Aspect consulting
IN-DEPTH PERSPECTIVE

LONG-TERM MONITORING PLAN
Des Moines Creek Regional Detention/Retention Facility
Prepared for: Des Moines Creek Basin Committee

Project No. 040106A-001-2.3 • December 8, 2005

Aspect Consulting, LLC

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Executive Summary

The Des Moines Creek Basin Committee has designed a suite of projects intended to aid in the protection and restoration of the 3.5-mile-long Des Moines Creek System. The Des Moines Creek Regional Detention/Retention Facility (RDF) is one of the major components of this suite of projects. It is designed to attenuate peak flows by enhancing storage capacity in the vicinity of the Northwest Ponds, located on and near the Tyee Golf Course, south to southwest of the Seattle-Tacoma International Airport.

Construction of the RDF will necessitate large-scale excavation of soil that will require export or on-site reuse. During the design phase of the project, an environmental soil sampling program was completed by King County to evaluate disposal and end-use options for the excavated material. Elevated levels of arsenic were measured in the proposed excavation areas with concentrations increasing with depth. Concerns were raised in regards to arsenic impacts on the RDF project by Ecology representatives during the permitting process associated with a 401 Water Quality Certification (WQC). Following issuance of the 401 WQC, the Des Moines Creek Basin Committee entered into the Washington State Department of Ecology's Voluntary Cleanup Program (VCP) to negotiate mitigation measures necessary to protect for potential impact from construction and long-term operation of the RDF.

In support of the 401 WQC process, several studies have been conducted to document the occurrence, mobility, and fate and transport of arsenic near the project site. Initially, the Arsenic Issues Evaluation Report (Aspect Consulting and others, 2004b) predicted how the RDF project would affect arsenic levels in the environment resulting from the project construction and operation, while the 2004 *Sampling and Analysis Plan* (Des Moines Creek Basin Committee, 2004) presented a methodology and multi-media sampling program to monitor for the potential impacts. These initial two documents were supplemented by a series of Technical Memoranda, each examining a specific issue, including cap design, soil segregation, arsenic mobility, and preliminary sampling results.

The conclusions of the studies suggested that project design modifications and monitoring scenarios would provide reasonable assurance that the project could be constructed without causing long-term impacts to surface water quality or downgradient receptors, and allow appropriate response time if unanticipated impacts occur during the monitoring period. Furthermore, inspection of the background and baseline monitoring data set indicate observed arsenic concentrations below their respective regulatory standards outlined in this *Long-Term Monitoring Plan* for all media except some soils, which will be contained as part of the design modifications.

The long-term monitoring program presented here was developed based on these initial monitoring results, the findings of the Technical Memoranda, and ongoing negotiations with Ecology.

1 Introduction

This document introduces the Des Moines Creek Regional Detention Facility's Long-Term Monitoring Plan (LTMP), designed to monitor arsenic concentrations and potential related impacts arising from construction and operation of the RDF.

1.1 RDF Project

Over time, urban development of the Des Moines Creek watershed has resulted in increased stream flows and channel erosion in the creek, limiting suitable fish habitat. Existing land use plans indicate increasing urbanization of the watershed will occur in the future. The Des Moines Creek Basin Committee (Basin Committee), an multijurisdictional forum including King County, the City of SeaTac, the City of Des Moines, the Port of Seattle, and the Washington State Department of Transportation, has worked cooperatively for a number of years on a basin planning project (Des Moines Creek Basin Committee, 1997). The Basin Committee identified construction of a RDF to temporarily store excess runoff and reduce downstream impacts as one among several projects to improve conditions in Des Moines Creek.

The RDF is currently under construction in the upper reach of the West Fork of Des Moines Creek, near the Northwest Ponds--an open water body in an surrounding wetlands area--and Tyee Golf Course, south/southwest of Seattle-Tacoma International Airport. The RDF project works in conjunction with several other projects. A flow bypass will be constructed to route a portion of stream flows in the East Fork of Des Moines Creek directly to Puget Sound, reducing instream flows during storm events. A diversion pipe will also route portions of East Fork stream flows that exceed the capacity of the bypass pipeline to the RDF impoundment area for controlled release to Des Moines Creek. The single RDF will thus serve both major tributaries of Des Moines Creek. A new, higher capacity channel has been constructed for the West Fork of Des Moines Creek. In addition to improving conditions in Des Moines Creek, the overall RDF project will also reduce flooding and open water areas at the golf course directly south of the airport runways, which will reduce potential risks to airplanes from bird impacts, consistent with Federal Aviation Administration (FAA) requirements.

