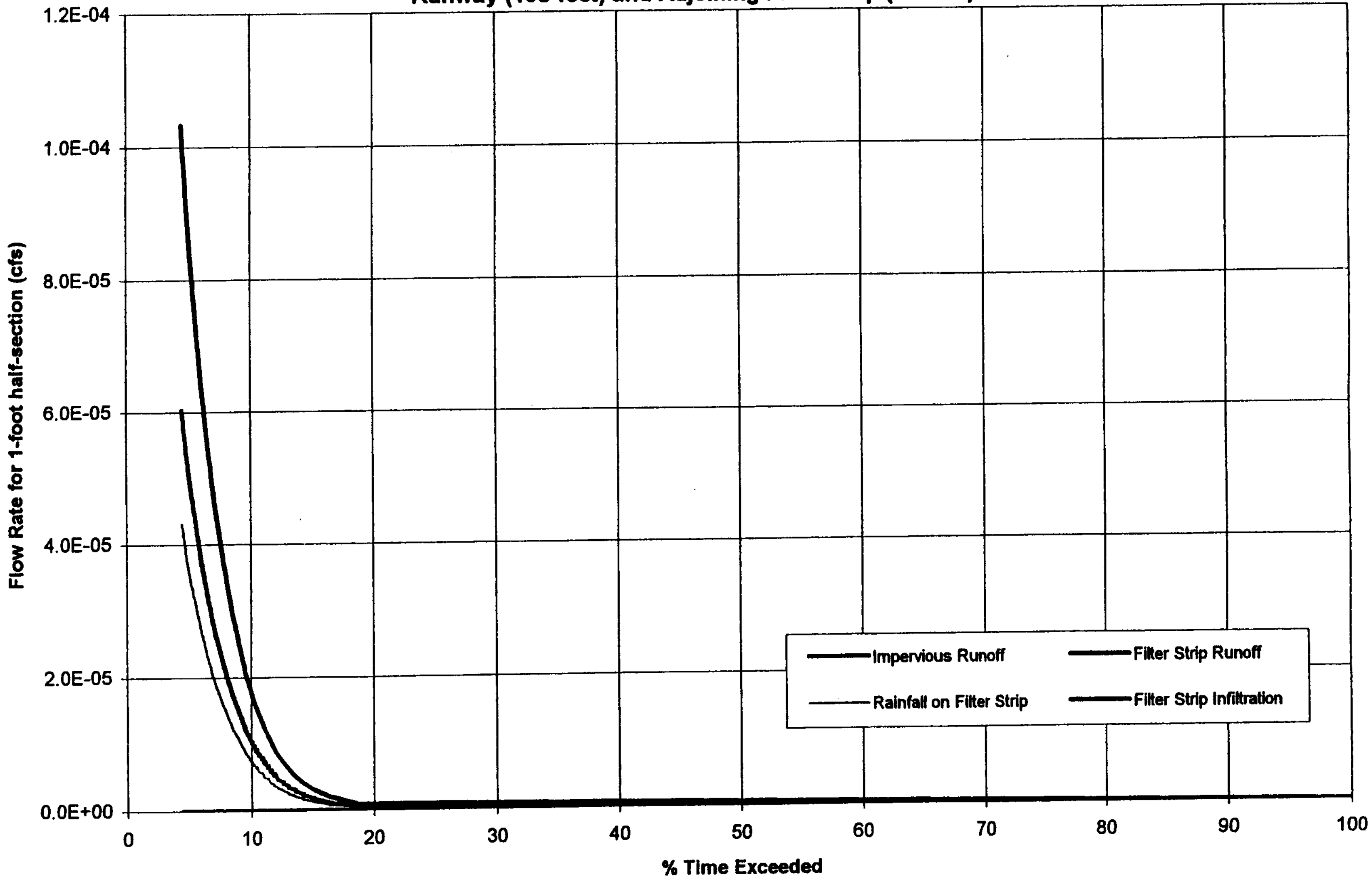


Figure 2. Annual Flow Duration Curves for a One-foot Wide Section of Taxiway (140 feet slope length) and Adjoining Filter Strip (75 feet)

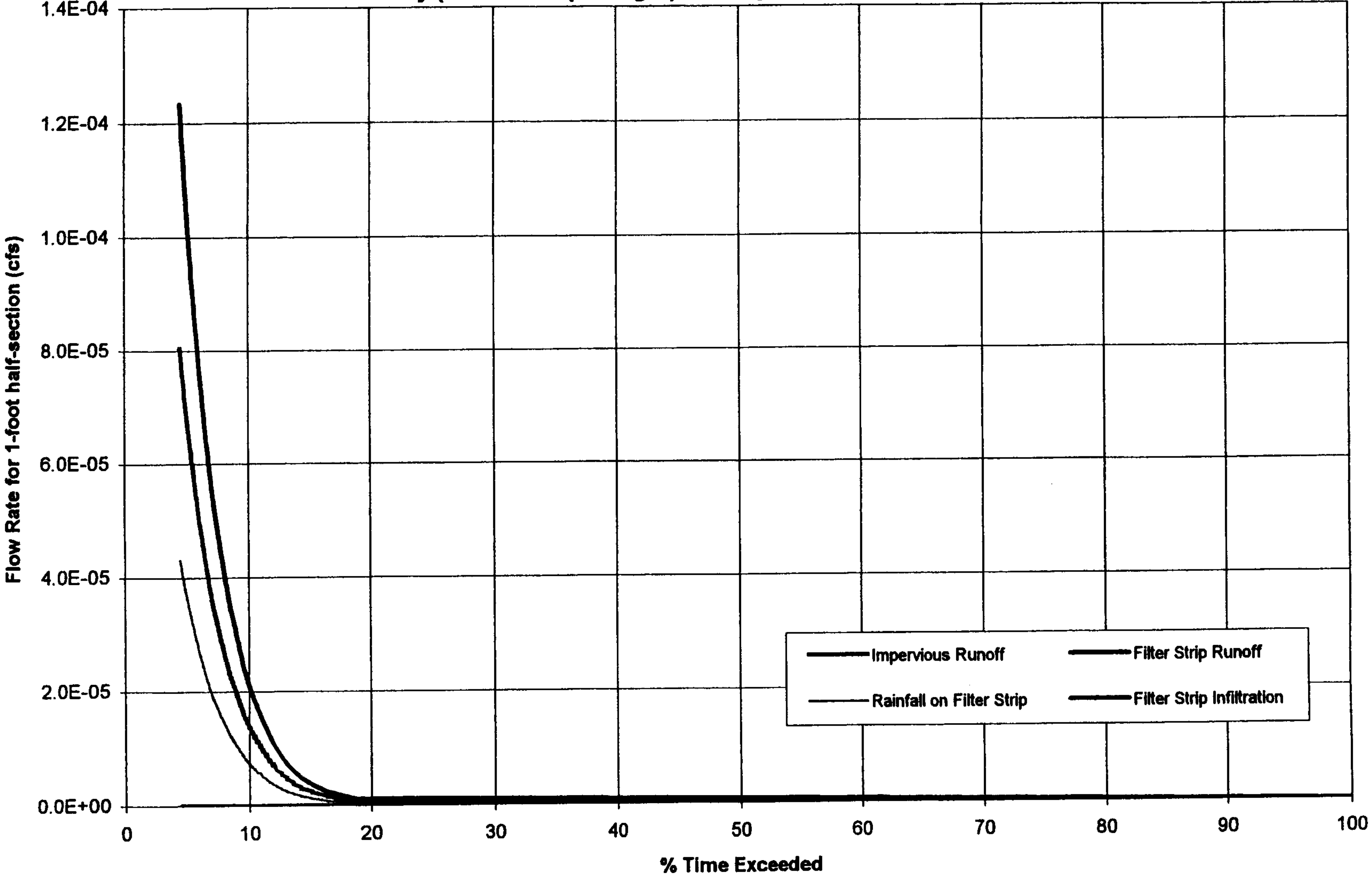
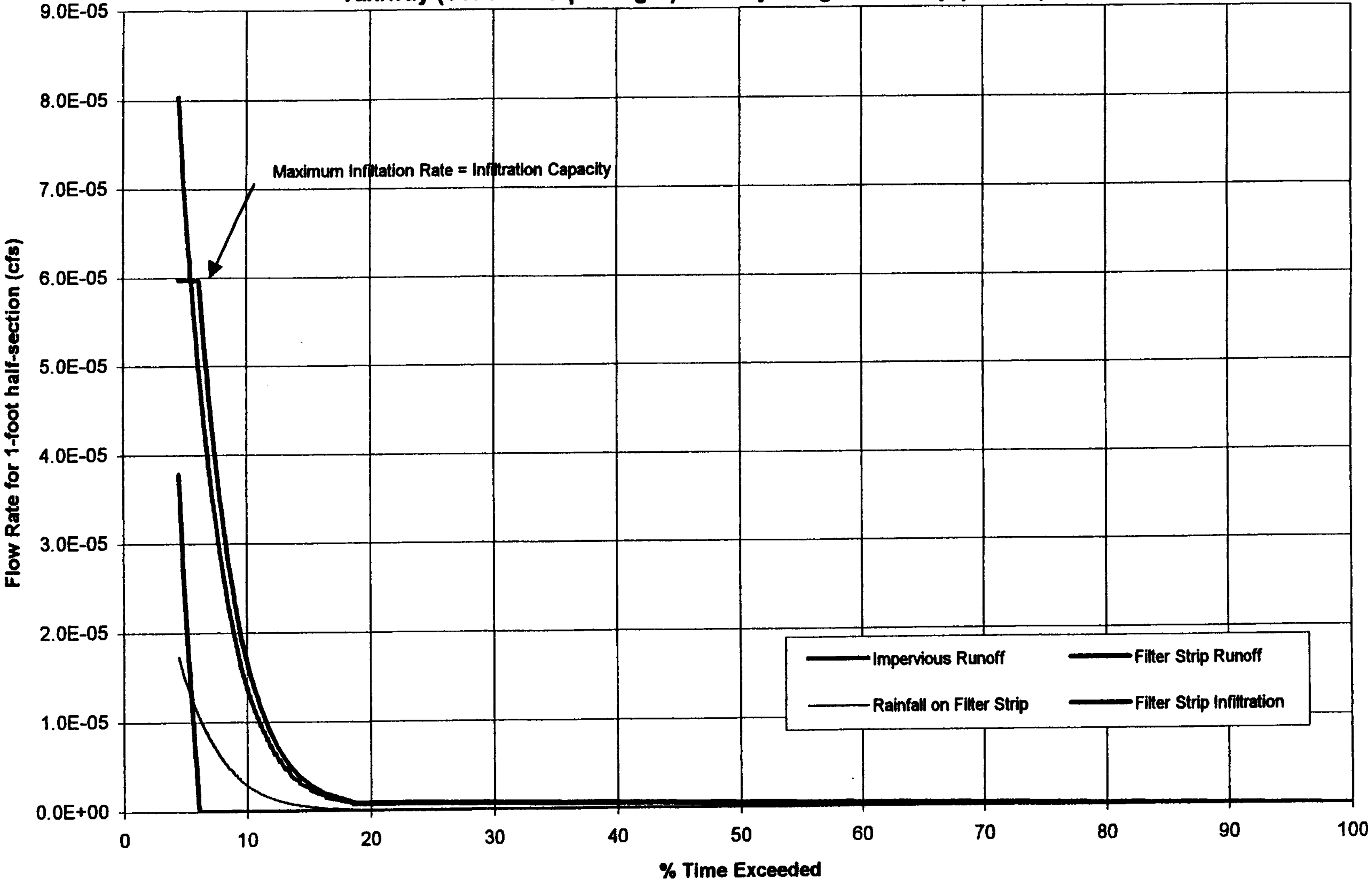


Figure 3. Annual Flow Duration Curves for a One-foot Wide Section of Connecting Taxiway (140 feet slope length) and Adjoining Filter Strip (30 feet)



Figures 4, 5 and **6** present the monthly recharge rate for the three filter strip scenarios described above (incident precipitation and pavement runoff). The figures show the total infiltration, potential evapotranspiration and net recharge below the root zone into the fill. The recharge volume is the product of the infiltration rate and the area of the filter strip.

The effect of the additional infiltrated water to the fill would be to enhance the effect of delayed discharge from the fill's drainage layer during the August-September low flow period in Miller and Walker creeks. A simple extrapolation of the Hydrus-2D/Slice model results on a per-acre basis would suggest that secondary recharge would have the potential to increase Miller Creek August flows by an additional 0.04 cfs and September flows by 0.025 cfs. Using the same extrapolation approach, Walker Creek flows would increase in August by 0.005 cfs and in September by 0.003 cfs. This simple extrapolation does not consider geographic and hydraulic effects that are present, and the extrapolation may overestimate delay times for this groundwater flow. This is because the recharge is not uniform across the surface of the impervious fill area, localized areas of the fill will experience elevated saturation compared to other sections, and the added volumes may pass more quickly through the wetter zones than was calculated in the Hydrus-2D analysis. However, during drier years, saturation levels will be reduced and delay times would not be expected to shorten. Therefore, the simple extrapolation is considered a reasonable estimate and has been used directly in this assessment.

RESERVED STORMWATER RELEASE

The Port proposes to construct additional stormwater storage facilities that would collect and store winter season runoff until needed to support low flows during the dry season. When low flow conditions would occur in the stream, the stored stormwater would be released at a prescribed rate, aerated and discharged to the stream system to sustain desired instream flow rates. The reserved stormwater release facilities are proposed by the Port in the Des Moines Creek and Miller Creek basins. The facilities are proposed to be constructed as additional storage volume in the base of selected detention facilities, with each facility having a dedicated, gated discharge outlet, allowing the stormwater to be discharged when needed.

The required storage volume to be held in reserve can be determined based on the necessary rate and duration of discharge to support low flows in the respective stream system. In both Des Moines and Miller Creeks, additional discharge is predicted to be needed to sustain 7-day low flows to preproject (1994) levels. In Miller Creek at the SR 509 crossing, the predicted deficit in 7-day duration/2-year frequency stream discharge rate was determined to be 0.10 cfs, after accounting for the hydrologic changes on the STIA site, the discharge of pervious fill recharge and secondary impervious runoff recharge, and changes in non-hydrologic flows. In Des Moines Creek, the predicted deficit would be 0.08 cfs. **Tables 9 and 10** describe how the required discharge rates were determined for Miller and Des Moines Creeks, respectively.

Figure 4. Predicted Infiltration, PET and Total Recharge on Runway Filter Strip (75 feet)

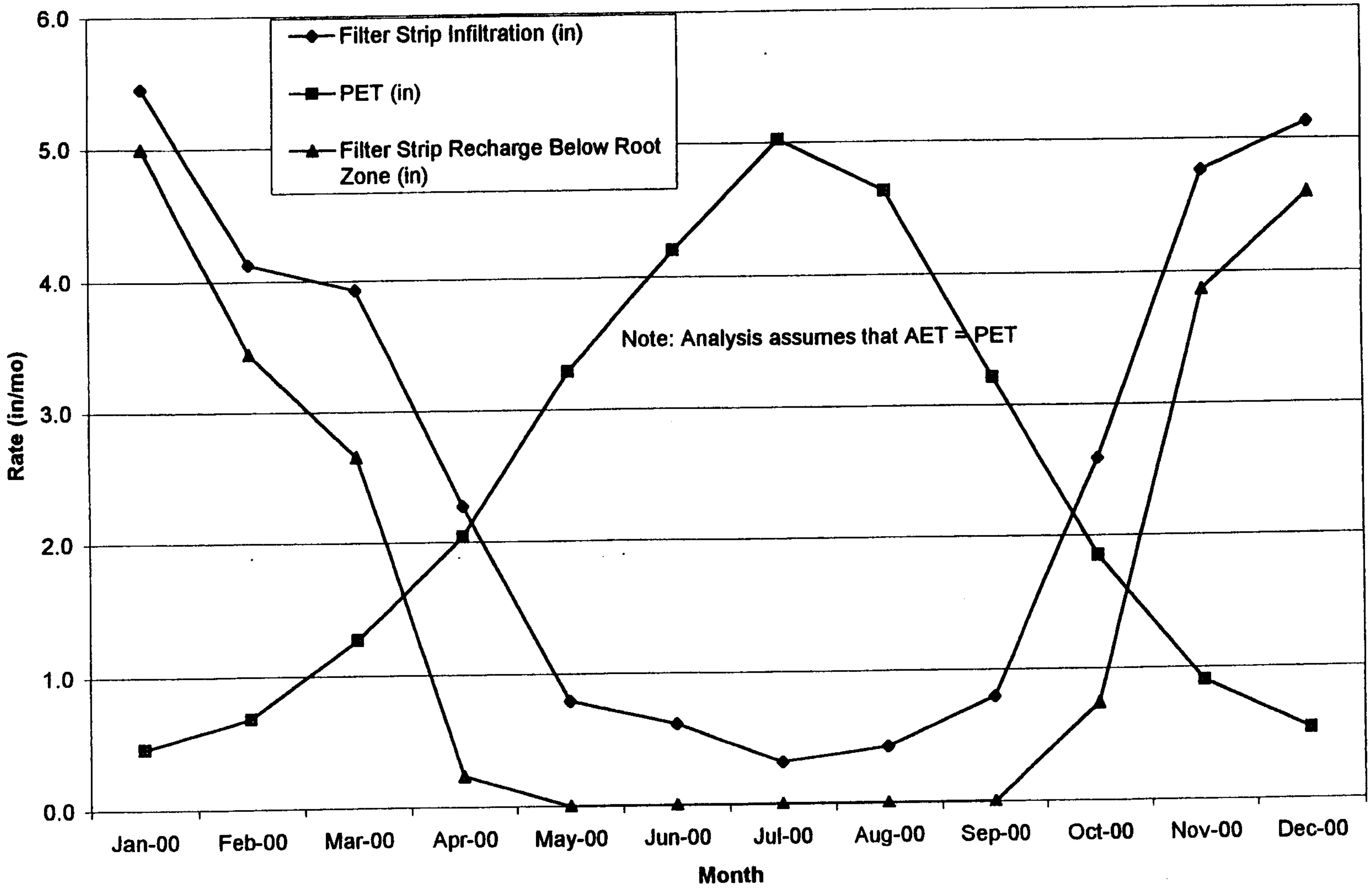
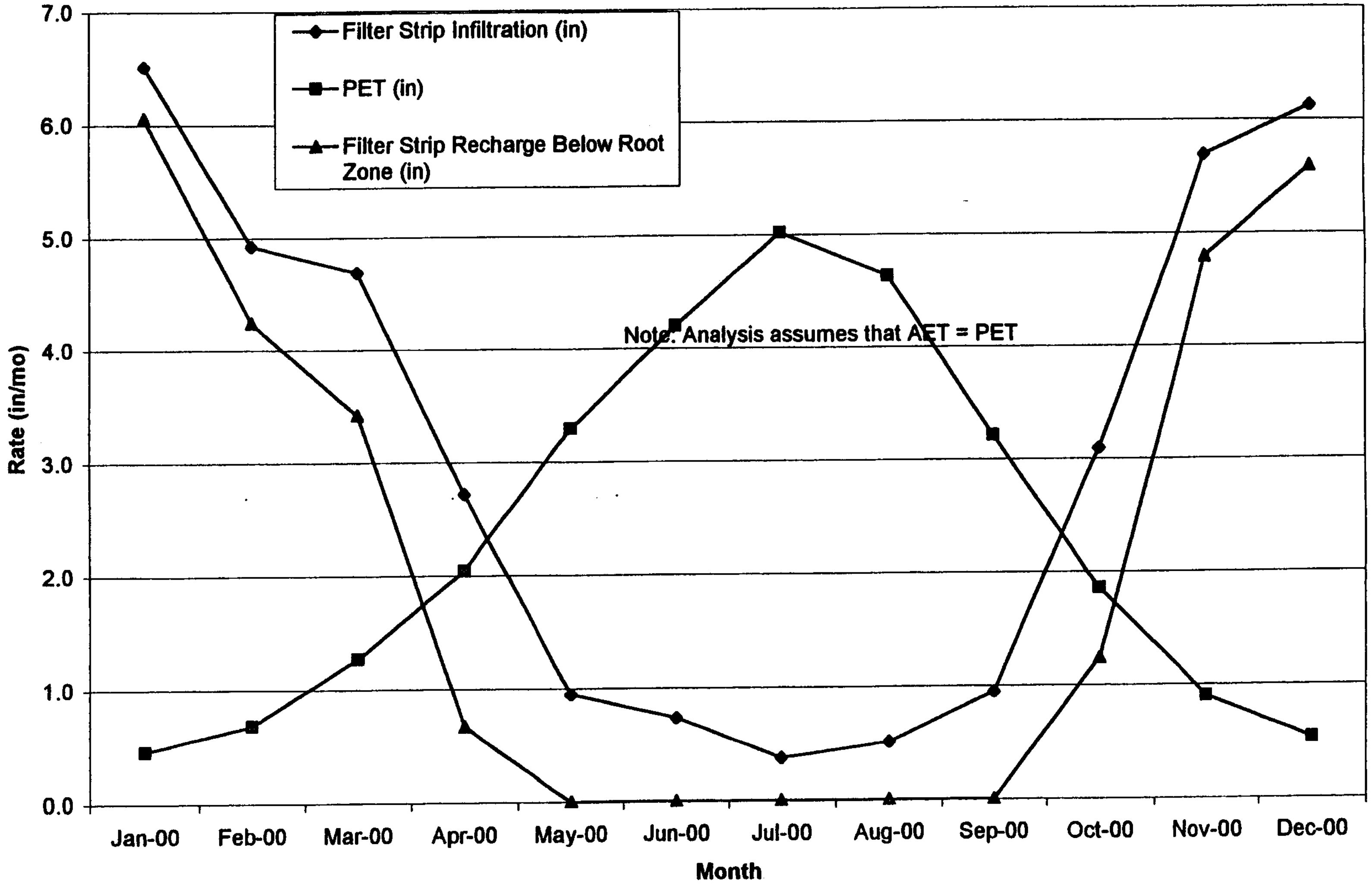


Figure 5. Predicted Infiltration, PET and Total Recharge on Taxiway Filter Strip (75 feet)



Note: Analysis assumes that AET = PET

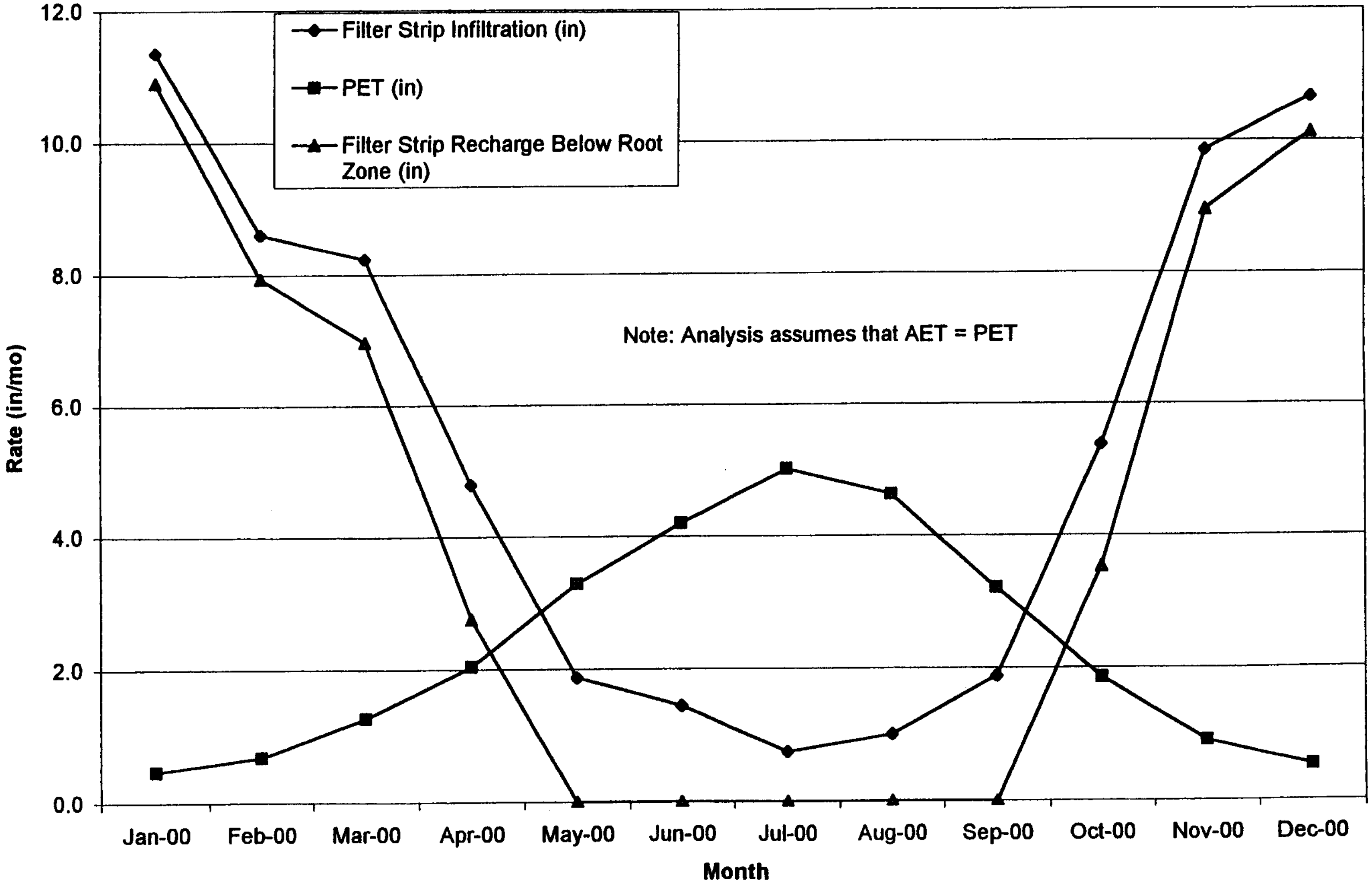


Figure 6. Predicted Infiltration, PET and Total Recharge on Connecting Taxiway Filter Strip (30 feet)

Table 9:
Miller Creek Reserved Stormwater Release Rate Determination

Period of Flow	HSPF Model Streamflow (cfs)		Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[2] (cfs)	2006 Condition with Fill Discharge and Non-Hydrologic Changes[3] (cfs)	Net Deficit from 1994 Condition = Reserved Release Rate (cfs)
	1994 Condition	2006 Condition					
August	1.27	1.10	0.108	(0.04)	0.04	1.21	0.06
September	1.50	1.40	0.065	(0.04)	0.025	1.45	0.05
August/ September	1.39	1.25	0.09	(0.04)	0.03	1.33	0.06
7-day/ 2-year low flow	0.79	0.64	0.065[4]	(0.04)	0.024[4]	0.69	**0.10**

[1] Miller Creek at SR 509

[2] Assumes secondary recharge volumes from impervious areas behave similar to pervious area recharge volumes.

[3] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes and secondary impervious recharge.

[4] Calculated as 75 percent of the average increase in discharge over August and September.

Table 10:
Des Moines Creek Reserved Stormwater Release Rate Determination[1]

Period of Flow	HSPF Model Streamflow (cfs)		Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[2] (cfs)	2006 Condition with Fill Discharge and Non-Hydrologic Changes[3] (cfs)	Net Deficit from 1994 Condition = Reserved Release Rate (cfs)
	1994 Condition	2006 Condition					
August	1.08	1.07	—	—	—	1.07	0.01
September	1.64	1.73	—	—	—	1.73	—
August/ September	1.36	1.40	—	—	—	1.40	—
7-day/ 2-year low flow	0.35	0.27	—	—	—	0.27	**0.08**

[1] Des Moines Creek at South 200th Street

[2] Assumes secondary recharge volumes from impervious areas behave similar to pervious area recharge volumes.

[3] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes and secondary impervious recharge.

A review of the differences between 1994 and 2006 low flow conditions predicted by the HSPF modeling for varying return frequencies and durations (refer to Appendix D) concluded that the greatest differences in flow rates were predicted for the 2-year return frequency, and that the differences in flow rates were consistent across durations ranging from 7 days to 90 days. Hence the 7-day/2-year low flow condition was selected as the criteria for establishing the reserve stormwater release rate.

Criteria for establishing the appropriate duration of the reserved stormwater release was made based upon a review of the pattern of low flow occurrences. **Figure 7** is a histogram showing when Day 1 of the 7-day duration low flow periods would occur in Miller Creek at SR 509 based on HSPF modeling of the 2006 condition. The analysis extends over a 47-year period from 1949 through 1995. A similar analysis for Des Moines Creek at South 200th Street is presented in **Figure 8**. The figures indicate that in both basins, if the reserved stormwater release commenced at a fixed calendar date and extended over a 60-day period, the release would coincide with the 7-day low flow period in 83 to 85 percent of the years. Similarly, if a 45-day-long release were initiated each year on a fixed date, the release would coincide with the 7-day low flow period in 72 to 74 percent of the years. The clustering of the 7-day low flow occurrences within August and September allows a release over a limited timeframe to provide a high level of confidence that the release will coincide with low flow conditions in the streams.

The effectiveness of the reserved stormwater release in mitigating 7-day low flows in Miller and Des Moines Creeks can be enhanced through active management of the release in response to measured flows in the streams. Rather than initiating the release on a fixed date each year, the reserve would be released when the discharge in the stream drops to a predetermined rate. It is recommended that data from existing King County stream gages be used to decide when the release of the reserve should commence. Using existing gages provides the benefit of historic gage data and eliminates the uncertainty of whether a new gage is properly rated. These gages can also be monitored in real time, facilitating reserve management and allowing rapid response to changing stream conditions. Utilizing such an active management procedure, a reserve discharge duration of 45 days would be sufficient to ensure the release would support necessary stream discharges throughout portions of all low flow events, including extended drought conditions, and throughout the full duration of the vast majority of low flow events.

Based on a 45-day discharge duration and the release rate identified in Table 9, the required reserved stormwater storage volume in Miller Creek above SR 509 would be (010 cfs × 3600 seconds × 24 hours × 45 days /43,560 sq. ft. =) 8.9 acre-feet. Similarly, the required reserved stormwater storage volume in Des Moines Creek above South 200th Street would be 7.1 acre-feet.

SUMMARY OF LOW STREAMFLOW EFFECTS

The predicted effects of the various factors on low streamflows in Miller, Walker and Des Moines Creeks are compiled in **Tables 11, 12** and **13**, respectively. In all three streams, average August and September flows are predicted to increase, and 7-day low flows are expected to match pre-project conditions. A net increase of 3 percent in August/September average flows is predicted in Miller Creek at SR 509. In the upper reach of Walker Creek, average August and September flows are predicted to increase by 26 percent. Des Moines Creek average August and September discharges at South 200th Street would increase by 9 percent.

Figure 7: 7-Day Low Flow Occurrences in Miller Creek, 1949-1995

Derived from HSPF model results for proposed (2006) conditions

█ - Occurrence of Day 1 of 7-day low flow event for calendar year

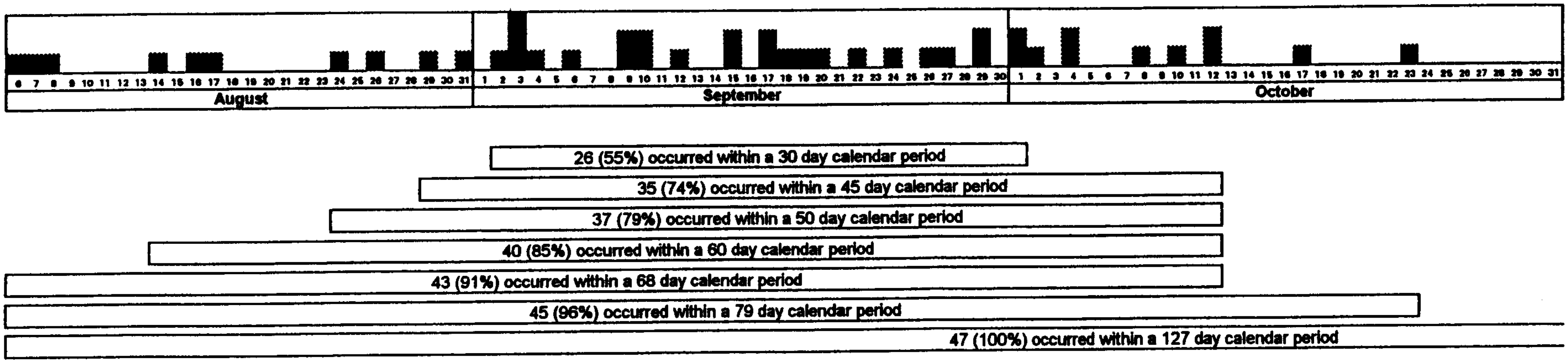


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Figure 7: 7-Day Low Flow Occurrences in Miller Creek, 1949-1995

Derived from HSPF model results for proposed (2006) conditions

■ - Occurrence of Day 1 of 7-day low flow event for calendar year

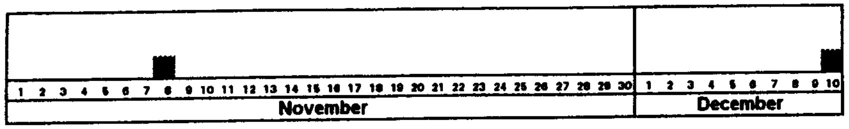
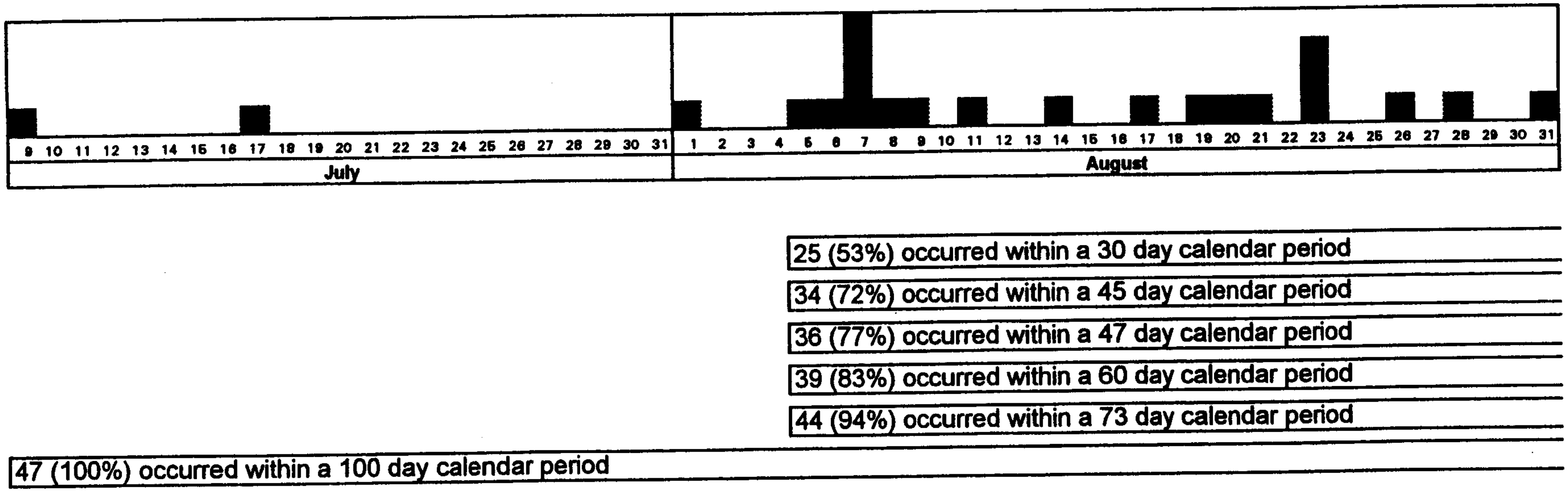


Figure 8: 7-Day Low Flow Occurrences in Des Moines Creek, 1949-1995

Derived from HSPF model results for proposed (2006) conditions

■ - Occurrence of Day 1 of 7-day low flow event for calendar year



25 (53%) occurred within a 30 day calendar period

34 (72%) occurred within a 45 day calendar period

36 (77%) occurred within a 47 day calendar period

39 (83%) occurred within a 60 day calendar period

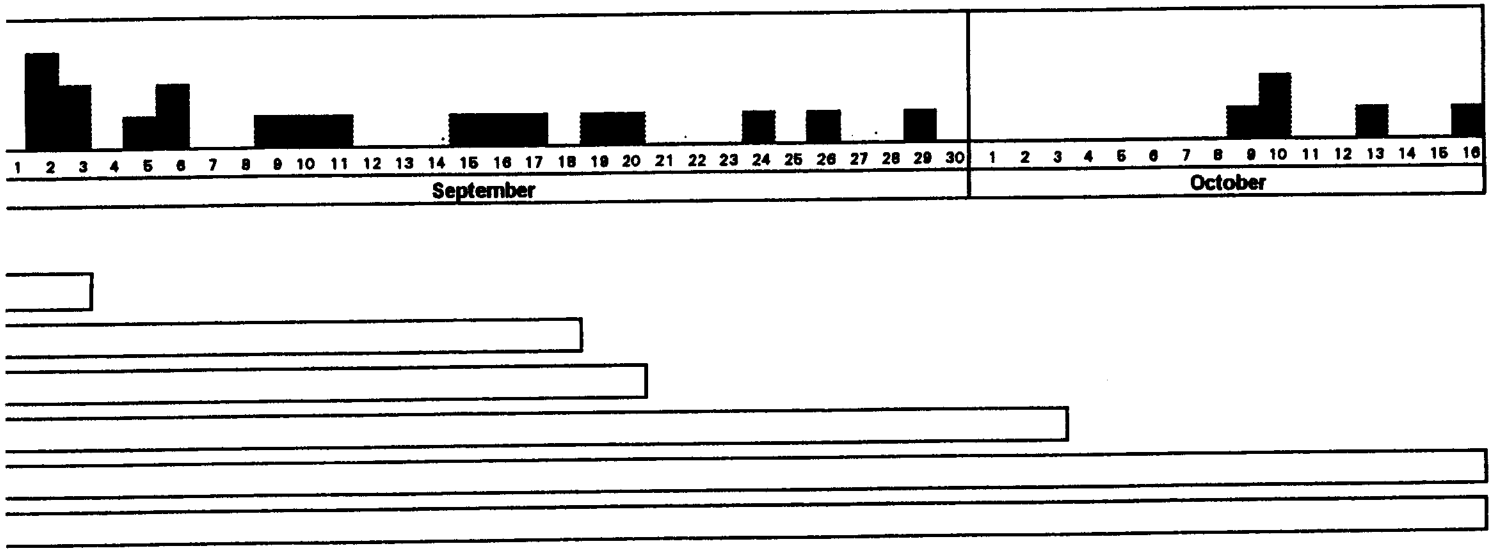
44 (94%) occurred within a 73 day calendar period

47 (100%) occurred within a 100 day calendar period

Figure 8: 7-Day Low Flow Occurrences in Des Moines Creek, 1949-1995

Derived from HSPF model results for proposed (2006) conditions

▇ - Occurrence of Day 1 of 7-day low flow event for calendar year



AR 009552

In Walker Creek, the discharge from recharge to the runway fill is estimated to be sufficient to maintain 7-day duration/2-year frequency low flows to pre-project levels. In Miller and Des Moines Creeks, 7-day/2-year low flows would be supplemented by reserved stormwater releases to maintain pre-project discharge rates in the streams.

Table 11:
Summary of Miller Creek Streamflow Effects[1]

Period of Flow	HSPF Model Streamflow (cfs)		Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[2] (cfs)	Reserved Stormwater Release (cfs)	Predicted 2006 Condition[3] (cfs)	Net Change from 1994 Condition (cfs)
	1994 Condition	2006 Condition						
August	1.27	1.10	0.108	(0.04)	0.04	0.10	1.31	+ 0.04
September	1.50	1.40	0.065	(0.04)	0.025	0.10	1.55	+ 0.05
August/ September	1.39	1.25	0.09	(0.04)	0.03	0.10	1.43	+ 0.04
7-day/2-year low flow	0.79	0.64	0.065[4]	(0.04)	0.024[4]	0.10	0.79	-0-

[1] Miller Creek at SR 509

[2] Assumes secondary recharge volumes from impervious areas behave similar to pervious area recharge volumes.

[3] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes, secondary impervious recharge, and reserved stormwater release.

[4] Calculated as 75 percent of the average increase in discharge over August and September.

Table 12:
Summary of Walker Creek Streamflow Effects[1]

Period of Flow	HSPF Model Streamflow (cfs)		Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[2] (cfs)	Reserved Stormwater Release (cfs)	Predicted 2006 Condition[3] (cfs)	Net Change from 1994 Condition (cfs)
	1994 Condition	2006 Condition						
August	0.033	0.031	0.005	—	0.005	—	0.041	+ 0.008
September	0.035	0.039	0.003	—	0.003	—	0.045	+ 0.010
August/ September	0.034	0.035	0.004	—	0.004	—	0.043	+ 0.009
7-day/2-year low flow	0.021	0.015	0.003[4]	—	0.003[4]	—	0.021	-0-

[1] WalkerCreek near 12th Avenue South

[2] Assumes secondary recharge volumes from impervious areas behave similar to pervious area recharge volumes.

[3] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes, secondary impervious recharge, and reserved stormwater release.

[4] Calculated as 75 percent of the average increase in discharge over August and September.

Table 13:
Summary of Des Moines Creek Streamflow Effects[1]

Period of Flow	HSPF Model Streamflow (cfs)		Discharge of Pervious Fill Recharge (cfs)	Non-Hydrologic Changes (cfs)	Discharge of Secondary Impervious Recharge[2] (cfs)	Reserved Stormwater Release (cfs)	Predicted 2006 Condition[3] (cfs)	Net Change from 1994 Condition (cfs)
	1994 Condition	2006 Condition						
August	1.08	1.07	—	—	—	0.08	1.15	+ 0.07
September	1.64	1.73	—	—	—	0.08	1.81	+ 0.17
August/ September	1.36	1.40	—	—	—	0.08	1.48	+ 0.12
7-day/2-year low flow	0.35	0.27	—	—	—	0.08	0.35	-0-

[1] Des Moines Creek at South 200th Street

[2] Assumes secondary recharge volumes from impervious areas behave similar to pervious area recharge volumes.

[3] Sum of 2006 HSPF streamflow, fill pervious recharge, non-hydrologic changes and secondary impervious recharge.

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APPENDIX A

Comparison of Pacific Groundwater and Hart Crowser Fill Modeling Approaches

Appendix A
Comparison of Pacific Groundwater and Hart Crowser Fill Modeling Approaches

Estimation of Recharge Generated at the Land Surface

Study	Factor	Approach	Significance
PGG	Precipitation	Steady monthly rates based on long-term monthly averages	Coarser resolution of precipitation input, step-wise specification of changes in monthly recharge, doesn't account for high intensity storm events.
HC		13-year actual and synthetic daily precipitation record	Finer resolution of precipitation input, portrays variability within a given month, simulates high intensity storm events.
PGG	Runoff	Assumed zero runoff.	Magnitude consistent with HSPF modeling except for till and wetland surfaces. However, runoff from till and wetland surfaces handled independently as "rejected recharge" by slice model.
HC		HELP model used SCS runoff curve method. Values range from 0 to 1 in/yr.	Not significantly different than PGG values for HC modeled areas (lower runoff). HC model did not include conditions associated with wetland soils.
PGG	Plant ET	Blaney Criddle calculations, based on temperature, plant type and latitude.	Numbers are very similar between methods.
HC		SoilCover uses modified Penman approach based on plant type, temperature, humidity and solar radiation.	Numbers are very similar between methods.
PGG	Recharge	Daily soil moisture balance, accounts for root zone extending into shallow perched water table.	PGG recharge based on monthly average precipitation, therefore presented as monthly averages. Allows negative recharge where plants tap the water table during hot summer months.
HC		Daily soil moisture balance, water table always outside of root zone.	HC recharge method allows for variability with daily precipitation numbers. Recharge generally not estimated for areas where root zone reaches water table (e.g. wetlands, over very shallow till).

Appendix A

Comparison of Pacific Groundwater and Hart Crowser Fill Modeling Approaches

Modeling of 1-D, Vertically Downward Flow in the Vadose Zone

Study	Factor	Approach	Significance
PGG	range of soil types	Uses averaged combination of soil groups for general fill. Assumes instantaneous flow for coarse sand and gravel (Group 1a)	Generalized fill did not allow comparison between various likely fill properties, but assumed a representative combination.
HC		Separately simulates three different soil groups for embankment fill as well as natural outwash soils. Does not assume instantaneous flow for sand and gravel (Group 1b)	Comparison suggested little difference in vertically downward, 1-D, unsaturated flow between three fill types modeled.
PGG	soil characteristic curve	Based on Rosetta database and methods by Van Genuchten and Maulem.	HC approach same as PGG.
HC		Based on Rosetta database and methods by Van Genuchten and Maulem.	PGG approach same as HC.
PGG	presence of gravel in soil	Assumes no flow in gravelly pockets. Recharge inflow distributed to non-gravelly portions of soil. Exception for Group 1a soils, where flash flow is modeled.	More accurately represents role of gravel in general fill. May overestimate immediate water delivery in Group 1a soils near wall.
HC		Adjusts soil properties used in characteristic curve generation for presence of gravel. Does not exclude unsaturated flow from gravelly component of soil.	Reduces the intensity of recharge loading on unsaturated flow pathways. May cause additional dampening of recharge pulse due to a more "spread out" moisture distribution.
PGG	recharge input	Step-wise, monthly values.	Reduces model resolution to monthly recharge steps. Average recharge values over a month, so that October values are low whereas (in actuality) late October recharge is high).
HC		Continuous daily values.	Better resolution of recharge inflow. May lead to more gradual ascension of 1-D flow at bottom of modeled vadose zone.
PGG	discretization of model cells	Used Hydrus 2D with 6-inch model cells.	Well suited discretization for unsaturated flow problems.
HC		Used HELP, which automatically creates model cells of approximately 17-foot thickness in berm fill.	Numerical dispersion associated with thick model cells may articially "smear" out the recharge pulse, thus affecting the timing and maximum intensity of discharge at the bottom of the vadose zone.
PGG	thickness of vadose zone in native soil	Vadose zone modeling not performed for native soil, assumed that small depth to water causes negligible lagging and dampening of the recharge pulse	Likely minor underestimation of lagging and dampening over 5-foot soil distance.
HC		Modeled 5 feet of vertical downward unsaturated flow in native soil using HELP model.	Estimates some lagging and dampening of recharge pulse over 5 feet of soil. Cannot readily compare with PGG data.
PGG	thickness of embankment fill	Multiple simulations used for thicknesses ranging from 30 to 150 feet.	Allows representation of different timing of recharge from different thicknesses of fill, to be summed up for lateral, saturated flow "slice model".
HC		All simulations use thickness of 100 feet.	Single thickness represents conditions along one portion of the "embankment slice". Multiple conditions expected. Data from single thickness do not represent combined timing of all recharge along slice.
PGG	application of predicted discharge	Used as input to slice model.	Slice model simulates variable slopes and permeabilities of native soil aquifer, variable recharge of variable thickness embankment fill, and effects of storage and flow accumulation along saturated flowpath beneath berm.
HC		Presented as discharge to native soil aquifer beneath the berm.	Representative for 100-foot thick berm only. Discharge in aquifer is not cumulative over the entire cross-section beneath the berm, and does not allow for affects of storage and flow accumulation.

Appendix A

Comparison of Pacific Groundwater and Hart Crowser Fill Modeling Approaches

Modeling of Lateral Saturated Flow Towards Wetland and Miller Creek

Study	Factor	Approach	Significance
PGG	vertically downward inflow to water table	Imported from 1-D unsaturated flow modeling using a variety of berm thicknesses.	Variable thicknesses and flow properties needed to simulate combined recharge input along the slice, and therefore to model flow accumulation along entire slice (with storage effects).
HC		Exerpted from 1-D unsaturated modeling using a single berm thickness and variable soil properties for berm.	Slice model not performed. Cumulative flow along saturated shallow aquifer cross-section not modeled.
PGG	variation in slope and permeability of shallow aquifer	Based on slope of till surface and land surface, and on different native materials in upland and wetland.	Important because gentle slope and lower permeability beneath wetland causes groundater flow to come to surface (existing condition) or to drain (built condition).
HC		Assumed constant, does not extend to lower slopes and permeabilities beneath wetland.	Because wetland was not modeled, no groundwater flow is forced to the surface (existing condition) or to the drain (built condition). Drain discharge equals zero.
PGG	aquifer storage along slice and time lags for GW flow	Modeled using forward difference, finite element approach.	Causes lags and dampening of inflow from vadose zone to discharge at toe of cross-section model.
HC		Not modeled.	Lags and dampening of inflow from vadose zone to discharge at toe of saturated cross-section not modeled.

APPENDIX B

Estimates of Miller Creek Streamflow Effects As Predicted with Slice Model

Appendix B
Estimates of Miller Creek Streamflow Effects as Predicted with Slice Model

Slice Model Length	1150	feet
Slice Model Width	1	feet
Slice Model Area	0.0264	acres
Embankment Distance Along Miller Creek	5400	feet
Idealized Area of Slices Along Miller Creek	142.6	acres

Existing Condition	**Aug**	**Sept**	
Predicted GW Discharge from Native Soil Aquifer	8.68E-06	8.68E-06	cubic feet per second per foot width (from Fig. 3-6)
Predicted SW Discharge over Native Soil Aquifer	0	0	cubic feet per second per foot width
Predicted Total Flow to Creek/Wetlands	8.68E-06	8.68E-06	cubic feet per second per foot width
Predicted GW Discharge from Native Soil Aquifer	4.69E-02	4.69E-02	cubic feet per second along reach of Miller Creek
Predicted SW Discharge over Native Soil Aquifer	0	0	cubic feet per second along reach of Miller Creek
Predicted Total Flow to Creek/Wetlands	0.0469	0.0469	cubic feet per second along reach of Miller Creek

Built Condition	**Aug**	**Sept**	
Predicted GW Discharge from Native Soil Aquifer	8.68E-06	8.68E-06	cubic feet per second per foot width (from Fig. 3-13)
Predicted GW Discharge in Drain at Toe	2.03E-05	1.22E-05	cubic feet per second per foot width (from Fig. 3-13)
Predicted Total Flow to Creek/Wetlands	2.89E-05	2.08E-05	cubic feet per second per foot width
Predicted GW Discharge from Native Soil Aquifer	4.69E-02	4.69E-02	cubic feet per second along reach of Miller Creek
Predicted GW Discharge in Drain at Toe	1.09E-01	6.56E-02	cubic feet per second along reach of Miller Creek
Predicted Total Flow to Creek/Wetlands	0.1563	0.1125	cubic feet per second along reach of Miller Creek

Differences between Built and Existing Conditions	**Aug**	**Sept**	
Increase in Predicted Baseflow Contribution: Built - Existing Condition	2.03E-05	1.22E-05	cubic feet per second per foot width
Increase in Predicted Baseflow Contribution: Built - Existing Condition	0.1094	0.0656	cubic feet per second along reach of Miller Creek
Ratio of Baseflow Contribution: Built/Existing Condition	333%	240%	
Increase in Predicted Baseflow	0.00077	0.00046	cubic feet per second per idealized acre

Application Across Miller Creek Fill Footprint			
Pervious Fill Area in Miller Creek basin	141.4	141.4	acres
Increase in Predicted Baseflow for Pervious Fill Area in Miller Creek	0.108	0.065	cubic feet per second

APPENDIX H

APPENDIX H

ANALYSIS OF INDIRECT IMPACTS TO WETLANDS FROM SR 509 TEMPORARY INTERCHANGE

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Consultants in Engineering and Environmental Sciences
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MEMORANDUM

To: Jonathan Freedman, U. S. Army Corps of Engineers

From: Jim Kelley, Wetland Ecologist

cc: Elizabeth Leavitt, Port of Seattle

Date: May 3, 2000

Re: ***Analysis of indirect impacts to wetlands from the temporary SR-509 interchange – Seattle-Tacoma International Airport***

This memorandum provides an overview of the SR-509 Temporary Interchange at South 176th Street, a description of current conditions at the site, and evaluates the potential impacts to adjacent wetlands that may result from the project. The interchange project involves no discharge of fill material into waters of the United States including wetlands. Furthermore, we have analyzed potential indirect impacts to wetlands and concluded that no significant indirect impacts to wetlands will occur. The interchange is also constructed on existing road fill and other disturbed areas that do not act as buffers to protect the functions of adjacent wetlands.

PROJECT OVERVIEW

To provide construction vehicles direct access from SR-509 to the west side of Seattle-Tacoma International Airport (STIA), a temporary interchange would be constructed near the existing South 176th Street overpass. The half-diamond interchange would consist of an exit ramp from southbound SR-509 to South 176th Street and an entrance ramp from 176th Street to northbound SR-509.

The Port will use the interchange as part of its fill haul route during construction of the third runway, as described in the 1996 Final Environmental Impact Statement (EIS) and 1997 Final Supplemental EIS prepared pursuant to the National and State Environmental Policy Acts (see Federal Aviation Administration Record of Decision dated July 3, 1997 for a discussion of the EISs). This facility will be dedicated to haul vehicles for the third runway construction at STIA and will be removed upon completion of the third runway construction. The Port will be responsible for operation and maintenance of temporary and permanent drainage features throughout construction of the third runway project as stated in the Temporary Interchange Design, Construction and Operation Agreement.

As explained in the following sections, the temporary interchange was designed to avoid any direct fill impacts to wetlands. The interchange will be largely constructed on existing SR-509 road fill. Where necessary, short (less than 30 ft high) retaining walls are used to assure the project can be constructed on the existing road. Stormwater detention facilities, water quality treatment facilities, construction methods, and construction monitoring procedures have been developed to assure that impacts to the wetlands do not occur.

SITE CONDITIONS

Proximity to wetlands

Portions of the temporary interchange are located between Wetland 43 and Wetland 44. Wetland 44 is located generally east of and Wetland 43 is generally west of SR-509 and the project.

Construction of the southbound exit ramp will be between the existing SR-509 and the delineated edge of Wetland 43. Construction will occur more than 55 feet from the wetland edge. The land between the wetland and SR-509 consists of the SR-509 fill prism, including a gravel maintenance road. The area is vegetated with grass, invasive shrubs (Scots broom and Himalayan blackberry), and red alder saplings. This vegetation is periodically mowed and does not serve to protect the wetland from ongoing and adjacent disturbances.

Construction of the northbound entrance ramp of the temporary interchange generally occurs greater than 50 feet from the edge of Wetland 44. The ramp lies 20 to 50 feet from the wetland for about 100 linear feet near its start at South 176th Street. The ramp is 12 to 50 feet from the wetland edge for about 200 linear feet near its mid-point. The land between the wetland and SR-509 consists of the SR-509 fill prism and fill placed on Parcels 494, 496, 497, and 498. The area is vegetated with grass and invasive shrubs (Scots broom and Himalayan blackberry). This vegetation is periodically mowed and does not serve to protect the wetland from ongoing and adjacent disturbances.

Both Wetlands 43 and 44 lie within the Walker/Miller Creek Watershed. Walker Creek begins at the western edge of Wetland 43. Adjacent land use consists of single-family housing and SR-509 (which bisects the originally contiguous wetland). Wetland 44 is forested and Wetland 43 has forested, shrub, emergent and open-water components.

Historical aerial photos from 1961 (attached) show the wetland areas (prior to construction of SR-509) were once contiguous, largely farmland, with a drainage ditch crossing the area. In 1978 the wetlands were bisected by the construction of SR-509, and the hydrologic connection between the wetlands maintained via a 36-inch diameter culvert installed under the roadway.

Previous Earthwork

SR-509 from milepost 22.98 to milepost 24.11 including the South 176th Street bridge, was constructed in 1978. Generally, the section of road north of the South 176th Street bridge is predominantly fill. Approximately 200 feet north of the South 176th Street bridge SR-509, is constructed in a cut, which continues south of the bridge on both sides of SR-509. A portion of the northbound temporary interchange will cross Parcels 496, 497, and 498. The steep slope along the north and western edges of these parcels suggests that they are also fill materials. These parcels once contained a residence and a metal outbuilding, which have recently been demolished.

The majority of the southbound portion of the temporary interchange will also be constructed on the existing SR-509 fill trapezoid. However, as the temporary interchange approaches South 176 Street through the SR-509 right-of-way it will cross disturbed native soil (greater than 100 feet from the wetland edge). The northbound portion of the temporary interchange will be constructed on the existing SR-509 fill within the right-of-way trapezoid and on the existing fill of Parcels 496, 497, and 498.

Existing Drainage Features

Existing drainage facilities associated with SR-509 are described in the *Hydrologic Report- SeaTac International Airport Third Runway Direct Access* (HNTB 2000) (See Attached).

The existing drainage in the vicinity of the SR-509/South 176th Street bridge is composed of two primary systems, a groundwater collection system and a storm water runoff collection system.

The groundwater collection system for SR-509 is located in the vicinity south of the South 176th Street bridge. This system, which consists of perforated pipes within the roadway sub-grade, collects the groundwater surfacing in the SR-509 cut section. The collection system conveys collected water to drain lines near the east and west edge of SR-509. The drain line on the eastside crosses SR-509 just north of the South 176th Street overpass to connect with the drain line on the west side. The combined flow is conveyed down the west edge of the highway, bypassing the stormwater detention system at the base of the SR-509 embankment. The flow is then discharged to Wetland 43.

Three storm drain sub-basins collect the runoff from SR-509, the bridge, and their vicinity. The total collection area is approximately 45 acres, including approximately 8 acres of impervious surface (primarily SR-509 and South 176th Street) and 37 acres of pervious wetland and residential land uses. Detention and water quality facilities intended to treat this runoff are generally undersized when compared to the standards used to design the temporary interchange.

The south sub-basin is approximately 12.6 acres; it collects the roadway runoff from the southern end of SR-509 to just north of the South 176th Street overpass. Runoff from the northbound roadway is collected at the median barrier in catch basins and conveyed to an enclosed drainage system at the west edge of the pavement. The runoff from the southbound roadway is collected in a roadside ditch and combined with the runoff from the northbound roadway in the storm sewer.

The middle sub-basin is approximately 20.7 acres and extends approximately 1,150 feet north of the South 176th Street overpass. Roadway runoff is collected in roadside catch basins that outlet to the ditch and wetland east of SR-509. The wetland east of SR-509 drains to the stormwater facility on the west side of SR-509 through a 36-inch diameter culvert crossing.

The north sub-basin is approximately 11.7 acres and extends approximately 1,300 feet south from South 168th Street. The runoff from this sub-basin is collected at the roadside gutter in catch basins and conveyed to a ditch (on the east side of SR-509) that crosses to a stormwater detention pond on the west side of SR-509 through a 24-inch diameter culvert.

PROJECT DESIGN

The temporary interchange has been designed to avoid significant hydrologic and water quality impacts to wetlands or Walker Creek. Hydrologic designs and their potential impacts are discussed in the following sections.

New Groundwater Management

Drainage for the structural earth walls of the interchange will be the only new subsurface drainage systems for this project. These will consist of "weep-holes" (see WL-1 and WL-2 in the Attached Plan Sheets) that will allow the small amounts of water that may infiltrate the fill to seep from behind the wall to the surface.

The existing subsurface drainage conveyance system serving SR-509 in the vicinity of the South 176th Street bridge will be modified (by adding a bypass pipe segment [see Sheet D1]) to avoid damage to the system from construction of the proposed southbound off-ramp. This modification will not alter the flow volume or timing of groundwater flow that eventually discharges to Wetland 43.

New Stormwater Management Facilities

The stormwater drainage system has been designed to capture runoff from the new impervious surface area and to detain accumulated runoff consistent with King County Level 2 requirements. The stormwater system will capture and detain runoff from an additional 40 percent of the existing road surface consistent with the *Stormwater Effects Guidance* provided by WSDOT and National Marine Fisheries Service (NMFS) for salmon listed under the Endangered Species Act (ESA). All collected runoff will be treated to improve water quality prior to discharge into the existing WSDOT pond system and outfall.

The drainage design was completed using the King County Surface Water Design Manual (1998 edition). Runoff volumes were modeled using the King County Runoff Time Series (KCRTS) model, but for comparison, the project was also analyzed using the

Santa Barbara Unit Hydrograph method (using "WaterWorks" software). The results showed that the KCRTS model offers a more conservative design, providing facilities that are more protective of downstream wetlands and creeks. The detention pond sizing and release rates meet Level 2 Flow Control requirements.

The temporary interchange will add approximately 1.66 acres of impervious surface and reduce the pervious surface in the vicinity by the same area. The system will also collect runoff from an additional 40 percent (0.67 acre) of the existing roadway's impervious surface to meet requirements of the NMFS retrofit agreement. A total of 2.47 acres would flow to the new detention and water quality facilities. The areas draining to the new detention pond would account for approximately 26 percent of the total impervious surface in the three sub-basins (calculated after the interchange construction).

An existing roadside drainage ditch would be modified to develop the water quality treatment facilities required for the project. This existing ditch drains to an existing stormwater pond outfall (at Station 932+00), that will be redeveloped as a wet biofiltration swale. The outlet pipe from new ponds will discharge into the wet biofiltration swale at approximately Station 929+00, storm water will flow north to the swale, with treated water exiting into the discharge channel from the existing pond. The wet biofiltration swale will be designed and constructed to meet the King County Surface Water Design Manual standards.

The detention facility for the project is designed to comply with King County Level 2 Flow Control, which requires the developed discharge durations to match 50 percent of the pre-developed 2-year to the full 50-year peak flow. The 50 percent release rate is intended to minimize the erosive effects of runoff on creeks and streams (for this project, a large area of Wetland 43 will be provided with additional protection above the Level 2 standard). The specified release rates (see below) will be achieved using an outlet control structure with multiple orifices that allows staged discharge from the detention pond. For all storm events, the post-project peak flow rate will be below the existing peak flow rates.

	Peak Flow (cfs)	
Storm Event	Existing	Proposed
2-year	0.189	0.092
10-year	0.232	0.190
25-year	0.238	0.225
50-year	0.345	0.230
100-year	0.398	0.232

The Hydraulic Report for this project has been reviewed and approved by the WSDOT Olympia Service Center Hydraulics Office, as well as the WSDOT Northwest Region Hydraulics Office. In addition, comments concerning detention and treatment from an independent reviewer were received and addressed. The comments raised by the independent reviewer were researched, and an independent evaluation by King County has indicated that the design meets the current detention and treatment requirements. The stormwater conveyance system was analyzed using current WSDOT methods and is also compliant.

The hydraulic design also meets the requirements for "No Effects" prescribed under the WSDOT stormwater guidance concerning ESA agreed upon by NFMS.

The stormwater detention pond and biofiltration facilities will remain in place following demolition of the temporary interchange; thus, the benefits derived from the stormwater facilities will be permanent.

Construction stormwater, sediment, and erosion control

A Stormwater Pollution Prevention Plan (SWPPP) details stormwater management for the SR-509 interchange during construction and operation (See Attached). These plans identify the BMPs necessary to protect adjacent wetlands and surface water from potential water quality impacts during construction.

The BMPs—combined with the small size of the project, construction timing, and other site conditions—provide a high level of protection to adjacent sensitive areas. Construction of the project will result in a small, linear disturbance footprint, from which stormwater can readily be collected and conveyed to treatment facilities. The linear configuration reduces the likelihood that, even if BMPs failed, significant amounts of stormwater could concentrate and cause significant damage.

A proactive monitoring plan will be implemented to assure that all planned BMPs are properly implemented and maintained. Monitoring of the BMPs during storms will verify that they are effective and help identify maintenance needs to prevent potential failures. Monitoring of BMPs includes the following actions:

- Inspection during and following construction to assure that they are constructed properly,
- Inspecting each BMP following 0.5 inch of rain to determine whether any maintenance is required,
- Monitoring discharge and receiving waters to verify that permit conditions are met and that BMPs are effective,
- Use of advanced treatment methods as a contingency treatment method if monitoring demonstrates this need.

The SR-509 interchange includes the following features to assure the project can be constructed to meet water quality standards and protect adjacent wetlands:

- Protect wetland and buffers with installation of 2 layers of silt fence,

- Minimize disturbance of vegetation and soil when installing and maintaining sediment and erosion control measures,

- Treat unworked areas with erosion control cover measures according to the *King County Surface Water Design Manual,*

- Apply water to the site as necessary to control dust,

- Limit clearing and grubbing to areas that will be worked within the next 7 days,

- The contractor shall construct a temporary sedimentation pond at the site of the new stormwater detention pond at the north end of the project on the east side of the embankment prior to other land-disturbing activities (See D-1 through D-3 and details on DD-1 in Attached Plan Sheets),

- The contractor shall operate the two existing ponds on the west side of SR-509 and the new pond as sedimentation ponds. Runoff shall be diverted to the ponds (See D-3 and details on ST-1 in Attached Plan Sheets),

- The contractor shall install catch basin inserts into all existing storm drains and into all storm drains (as they are made operational).

POTENTIAL FOR DIRECT AND INDIRECT IMPACTS TO WETLANDS 43 AND 44

Ecological Conditions

No Direct or indirect impacts to water quality conditions. Based on the stormwater management facilities and BMPs described above, the temporary interchange project will not degrade water quality conditions in the wetlands. Stormwater management facilities meet King County Stormwater Manual standards and WSDOT/NMFS treatment and retrofit guidelines for "no effect." Following demolition of the interchange, stormwater quality facilities that treat stormwater which is currently untreated, will remain. This will result in a net long-term benefit to water quality conditions in the wetland.

No Direct or indirect impacts to water quantity

Based on the stormwater management facilities and BMPs described above, the temporary interchange project will not significantly alter runoff rates that could impact downslope wetland or stream habitat. Stormwater management facilities meet King County stormwater requirements. The new detention facilities result in no significant delay in stormwater runoff reaching the wetlands because Level 2 control matches past project runoff to pre-project conditions. This effect is beneficial overall in that it potentially moderates water level fluctuations that can be detrimental to some aquatic species. The separation of the existing groundwater collection system from stormwater management systems will prevent any changes to the water quantity (volume and timing) of groundwater flow that currently reaches Wetland 43.

Ecological Functions

Five biological functions were examined. These functions determine the degree to which the wetlands: (1) support resident and anadromous fish, (2) provide songbird habitat, (3) provide waterfowl habitat, (4) provide amphibian habitat, and (5) provide small mammal habitat. Four physical functions provided by wetlands were also examined. These functions examined the wetlands' ability to: (1) export organic matter to downslope systems, (2) maintain groundwater exchange, (3) provide flood storage, and (4) enhance nutrient retention and sediment trapping.

Based on evaluations of the physical and biological indicators of wetland function observed in each wetland, professional judgement, and knowledge of other wetland ecosystems in the Puget Sound region (urban and non-urban), the functional performance of these wetlands was evaluated. Functional performance ratings were assigned as follows:

> **High-** The wetland contains several important characteristics required to perform the function, and lacks indicators that prohibit the function from occurring in the wetland.
>
> **Moderate-** The wetland contains one or more characteristics required to perform the function; however, several of these may be secondary indicators. The wetland may contain one or more characteristics that interfere with or prevent optimal performance of the function in question.
>
> **Low-** The wetland lacks significant indicators that the wetland could perform the function in question. One or more indicators that the wetland does not perform the function are typically present.

Supports resident and anadromous fish.

Wetland 43 rates as moderate for this function because the wetland has persistent open water that is connected to Walker Creek, it is likely that this wetland directly supports resident fish. Walker Creek provides habitat for coho salmon downstream of Wetland 43. ESA listed fish species are not reported in the creek or Wetlands 43 and 44. The creek and wetlands do not provide habitat for listed species due to the small size of the creek, hydrologic conditions in the wetlands, and lack of suitable habitat features. There are no historical records indicating listed species once used these habitats. No salmonid or resident fish use is likely in Wetland 44, and it is rated low for this function. Wetland 44 has a seasonal hydrologic connection to Wetland 43 via a 36-inch diameter culvert under SR-509, but it does not contain significant fish habitat due to the lack of persistent surface water at sufficient depth. Both wetlands indirectly support fish by providing hydrologic functions, as described below.

Direct impacts to fish habitat will not occur during the construction and operation of the temporary interchange because no stream channel, fish habitat, or riparian area will be modified. The 36-inch diameter culvert connection between each wetland will remain and will not be altered. No vegetation that provides shade or organic matter input to streams will be removed.

Indirect impacts to fish habitat will not occur during the construction or operation of the temporary interchange, as explained in sections addressing project design, stormwater management, and wetland protection strategies

Provides habitat for song (passerine) birds

Wetlands 43 and 44 provide moderate to high habitat for songbirds. The vegetation of both wetlands provides multi-layered structure, standing dead snags, and abundant sources of food for various songbird guilds. Because Wetland 43 is larger, contains a greater number of habitat types, and contains areas more isolated from areas of human use, it provides higher quality habitat than Wetland 44. However, the location of these wetlands within an urban environment and in relation to SR-509 results in human disturbance that limits the types of species that may use the wetlands as habitat. Species using the wetland are typically tolerant of human disturbance.

No direct impacts will affect the wetlands' ability to provide habitat for songbirds during the construction and operation of the temporary interchange, because no habitat characteristics of the wetland will be changed by the project.

Increased noise from the construction and operation of the temporary interchange will not result in significant indirect impacts to passerine birds because the resident or transient bird populations that use the wetland are adapted to the high levels of noise and human disturbance that are currently present in the area. For example, the wetland adjacent to the entire project already lies near SR-509, South 176th Street, or other developed property that generate human disturbance and noise impacts. The vegetated slopes of the existing SR-509 road bed (the construction site for most of the project) are maintained as highway right-of-way through mowing and periodic clearing of woody vegetation. The portions of several parcels subject to construction are largely clear of woody vegetation as a result of former residential land uses. As a result, constructions near the wetland will neither remove any significant habitat for passerine birds nor remove any vegetation barrier that would screen the wetlands from adjacent disturbances.

Provides waterfowl habitat

Wetland 43 rates as moderate to high and Wetland 44 rates as low for this function. Wetland 43 has persistent open water and emergent vegetation that provide habitat for a variety of nesting and foraging waterfowl species. Wetland 44 does not contain open water or suitable habitat for nesting, foraging, or migrating waterfowl. Neither wetland provides suitable nesting (critical habitat) or foraging habitat for marbled murrelets. Bald eagles have not been observed in Wetland 44, but they could potentially prey upon waterfowl that use the wetland.

No indirect impacts to the characteristics of the wetland that provide waterfowl habitat functions will occur from construction or operation of the temporary interchange. Significant waterfowl habitat is not present in Wetland 44. In Wetland 43, waterfowl habitat is located over 800 feet from the project site and is densely screened from the project by forested vegetation. Thus, the project is unlikely to significantly affect levels of human disturbance in this wetland.

Provides amphibian habitat

Wetland 43 rates as moderate to high for this function, while Wetland 44 rates as low for this function. Wetland 44 contains significant open water, emergent vegetation, and downed woody debris that are key habitat features for amphibians. Wetland 44 lacks these features. Amphibian habitat adjacent to both wetlands is poor due to a variety of land-uses. In addition, the wetlands are isolated from other suitable breeding habitat that further limits the habitat value of the wetlands for amphibians.