1.1.1 RDF Operation

The Des Moines Creek RDF Project will temporarily store storm flows from both the West Fork and East Fork of Des Moines Creek and provide for controlled release of the stored water to the West Fork channel through designed flow control structures. The effect of the RDF project will be to reduce peak discharge rates and flow volumes in Des Moines Creek, thereby reducing erosion in the ravine south of 200th Street, stabilizing the stream channel, and supporting the maintenance of suitable fish habitat.

After construction of the RDF project is completed, the average surface water elevations at the Northwest Ponds (NWPs) will be lowered by approximately 1.2 feet in winter and 0.5 feet in summer. Flows from frequent annual storms and less frequent, larger storms

with relatively small return intervals will be stored behind the West Berm at the NWPs. During infrequent, larger floods (those exceeding an approximate 10-year return interval), flows will also be stored behind the East Berm in the Approach Light Road Pond. Under existing conditions, areas of the Tyee Golf Course near the NWPs are flooded for extended time periods in most years. With construction of the RDF project, the range of fluctuations in water surface elevations at the NWPs will be greater than under current conditions, but the duration of flooding above pond base elevations will be decreased. The annual number of flood-dry cycles on lands adjacent to and somewhat higher than the ponds will therefore be increased during RDF project operation.

The Tyee Bypass pipeline will route some flows from the East Fork of Des Moines Creek around the creek to discharge in Puget Sound. During larger storm events, when the capacity of the bypass line is exceeded, excess flows from the East Fork will be routed to the Tyee Diversion pipeline and discharged to the NWPs through the West Berm. Those discharges during large storms will occur into standing water. A Port stormwater runoff line (SDS 4) that currently discharges to Des Moines Creek will also be connected to the Tyee Diversion pipeline. During smaller storm events, when no East Fork flow is diverted to the NWPs, the SDS 4 discharge into the Tyee Diversion pipeline may occur onto land above the lower water elevations behind the West Berm.

Discharges from the RDF will be controlled by flow control structures associated within the West Berm and East Berm. Installation of the final design flow control orifices will be delayed several years after RDF construction is completed to allow time for planted vegetation to grow and be capable of surviving periodic inundation. The orifices may also be modified at a later time as an adaptive management step, if needed to preserve planted vegetation or forested areas, or to modify downstream flow levels.

No regular sediment removal actions, or additional soil excavations, are planned for the NWPs detention area as part of normal RDF operations.

1.2 History of Arsenic Issues, Ecology Coordination

The King County Department of Natural Resources and Parks (King County) completed two phases of a soil investigation program designed to provide upland and wetland soil chemistry data for a number of sample locations within the RDF excavation areas (identified as Cell 1 and Cell 2). The purpose of the County's soil sample program was to provide data to evaluate disposal and end-use options for approximately 45,000 cubic yards (cu. yd.) of excavation spoils resulting from lowering the existing ground surface to approximate elevation 245 feet. Soil chemistry data would enable evaluation of excavated soil handling options, identification of soil staging areas, soil disposal/treatment options, and end-use options for clean soil such as in-fill for the abandoned section of the Des Moines Creek channel and slope dressing. Sample data indicated elevated arsenic levels associated with organic rich soil (peat horizons) within the planned RDF footprint. Only two samples from Cell 1 exceeded 120 milligram/kilogram (mg/kg) (dry weight basis) with nine non-detections, while in Cell 2, only one samples exceeded 100 mg/kg with coincidently nine additional non-detects. Of the 42 samples analyzed for arsenic during the second phase of sampling, 17 exceeded 20 mg/kg, the Model Toxics Control Act (MTCA) Method A Soil Cleanup Level for arsenic. The mean arsenic concentration for all samples, including non-detects, was 42 mg/kg,

ranging in magnitude from non-detect to 432 mg/kg. Most of the sampled borings had an "inverted" depth profile, with arsenic concentrations increasing with depth. These results indicated a potential for elevated arsenic levels in post-excavation, near-surface soils at the RDF. The data also raised the possibility that construction and operation of the RDF project as proposed could result in mobilization and transport of arsenic. Thus, arsenic was identified as a potential concern only shortly before the planned start of construction in 2004.

The source of the arsenic has not been conclusively determined, although available evidence suggests that the peat deposits act as a sink, slowly accumulating trace concentrations of arsenic naturally present in groundwater over many thousands of years. While the arsenic source has not been specifically identified, distribution of arsenic at the site does not suggest deposition of airborne ASARCO contamination as the sole direct source. Historic agricultural use of arsenic as a pesticide and volcanic activity in and adjacent to the Puget Sound Basin are potential contributors. There are no known or reported arsenic generating operations or activities associated with airport operations.