Because interchange construction and operation will not alter wetland vegetation or hydrology, no direct impacts to amphibian habitat will occur. The project will not remove forested areas potentially used by adult amphibians, nor will it create any migration barrier between breeding habitat in the wetland and suitable terrestrial habitat elsewhere in the watershed. As explained elsewhere, Level 2 storm water management and water quality treatment facilities will prevent increased water level fluctuations or water quality impacts that could affect amphibian populations. Indirect impacts to amphibians through increased noise are unlikely.

Provides small mammal habitat[1]

Wetland 43 and Wetland 44 are rated moderate to high for this function. The vegetation in the wetlands provides heterogeneity, standing dead snags, and offers good cover and food for small mammals. Both wetlands are adjacent to SR-509 and residential development, noise and other human disturbances are prevalent in each wetland. This condition has also eliminated and fragmented habitats in adjacent upland areas, such that use of the wetlands by small mammals is limited to those tolerant of human activity.

Small mammals that are expected to use the wetlands include raccoon, opossum, coyote, mice, rats, and squirrels. Beavers inhabit portions of Wetland 43.

Significant indirect impacts, including human disturbance, to the wetlands' small mammal habitat functions will not occur. For example, while construction activities will occur near the wetland, the wetland adjacent to the entire project is already bisected by SR-509 and is near South 176th Street or other developed property. This results in ongoing human disturbance and noise. The vegetated slopes of the existing SR-509 roadway (the construction site for most of the project) are maintained as highway right-of-way through mowing and periodic clearing of woody vegetation. Portions of several parcels that are part of construction are clear of woody vegetation due to past residential landuses. As a result, construction near the wetland will neither remove any significant habitat for small mammals nor remove any vegetation barrier that may screen the

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[1] The wetlands do not provide significant habitat for large mammals because they are too small to independently support the habitat requirements of large mammals found in western Washington. Large mammals cannot use the wetlands because adjacent development and habitat fragmentation prevents access.

wetlands from human disturbance. The project will not create any new barriers that would significantly alter movements of small mammals between the wetlands and other areas of suitable habitat because the existing SR-509 roadway is already a significant barrier to wildlife movement.

Exports organic matter

Both Wetlands 43 and 44 rate as high for the export of organic matter to downslope aquatic systems (i.e., Walker and Miller creeks). This function is enhanced by seasonal (Wetland 44) and perennial (Wetland 43) channelized flow, presence of open water, and a deciduous forest overstory.

Direct or indirect impacts to this function will not occur during the construction and operation of the temporary interchange because the stream channels, hydrologic conditions, or riparian area will not be modified. The 36-inch diameter culvert connection between each wetland will remain and will not be altered. No vegetation that provides organic matter input to streams will be removed.

Maintains groundwater exchange

Both Wetlands 43 and 44 rate as high for this function. Each wetland is predominately an area of groundwater discharge, as evidenced by springs and seepage areas in several locations.

No direct or indirect impacts will interfere with the wetland's ability to maintain groundwater exchange during the construction and operation of the temporary interchange. Existing groundwater collection facilities located beneath SR-509 will be maintained during construction and operation. They will remain isolated from new and existing stormwater conveyance systems, so that no change in the rate or quality of groundwater entering the wetland will occur. Existing road fill upon which the project will be built does not provide groundwater discharge functions because the fill is elevated above the ground surface and thus isolated from groundwater tables. The SR-509 pavement surface prevents infiltration of rainwater into the fill, so there is no source of water to discharge from the fill. Drainage for the structural earth walls will contain subsurface drainage systems that allow the small amount of groundwater that could otherwise collect behind them to discharge to the wetland. Infiltration through stormwater detention facilities will likely replace the small reductions in infiltration through the existing fill due to new impervious surfaces[2].

Provides flood-storage and runoff de-synchronization

Wetland 43 rates as high and Wetland 44 rates as low to moderate for this function. Wetland 44 is a slope and offers hydrologic roughness that slows and temporarily detains stormwater. Wetland 43 is a large depression that detains floodwater and moderates peak flows in Walker Creek, which has its source in this wetland.

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[2] Infiltration into fill immediately adjacent to the wetland would not affect creek base flows because the time of travel between the point of infiltration and downslope discharge site 10 – 50 feet away would be very short. Therefore, the effect of reduced infiltration due to new pavement would not be significant.

No direct or indirect impacts will occur to these wetlands' ability to provide flood-storage and moderate peak flows during the construction and operation of the temporary interchange, because no physical modification to the wetland will occur. Wetland area, existing hydrologic connections, wetland topography, and wetland vegetation will not be altered by the project.

Enhances nutrient retention and sediment trapping

Wetland 43 rates as high and Wetland 44 rates as moderate for this function. Wetland 44 is a slope with channelized flow that exits the wetland through a 36-inch diameter culvert at SR-509. The wetland may act as a sink for sediment that enters the perimeter of the wetland. However, due to the high gradient and eroded channel in the base of the ravine, it is also likely to be a source of sediment to Wetland 43. The large area, dispersed channels, low-flow velocities, and dense vegetation in Wetland 43 create nearly optimal conditions for nutrient retention and sediment trapping. The open water in Wetland 43 would be subject to high solar radiation during the summer months and would contribute to high stream temperatures in the upper portion of Walker Creek.

No direct or indirect impacts will interfere with the wetland's ability to retain nutrients and trap sediments during the construction and operation of the temporary interchange. Wetland area, existing hydrologic connections, and wetland vegetation will not be impacted during the project.

Buffer Functions

As explained above, the temporary interchange project will not result in significant indirect impacts to the functions provided by Wetlands 43 and 44. The modification to the wetland buffer through development of the interchange will not alter characteristics of the wetland that are critical to providing the various functions analyzed above. Neither will the modifications alter the protective functions that a buffer could provide (i.e., screening of the wetland from human activities or protection of water quality), because significant woody vegetation is removed through periodic maintenance and because stormwater is not conveyed to the buffer for treatment. Therefore, it is apparent that the areas modified for the interchange do not provide significant protective functions as a wetland buffer. Their ability to function as wetland buffer has been eliminated by past filling and their existing land uses (i.e., as highway, street, and residential areas) that result in periodic mowing and elimination of most native vegetation.

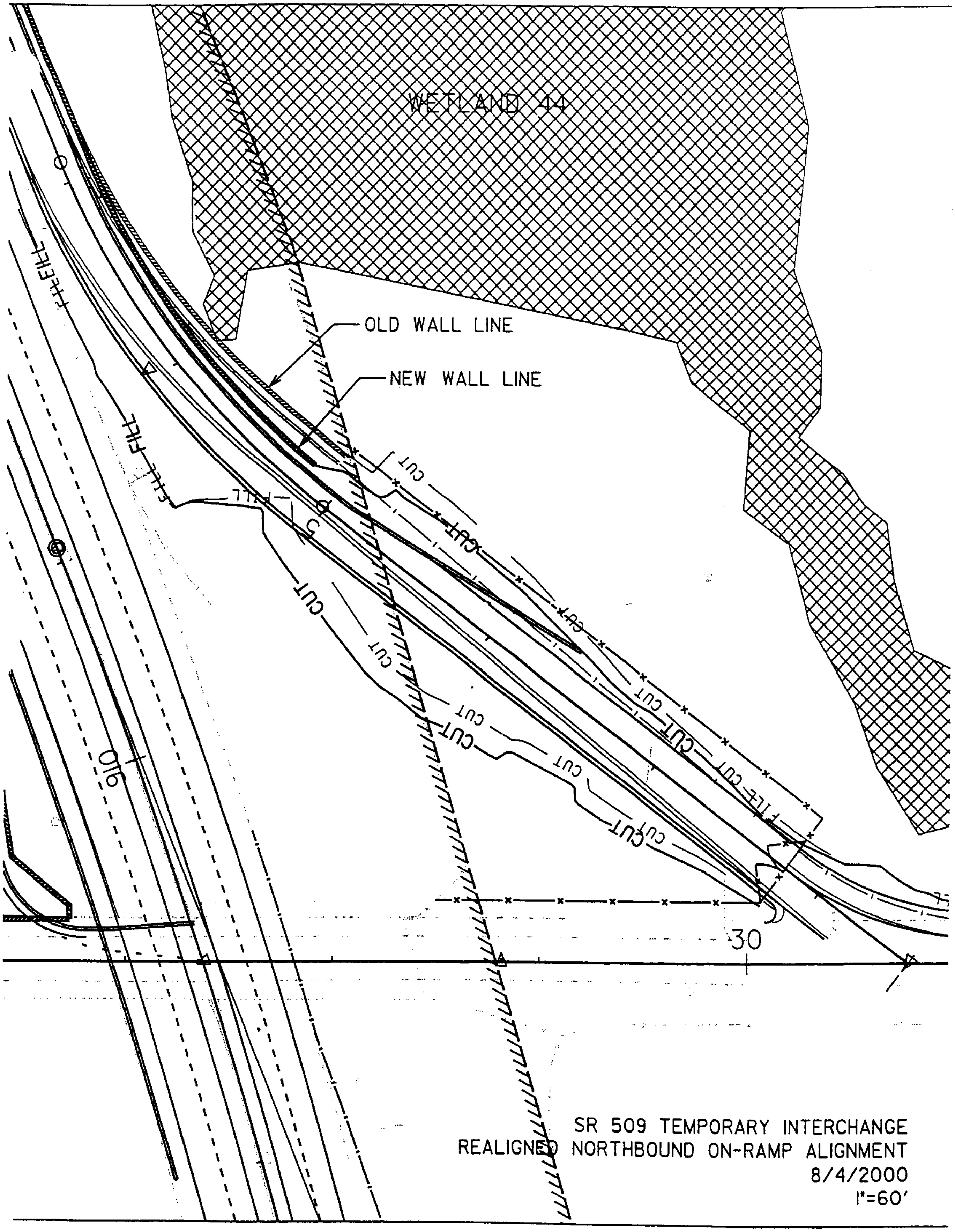
CONCLUSION

The proposed interchange project involves no discharge of fill material to waters of the United States. Further, the proposed interchange project has been exhaustively evaluated for potential direct and indirect impacts to the condition and ecological functions provided by the wetlands. Based on the project design and analysis presented above, no direct impacts and no significant indirect impacts to the wetland will occur.

Attachments:

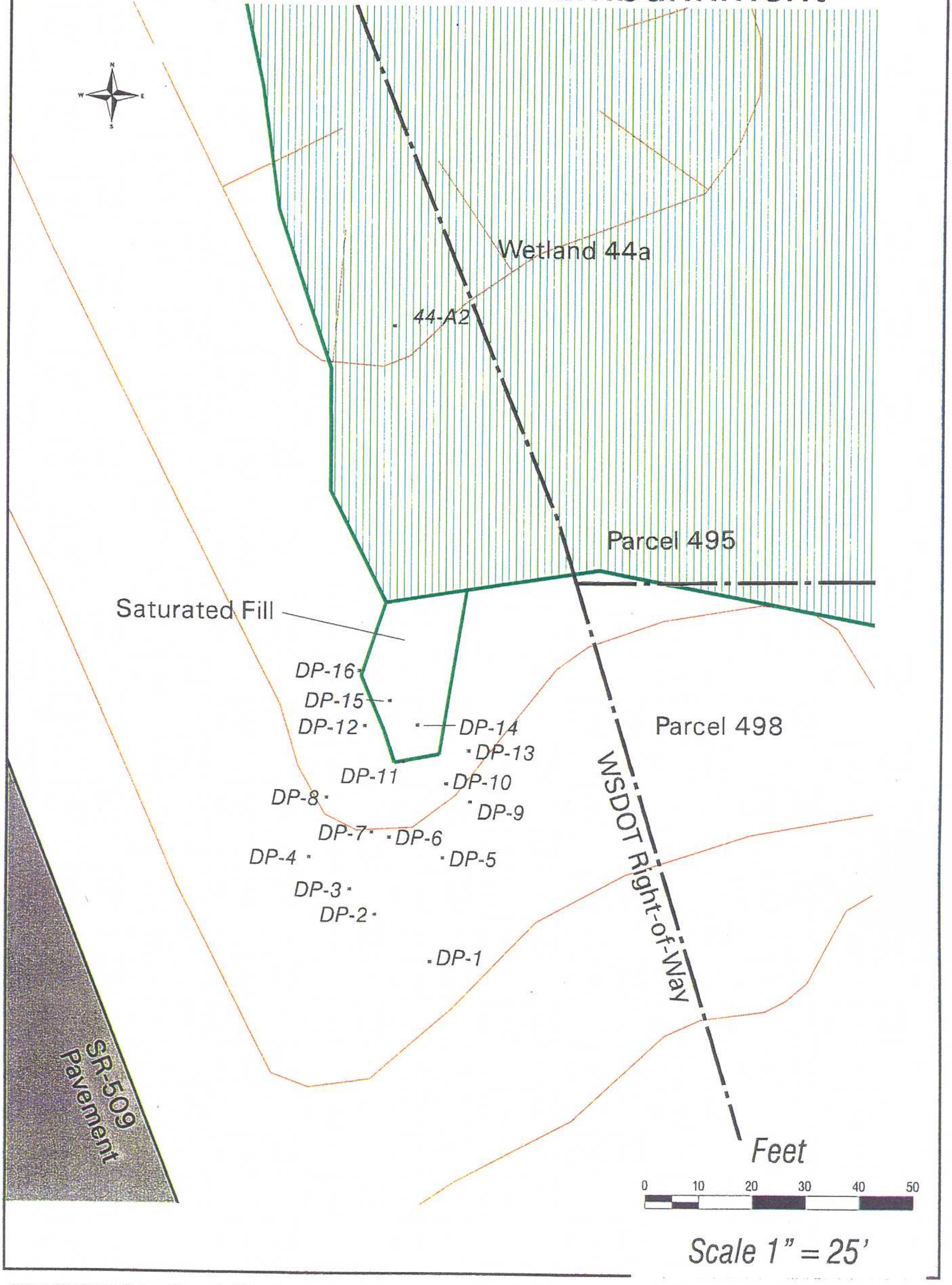
Plan Set
Hydraulic Report
1961 and 1995 aerial photographs
Wetland delineation map

\\KIRKLAND_1\VOL1\DATA\working\2912\55291201\03mpu\509 Wetland Memo_.doc



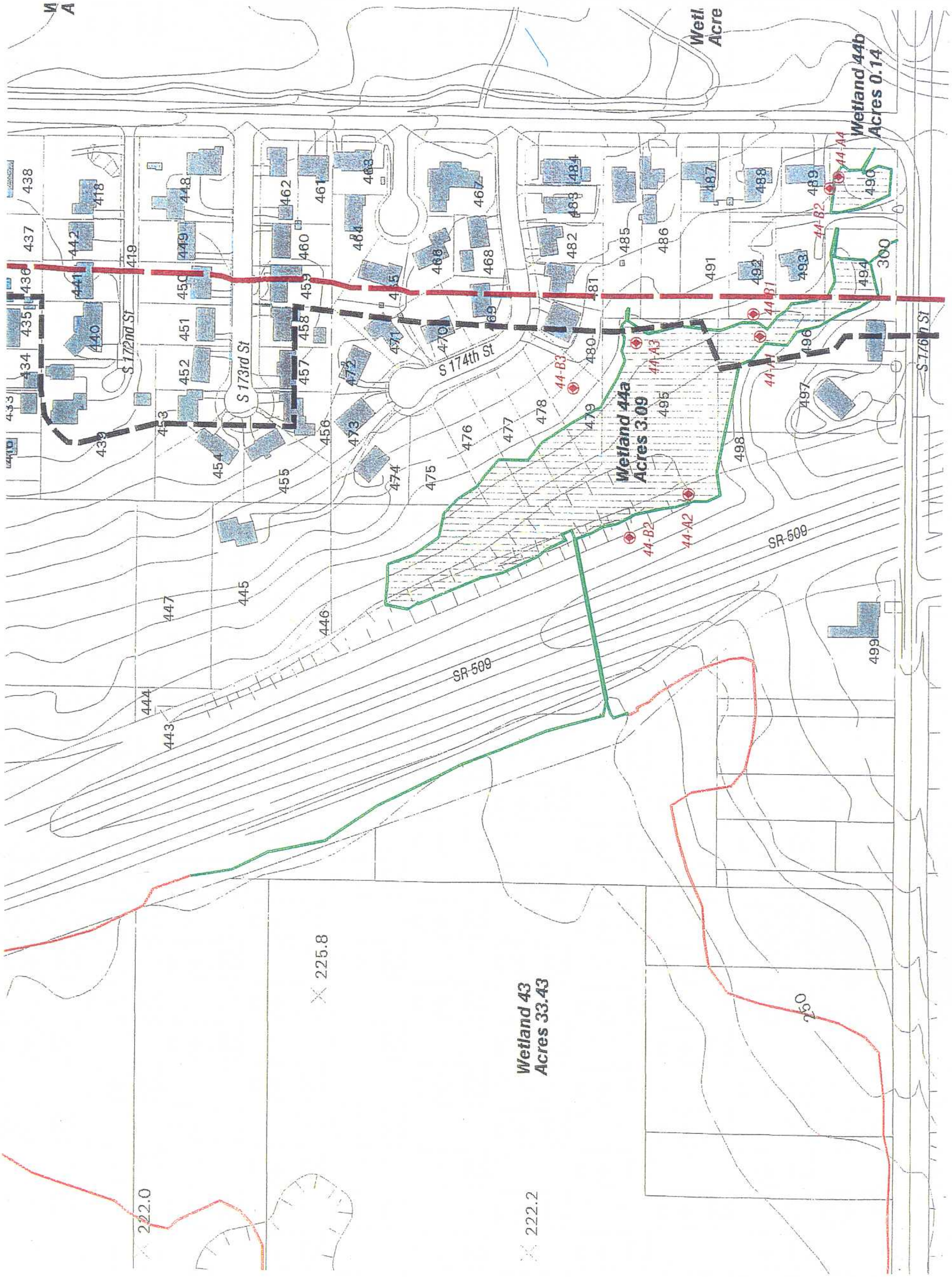
SR 509 TEMPORARY INTERCHANGE
REALIGNED NORTHBOUND ON-RAMP ALIGNMENT
8/4/2000
1"=60'

Saturated Fill on SR-509 Embankment



Scale 1" = 25'

Prepared by Parametrix, Inc. File: seatac2/plotamls/p_ponds_032300.am creating srvy44a-000613.gra Date: June 15, 2000


Wetland 44b
Acres 0.14
Wetland 44a
Acres 3.09
Wetland 43
Acres 33.43
Wetl
Acre
SR-509
SR-509
S 172nd St
S 173rd St
S 174th St
S 176th St
44-A4
44-B2
44-B1
44-A1
44-A3
44-B3
44-A2
44-B2
300
225.8
222.0
222.2
250
438
437
436
435
434
433
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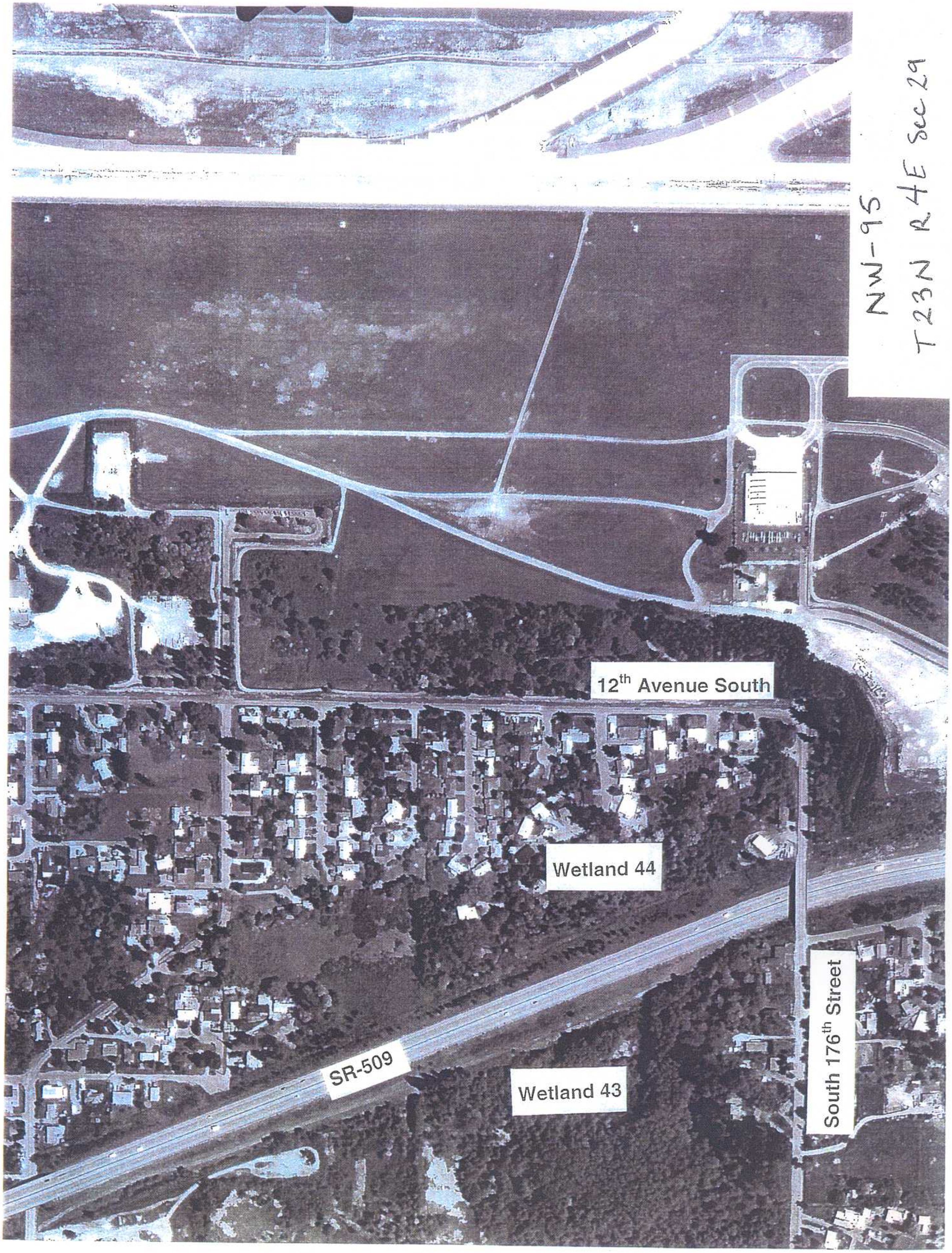
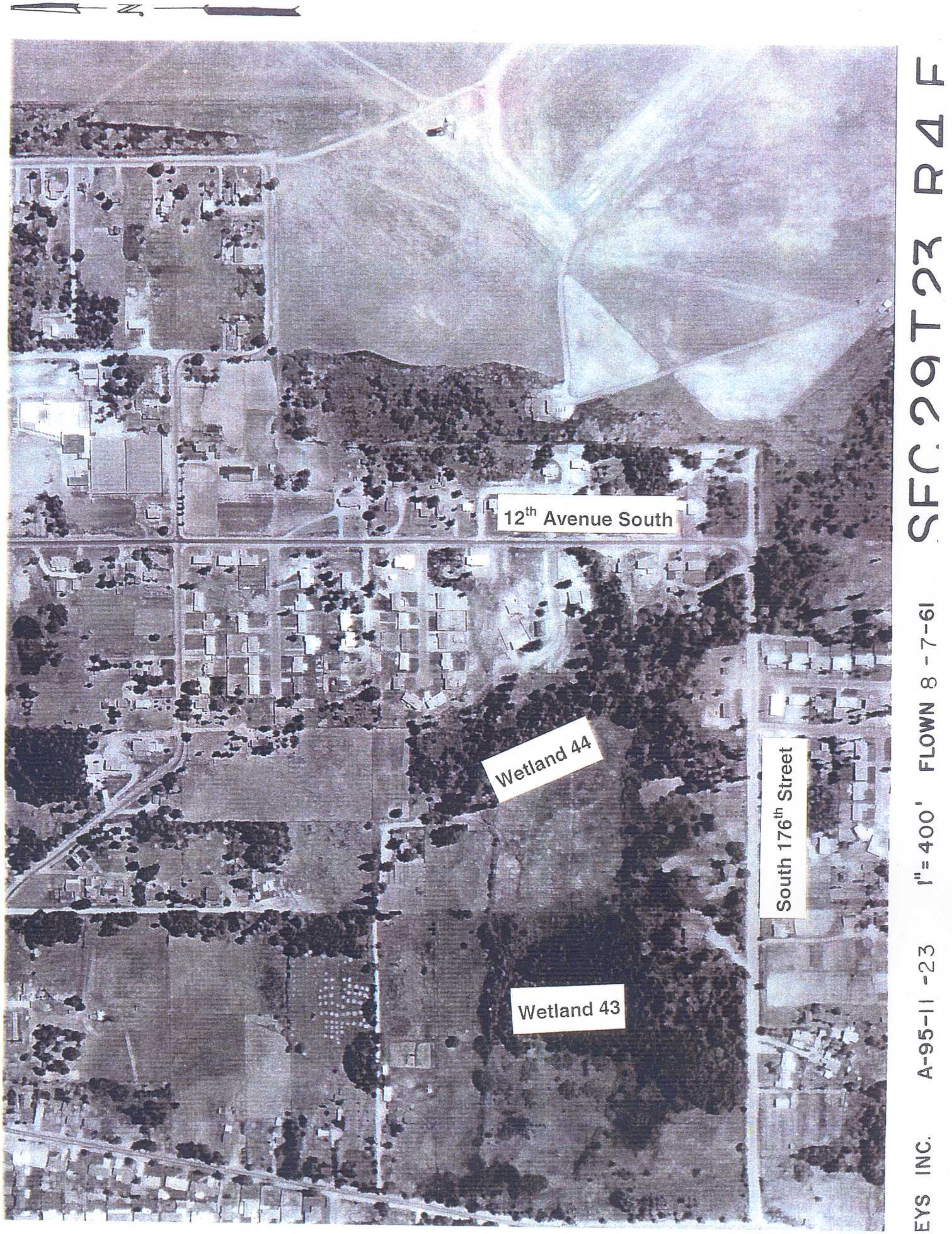


NW-95
T23N R4E Sec 29


N
12th Avenue South
Wetland 44
South 176th Street
Wetland 43
SEC.29 T23 R4E
EYS INC. A-95-11-23 1"=400' FLOWN 8-7-61

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 3755
SEATTLE, WASHINGTON 98124-3755

REPLY TO
ATTENTION OF

Regulatory Branch

AUG 24 2000

Elizabeth Leavitt
Manager, Aviation Environmental Programs
17900 International Blvd., Suite 301
Sea-Tac WA 98188-4236

Reference: 1996-4-02325
Seattle, Port of

Dear Ms. Leavitt:

Enclosed is a copy of our Memorandum for the Record confirming the final jurisdictional determination for your proposed SR 509 Temporary Interchange. We concur with the boundaries as outlined in the map submitted by Parametrix Inc. on your behalf, dated June 15, 2000. Our concurrence is also based on site visits performed by U.S. Army Corps of Engineers (Corps) staff on May 25, 2000, and June 8, 2000, and preliminary field data submitted by Parametrix on June 12, 2000.

This new information warrants revision of the southern boundary of Wetland 44a, previously confirmed by the Corps based on the revised draft "Wetland Delineation Report, Master Plan Update Improvements for Sea-Tac International Airport", prepared by Parametrix Inc., dated August 1999. This wetland delineation confirmation revision may be appealed if you so choose. Enclosed is the March 9, 2000, administrative appeal rule package.

The most recent plans for the proposed SR 509 Temporary Interchange, dated May 3, 2000, include the discharge of fill material into 0.011 acres, or approximately 500 square feet of a jurisdictional wetland. We will analyze this additional impact together with all of the project impacts for the Sea-Tac Master Plan update project in making a permit decision. You are not authorized to proceed with the work outlined in the SR 509 Temporary Interchange plans before we reach a permit decision for the entire project. If you decide to redesign the project to avoid Corps jurisdiction, please submit new project plans to the Corps for review.

For your information, when the Corps has completed revising the original Memorandum for the Record for all waters of the United States, including wetlands in the project area, we will provide you a copy. If you have any questions, feel free to contact Mr. Jonathan Freedman, the project manager at (206) 764-6905.

Sincerely,

SIGNED

Thomas F. Mueller
Chief, Regulatory Branch

Enclosures

Copy Furnished: Parametrix Inc., Attn, Jim Kelley

NWS-OD-RG 13 June 2000

MEMORANDUM FOR RECORD: Jurisdictional Determination

1. **Applicant.** Port of Seattle - Third Runway Project
1996-2-02325

2. **Background/Project Description.** The U.S. Army Corps of Engineers (Corps) is currently reviewing the Port of Seattle's (Port) proposal to construct a third runway and related facilities at Sea-Tac International Airport (STIA), located at the city of Sea-Tac, Washington. The Corps has not, to date, made a permit decision on the proposal. It came to the Corps' attention that the Port had plans to begin construction on a temporary interchange at S. 176th St. and SR 509 during the summer of 2000. The temporary interchange would facilitate truck access for fill material for the third runway, which is being stockpiled on upland portions of the Port's property. The Port is fully aware that any construction they do related to the Third Runway project on uplands before the Corps has made a permit decision, they do so at their own risk. The Corps will consider any of those activities preceding our permit decision in our final determinations for the project as if they were still prospective.

The Port, concerned citizens and scientists, Washington State Department of Transportation (WSDOT), and Congressional entities have all requested that the Corps make a jurisdictional determination on the construction of the temporary interchange. The Corps has reviewed the following documents in making our determination in relation to this specific action for the project:

Project Manual, Including Specifications for SR 509 Temporary Interchange at South 176th Street, prepared by the Port of Seattle, dated March 1, 2000. This appears to be a bid document.

Port of Seattle Advertisement for Bids document (SR 509 Temporary Interchange at South 176th Street), dated March 22, 2000.

Letter from the City of Burien to Mayor of Sea-Tac expressing concern over the temporary interchange, dated March 28, 2000.

Letter from Hesell/Fetterman to WSDOT and Washington State Department of Ecology (Ecology) concerning temporary interchange, dated April 6, 2000.

Hydraulic Report (Seatac International Airport Third Runway Direct Access, Temporary Interchange at SR 509 and South 176th Street, SR 509 M 23.19 to 23.71), prepared by HNTB Corporation, dated April 12, 2000. The report was addressed to WSDOT.

Memorandum (Analysis of indirect impacts to wetlands from the temporary SR-509 interchange - Seattle-Tacoma International Airport), prepared by Parametrix, dated May 3, 2000.

A full set of construction plan drawings for the Temporary Interchange project, prepared by HNTB Corporation. The Corps received this set of drawings on May 8, 2000. The drawings are dated February 24, 2000.

Letter from Peter Eglick, Attorney (Helsell Fetterman) for Airport Communities Coalition (ACC), dated May 24, 2000.

Report prepared by Azous Environmental Sciences (Review of Wetlands Impacts Resulting from Construction of Temporary Intercahnge at SR 509 and S. 176th Street), dated May 24, 2000.

Letter from the Law Offices of Helsell/Fetterman concerning the ACC's Supplemental 60 Day Notice of Intent to Sue, dated June 2, 2000.

Report prepared by Azous Environmental Sciences (Review of Wetland 44a in Relation to proposed Temporary Interchange at SR509 and S. 176th Street), dated June 5, 2000.

Letter from the Law Offices of Helsell/Fetterman to Mr. Phil Schneider, Habitat Biologist, Washington Department of Fish and Wildlife (WDFW), dated June 6, 2000.

Report prepared by Columbia Biological Assessments (Sea-Tac International Airport SR-509 Temporary Interchange at S 176th Street and Its Potential Impacts on Fisheries Resources of Walker Creek), dated June 6, 2000. This report was addressed to Phil Schneider (WDFW) with a copy to the Corps.

Preliminary information (map, data sheets, soil descriptions) for the east side area of the proposed temporary interchange, submitted by Parametrix, dated June 12, 2000.

A series of e-mail exchanges between Ecology, the Corps, and King County (King County is the lead on reviewing the Port's most recent Stormwater Plan for the proposed Third Runway Project), concerning the temporary interchange. E-mails from Ecology were forwarded to the Corps on May 23, 2000; May 26, 2000; June 2, 2000.

It should be noted that the above document list is not an exhaustive list. The Corps has received letters of concern from citizens in regards to the temporary interchange project stating that there may be direct and indirect impacts to wetlands. The Corps has considered all submittals for our decision relevant to the temporary interchange. All information, documentation, reports, letters, etc., which the Corps received in response to the Ports proposal to move forward with construction of the temporary interchange remain a part of the official Corps record for this permit action.

3. **Site Visits.** In addition to the Corps reviewing all of the relevant information concerning the temporary interchange, the Corps conducted site visits to this area on three separate occasions. These include the following:

Summer of 1998. The Corps conducted dozens of site visits to the area of the Third Runway Project during this period of time, as the Port acquired properties in the buy-out and project impact areas. The Corps does not have specific data sheets correlating to Wetland 43 (located on the west side of SR 509) or Wetland 44a (located on the east side of SR 509). There is conflicting information presented in the Wetland Delineation Report (Report), prepared by Parametrix, and dated August 1999, for Wetland 43. According to Figure 4 of the Report, the Corps never did confirm the boundaries of Wetland 43, but we had confirmed the entire boundary for Wetland 44a. Table 3 of the Report (Summary of wetland and other waters of the U.S. areas in the STIA Master Plan Update improvements area), does not even list Wetland 43, nor is it described in the Report. However, Map #10 in the Report shows part of the eastern boundary of Wetland 43 as being surveyed and confirmed by the Corps. In addition, the Report shows the northern edge of Wetland 44a was neither surveyed, nor confirmed by the Corps (the Corps points this out in our MFR for the wetland delineation - final document in progress). The Corps did not concentrate our efforts in confirming the wetland delineation lines in this area since during the summer of 1998, we were not made aware of any construction impacts (either direct or indirect) that were proposed or anticipated in this area.

Parametrix contends that the Corps did look specifically at the wetland delineation line for Wetland 44a in the area closest to the proposed temporary interchange; however, neither the project manager nor the environmental analyst who conducted all site visits can recall with any certainty that we **specifically** (as in which flags) looked at the entire line in this area. After receipt of the information regarding the SR 509 temporary interchange, the Corps determined it was appropriate to conduct another site visit to accurately confirm the delineation in this area due to the proximity of the proposed temporary interchange to wetlands 43 and 44a.

May 25, 2000. Corps staff met with Parametrix and the Port on site at the proposed interchange location to review project plans and to consider comments we had received from Azous Environmental Sciences concerning the wetland delineation in the project plans - specifically concerning Wetland 43. While on site, Corps staff requested that we closely look at the " pinch" point for Wetland 44a (that point at which the proposed retaining wall for the interchange comes closest to the delineated wetland - approximately 12 feet). During that inspection, it became apparent that the wetland delineation was inaccurate for the western boundary of Wetland 44a, since there was hydrology and wetland vegetation expression above and east of the wetland delineation line flagged by Parametrix in the summer of 1998 and presented in the wetland delineation report, dated August 1999). Soils dug in this area were clearly hydric. Several plots which the Corps took outside of the delineated area, contained the 3 wetland parameters (hydrophytic vegetation, wetland hydrology, and hydric soils). We collected some data (see attached data sheets). The potential wetland continued upslope from the Wetland 44a boundary. We also inspected the rock lined highway swale, which had clearly not been maintained for quite some time. Much of the site in this location was dominated by Himalayan blackberry, with an understory of horsetail, and grasses (fescue, some velvet grass, and bentgrass). We asked the Port to remove the blackberries by hand and to look at the area and submit a report of their findings. Based on the information we collected and observed in the field, and the Port's own data, there appears to be an area within the footprint of the retaining wall for the temporary interchange which meets the three parameters for a wetland. It was agreed that the Corps had to make a decision on whether this wetland was jurisdictional and to consider all relevant factors for making a decision. One relevant factor to be considered was that the wetland had formed in fill soils placed in 1978 for construction of SR 509 (see more discussion below in jurisdictional determination).

In addition to inspecting the area around Wetland 44a, we also inspected the area on the west side of SR 509, inclusive of Wetland 43. The discrepancy between HNTB's project plans and the wetland delineation, as pointed out in the Azous Report, became apparent during our site visit. The area in question contained two older and vegetated (PSS/PEM/POW) stormwater ponds constructed by WSDOT for SR 509. The ponds were excavated in hydric soils (wetlands), and as such, would be considered jurisdictional, if the project included discharges into these ponds. Maintaining the ponds to original depths and configuration could be authorized via Nationwide Permit 3, but as of the date of this MFR, the Port does not have plans to impact these ponds either by filling or maintaining them to original contours. In the wetland delineation which Parametrix prepared for the project as a whole (August 1999), the stormwater ponds in this area were included within the boundaries of Wetland 43. HNTB excluded the stormwater ponds from Wetland 43 per the request of WSDOT. According to HNTB, WSDOT requested that the ponds not be included in the wetland area because it is within WSDOT's right-of-way, and WSDOT (erroneously) assumed that the ponds would not be jurisdictional. Since the ponds are jurisdictional, HNTB will revise the temporary interchange drawings to reflect this.

Based on this site inspection, the Corps was able to confirm the wetland delineation line for Wetland 43 - it is clearly demarcated by a compacted gravel fill access road. The wetland edge starts at this fill prism and continues westward into a large wetland system (known as the Airport Park Wetland). There will be no direct impacts to this wetland from the construction of the temporary interchange on the west side of SR 509. This statement is based on the Port's assertion that the stormwater outfall into the stormwater ponds does not need to be retrofitted for the construction of the temporary interchange. We will not know that for sure until all the stormwater issues are worked out between Ecology, WDFW, King County, and the Port.

In addition, the Corps has determined that it is appropriate to confirm the delineation of the northern edge of Wetland 44a since the Port now has access to this property and it is in the vicinity of the proposed temporary interchange. The Corps plans on doing this in the near future.

June 8, 2000. The Corps (Gail Terzi, Tom Mueller, Geoff Mueller), EPA (Steve Roy, EPA attorney - Deborah Hilsman), Port (Elizabeth Leavitt, Tom Walsh - Port attorney), Parametrix (Jim Kelley), and HNTB engineer (Jim Soukup) all visited the site. During this site visit, the Port presented information that they believed should lead the Corps to conclude that it should not regulate those areas adjacent to the western boundary of Wetland 44a which met the 3 wetland parameters.

The Port's contention is that the hydrology associated with the subject area is due to either (1) the unmaintained rock lined highway swale leaks laterally during storm events to express hydrology in that area of the fill material, or (2) all/some of the subsurface drains installed by WSDOT when SR 509 was built are not functioning properly, thereby leaking subsurfacely, and expressing on the surface at the base of the fill slope. The Port also stated that the catch basin (located at the top of the fill slope between the SR 509 fill embankment and the highway) which captures groundwater from the subsurface drains in the cut for SR 509 construction may be cracked and leaking, thereby allowing groundwater and/or stormwater to infiltrate in the fill area, which is being expressed through the now hydric fill at the base of the slope for SR 509. We all had a long discussion of the potential source(s) of hydrology in the field. Several plots were dug - no official data was taken during this site visit. All in attendance agreed that the area in question met the three wetland parameters.

One option presented to the Port was that they could maintain the highway drainage system (ie - fix the leakage problem, reconstruct and line the rock lined swale, inspect the catch basin, etc.). Then the Corps could revisit the site later, such as in the early spring of 2001, to see if the subject area still met the 3 wetland parameters. If it did not meet the three wetland parameters, this would potentially substantiate their opinion that the hydrology was artificially created from leakage from the stormwater swale constructed in the fill embankment or the subsurface drains. The Port has declined to take this option.

4. Jurisdictional Determination. The following factors were considered in our decision:

- Preceding the construction of SR 509 around 1978, Wetlands 43 and 44a were one very large contiguous wetland system. Construction of the highway bisected the wetland into two parts. Inspection of aerial photography has substantiated this.
- A majority of the fill for this area of SR 509 was placed in a wetland. It appears from the surrounding landscape, that some hillsides were cut and some wetlands were filled for construction of SR 509. The drainage patterns in this entire area have been substantially altered, and the present condition has existed for at least 22 years.
- This area does not meet the definition of discharges not requiring permits as described at 33 CFR, Section 328.3(e). It is not a " waterfilled depression created in dry land incidental to construction activities."
- The fill material for the SR 509 embankment has been in place for some 22 years. It would now be considered a new normal circumstance. It is apparent that the wetlands have formed at the area where two fill slopes intersect. This is at the point where the slopes briefly flatten out before continuing easterly, down another fairly steep slope to the native wetland in the original landscape position.
- The delineation for Wetland 44a, as depicted in the wetland delineation report, included an area upslope (west of) the native soils and wetland. The Corps accepted this as a new normal circumstance and considered this area as jurisdictional wetland. The wetland conditions presented further upslope (continuing in a westerly direction) and outside of the original wetland delineation line for Wetland 44a have the same characteristics as the area included in the original delineation. It should be noted that the Port contends that the hydrology associated with the area of Wetland 44a in the fill slope which was included in the original delineation is driven by capillary fringe of the wetland hydrology immediately downslope. The Port has stated that they believe that capillary action could not account for the wetland hydrology further upslope (it is generally accepted that capillary fringe action can occur in about 12 inches of non-sandy soils).
- The hydrology associated with the subject area appears to be coming from either groundwater, subsurface seepage of

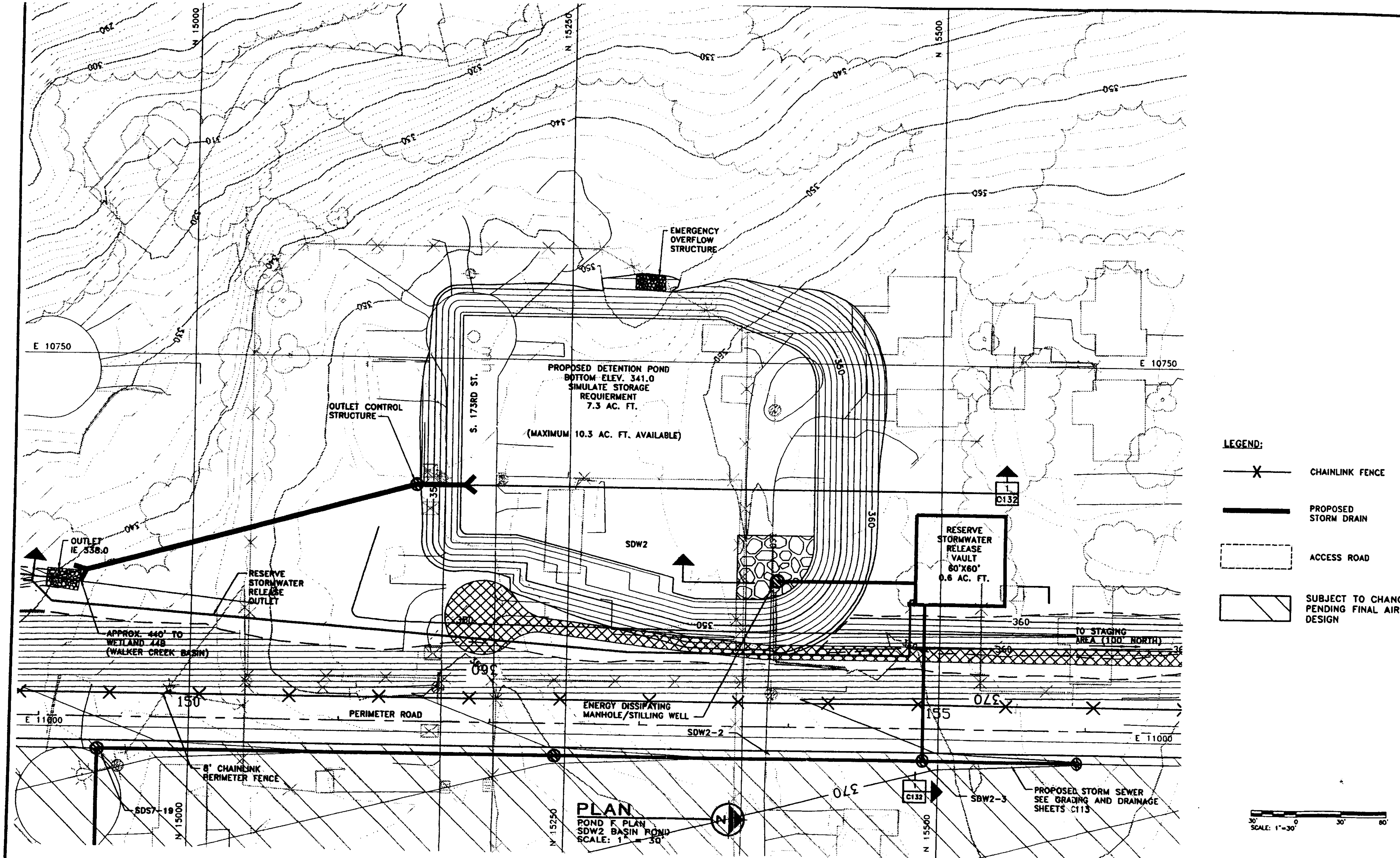
APPENDIX I

APPENDIX I

STORMWATER DETENTION POND DESIGN FOR THE MILLER CREEK BASIN

POND PLAN AND PROFILES

Plan Ref. No.	Sheet Title
C131	POND F PLAN
C132	POND F PROFILE
C133	POND D OUTLET PLAN
C133.1	POND D PLAN
C134	POND D PROFILE
C134.1	POND D SECTIONS
C135	POND G PLAN
C135.1	PONDG MISCELANEOUS PROFILES
C136	POND G PROFILE
C137	POND C PLAN
C138	POND C PROFILE
C139	SDS4 BASIN VAULT PLAN AND PROFILE
C140	SDS7 BASIN VAULT PLAN AND PROFILE
C141	SDS3, 3A, AND 5 BASIN VAULT PLAN AND PROFILE
C142	NOT USED
C143	NOT USED
C144	NOT USED
C145	SDN3 BASIN VAULT PLAN AND PROFILE
C146	SDN2/SDN4 BASIN VAULT PLAN AND PROFILE
C147	M6 BASIN VAULT (NEPL) PLAN AND PROFILE
C148	SDN1 BASIN VAULT PLAN AND PROFILE
C149	SDN6 BASIN (CARGO) VAULT PLAN AND PROFILE
C150	SDN3A BASIN VAULT C1 AND C2 PLAN AND PROFILE
C151	SDN1A BASIN VAULT G1 PLAN AND PROFILE

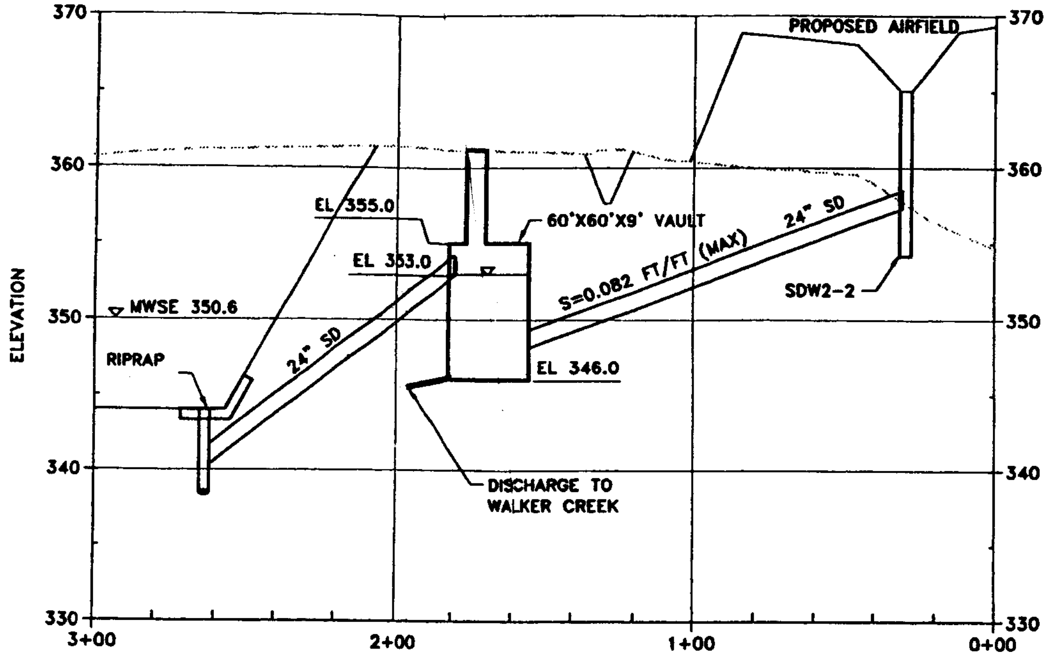


Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6

SHEET TITLE: POND F PLAN
SDW2 BASIN POND

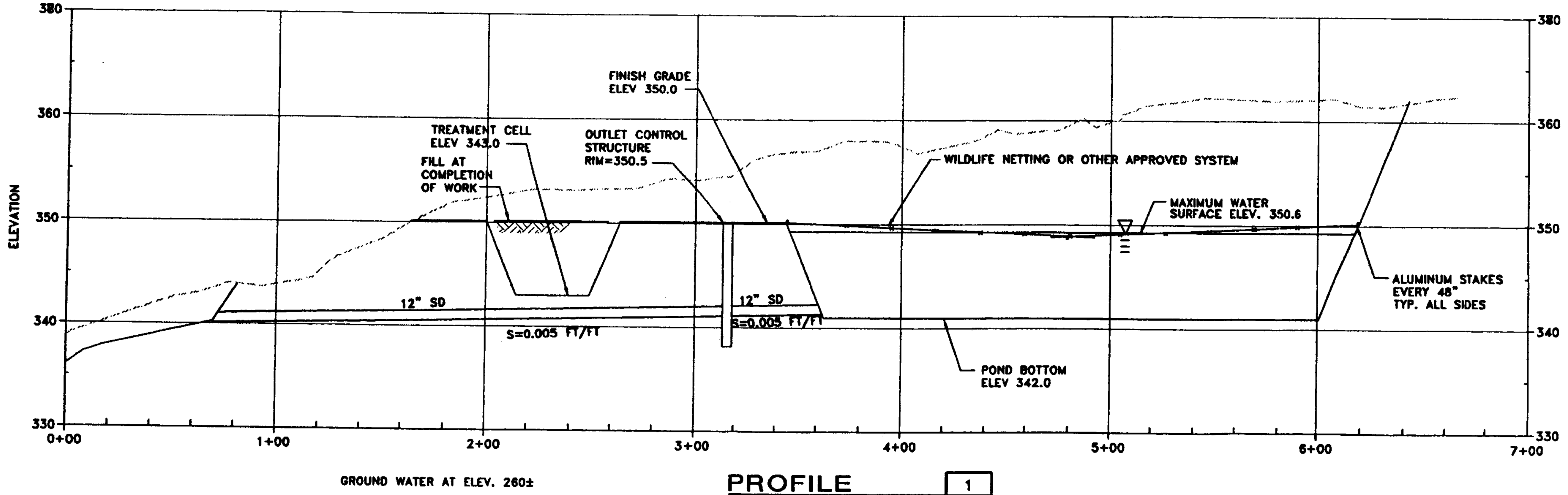
DATE	DEC. 15, 2000
CONSULTANT'S NO.	
PORT OF SEATTLE NO.	EXHIBIT_ C131



PROFILE

STORM DRAIN AND RESERVE
STORMWATER RELEASE VAULT PROFILE
SCALE: 1" = 30'

2
C131



PROFILE

POND F PROFILE
SDW-2 BASIN POND
SCALE: 1" = 30'

1
C131

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

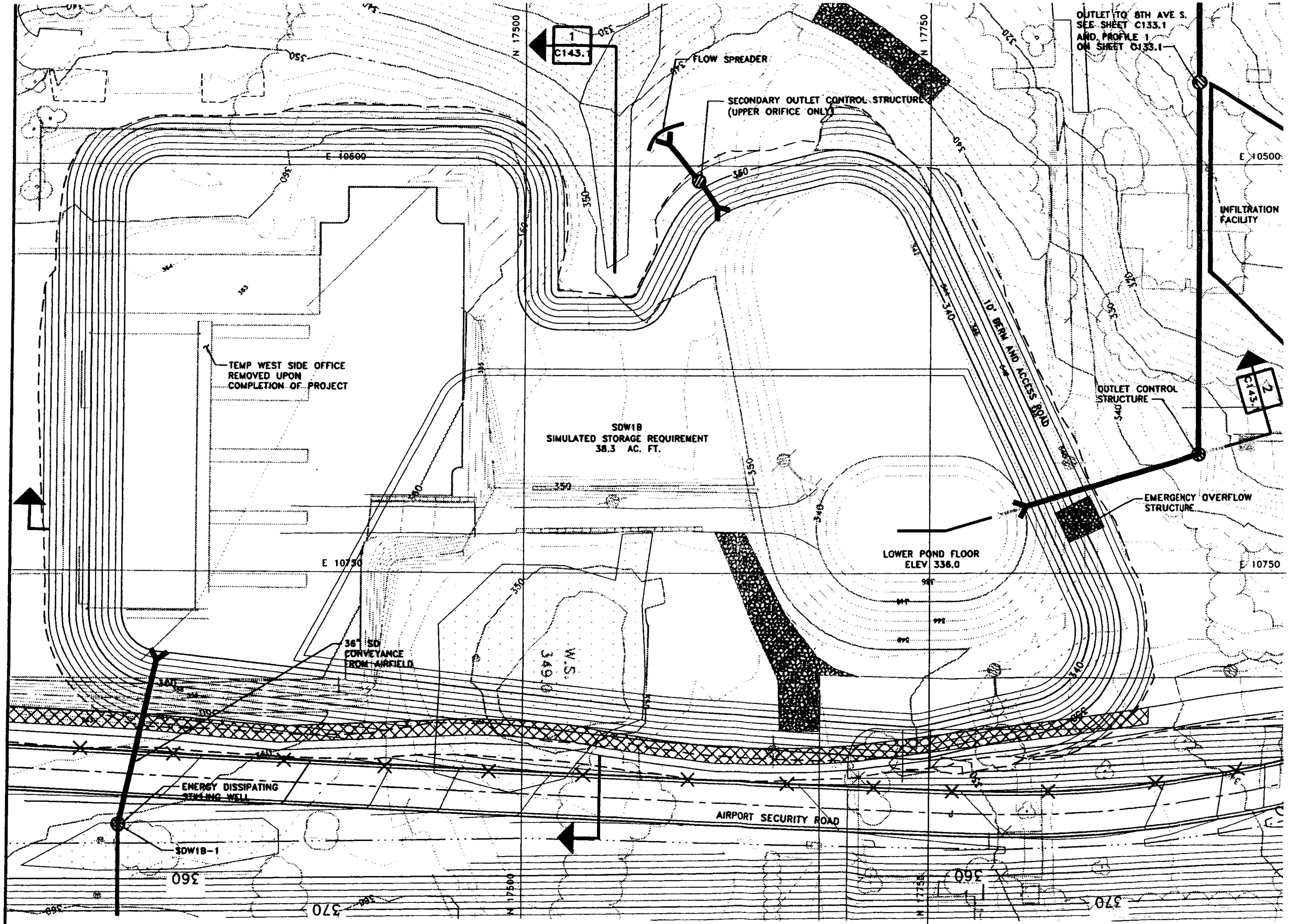
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: **POND F PROFILE**
SDW2 BASIN POND

DATE
DEC. 14, 2000

CONSULTANT'S NO.

PORT OF SEATTLE NO.
EXHIBIT_C132



PLAN

POND D PLAN
SDW1B BASIN POND
SCALE: 1" = 30'

NOTE:

THE DESIGN WILL ACCOMMODATE A TOTAL POND VOLUME OF 38.34 AC. FT. BY EXPANDING POND D TO THE SOUTH AS SHOWN.

LEGEND:

	TEMPORARY SWALE
—×—	CHAINLINK FENCE
━	PROPOSED STORM DRAIN
▭	ACCESS ROAD AROUND POND G
▭	WETLANDS

30' 0 30' 60'
SCALE: 1"=30'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

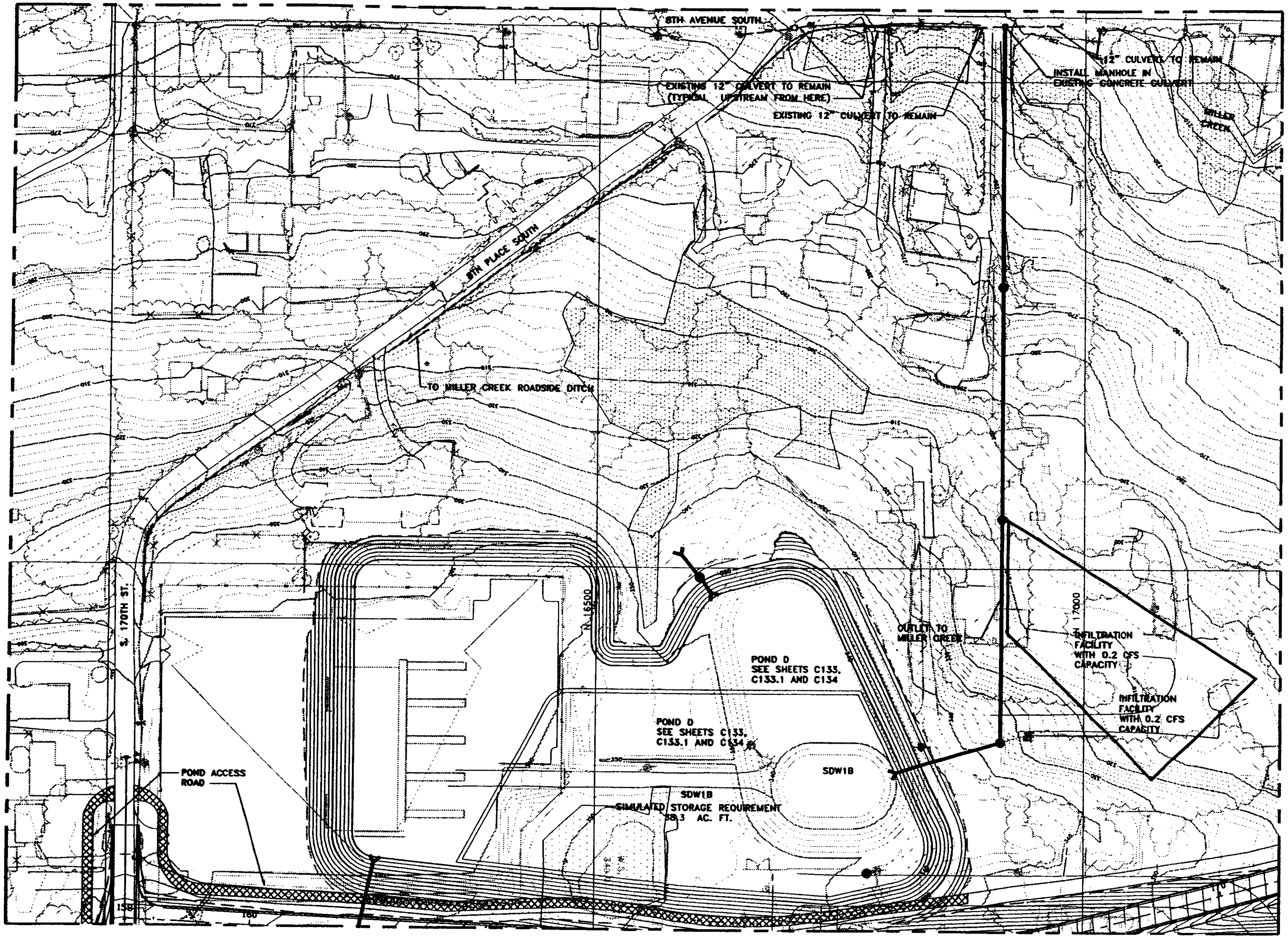
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6

SHEET TITLE: POND D PLAN
SDW1B BASIN POND

DATE
DEC. 15, 2000

CONSULTANT'S NO.

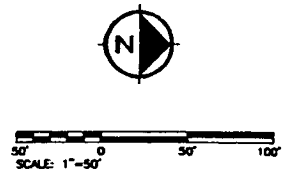
PORT OF SEATTLE NO.
EXHIBIT_ C133



NOTES:

LEGEND:

———	STORM DRAIN PIPE



Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

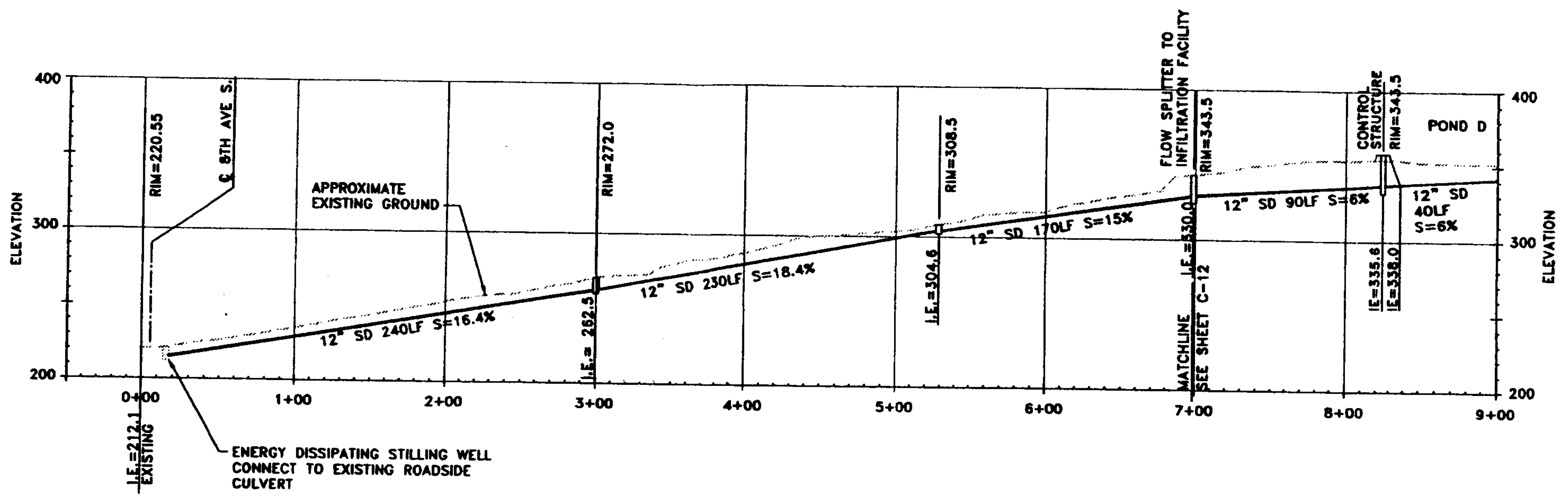
SHEET TITLE: **POND D - OUTLET PLAN**

DATE
DEC. 15, 2000

CONSULTANT'S NO.

PORT OF SEATTLE NO.

EXHIBIT_ C133.1



PROFILE

POND D DISCHARGE TO MILLER CREEK
SCALE: H 1" = 50'
V 1" = 50'

1
C131

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

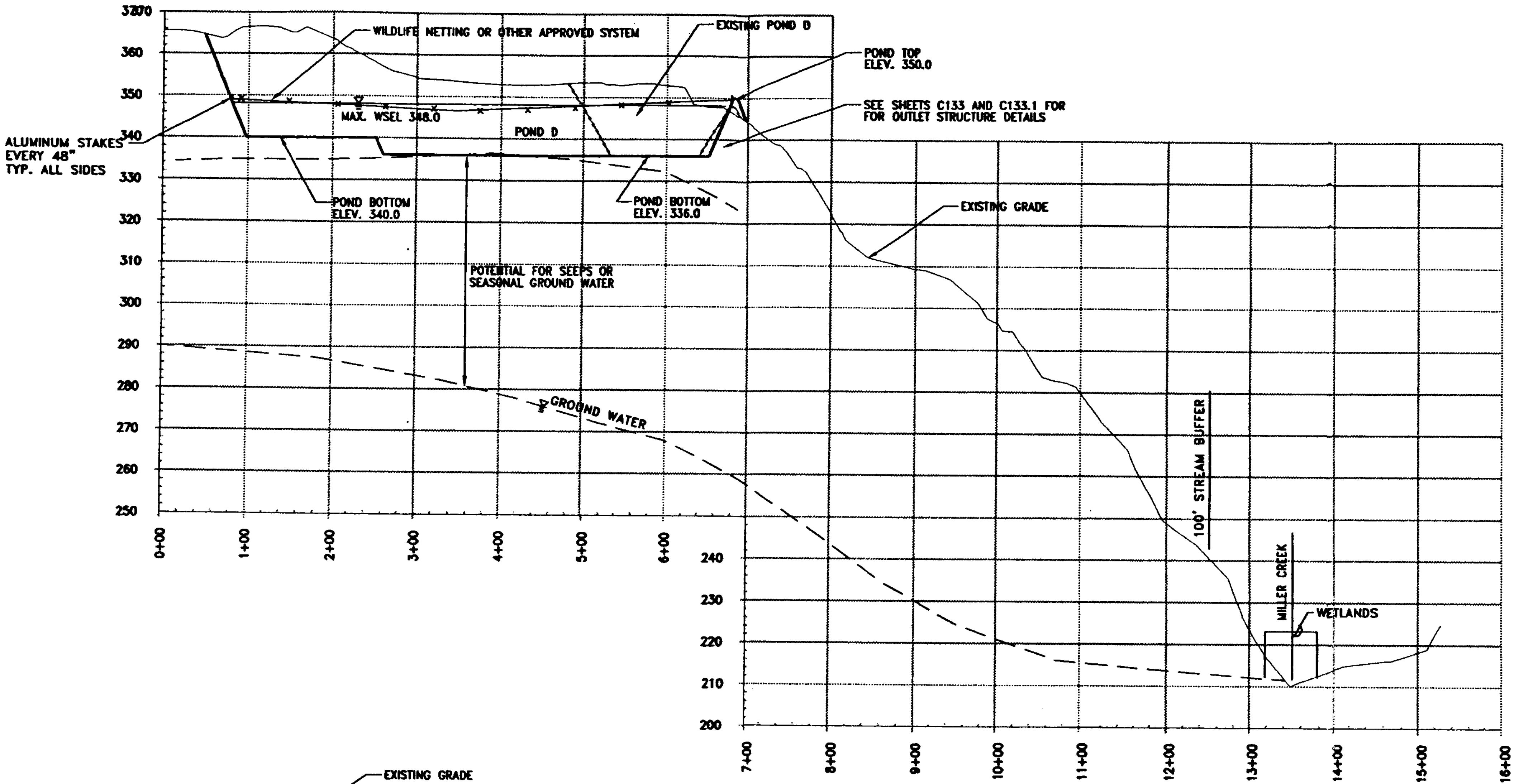
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: **POND D PROFILE**
SDW1B BASIN POND

DATE
DEC. 14, 2000

CONSULTANT'S NO.

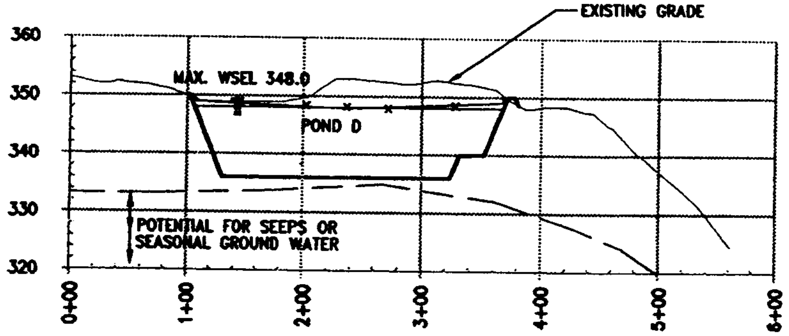
PORT OF SEATTLE NO.
EXHIBIT_C134



SECTION

DETENTION POND
SECTION LOOKING WEST
N.T.S

1
C134.1



SECTION

DETENTION POND
SECTION LOOKING SOUTH
N.T.S.

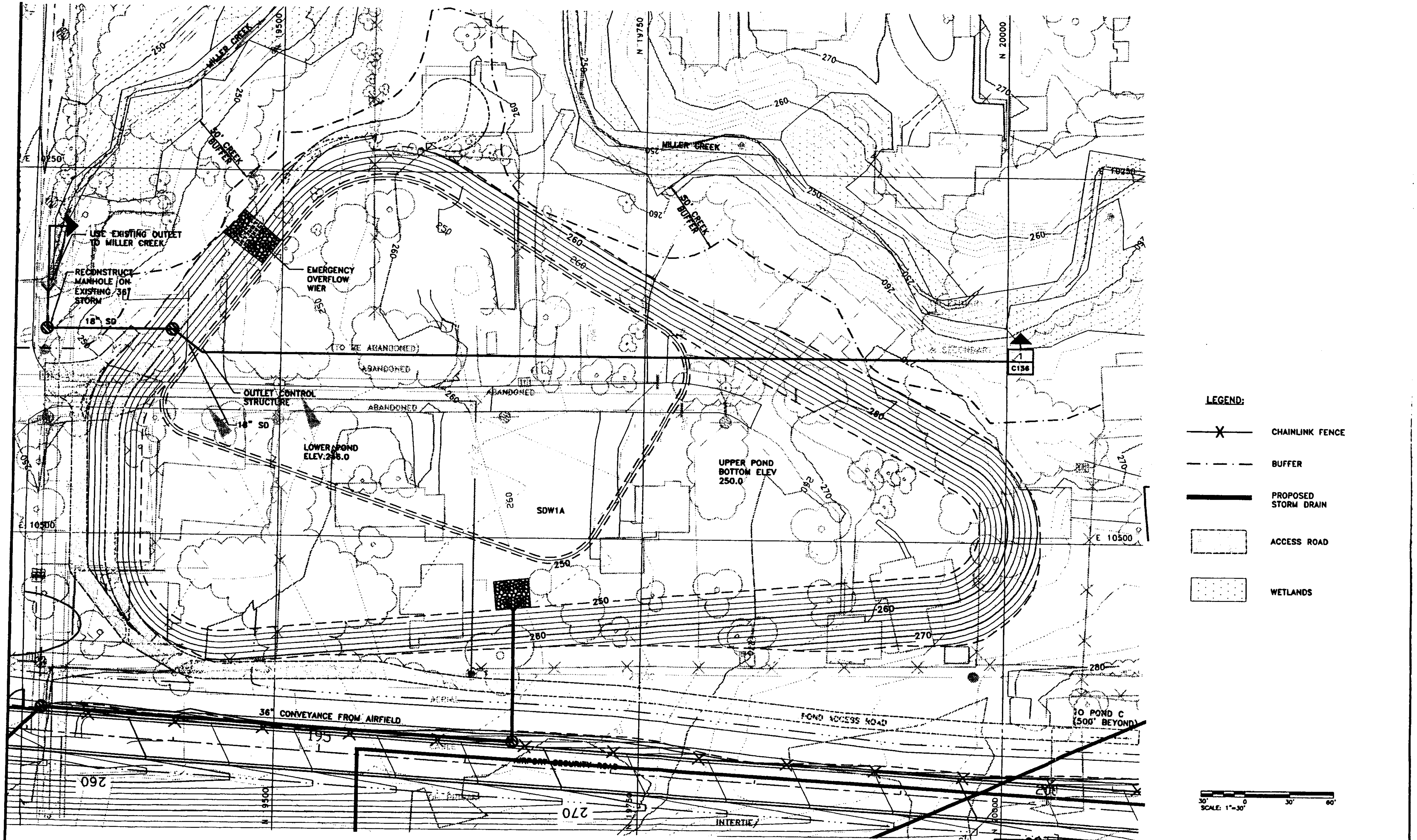
2
C134.1

NOTES:

1. GROUND WATER ELEVATIONS ARE APPROXIMATE BASED ON AVAILABLE GEOTECHNICAL INVESTIGATIONS AND HYDROGEOLOGIC ELEVATION WILL BE INCLUDED AS PART OF THE FINAL DESIGN ANALYSIS.