Construction and post-construction operations of the RDF have the potential to change the existing hydrology and geochemical conditions in the project area and could result in mobilization and transport of arsenic. The long-term monitoring program is designed to monitor for such potential long-term impacts, with sufficient lead time to develop contingency management plans if required prior to significant human exposures or environmental impacts.

1.3 RDF Construction

Construction activities for the RDF project, which in total will require at least two construction seasons (Phase I and Phase II), began in summer 2004. A contingent third construction season (continuation of Phase II) is earmarked for summer 2006. Construction activities are detailed in a series of engineering specification drawings (King County, 2003a, 2003b, 2003c and 2003d).

Phase I included the following major activities:

- Excavation of a realigned West Fork channel and abandonment (backfilling and regrading) of the existing channel;
- Planting vegetation along the new channel and placing grade controls;
- The construction of two flow control vaults along the new West Fork channel alignment, at the locations of the West Berm and East Berm;
- Lowering of water levels at the NWPs after the new channel and flow control vaults were completed; and
- Placing the West Berm preload to consolidate subsurface soils, which included excavation of approximately 3,000 cubic yards of peat (for preload stability).

During Phase I, additional minor activities were performed: some underground utilities were removed, a stream crossing for the future Tyee Bypass pipeline was constructed, and an existing weir in the stream channel was removed.

RDF construction is currently in Phase II and is scheduled to include the following major activities:

- Lowering of water levels at the NWPs to 242.0 feet;
- Dewatering in planned soil excavation areas (as required);
- Excavation of approximately 56,000 cubic yards of soils in Cell 1 and Cell 2 to the north and east of the easternmost NWPs, to a final grade of 244 to 245 feet (sloping toward NWPs). This phase of construction includes removal of soil with elevated arsenic concentrations and construction of a reactive barrier and clean soil cap over an approximate 2 acre area in Cell 1 and Cell 2;
- Construction of the Tyee Diversion pipeline and outfall at NWPs;
- Completion and final grading of the West Berm, including spillway;
- Construction of the East Berm, including spillway;
- Installation of anchor posts and wire grid over open water areas of NWPs; and
- Extensive revegetation in soil excavation areas, with shrub/scrub wetlands species.

During Phase II, the major staging/stockpile areas associated with soil excavations will be constructed. A small excavation will also be performed to provide enhanced surface water connection among the NWPs. A bypass will be constructed to reroute surface water inflows to NWPs around the area of planned soil excavation to the north.

Temporary erosion/sedimentation controls will be used throughout the period of RDF construction. All excavated materials will be segregated, dewatered, and either stockpiled for reuse (if clean) or disposed of off-site in an appropriate manner. Major revegetation plantings will occur, probably in the months of November or February.

1.4 401 Certification

In the context of obtaining a 401 Water Quality Certification (WQC), Des Moines Creek Basin Committee representatives met with the Washington State Department of Ecology (Ecology) in December 2003 to present and discuss the King County sampling results for arsenic. Following the December meeting, a consultant team on behalf of the Basin Committee performed additional evaluations based on the RDF project description and initial soil sampling results. A conceptual model was developed to provide a framework for considering possible arsenic releases associated with the RDF project. A number of project modifications designed to address arsenic conditions were identified for review. Several types of monitoring programs were developed to support further project design (for prevention/mitigation of possible project-related arsenic releases) and to provide environmental monitoring to identify project impacts. Basin Committee representatives and the consultant team met with Ecology on January 29, 2004 and orally presented their evaluations and proposed monitoring programs.

At the request of Ecology, the arsenic issues presentation given at the January 2004 meeting was documented in the *Arsenic Issues Evaluation Report* (Aspect Consulting and others, 2004b). In addition, a *Sampling and Analysis Plan* (Des Moines Creek Basin

Committee 2004, hereafter referred to as the 2004 SAP) was developed to obtain background and baseline environmental characterization data prior to, during, and after the Phase I construction period. Details of the 2004 SAP program are further described in Section 3; and environmental data collected to date under the 2004 SAP are presented in Appendix A. With submittal of the *Arsenic Issues Evaluation Report* (Aspect Consulting and others, 2004b) and the 2004 SAP Ecology determined it had sufficient technical support to issue a 401 WQC for the RDF project.

A public information meeting was held in June 2004, prior to the issuance of the 401 WQC, to present the arsenic issues and proposed management and mitigation strategy, and seek additional public comment. The 401 WQC was issued, and Phase I RDF construction commenced in summer 2004.