2. FINAL POND CONFIGURATION MAY VARY TO MAINTAIN STORM WATER STORAGE ABOVE THE OBSERVED GROUND WATER.

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5
SHEET TITLE: POND D SECTIONS AND DETAILS
DATE DEC. 14, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C134.1



PLAN

POND G PLAN
SDW1A BASIN POND
SCALE: 1" = 30'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

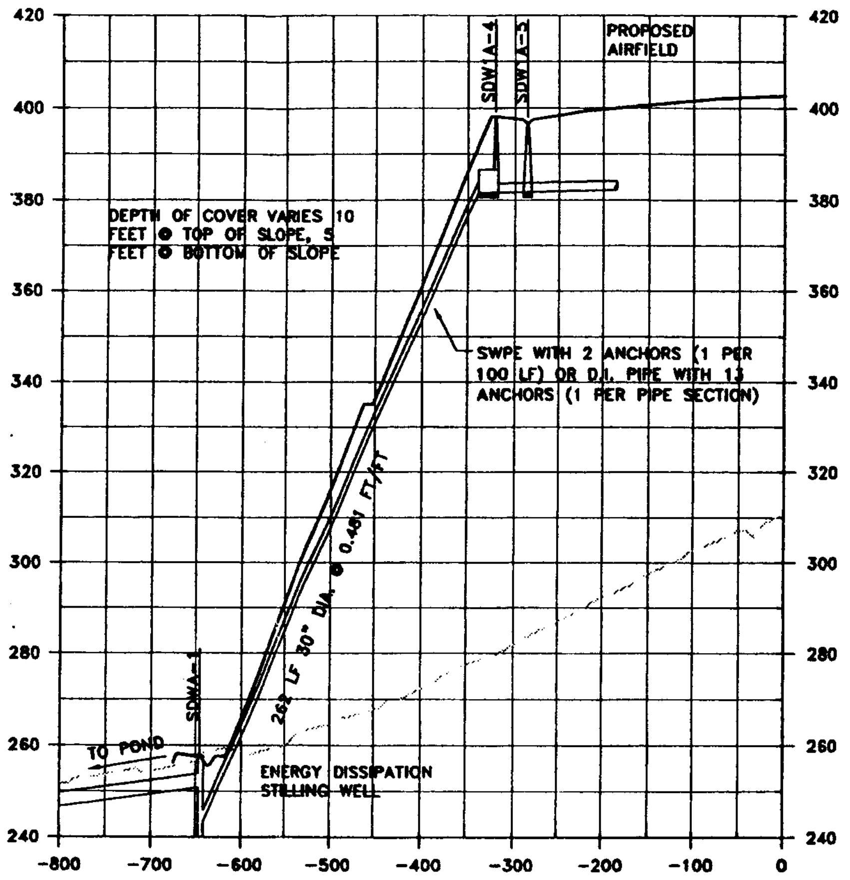
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: POND G PLAN
SDWIA BASIN POND

DATE
DEC. 15, 2000

CONSULTANT'S NO.

PORT OF SEATTLE NO.
EXHIBIT_ C135



PIPE DOWN EMBANKMENT WITH OR WITHOUT BENCHES

PROFILE

1
C-135

POND G – STORM SEWER PROFILE
SDW1A BASIN
SCALE: 1" = 100'

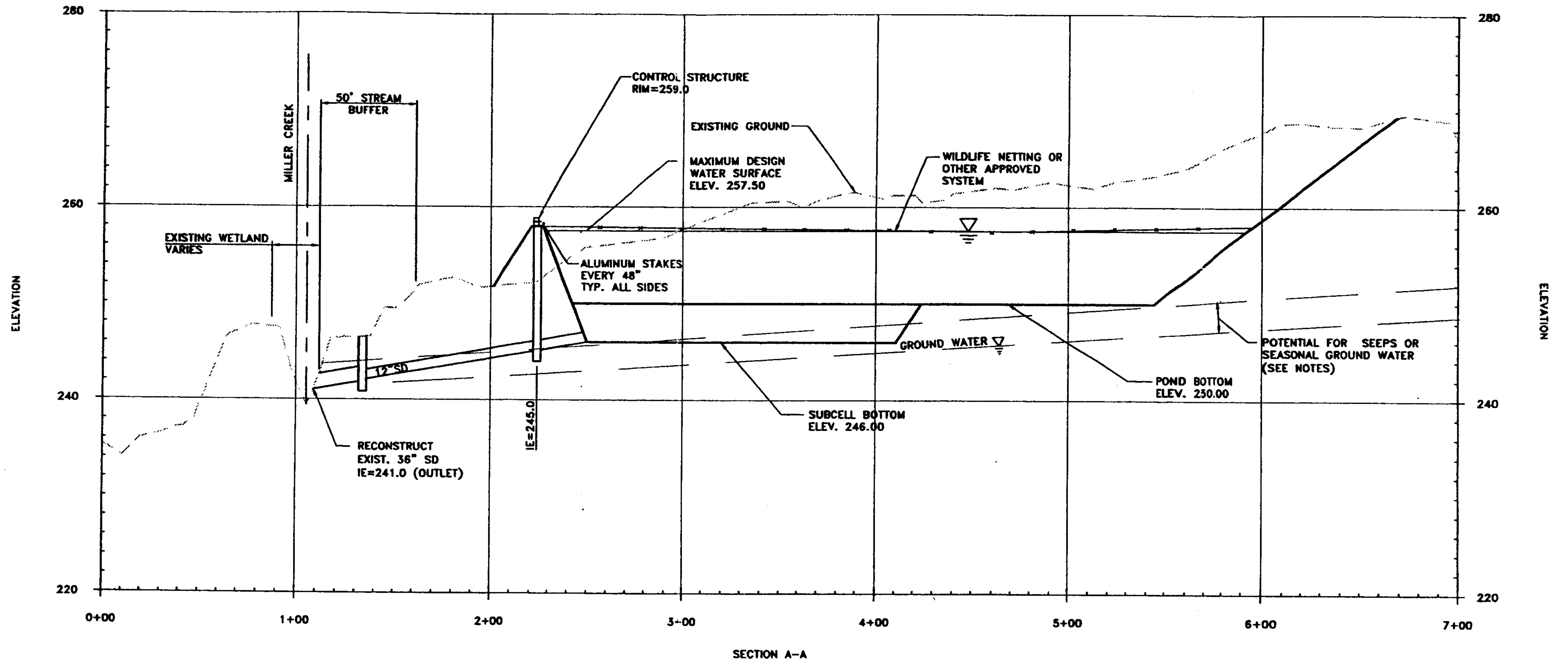
100' 0 100' 200'
SCALE: 1"=100'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: **POND G -MISCELANEOUS PROFILES SDW1A BASIN**

WORK ORDER NO.
CONSULTANT'S NO.
PORT OF SEATTLE NO. EXHIBIT_ C135.1



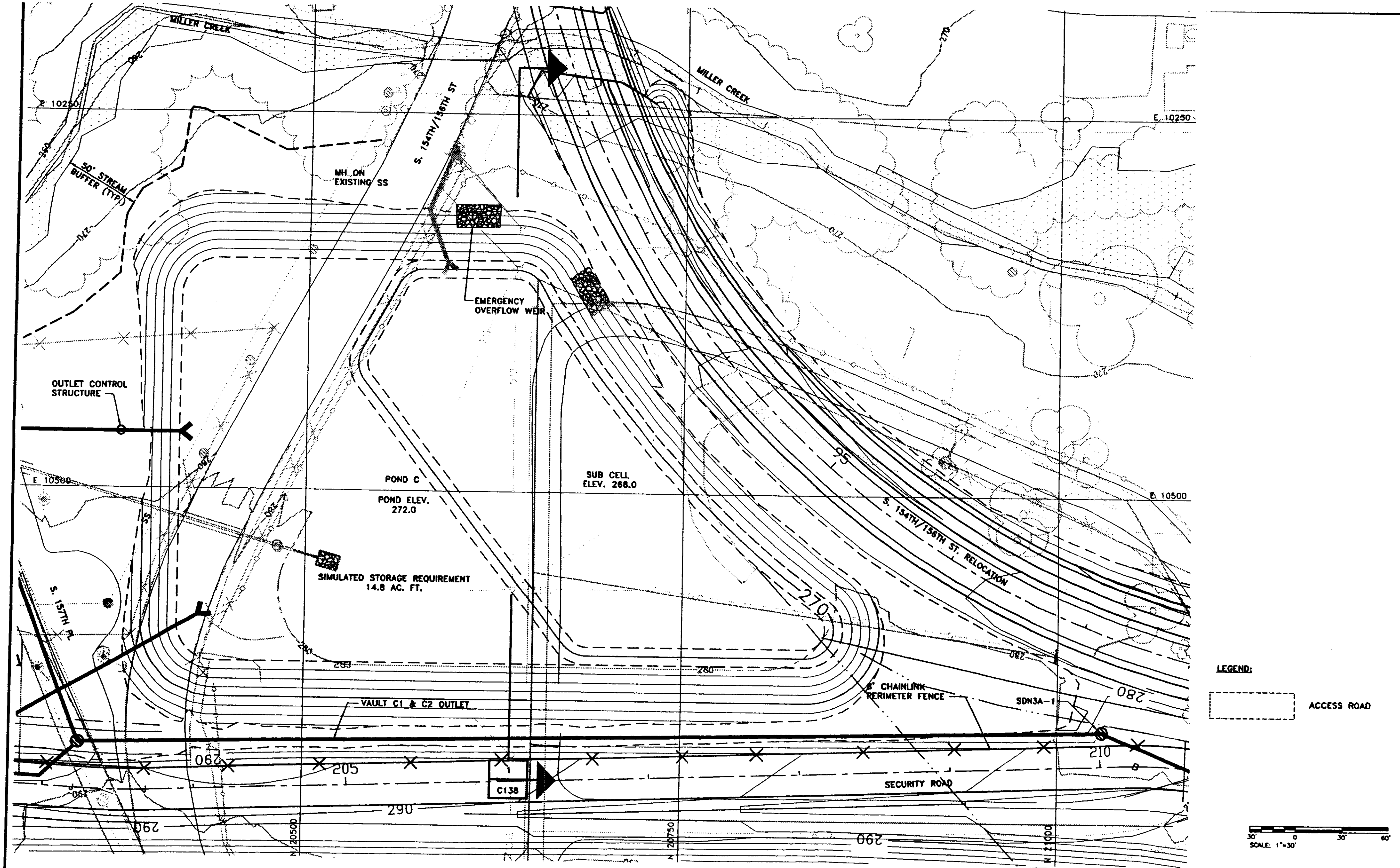
PROFILE

POND G PROFILE
SDW1A BASIN POND
SCALE: N.T.S.

NOTES:

1. GROUND WATER ELEVATIONS ARE APPROXIMATE BASED ON AVAILABLE GEOTECHNICAL INVESTIGATIONS AND HYDROGEOLOGIC ELEVATION WILL BE INCLUDED AS PART OF THE FINAL DESIGN ANALYSIS.
2. FINAL POND CONFIGURATION MAY VARY TO MAINTAIN STORM WATER STORAGE ABOVE THE OBSERVED GROUND WATER.

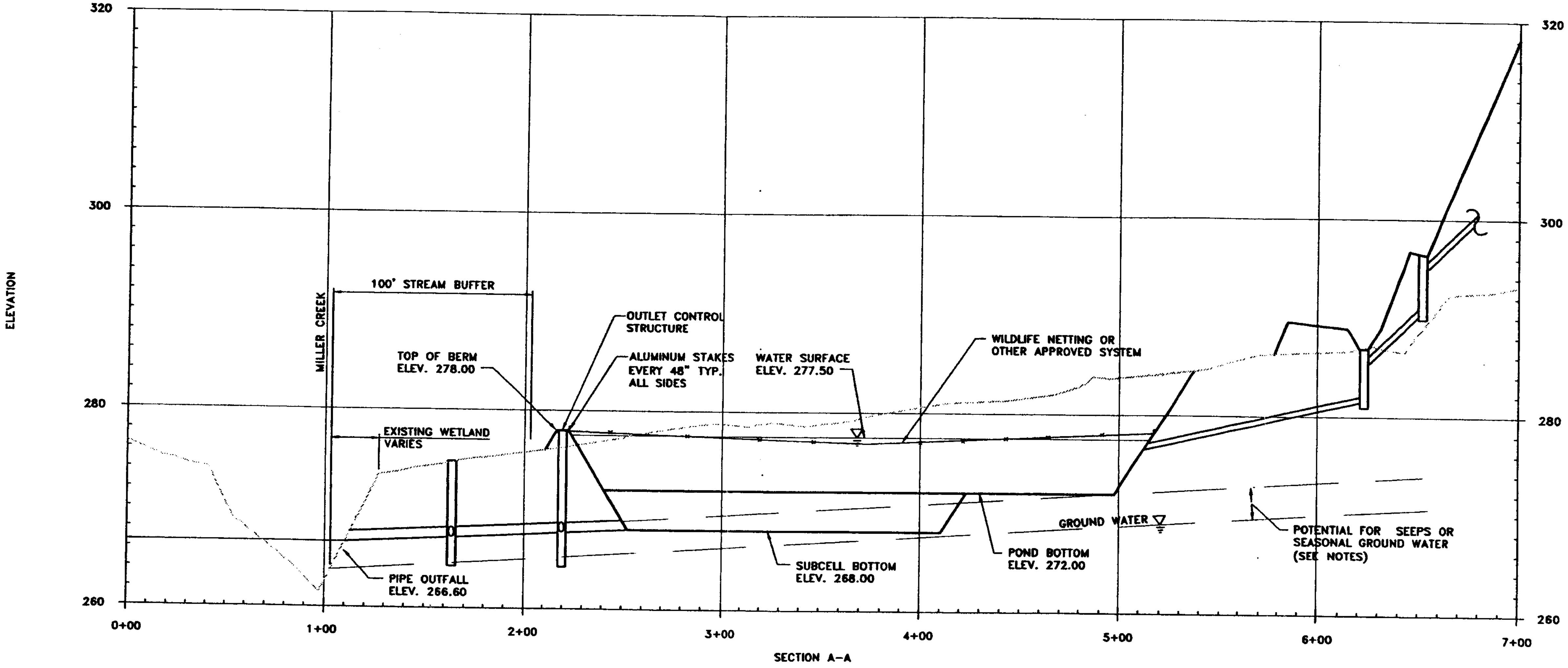
Port of Seattle SEA-TAC INTERNATIONAL AIRPORT	DATE DEC. 14, 2000
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6	CONSULTANT'S NO.
SHEET TITLE: POND G PROFILE SDW1A BASIN	PORT OF SEATTLE NO. EXHIBIT_ C136



PLAN
POND "C" PLAN
SCALE: 1" = 30'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6
SHEET TITLE: POND C PLAN
SDN3A BASIN POND

DATE
DEC. 15, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C137



SECTION A-A

NOTES:

1. GROUND WATER ELEVATIONS ARE APPROXIMATE BASED ON AVAILABLE GEOTECHNICAL INVESTIGATIONS AND HYDROGEOLOGIC ELEVATION WILL BE INCLUDED AS PART OF THE FINAL DESIGN ANALYSIS.

2. FINAL POND CONFIGURATION MAY VARY TO MAINTAIN STORM WATER STORAGE ABOVE THE OBSERVED GROUND WATER.

20' 0 20' 40'
SCALE: 1"=20'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

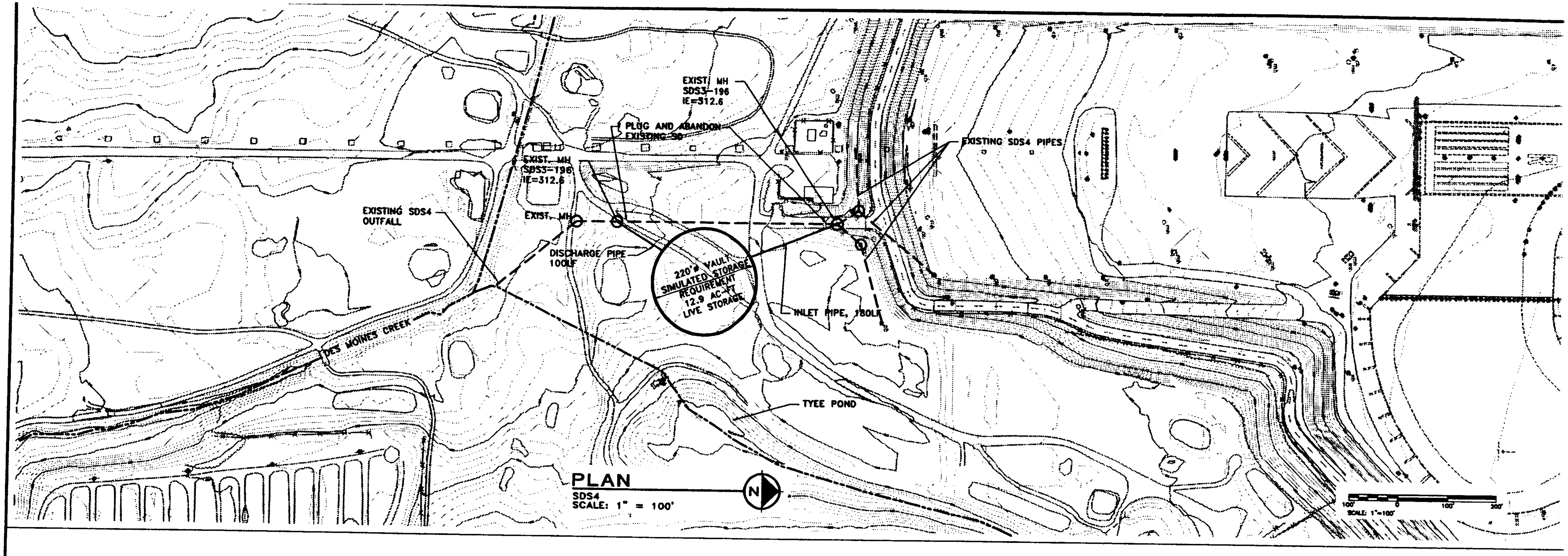
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6

SHEET TITLE: POND C PROFILE
SDW1A BASIN POND

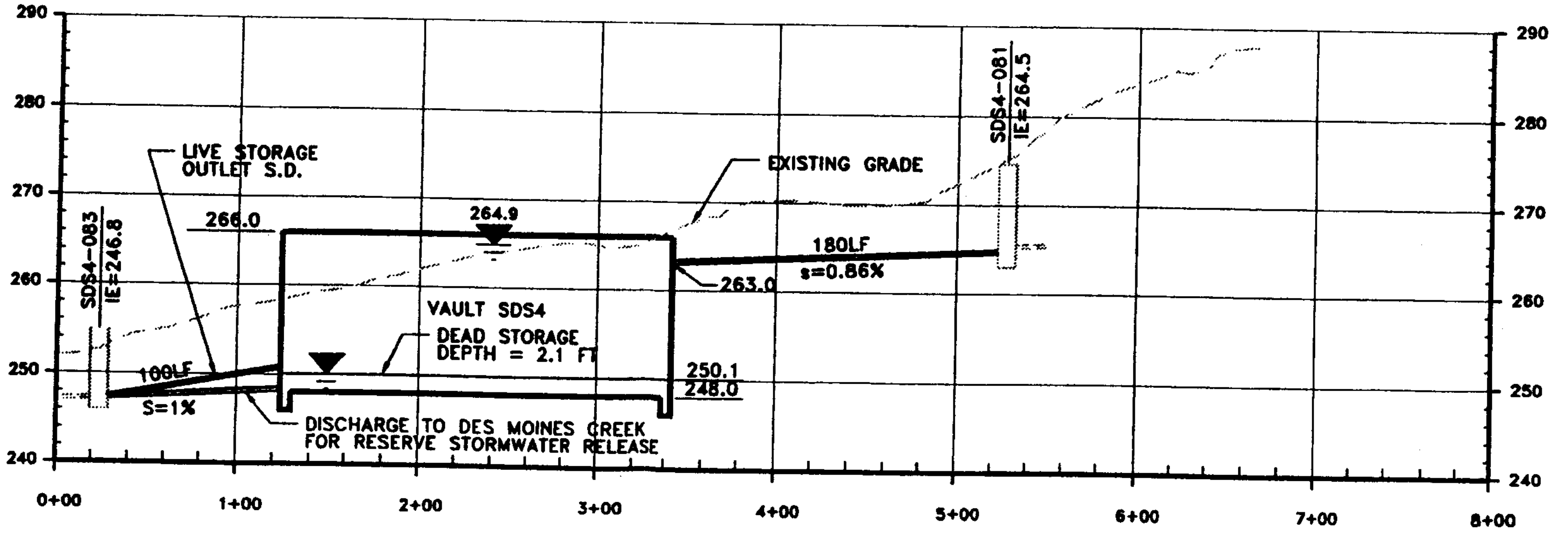
DATE
DEC. 14, 2000

CONSULTANT'S NO.

PORT OF SEATTLE NO.
EXHIBIT_C138



PLAN
SDS4
SCALE: 1" = 100'



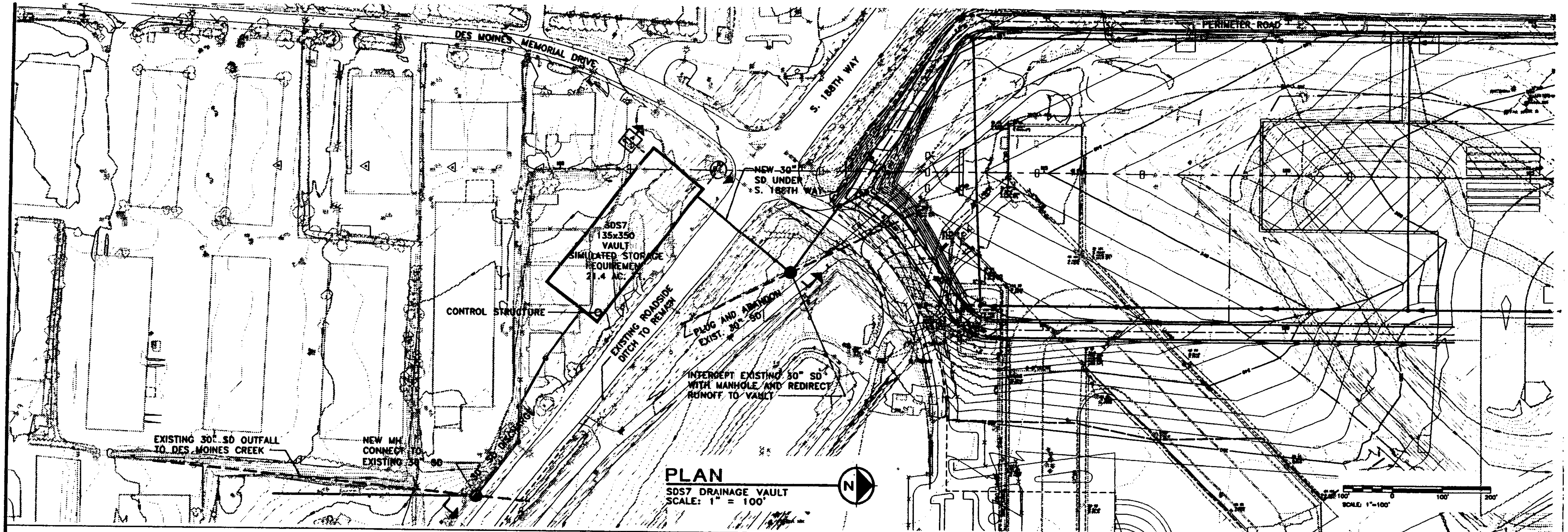
PROFILE
SDS4
SCALE: 1" = 50'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

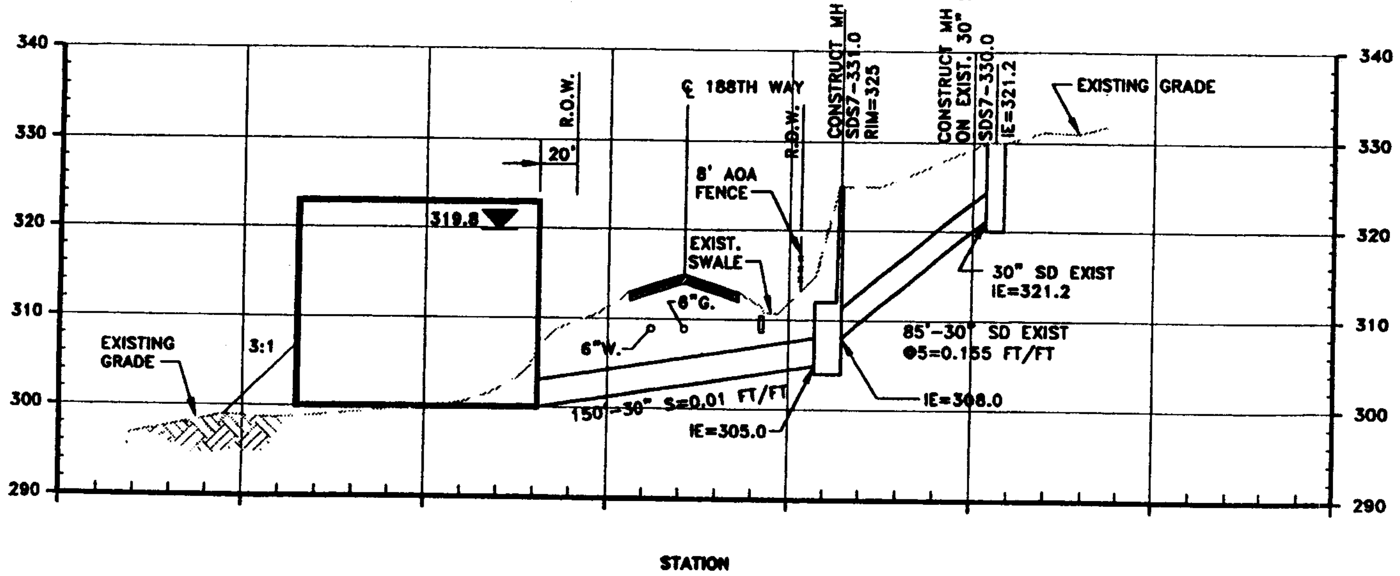
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6

SHEET TITLE: SDS4 BASIN VAULT
PLAN AND PROFILE

DATE
DEC. 15, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C139

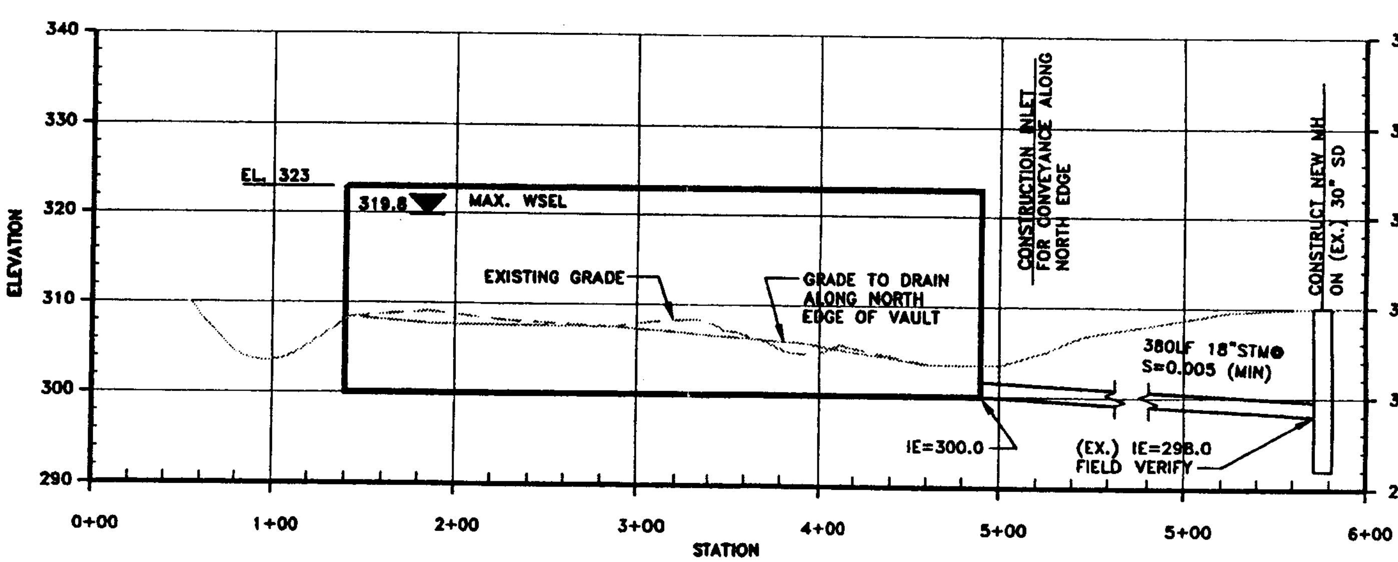


PLAN
SDS7 DRAINAGE VAULT
SCALE: 1" = 100'



SECTION A
SDS7 DRAINAGE VAULT
SCALE: 1" = 40'

1
C-18



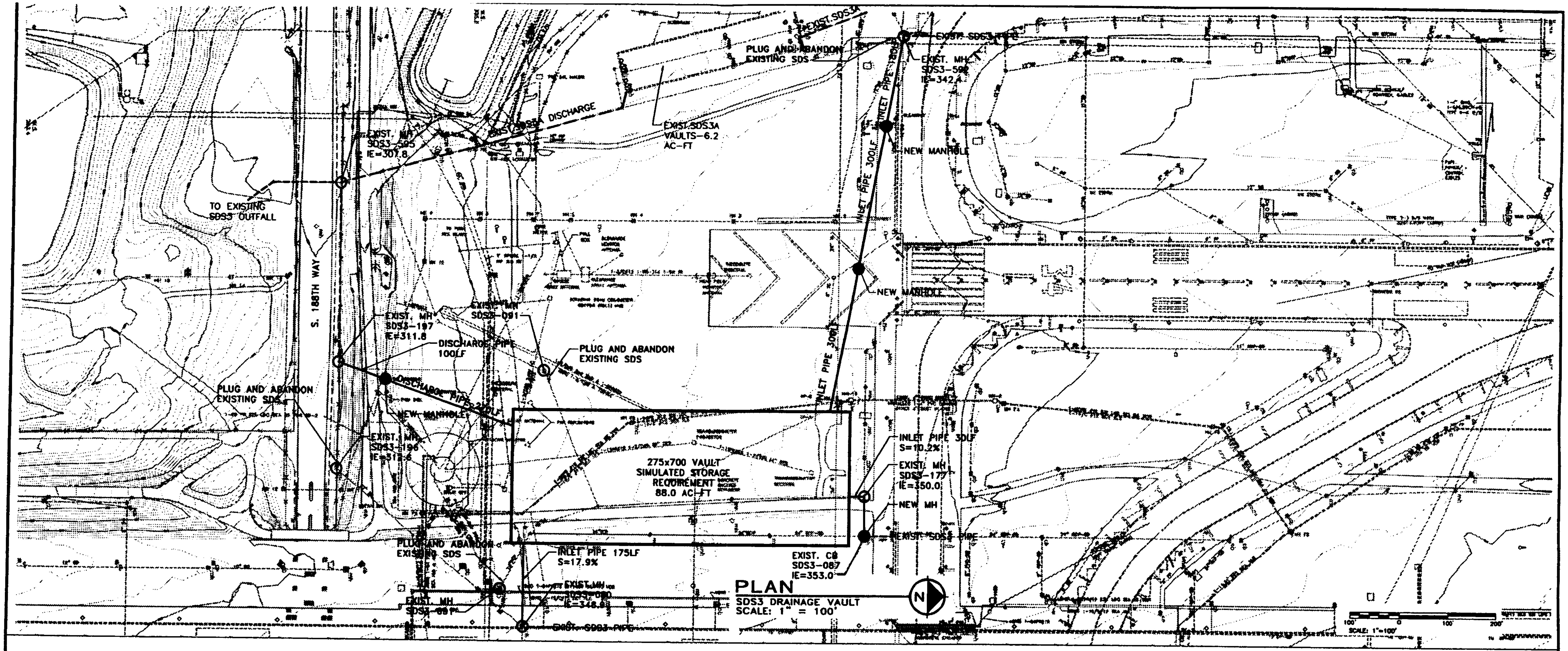
PROFILE
SDS7 DRAINAGE VAULT
SCALE: 1" = 50'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

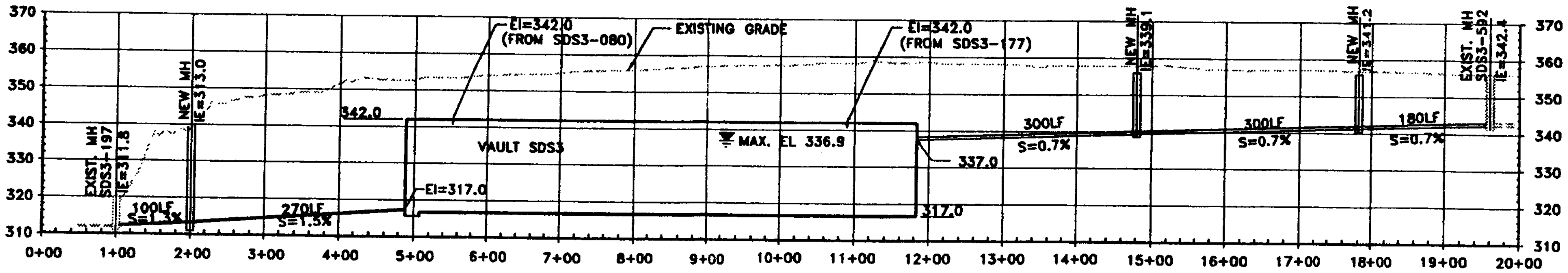
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: SDS7 BASIN VAULT
PLAN AND PROFILE

DATE
DEC. 15, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C140



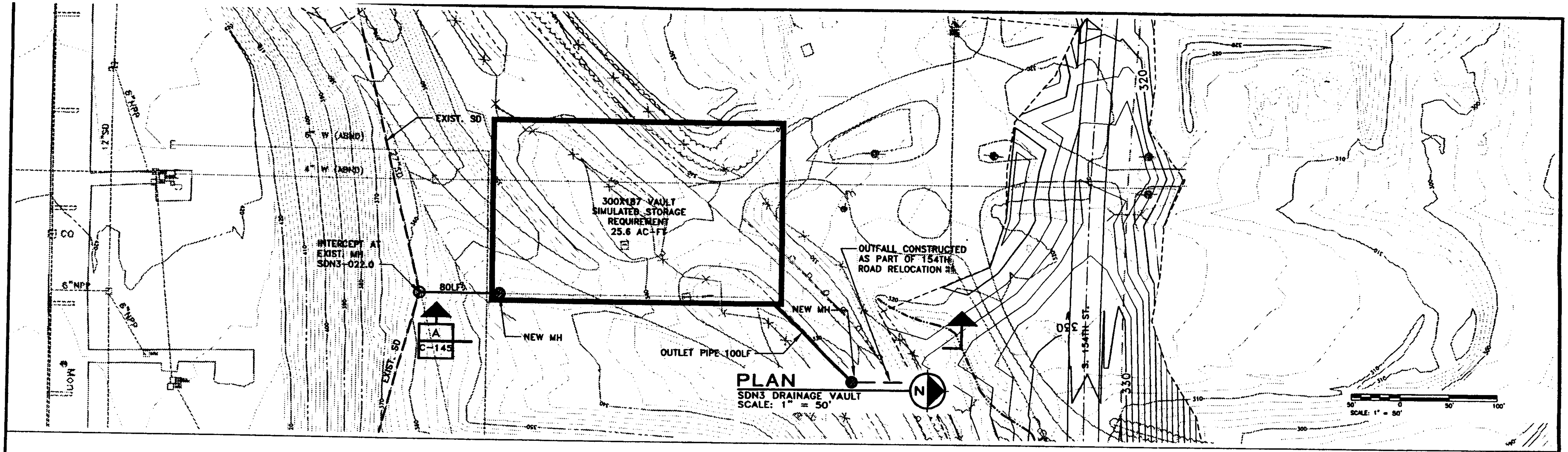
PLAN
SDS3 DRAINAGE VAULT
SCALE: 1" = 100'



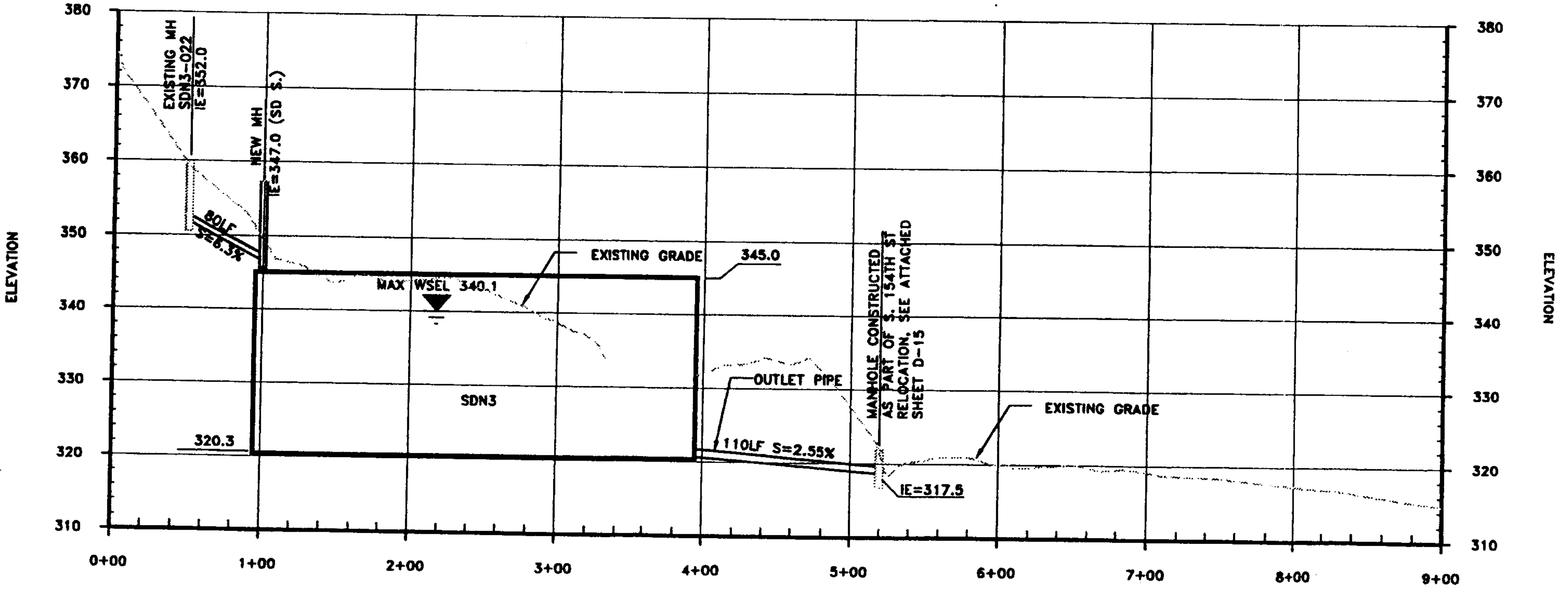
PROFILE
SDS3 DRAINAGE VAULT
SCALE: HORZ 1" = 100'
VERT 1" = 20'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5
SHEET TITLE: **SDS3, SDS3A AND SDS5 BASIN VAULT / PLAN AND PROFILE**

DATE	DEC. 14, 2000
CONSULTANT'S NO.	
PORT OF SEATTLE NO.	EXHIBIT_ C141



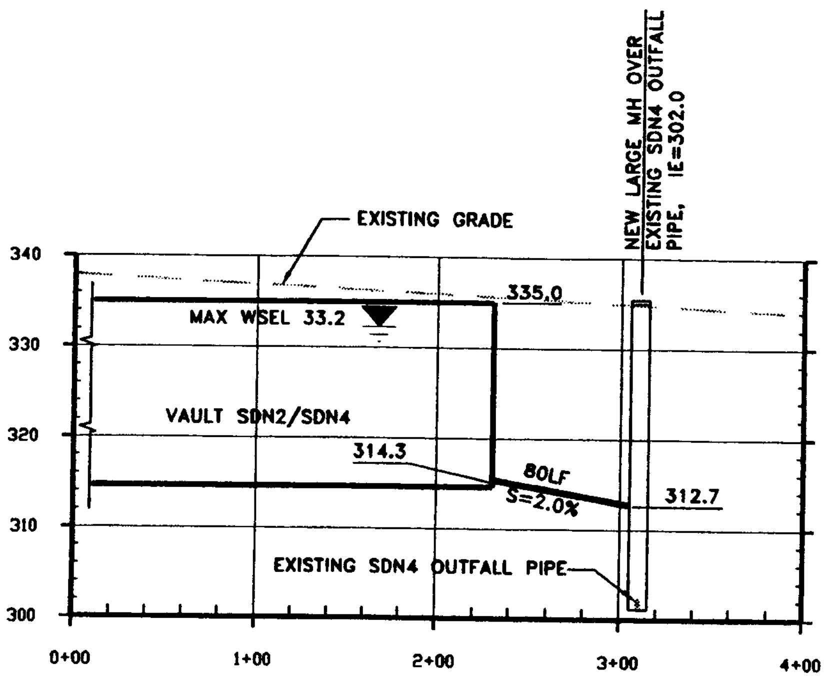
PLAN
SDN3 DRAINAGE VAULT
SCALE: 1" = 50'



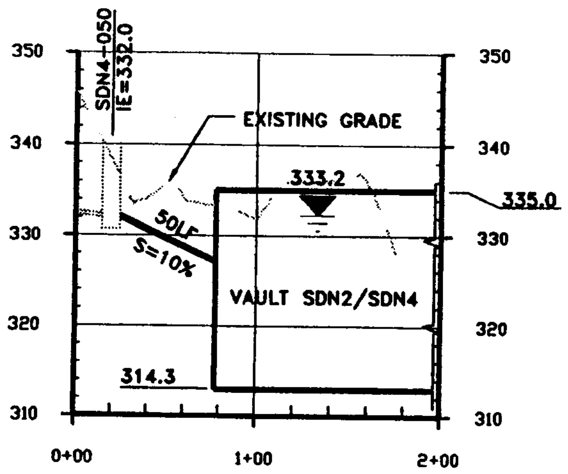
SECTION A 1 / C-145
SDN3 DRAINAGE VAULT
SCALE: HORZ 1" = 50'
VERT 1" = 10'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6
SHEET TITLE: SDN3 BASIN VAULT
PLAN AND PROFILE

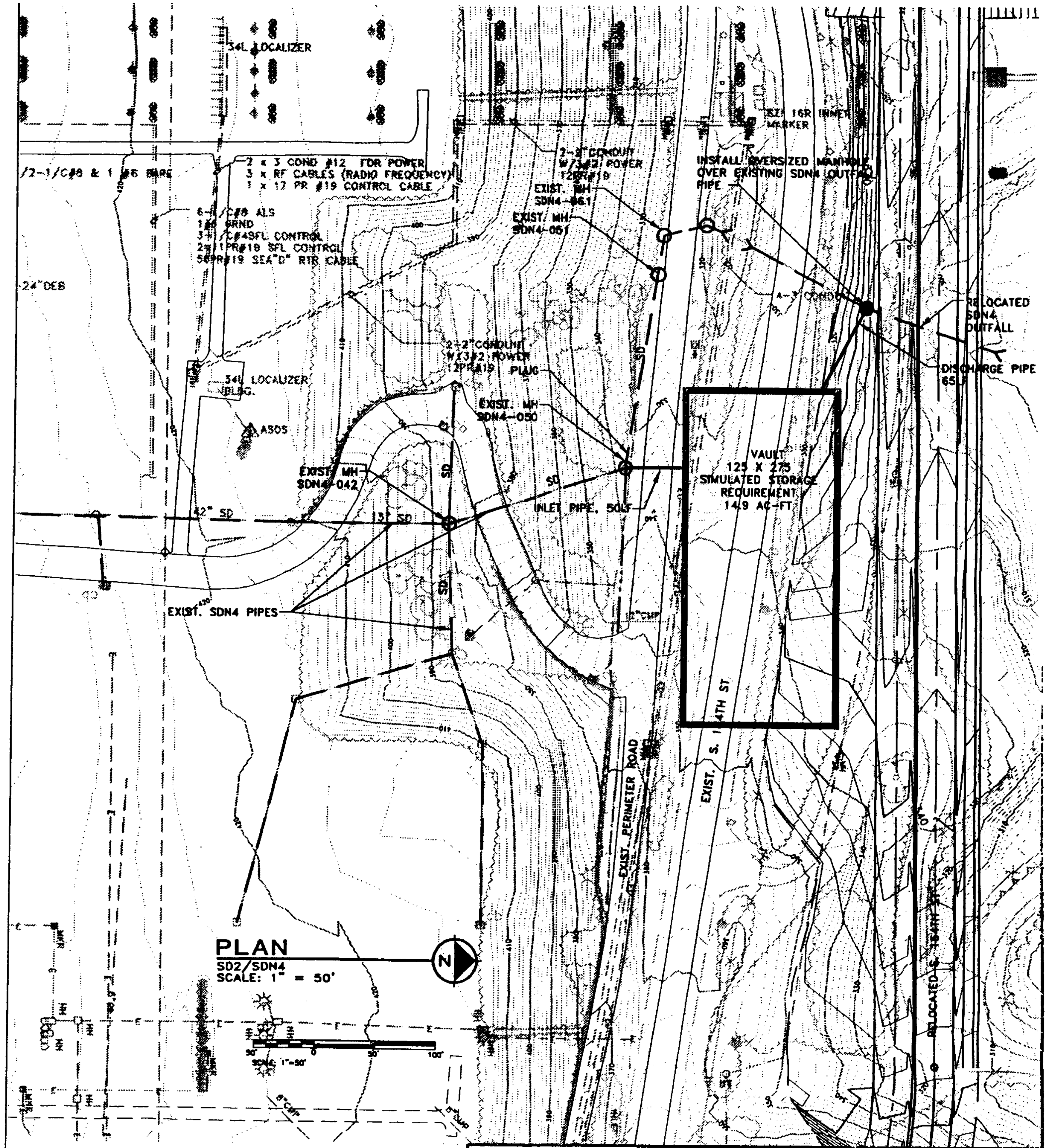
DATE	DEC. 14, 2000
CONSULTANT'S NO.	
PORT OF SEATTLE NO.	
EXHIBIT_	C145



PROFILE
SDN2/SDN4
SCALE: HORZ 1" = 50'
VERT 1" = 10'



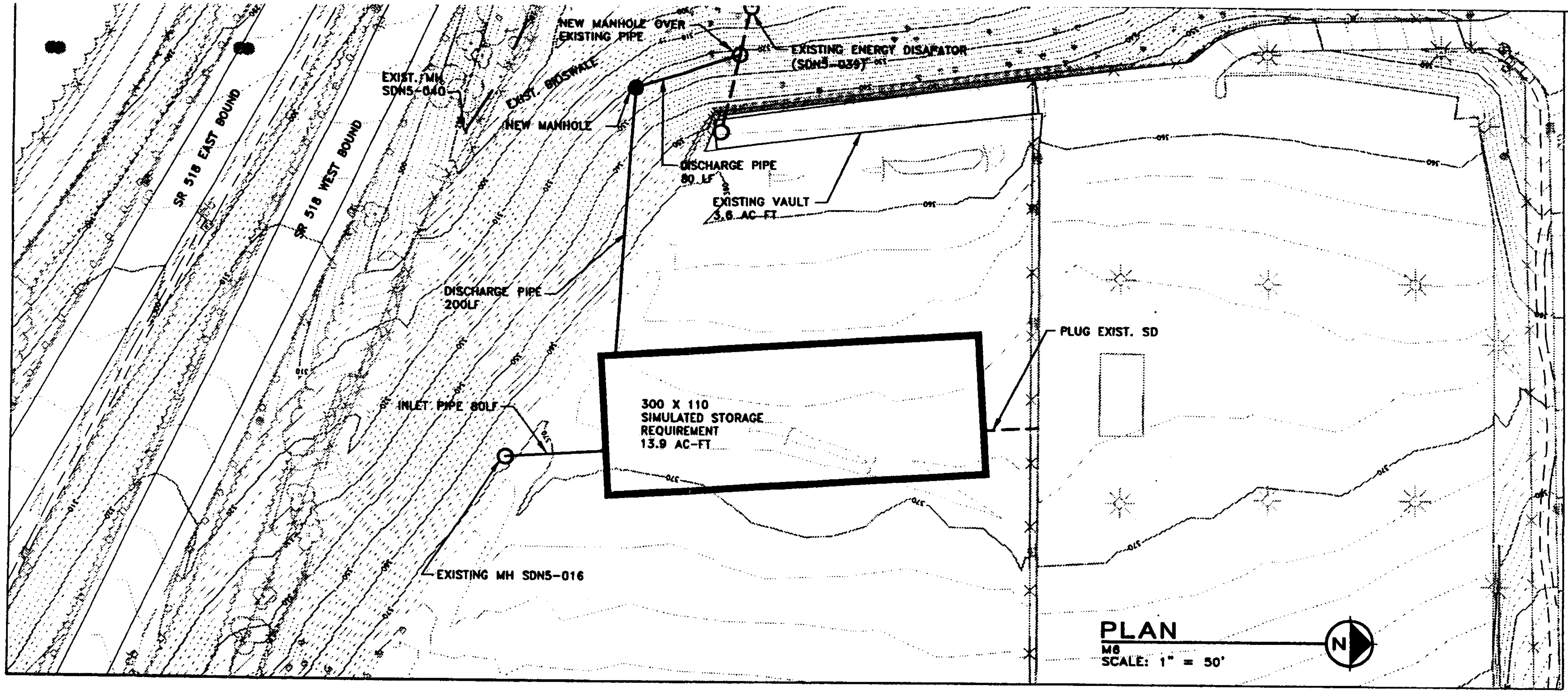
PROFILE
SDN2/SDN4
SCALE: HORZ 1" = 50'
VERT 1" = 10'



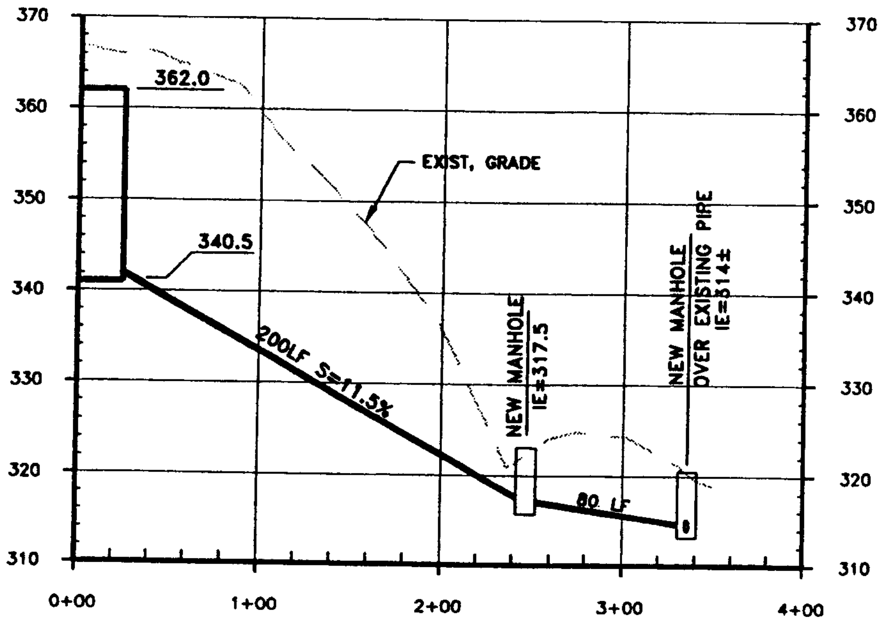
PLAN
SD2/SDN4
SCALE: 1" = 50'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5
SHEET TITLE: SDN2/SDN4 BASIN VAULT
PLAN AND PROFILE

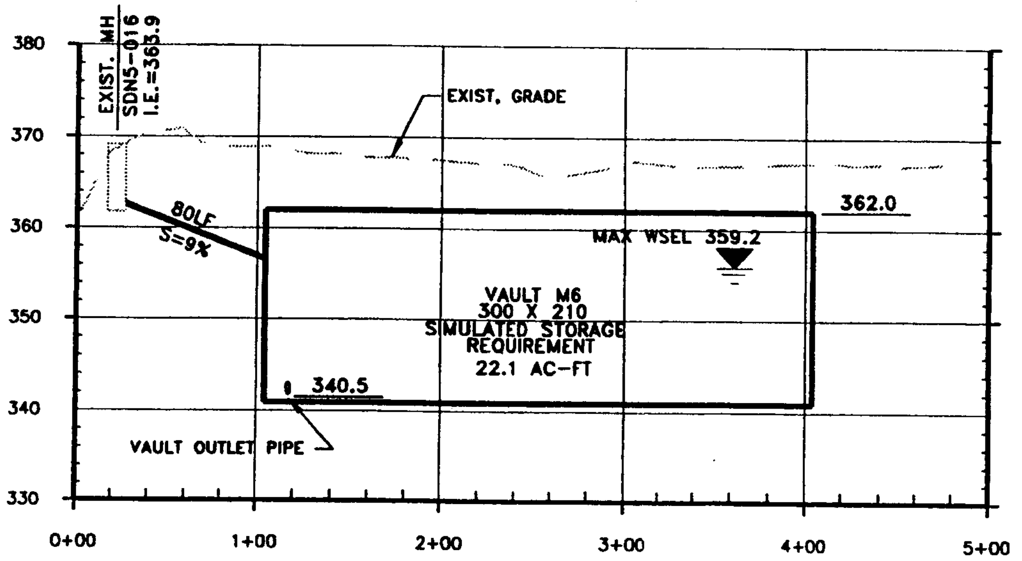
DATE DEC. 15, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C146



PLAN
M6
SCALE: 1" = 50'



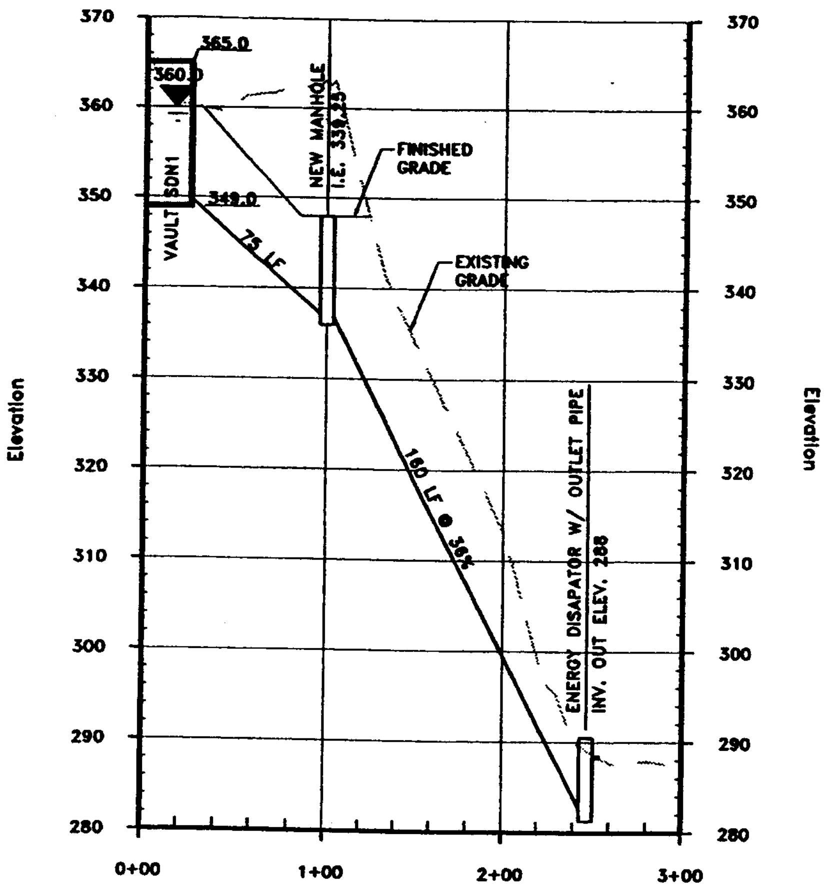
PROFILE
M6
SCALE: HORZ 1" = 50'
VERT 1" = 10'



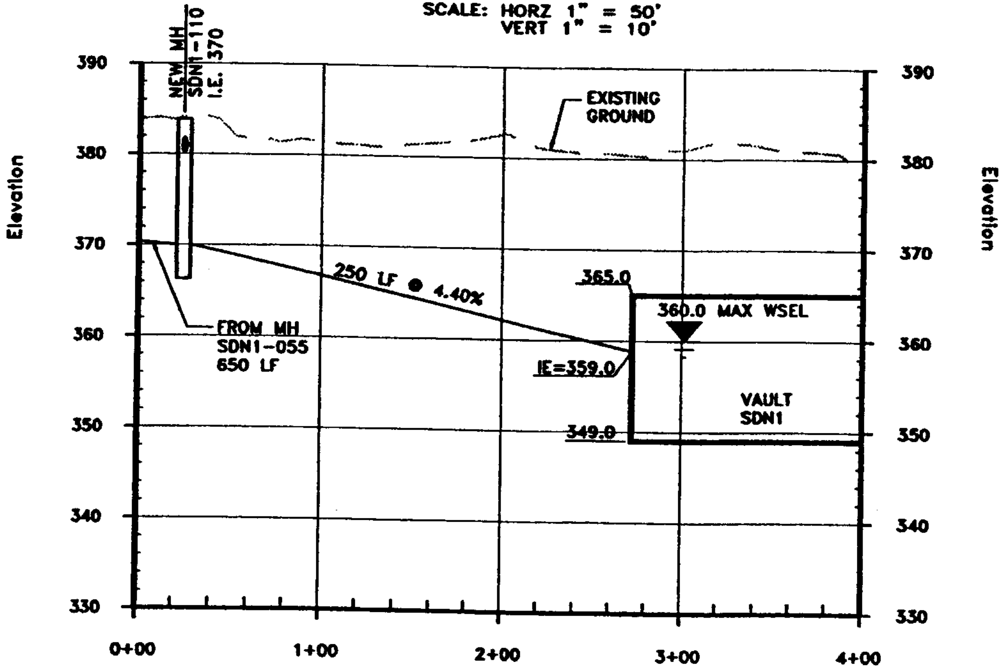
PROFILE
M6
SCALE: HORZ 1" = 50'
VERT 1" = 10'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 6
SHEET TITLE: **M6 BASIN VAULT (NEPL)**
PLAN AND PROFILE

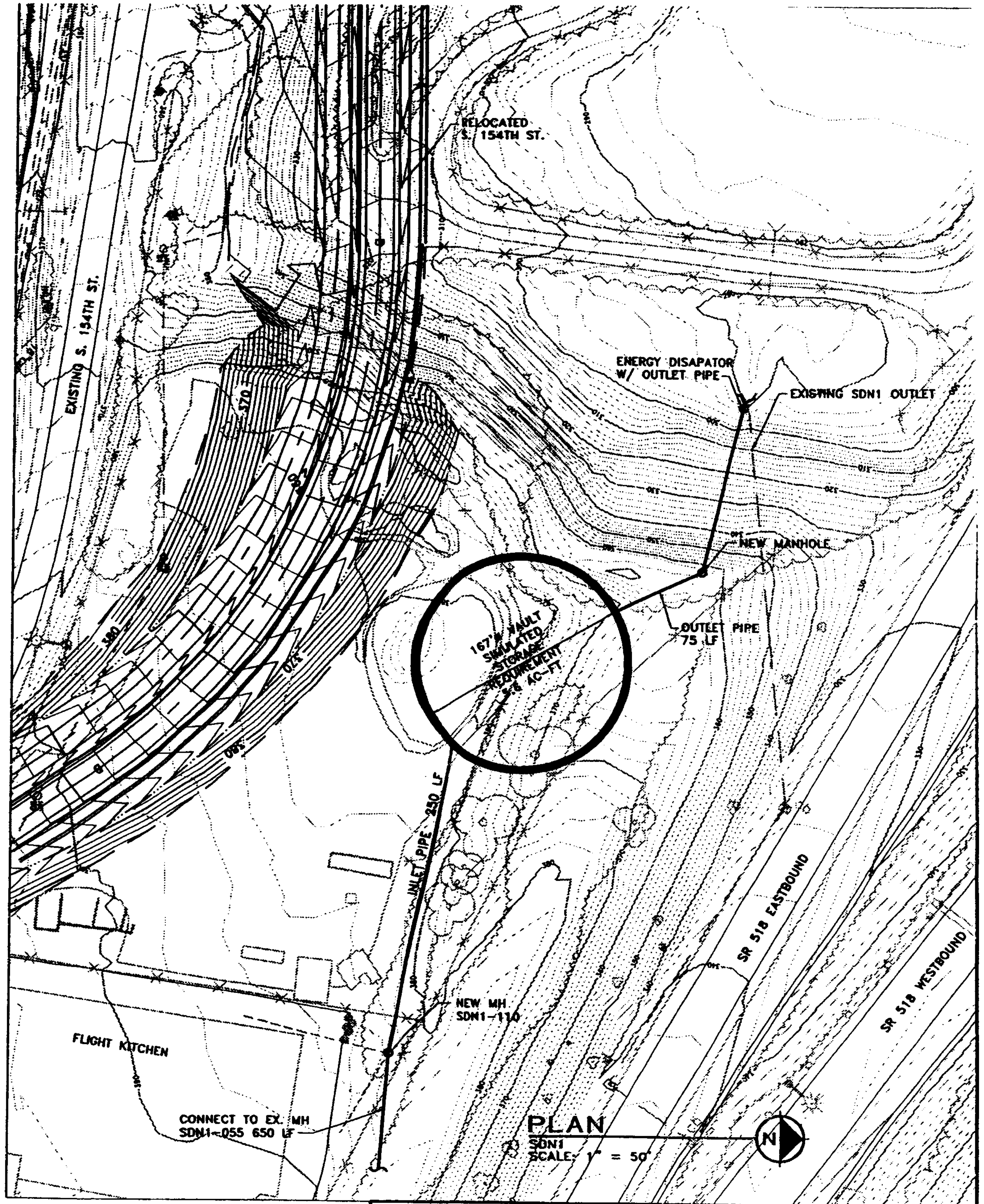
DATE
DEC. 14, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C147



PROFILE
SDN1
SCALE: HORZ 1" = 50'
VERT 1" = 10'



PROFILE
SDN1
SCALE: HORZ 1" = 50'
VERT 1" = 10'



PLAN
SDN1
SCALE: 1" = 50'

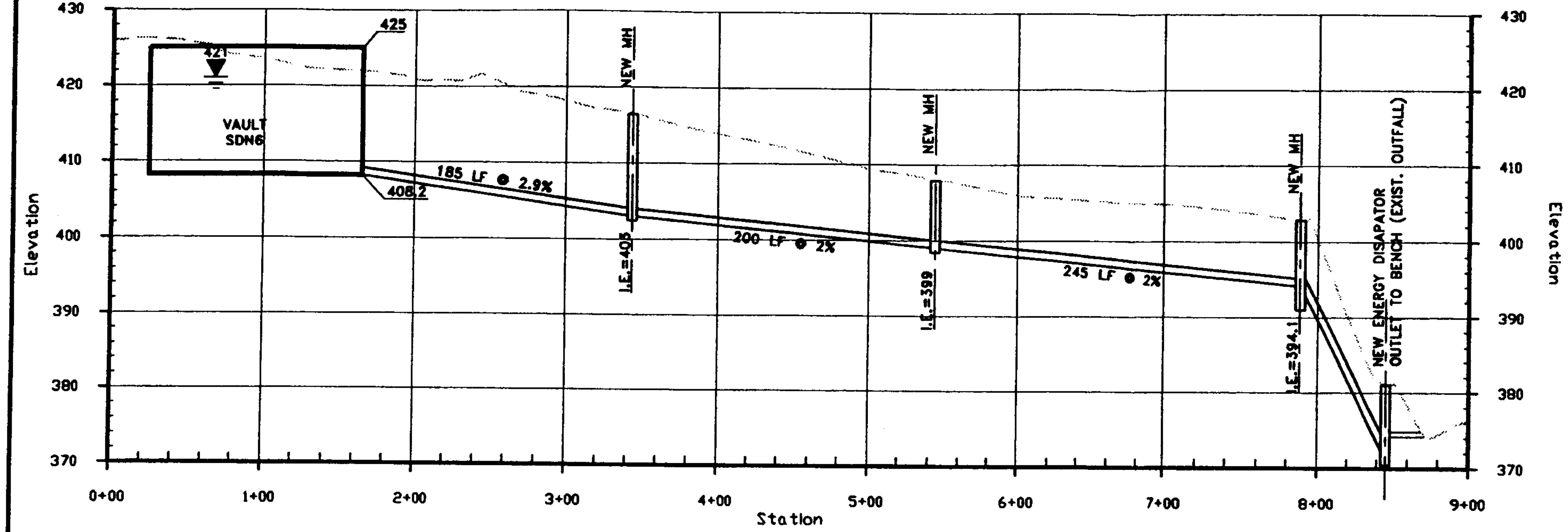
Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: SDN1 BASIN VAULT
PLAN AND PROFILE

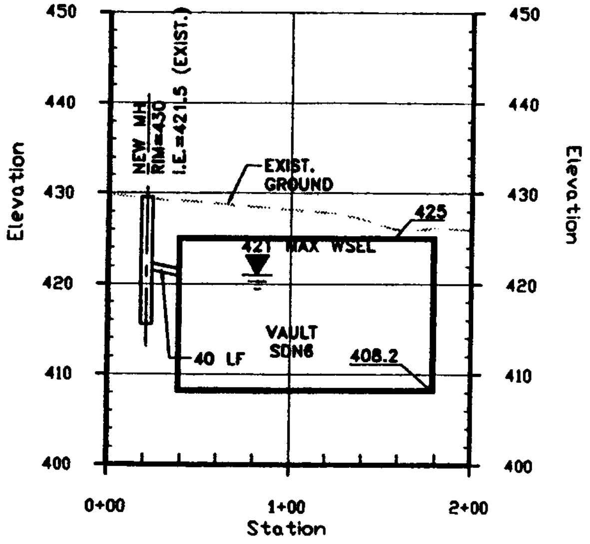
DATE
DEC. 15, 2000
CONSULTANT'S NO.

PORT OF SEATTLE NO.
EXHIBIT_ C148



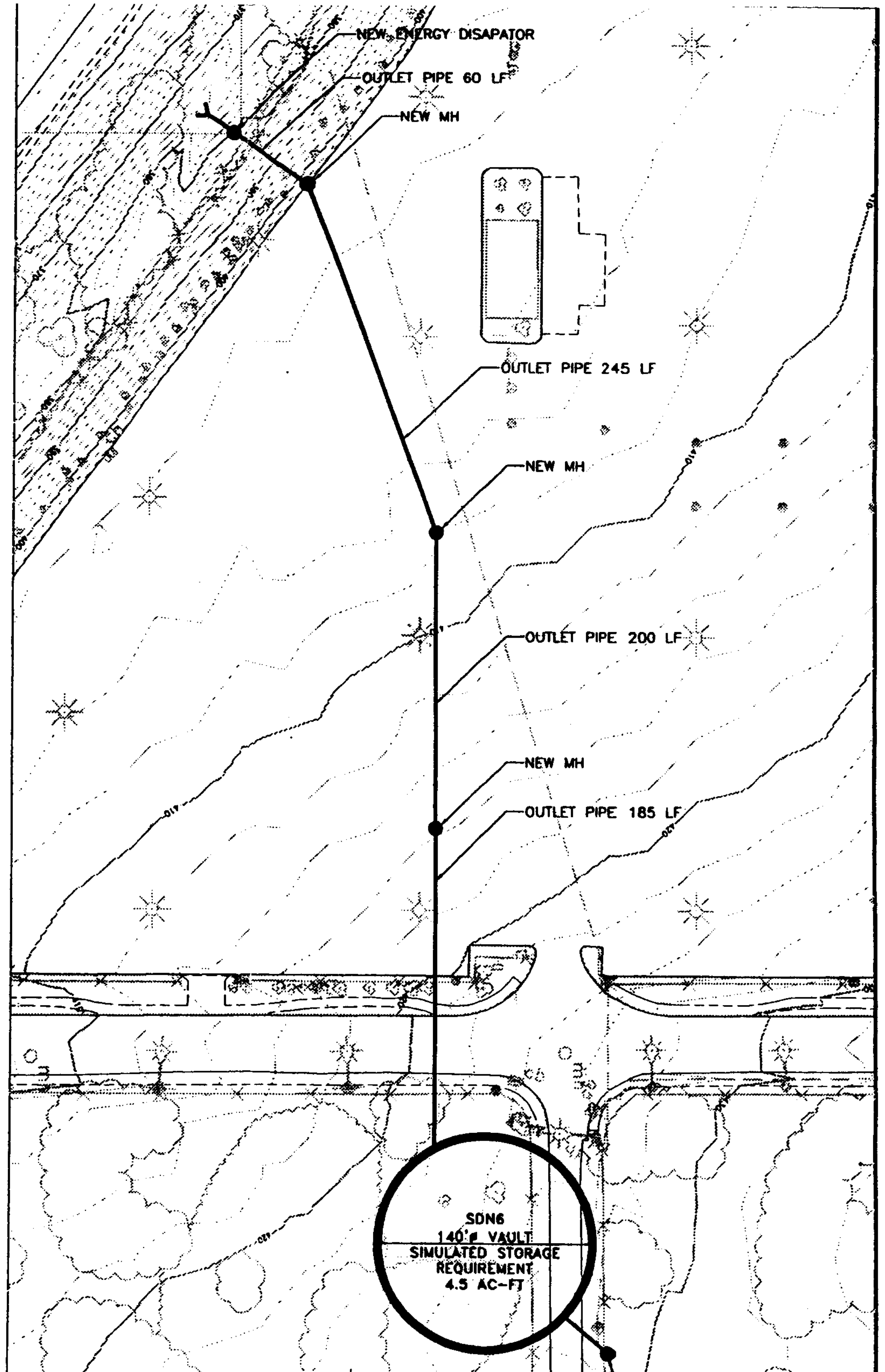
PROFILE

SDN6
SCALE: HORZ 1" = 50'
VERT 1" = 10'



PROFILE

SDN6
SCALE: HORZ 1" = 50'
VERT 1" = 10'



PLAN

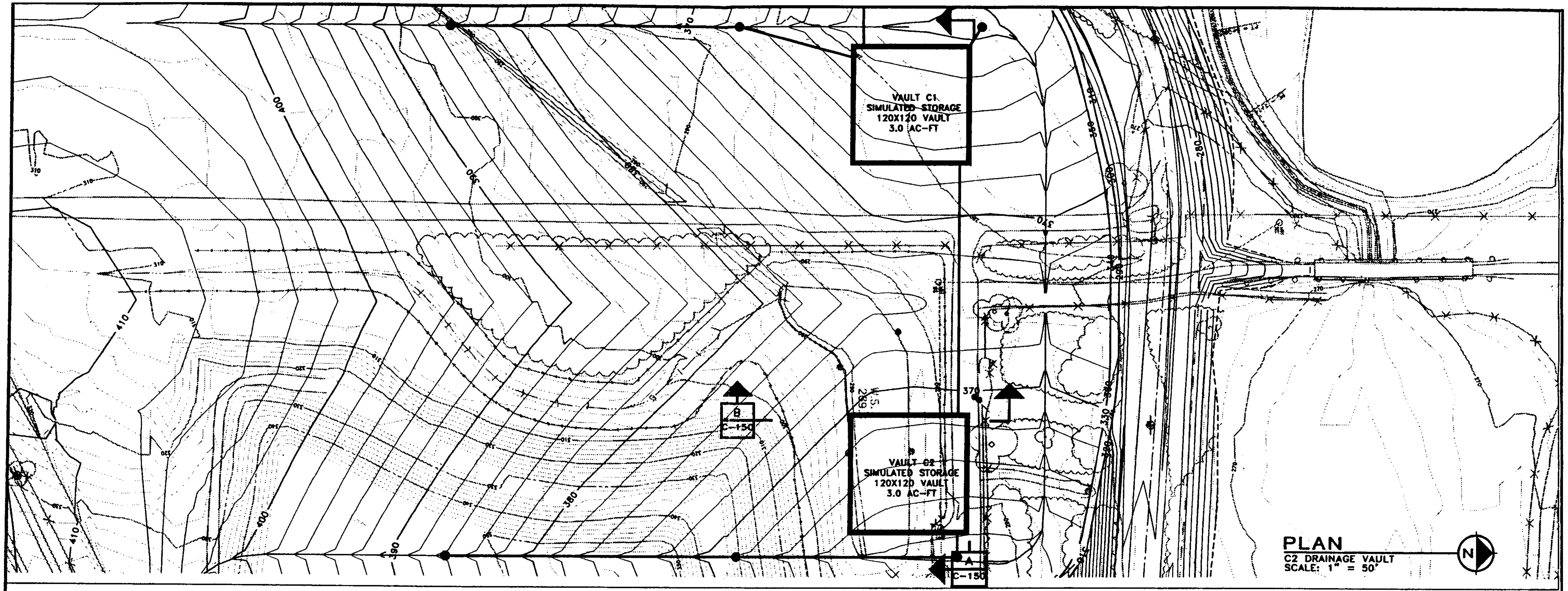
SDN1-OFF
SCALE: 1" = 50'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

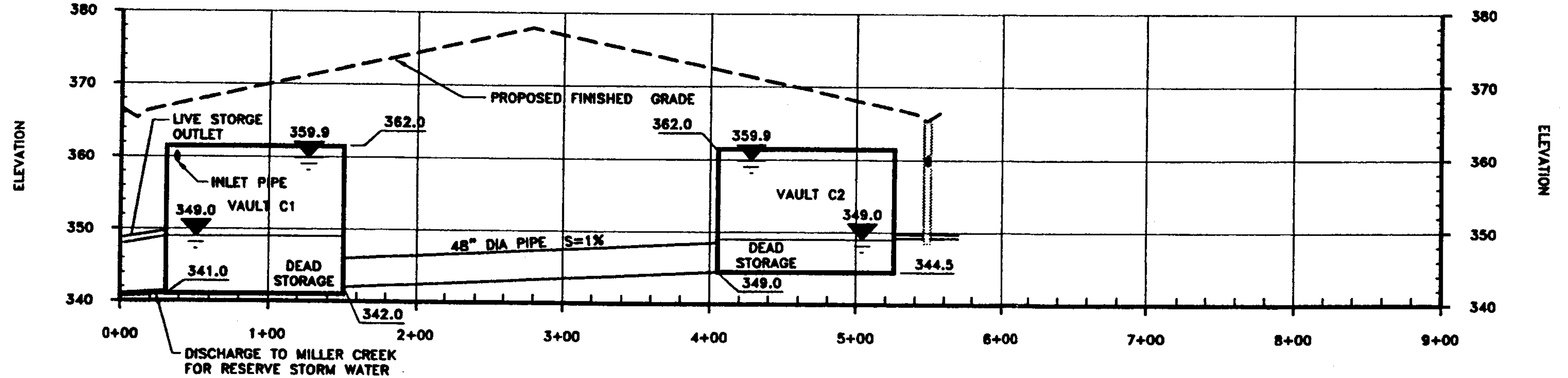
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: SDN6 (CARGO) BASIN VAULT
PLAN AND PROFILE

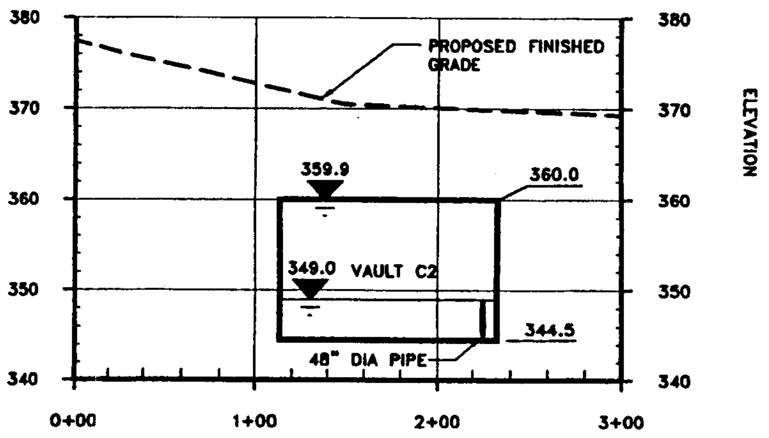
DATE
DEC. 14, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C149



PLAN
C2 DRAINAGE VAULT
SCALE: 1" = 50'



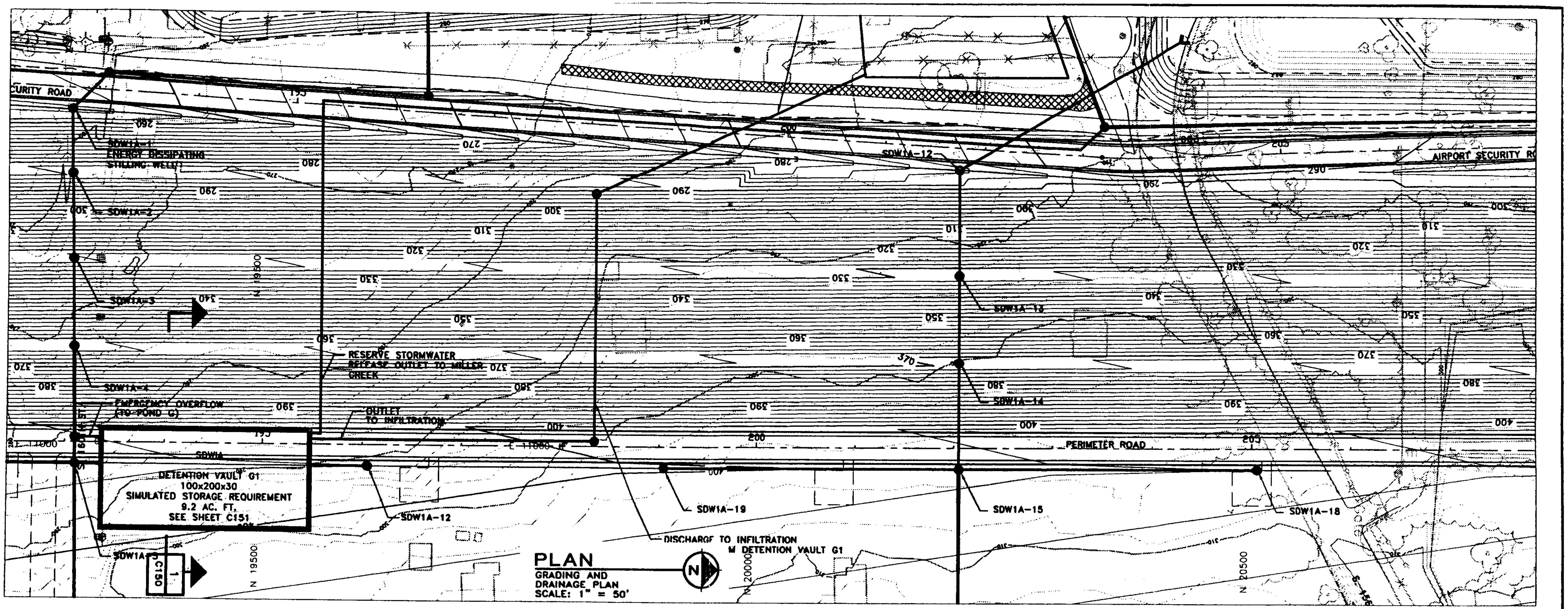
SECTION A
1
C-150
C2 DRAINAGE VAULT
SCALE: HORZ 1" = 50'
VERT 1" = 10'



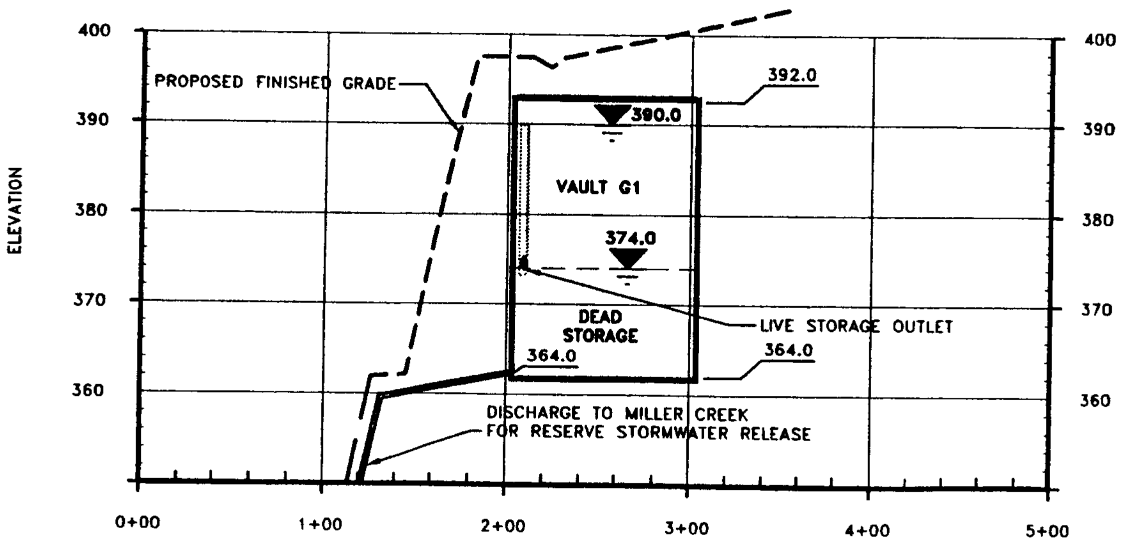
SECTION B
1
C-150
C2 DRAINAGE VAULT
SCALE: HORZ 1" = 50'
VERT 1" = 10'

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT
PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5
SHEET TITLE: SDN3 BASIN VAULT C2
PLAN AND PROFILE

DATE
DEC. 15, 2000
CONSULTANT'S NO.
PORT OF SEATTLE NO.
EXHIBIT_ C150



PLAN
GRADING AND DRAINAGE PLAN
SCALE: 1" = 50'



SECTION A
1
C-150

SDW1A DRAINAGE VAULT
SCALE: HORZ 1" = 50'
VERT 1" = 10'

NOTES:

LEGEND:

━	STORM DRAIN PIPE
▨	WETLANDS

50' 0 50' 100'
SCALE: 1"=50'

						128	129	130
110	111	112	113	114	115	116	117	118
119	120	121	122	123	124	125	126	127

KEY PLAN

Port of Seattle
SEA-TAC INTERNATIONAL AIRPORT

PROJECT: THIRD RUNWAY - EMBANKMENT CONSTRUCTION PHASE 5

SHEET TITLE: SDW1A BASIN VAULT G1
PLAN AND SECTION

DATE
DEC. 15, 2000

CONSULTANT'S NO.

PORT OF SEATTLE NO.
EXHIBIT_ C151

APPENDIX J

APPENDIX J

FEASIBILITY OF STORMWATER INFILTRATION

Feasibility of Stormwater Infiltration
Third Runway Project
Sea-Tac International Airport
SeaTac, Washington

Prepared for
Port of Seattle

December 14, 2000
J-4978-06

CONTENTS

FEASIBILITY OF STORMWATER INFILTRATION
THIRD RUNWAY PROJECT,
SEA-TAC INTERNATIONAL AIRPORT
SEATAC, WASHINGTON

SUMMARY

Infiltration tests have been performed for selected sites on the west side of the proposed runway embankment to evaluate the feasibility of infiltration as part of the Stormwater Management Plan (SMP) for the Sea-Tac Third Runway project. The testing performed to date shows infiltration is feasible in two of the areas tested (Areas 1 and 3). Preliminary design infiltration rates have been developed from the field tests using methods stipulated by King County (1998) as listed in Table 1. Based on these results, potential infiltration capacities (in cubic feet per second [cfs]) at the individual sites have been developed for nominal 8-foot-wide infiltration trenches totaling 400 feet in length:

- Infiltration Area 1 can accommodate stormwater disposal at an average rate of 0.30 cfs; and
- Infiltration Area 3 can accommodate stormwater disposal at an average rate of 0.15 cfs.

Additional trenches may be located in these areas to increase infiltration capacity, depending on site logistics.

These data are suitable for conceptual infiltration facility design. The infiltration capacity of any site will depend on the detailed design and layout (i.e., area and elevation) of the infiltration facility, and the degree of variability in soil conditions beneath the facility. Additional infiltration tests and soil borings will be needed to meet all the requirements of the King County Surface Water Design Manual (1998) and should be completed once provisional footprints of the facilities are established.

This report summarizes design requirements for infiltration facilities, field data collection performed by Hart Crowser, and results of our work to date for Infiltration Areas 1 and 3.

INTRODUCTION

As a result of increased stormwater storage capacity requirements in the SMP, Hart Crowser was tasked to investigate potential sites for infiltration of detained stormwater on the west side of the proposed Third Runway project area (see Figure 1 for general location). Based on the location of detention ponds C, D, and G, three sites were identified as potential sites for infiltration of water discharged from detention ponds and/or vaults on the airfield. Additionally, the footprint of detention ponds C, D, and G were also considered for potential infiltration capacity. Locations of the detention ponds and Infiltration Areas 1, 2, and 3 are shown on Figures 2 and 3.

Infiltration testing was conducted along with the collection of soils and groundwater data that are needed to establish if infiltration can be implemented in each area in accordance with the requirements of the King County Surface Water Design Manual (KCSWDM - King County, 1998). The overall requirements for infiltration facilities are summarized in the following section.

INFILTRATION FACILITY REQUIREMENTS

The following summary outlines the General Requirements (Section 5.4.1 of the KCSWDM) for infiltration facilities (ponds, tanks, and trenches) associated with the natural site conditions. Additional requirements identified below under "Other Engineering Considerations" need to be addressed by the engineering design team.

Soils

- The basic requirement is a minimum of 3 feet of permeable soil below the bottom of the facility and at least 3 feet between the bottom of the facility and the maximum wet-season water table.
- A minimum of two test pits or soil borings per 10,000 ft^2 of infiltration area are required to characterize the site.
- Test pits or borings should extend at least 5 feet below the bottom of the infiltration facility, and at least one test hole should reach the water table.

Measured Infiltration Rates

- The measured infiltration rate should be determined using either the double-ring infiltrometer test (ASTM Method D 3385, 2000) or the EPA falling head percolation test procedure (EPA, 1980).
- Sufficient tests should be performed to determine a representative infiltration rate but at least three tests shall be performed for each proposed infiltration facility.

Design Infiltration Rate

- The design infiltration rate should be calculated by Equation 5-9 of the KCSWDM, using the correction factors listed in that Section 5.4.1.

Off-site Groundwater Impacts

- The impacts of infiltration should be considered for the potential to provide increased water to landslide areas, increased groundwater resources available, increased water levels in closed depressions, and higher groundwater levels.

Groundwater Protection

Groundwater protection requirements call for implementing one of the following actions when infiltrating water from pollution-generating surfaces:

- Provide water quality treatment prior to infiltration; or
- Demonstrate that the soil beneath the infiltration facility has properties which reduce the risk of groundwater contamination from typical stormwater runoff.

Other Engineering Considerations

- 100-Year Overflow Conveyance
- Spill Control Devices
- Pre-settling
- Protection from Upstream Erosion
- Construction Guidelines.

This report by Hart Crowser provides a preliminary assessment of the soils, infiltration rates, and hydrology of each site to establish the feasibility of infiltration. Engineering aspects and site logistics will be addressed by the design team as part of final design.

APPROACH

The type of infiltration test chosen at each location was dependent on the depth of the target soil strata or pond elevation. Generally, for tests less than 4 to 5 feet below ground surface, test pits were dug and the double-ring infiltrometer method was used. This method involved repeatedly measuring a small (< 1/4 inch) change in water level in both the inner and outer rings while consistently maintaining a head between 5.5 and 6 inches in both rings until a relatively constant rate was obtained. Pre-soaking the test area is not required; however, to limit the amount of inconsistent readings at the beginning of the test, a pre-soaking period of approximately one hour was employed.

For testing depths below 5 feet, the EPA method was used in an augered hole with a 6-inch-diameter temporary casing inserted to prevent caving of the borehole walls. This method involved repeatedly measuring the water level drop from an initial head (6 inches above the base of the hole) over a given period until a relatively constant rate was obtained. At the end time interval the water level was adjusted back to the original head level prior to starting the next measurement. A minimum of four hours or overnight pre-soaking of the test zone was performed.

The seasonal high groundwater level was estimated by measuring current groundwater levels in existing or recently installed monitoring wells at each site and comparing these with longer records from existing nearby wells in similar hydrogeologic settings. Additionally, soil profile characteristics such as low chroma mottling were also reviewed to assess the seasonal high groundwater levels.

RESULTS

We have completed infiltration tests and soil borings at one pond location and three potential infiltration areas:

- Pond G;
- Infiltration Area 1 (between Pond C and Pond G);
- Infiltration Area 2 (south of Pond G); and
- Infiltration Area 3 (northwest of Pond D).

Results of the double-ring infiltrometer tests are listed in Table 2; results of the EPA method falling head percolation tests are listed in Table 3.

Work on Pond D is still in progress. A third pond location (Pond C) was considered but the presence of groundwater seepage precluded further consideration of infiltration at Pond C. Infiltration in Pond G and Area 2 proved to be unfeasible due to low permeability soils and/or high groundwater levels. Logs of soil borings and test pits are included in Appendix A for Infiltration Areas 1 and 3.

In the following summaries, we include an estimate of the design infiltration rate for each area. This is currently based on the average values of the measured infiltration rates for each area, factored by our estimate of the appropriate correction factors, as stipulated by King County (1998). However, given the variability of the soils encountered to date, the mean value may not be appropriate for the entire facility at each location. Final design would take into account the results of additional facility-specific testing, the actual geometry of the proposed facilities, and additional design adjustments to provide an adequate "factor of safety."

Final measured infiltration values will be recommended for the design of the proposed facilities after completion of the additional borings and tests needed to fulfill KCSWDM requirements.

Infiltration Area 1

Investigative explorations show a consistent slightly silty fine to medium sand occurring across the site. The sand unit starts just below the surface and extends to depths of 8 feet (approximately 268 feet elevation) where deeper material increases in silt content.

The groundwater level measured in the new monitoring well HC00-B333, during November 2000, had an elevation of 268.5 feet. Table 4 lists the seasonal water level variations for two comparable wells east of Infiltration Area 1 with water level records that include last year's seasonal high. Based on the average seasonal fluctuation in these wells, and assuming currently observed water levels correspond to the seasonal low, the projected seasonal high water level for HC00-B333 is 273.1 feet (approximately 8 feet below ground surface).

The locations tested exhibited medium to high infiltration capacities ranging from 4.6 to 20.4 in./hr. Results are summarized in Table 1.

To illustrate the infiltration potential of this site, we have estimated the infiltration capacity of 400 lineal feet of 8-foot-wide infiltration trench(es). Using a design infiltration rate of 4.2 in./hr, such trenches in Area 1 may be expected to infiltrate 0.30 cfs of stormwater from SMP area SDW1A.

Infiltration Area 3

Three test pits revealed varying shallow soil composition. The northern two test pits (HC00-TP338 and HC00-TP339) encountered silty fine to medium sand at elevations between 297 and 308 feet. Test pit HC00-TP337 in the southern portion of the site revealed dry silt from the surface at approximate elevation 309 feet, to the bottom of the test pit (approximate elevation 301 feet). Although not determined at this time, the groundwater level in Infiltration Area 3 is expected to be at a depth of at least 10 feet, based on the absence of seepage into the test pits. Local water table mapping by AESI (2000) suggests that the groundwater elevation in the shallow regional aquifer is around 230 to 240 feet at this location.

Double-ring infiltrometer tests were conducted in test pits approximately 3 to 4 feet below the ground surface (i.e., approximately 302 to 309 feet elevation). Two were located in a silty sand deposit and provided moderate infiltration rates of 7.5 and 5.0 in./hr. The third test was performed in finer-grained silty soil and gave an infiltration rate of 0.94 in./hr.

Using an estimated design infiltration rate of 2.7 in./hr and assuming overall trench dimensions of 400 feet by 8 feet, Area 3 should infiltrate approximately 0.2 cfs of stormwater from SMP area SDW1B. Additional trenches may be an option in this area; however, the proximity of the adjacent slope (greater than 15%) may require regrading to create benches. The KCSWDM indicates that a geotechnical assessment of slope stability would likely be required for construction of an infiltration facility in Area 3.

CONCLUSIONS

The results of our soil borings and infiltration tests show that Areas 1 and 3 are suitable for infiltration of detained stormwater. The infiltration capacities quoted in this report are provisional; the appropriate design infiltration rate for each area depends on the chosen location, layout, depth, and length of infiltration trenches. The implementation of infiltration facilities will necessitate full consideration of relevant engineering requirements as outlined in the KCSWDM.

Sincerely,

HART CROWSER, INC.

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REFERENCES

King County, 1998. King County Surface Water Design Manual, King County and Department of Natural Resources.

EPA, 1980. EPA Falling Head Percolation Test Procedure, Design Manual - Onsite Wastewater Treatment and Disposal Systems, EPA.

ASTM, 2000. Double Ring Infiltrometer Test, ASTM Method D 3385, Annual Book of ASTM Standards, Soil and Rock (1): D 420 - D 5799.

AESI, 1999. Seattle-Tacoma International Airport Ground Water Study, Associated Earth Sciences, Inc. and S. S. Papadopulos & Assoc.

Table 1 - Summary of Infiltration Testing Results; West Side of Third Runway Embankment

Location ID	Approximate Ground Surface Elevation in Feet (msl)	Measured Infiltration Rate in in./hr	Assumed Correction Factors $F_{testing}$	$F_{plugging}$	$F_{geometry}$	Design infiltration rate in in./hr	Estimated Infiltration Capacity in cfs using 200ft x 8ft trench(es) Number of Trenches 1 (200 linear ft)	2 (400 linear ft)	3 (600 linear ft)
Infiltration Area 1	(SDW1A)								
HC00-B327	276.1	20.40	0.3	0.9	1	5.51	0.20	0.41	0.61
HC00-B328	275.4	4.65	0.3	0.9	1	2.06	0.08	0.15	0.23
HC00-B329	280.8	18.45	0.3	0.9	1	4.98	0.18	0.37	0.55
Infiltration Area 2									
HC00-TP301	245.6	0.00	0.5	0.8	1	NA	NA	NA	NA
HC00-TP302	244.2	0.33	0.5	0.8	1	NA			
HC00-TP303	253.5	0.43	0.5	0.8	1	NA			
Infiltration Area 3	(SDW1B)								
HC00-TP307	309.2	0.94	0.5	0.9	1	0.42	0.02	0.03	0.05
HC00-TP308	304.9	5.00	0.5	0.9	1	2.25	0.08	0.17	0.25
HC00-TP309	311.7	7.50	0.5	0.9	1	3.38	0.13	0.25	0.38
Pond G									
HC00-B310A	264.9	0.24	0.3	0.8	0.25	NA	NA	NA	NA
HC00-B313A	260.2	1.68	0.3	0.8	0.25	NA			

Notes:

(1) Infiltration rates determined by double-ring infiltrometer (ASTM method D 3385) or a modified EPA falling head percolation test procedure (Design Manual - Onsite Wastewater Treatment and Disposal Systems, EPA, 1980)

(2) Correction Factors: per King County Surface Water Design Manual (1998)

$F_{testing}$ = 0.5 for ASTM method D3385 and 0.3 for EPA method

$F_{plugging}$ = 0.8 for fine sands and loamy sands, 0.9 for medium sands

$F_{geometry}$ = 0.25 to 1.0, values for the trenches all exceeded 1.0 and Pond G was < 0.25

Design infiltration rate = measure rate x $F_{testing}$ x $F_{plugging}$ x $F_{geometry}$

Table 2 - Double Ring Infiltrometer Tests

Test ID	Final Reading from Inner Ring in Inches	Time Increment in Minutes	Infiltration Rate in in./hr	Soil Descrpition
Infiltration Area 2				
HC00-TP301A *	0.11	191	0.03	SILT
HC00-TP302A	0.25	46	0.33	Gravelly, silty SAND
HC00-TP303A	0.28	39	0.43	Slightly gravelly SAND
Infiltration Area 3				
HC00-TP307A	0.25	16	0.94	SILT
HC00-TP308A	0.50	6	5.00	Slightly silty, fine to medium SAND
HC00-TP309A	0.50	4	7.50	Slightly silty, fine to medium SAND

* water seeping into test pit and pooling outside the rings

497806/3rd_infil_tests.xls Table 2

Table 3 - Falling Head Percolation Tests

Sheet 1 of 2

Location ID	Test Number	Elapsed Time in min	Change in Head in feet	Percolation Rate in in./hr	Soil Type
Infiltration Area 1					
HC00-B327A	1	2	0.06	21.60	Slightly silty, fine to medium SAND
		5	0.15	21.60	
	2	2	0.06	21.60	
		5	0.14	20.16	
	3	2	0.06	21.60	
		5	0.14	20.16	
	4	2	0.05	18.00	
		5	0.14	20.16	
	5	2	0.05	18.00	
		5	0.14	20.16	
	6	2	0.06	21.60	
		5	0.14	20.16	
HC00-B328A	1	2	0.02	5.40	Slightly silty, fine to medium SAND
		5	0.05	7.20	
		10	0.10	7.20	
	2	2	0.02	7.20	
		5	0.06	8.64	
		10	0.11	7.92	
	3	2	0.02	7.20	
		5	0.05	7.20	
		10	0.11	7.92	
	4	2	0.03	10.80	
		5	0.06	8.64	
		10	0.11	7.92	

497806/3rd_infil_tests.xls Table 3

Table 3 - Falling Head Percolation Tests

Location ID	Test Number	Elapsed Time in min	Change in Head in feet	Percolation Rate in in./hr	Soil Type
Infiltration Area 1					
HC00-B329A	1	2	0.05	16.20	Slightly silty,
		5	0.10	14.40	fine to medium
		10	0.20	14.40	SAND
		15	0.29	13.92	
		20	0.37	13.32	
		25	0.45	12.96	
	2	2	0.05	18.00	
		5	0.12	17.28	
		10	0.23	16.56	
		15	0.33	15.84	
		20	0.44	15.84	
	3	2	0.05	18.00	
		5	0.12	17.28	
		10	0.26	18.72	
		15	0.37	17.76	
		20	0.49	17.64	
	4	2	0.06	21.60	
		5	0.14	20.16	
		10	0.26	18.72	
		15	0.39	18.72	
Pond G					
HC00-B310A	1	30	0.01	0.24	Slightly silty,
	2	30	0.01	0.24	fine to medium
	3	30	0.01	0.24	SAND
HC00-B313A	1	30	0.07	1.68	Silty, gravelly
	2	30	0.06	1.44	SAND
	3	30	0.07	1.68	
	4	30	0.07	1.68	

497806/3rd_infil_tests.xls Table 3

Table 4 - Estimation of Seasonal High Water Level in Infiltration Area 1

Monitoring Well ID	Ground Surface in Feet (msl)	Top of Casing in Feet (msl)	——— Seasonal Water Level Range ———				Period of Record	Range of Fluctuation in Feet
			Minimum in Feet (msl)	Date	Maximum in Feet (msl)	Date		
HC99-B64	292	294.2	284.9	Nov-00	288.2	Jan-00	12/99 to 10/00	3.3
HC99-B73	291.7	293.80	283.42	Oct-99	289.3	Mar-00	10/99 to 10/00	5.88
HC00-B333	281	283.5	268.5	Nov-00				

Projected Seasonal High Groundwater Level in HC00-B333 = **273.09** = 268.5 + (3.3+5.88)/2

Vicinity Map

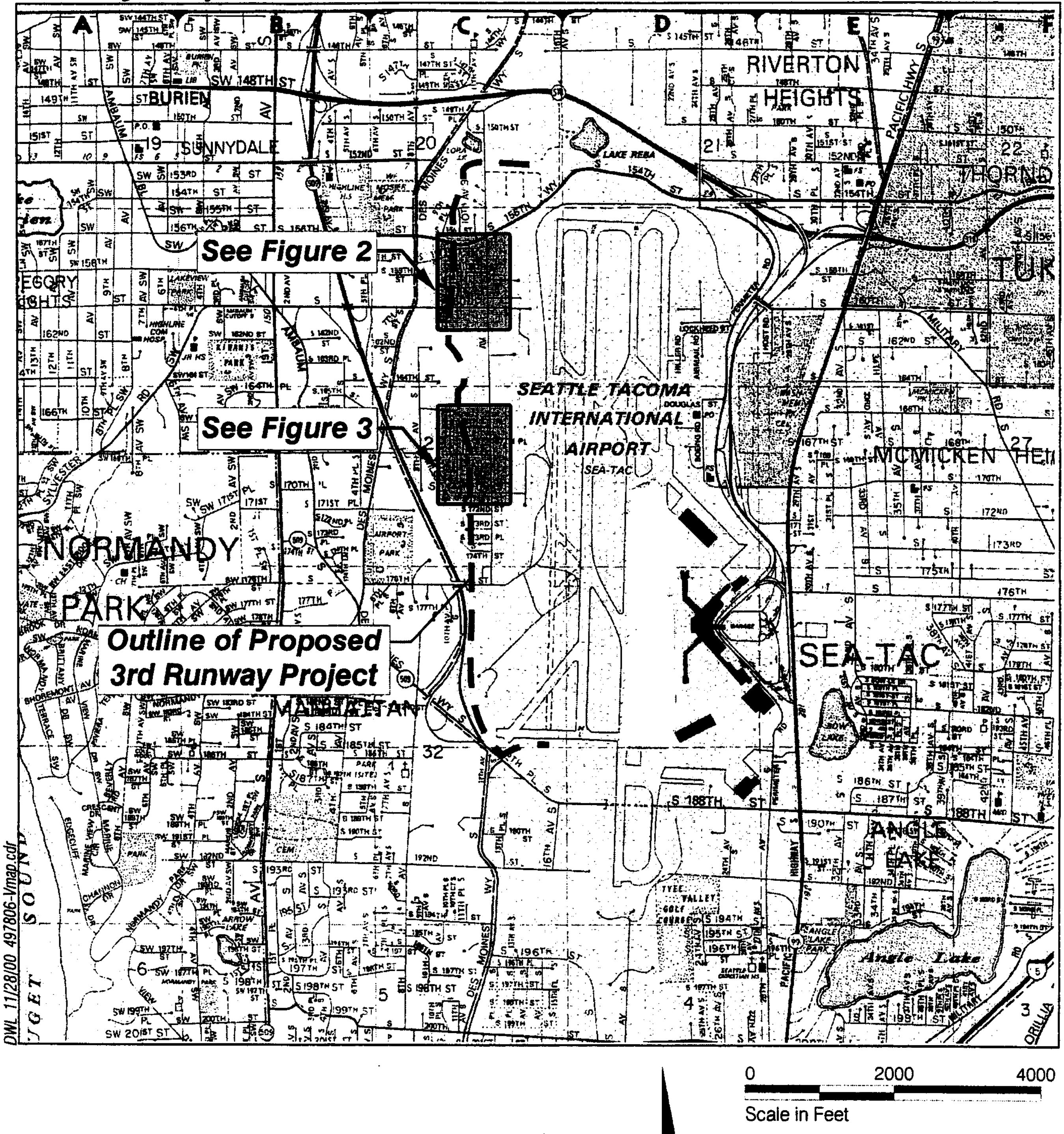

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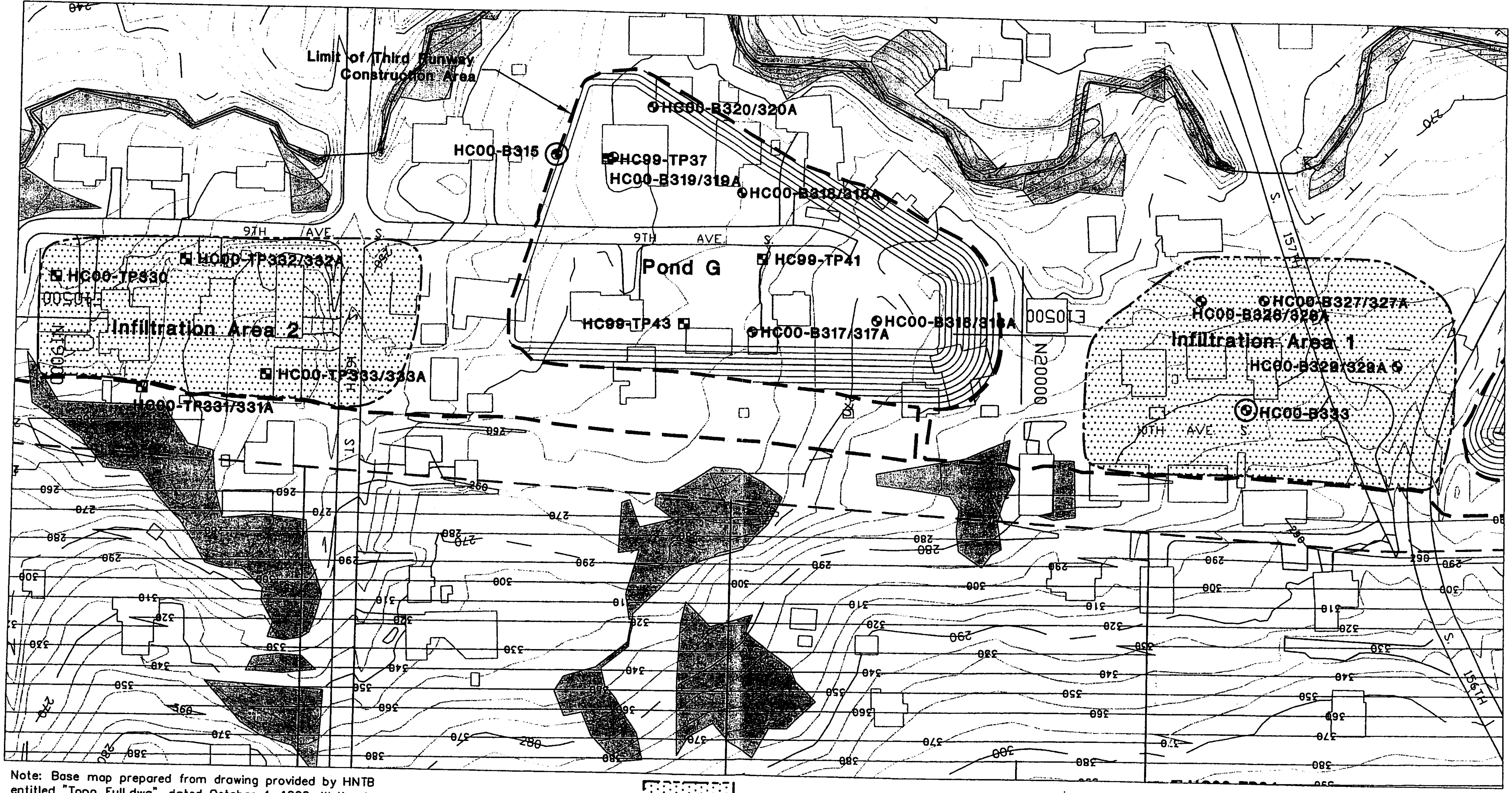
Figure 1

Site and Exploration Plan

Infiltration Testing



Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_110800.dwg", dated November 8, 2000.

▨ Infiltration Area

Exploration Location and Number

HC99-TP37 ◪ Test Pit

HC00-B311/311A ⊕ Soil Boring

HC00-B315 ⊙ Soil Boring Completed as Monitoring Well

N

0 100 200

Scale in Feet

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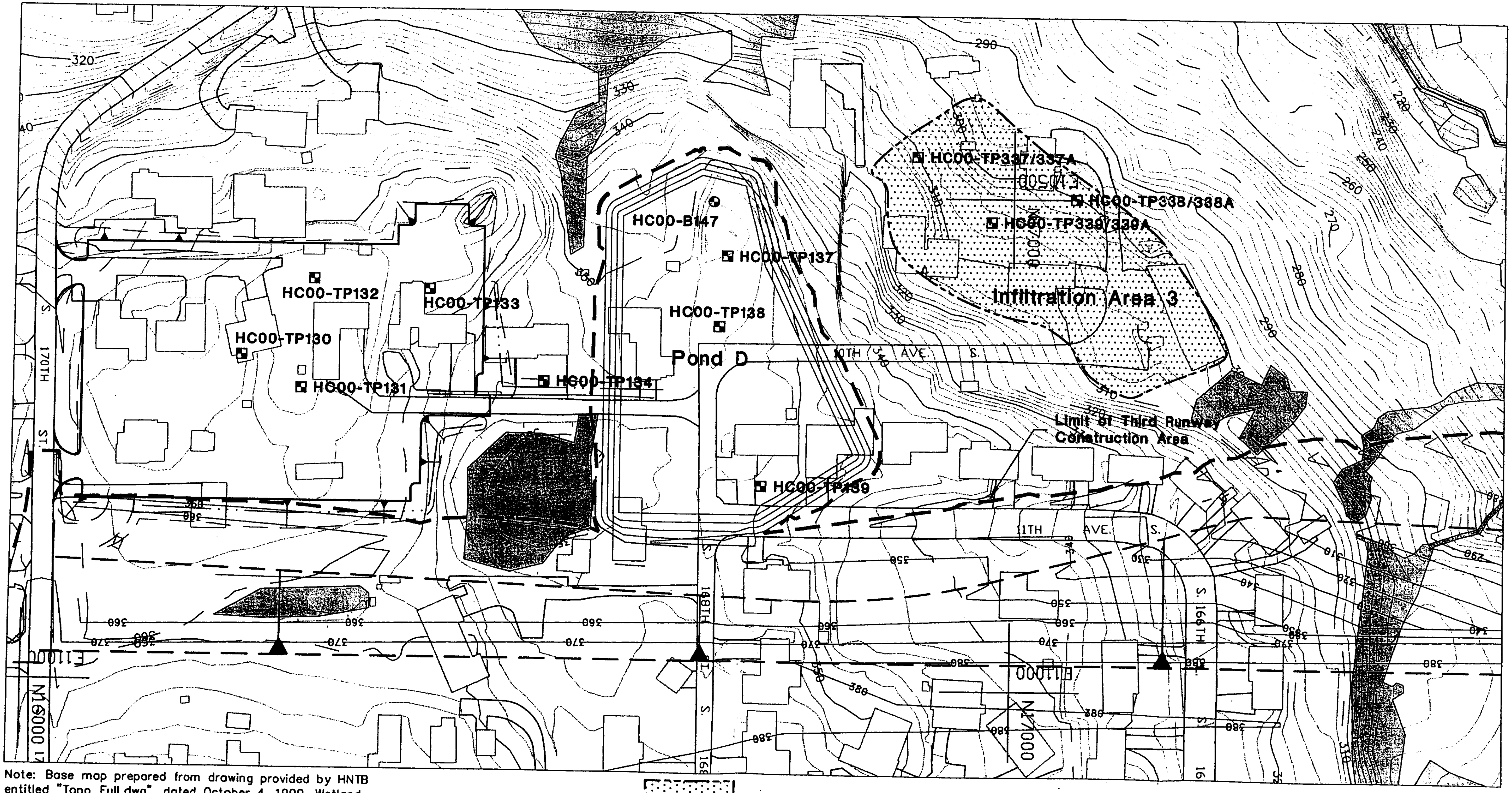
Figure 2

hel 12/5/00 1=1 (xref)see drawing file/charlie.pc2
49780648

Site and Exploration Plan

Infiltration Testing



Note: Base map prepared from drawing provided by HNTB entitled "Topo_Full.dwg", dated October 4, 1999. Wetland delineation prepared from drawing provided by Parametrix entitled, "W_110800.dwg", dated November 8, 2000.

hel 12/5/00 1=1 (xref)see drawing file/charlie.pc2
49780649

▒ Infiltration Area

Exploration Location and Number

HC99-TP37 ◪ Test Pit

HC00-B311/311A ⊕ Soil Boring

N

0 100 200
Scale in Feet

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Figure 3

APPENDIX A
EXPLORATION LOGS

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.
Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Test Symbols

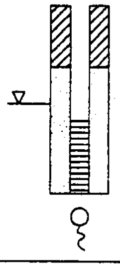
BORING SAMPLES

☒	Split Spoon
⧅	Shelby Tube
▥	Cuttings
◫	Core Run
*	No Sample Recovery
P	Tube Pushed, Not Driven

TEST PIT SAMPLES

☒	Grab (Jar)
⧄	Bag
⧅	Shelby Tube

Groundwater Observations



Surface Seal

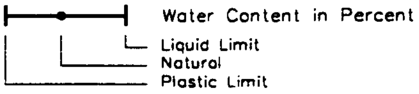
Groundwater Level on Date
(ATD) At Time of Drilling

Observation Well Tip or Slotted Section

Groundwater Seepage
(Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits



PID	Photoionization Detector Reading
CA	Chemical Analysis
DT	*In Situ* Density Test

BORING1.DWG

1=1

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Boring Log HC00-B327

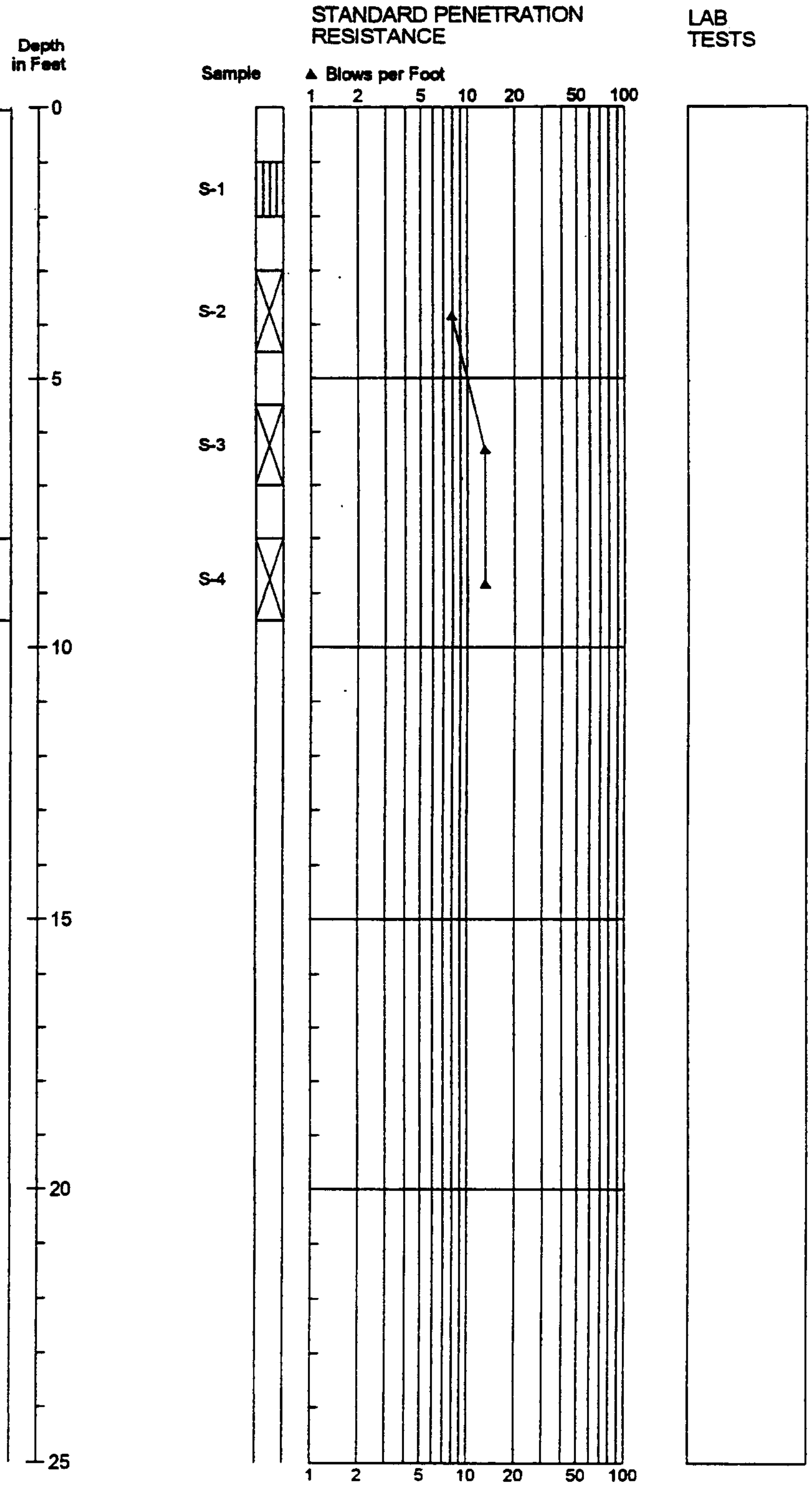
Soil Descriptions

Ground Surface Elevation in Feet: 276.1

Medium dense, moist, brown, slightly silty, fine to medium SAND, grading to slightly gravelly, fine to medium SAND.

Medium dense, moist, gray, slightly gravelly, very silty SAND.

Bottom of Boring at 9.5 Feet.
Completed 11/10/00.



BORING LOG 497806.GPJ HC_CORP.GDT 12 1 00

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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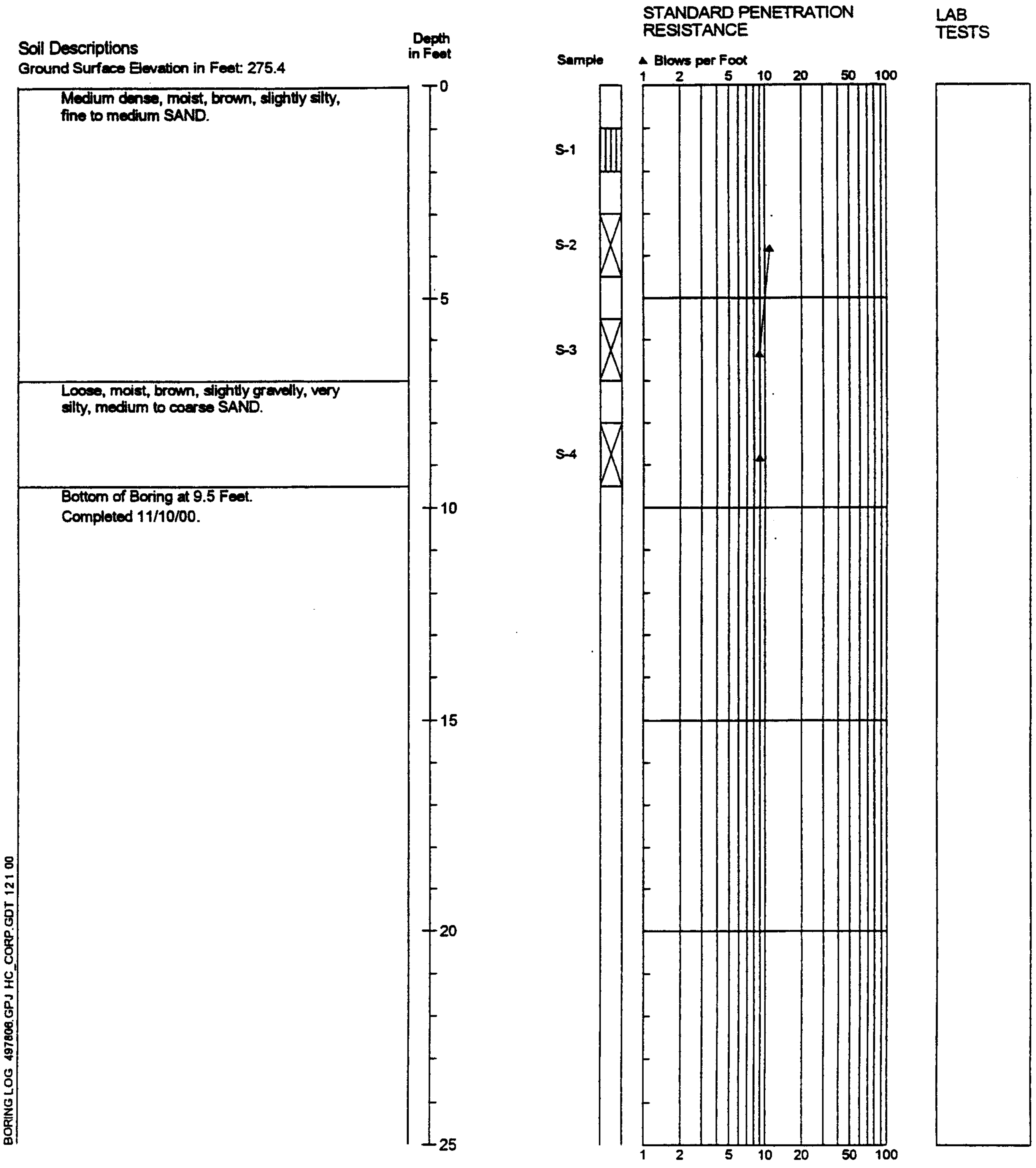
Figure A-2

Boring Log HC00-B328



Soil Descriptions
Ground Surface Elevation in Feet: 275.4

Medium dense, moist, brown, slightly silty, fine to medium SAND.

Loose, moist, brown, slightly gravelly, very silty, medium to coarse SAND.

Bottom of Boring at 9.5 Feet.
Completed 11/10/00.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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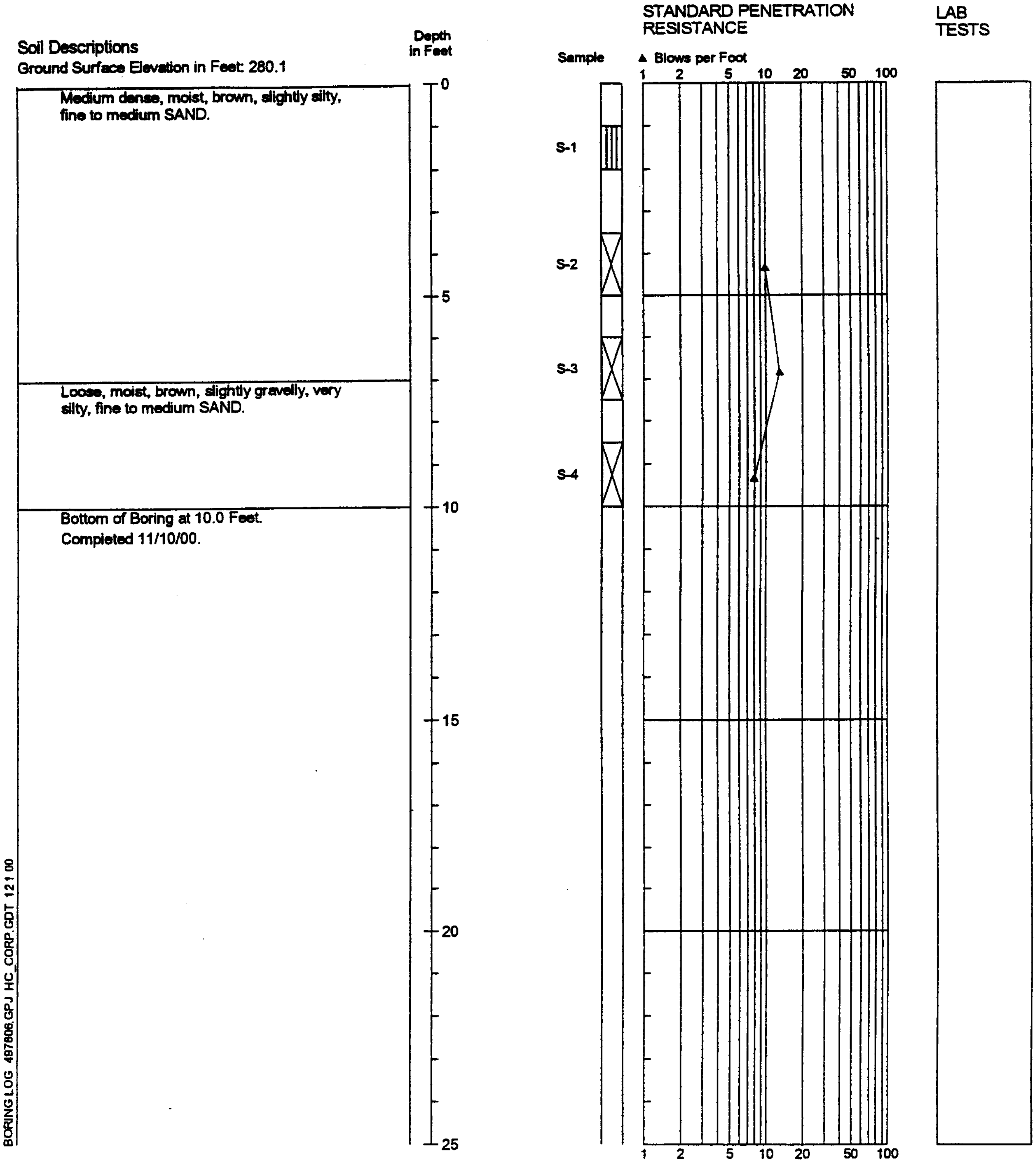
J-4978-06 11/00

Figure A-3

Boring Log HC00-B329



Medium dense, moist, brown, slightly silty, fine to medium SAND.

Loose, moist, brown, slightly gravelly, very silty, fine to medium SAND.

Bottom of Boring at 10.0 Feet.
Completed 11/10/00.

BORING LOG 497806.GPJ HC_CORP.GDT 12100

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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Figure A-4

Monitoring Well Log HC00-B333

Soil Descriptions
Ground Surface Elevation in Feet: 280.9

Loose, moist, brown, slightly gravelly, slightly silty, medium to fine SAND.

Loose, moist, brown, medium to coarse SAND grading to gray slightly gravelly, very clayey, fine to medium SAND.

Medium dense, moist, brown, slightly gravelly, silty, fine to medium SAND.

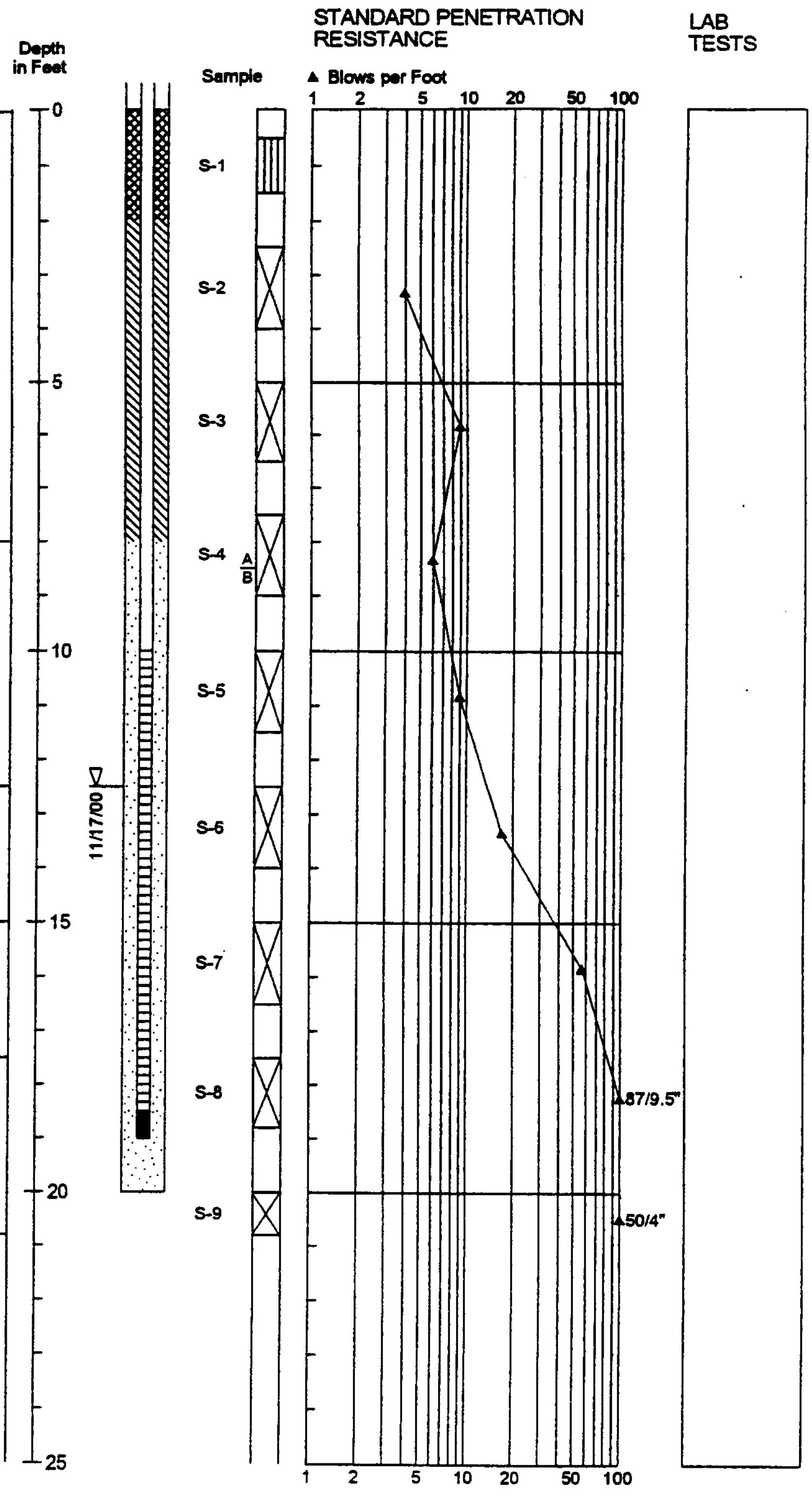
Hard, moist, gray, very sandy SILT.

Very dense, moist, gray, very silty, fine to medium SAND.

Bottom of Boring at 20.8 Feet.
Completed 11/15/00.

Top of Casing Elevation in Feet: 283.49

BORING LOG 497808.GPJ HC_CORP.GDT 12 1 00



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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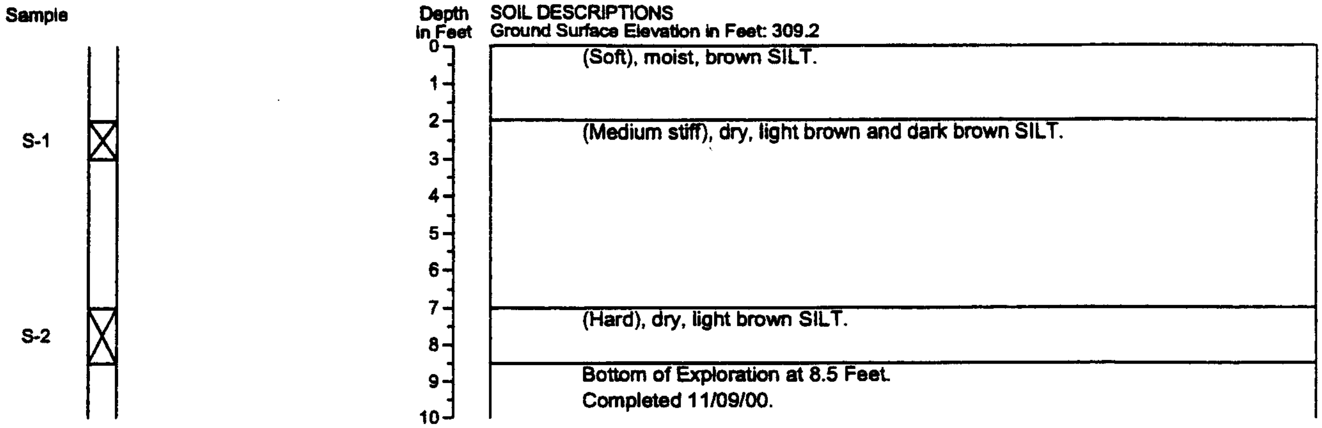
Figure A-5

Test Pit Log HC00-TP337



SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 309.2

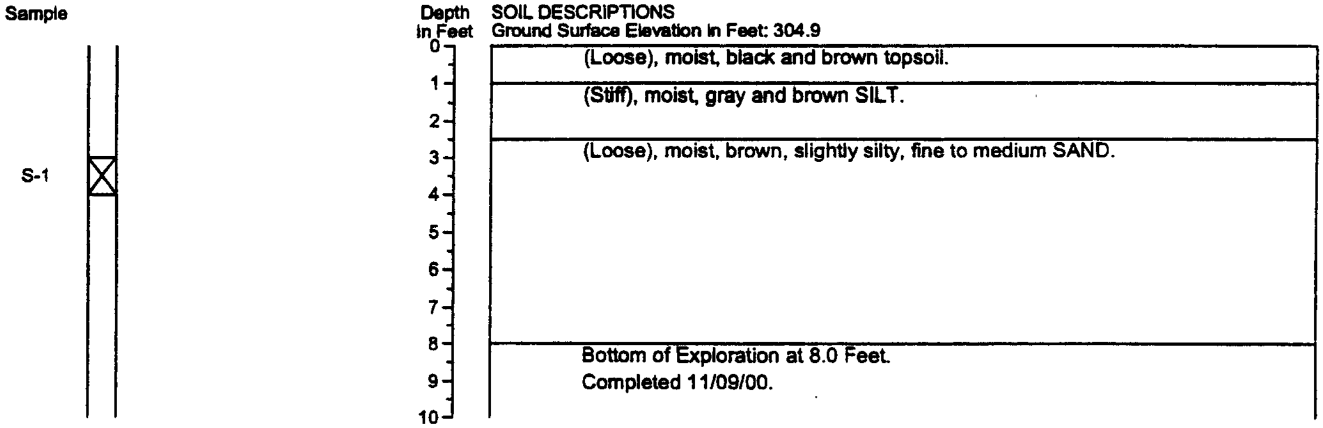
(Soft), moist, brown SILT.

(Medium stiff), dry, light brown and dark brown SILT.

(Hard), dry, light brown SILT.

Bottom of Exploration at 8.5 Feet.
Completed 11/09/00.

Test Pit Log HC00-TP338



SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 304.9

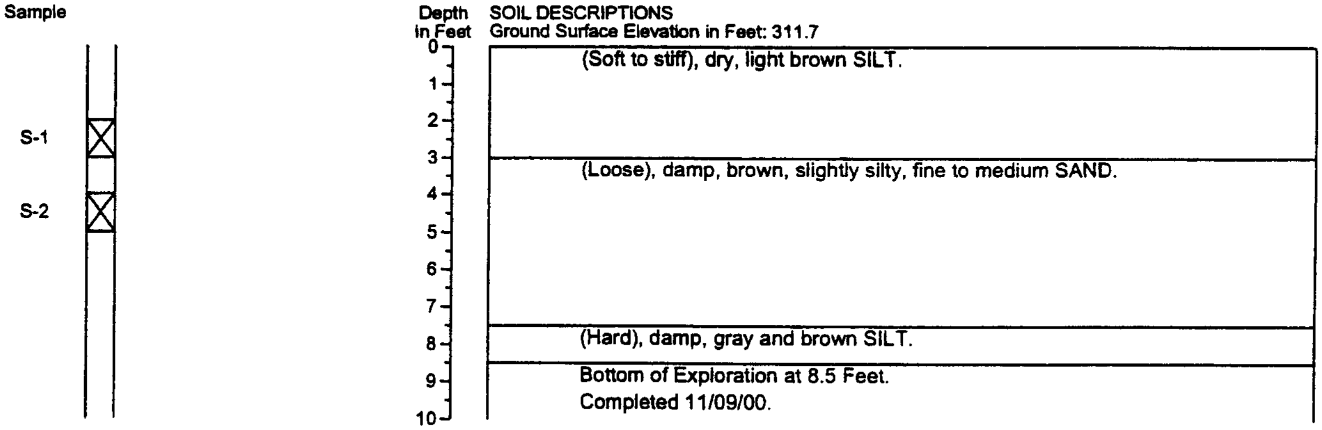
(Loose), moist, black and brown topsoil.

(Stiff), moist, gray and brown SILT.

(Loose), moist, brown, slightly silty, fine to medium SAND.

Bottom of Exploration at 8.0 Feet.
Completed 11/09/00.

Test Pit Log HC00-TP339



SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 311.7

(Soft to stiff), dry, light brown SILT.

(Loose), damp, brown, slightly silty, fine to medium SAND.

(Hard), damp, gray and brown SILT.

Bottom of Exploration at 8.5 Feet.
Completed 11/09/00.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground conditions, if indicated, are at time of excavation. Conditions may vary with time.

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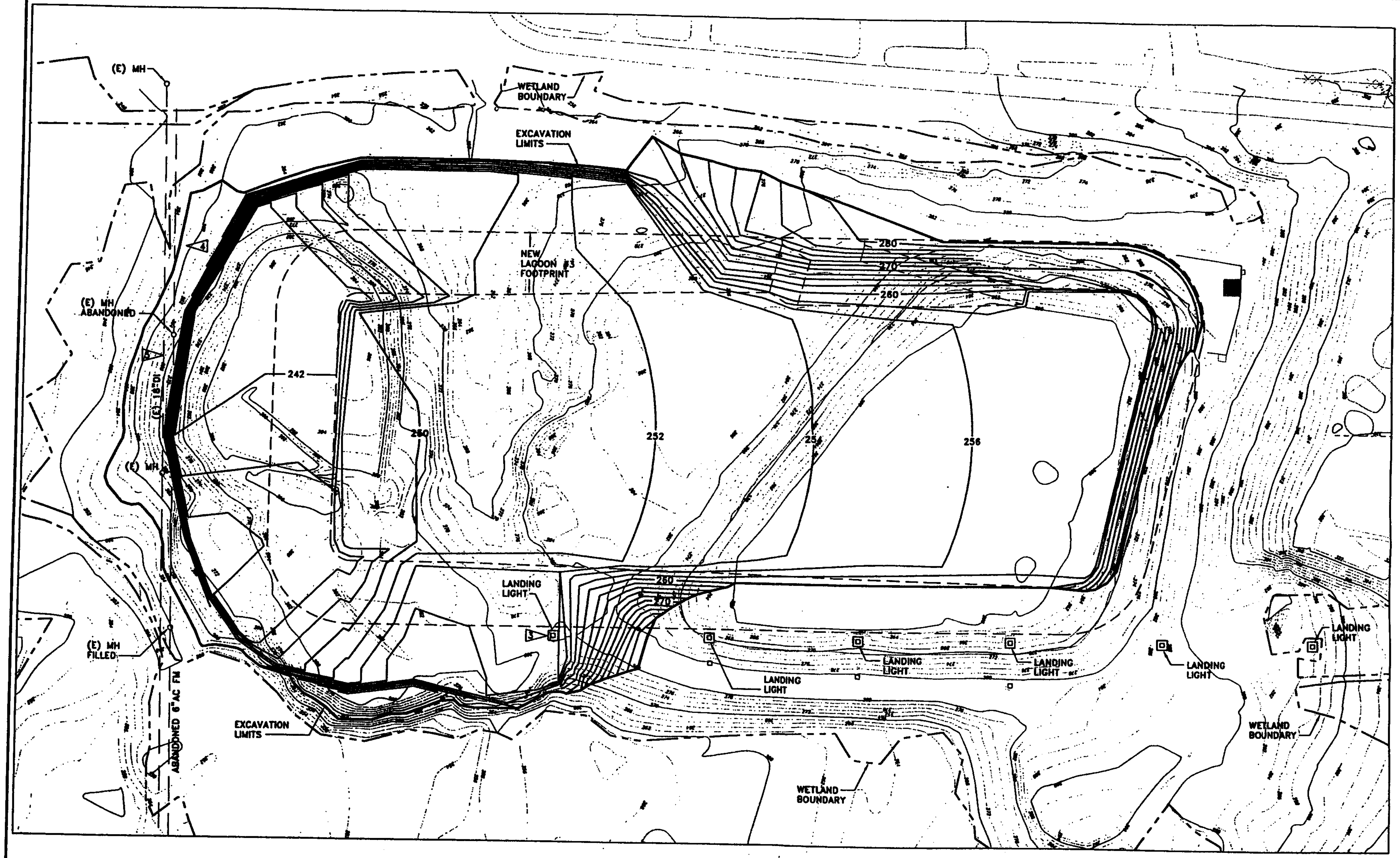
Figure A-6

APPENDIX K

APPENDIX K

IWS LAGOON #3 EXPANSION FOOTPRINT



CONSTRUCTION NOTES:

1. THE AREA TO THE SOUTH OF THE EXISTING LAGOON IS KNOWN TO CONTAIN BURIED CONSTRUCTION DEBRIS SUCH AS CONCRETE, WOOD, ASPHALT GRINDINGS, AND UNSUITABLE SOIL. SEE GEOTECHNICAL REPORT, BY ZIPPER ZEMAN ASSOC., FEBRUARY, 2000.

2. OVER-EXCAVATION BEYOND FINISH GRADE SHALL BE TO ELEVATIONS AS DETERMINED BY ENGINEER IN THE FIELD.

3. CONTRACTOR SHALL PROVIDE SHORING AS REQ'D TO PROTECT EXISTING LANDING LIGHT TOWERS IN EXCAVATION AREA AT ALL TIMES.

4. CONTRACTOR SHALL PROVIDE SHORING AS REQ'D TO PROTECT ACCESS ROAD DURING OVER-EXCAVATION.

5. CONTRACTOR SHALL VERIFY LOCATIONS AND DEPTHS OF EXISTING UTILITIES AND PROVIDE SHORING OR OTHER PROTECTION AS REQUIRED DURING OVER-EXCAVATION.

PLAN
LAGOON #3 EXCAVATION
SCALE: 1"=60'-0"

N

1"=60'   60 0 60 120
scale feet

CALL 48 HOURS
BEFORE YOU DIG
1-800-424-5555

998111.00\P8C003 XREF: BASE, LAGOON, SURVEY

Kennedy/Jenks Consultants
FEDERAL WAY, WA

MJW
TJK
RJS/KNG
AS NOTED
2/23/00
RCG

REVISIONS

PORT OF SEATTLE

SEA-TAC INTERNATIONAL AIRPORT
INDUSTRIAL WASTEWATER SYSTEM
LAGOON #3 EXPANSION PROJECT

EXCAVATION PLAN

C-100888
K/J 998111.00
STIA-0009-C-3