A series of six Technical Memoranda were developed in compliance with the 401 WQC:

- **Des Moines Creek Baseline Soil Boring Sampling Pre-Validated Data Evaluation** (S.S. Papadopulos & Associates, 2004) presented a preliminary evaluation of the Event 1 soil sample results and recommendations for Event 2 soil sampling to characterize the extent of arsenic in RDF Cell 1 and Cell 2 soil;
- **Overexcavation/Clean Cap Extent** (Aspect Consulting, 2004a) described the approximate volume of soil to be excavated during Phase II construction. The memorandum also included a cost estimate based on various overexcavation scenarios;
- **Excavation Materials Segregation & Volume of Clean Materials** (Aspect Consulting and S.S. Papadopulos & Associates, 2004) presented a plan for segregating soil excavated during Phase II construction and an updated volume/cost estimate;
- **Arsenic Mobility Evaluation** (S.S. Papadopulos & Associates, 2005) detailed the results of the arsenic mobility study conducted on RDF soils. The report also evaluated potential water quality impacts during construction;
- **Soil Amendment/Cap Design** (S.S. Papadopulos & Associates and Shannon and Wilson *in progress*) describes the arsenic treatability testing results and provides the technical basis for permeable reactive barrier and cap design; and
- **Preliminary Groundwater Quality Evaluation** (Aspect Consulting, 2004b) presented the results of the groundwater sampling from temporary and permanent monitoring wells. The results were used to predict water quality during preloading of soils during the construction of the West Berm. The memorandum also included results from the June and August 2004 quarterly baseline sampling events and evaluation of potential groundwater quality issues associated with construction dewatering discharge.

In addition, in compliance with the 401 WQC, the Basin Committee provided Monthly Status Reports (King County, 2004 and 2005a) to Ecology. The status reports provided routine updates on construction, sampling (construction, background, and baseline), and preliminarily analytical results. Relevant historical environmental documentation developed for t he RDF project is presented in Appendix E.

1.5 MTCA Requirements: VCP and Coordination Process

Following issuance of the 401 WQC, the Basin Committee, in consultation with Ecology, determined that mitigation measures concerning the occurrence of arsenic near the RDF facility would be best managed under the MTCA Voluntary Cleanup Program (VCP). In May 2004, the Basin Committee initiated discussion with Ecology to obtain technical support for developing and implementing appropriate arsenic mitigation measures during RDF construction. The Des Moines Creek Basin Committee formally applied to the VCP program on May 21, 2004, with response to initial comments followed by finalization of the VCP agreement on June 21, 2004 (Port of Seattle, 2004a and 2004b, respectively).

Starting in January 2005, Ecology and representatives of the Des Moines Creek Basin Committee participated in a series of RDF project coordination meetings. The coordination meetings served as a forum to systematically present, discuss, and resolve a series of technical, regulatory, and construction issues raised by the presence of elevated arsenic in the RDF project area. Meeting topics included: MTCA/401 Certification requirements, mitigation measures (including the permeable reactive barrier and clean cap design), bid specifications, applicable regulatory criteria, and requirements for long-term monitoring. The agenda and meeting minutes from each meeting were documented and distributed to Ecology and the Des Moines Creek Basin Committee (Glass and Aspect Consulting, 2005).

The long-term monitoring program presented below is the cumulative result of this process.

1.6 Long-Term Monitoring Plan Organization

The major sections contained in this Long-Term Monitoring Plan are as follows:

- **Section 2, Objectives**, presents the overall objectives of the long-term monitoring program designed for the Des Moines Creek RDF;
- **Section 3, Previous Monitoring Programs and Results**, summarizes the pertinent investigations, monitoring programs, and results collected to date;
- **Section 4, Long-Term Monitoring – Environmental Media**, describes the different media to be sampled as part of the Long-Term Monitoring Plan;
- **Section 5, Sampling and Analysis Program**, outlines sampling locations and field protocols for collecting soil cap, groundwater, surface water and sediment samples for long-term monitoring as well as vegetative cap observational monitoring ; and presents the applicable regulatory criteria that the results of the long-term plan will be evaluated against;
- **Section 6, Quality Assurance/Quality Control and Data Validation**, describes the Quality Assurance/Quality Control (QA/QC and the data evaluation elements of the plan).
- **Section 7, Data Evaluations**, outlines how the data will be evaluated against the regulatory standards;

- **Section 8, Data Management and Reporting**, describes how the data will be utilized and presented to Ecology;
- **Section 9, Contingent Actions**, presents the options available in case of an exceedance of a regulatory standard in potentially affected media;
- **Section 10, Schedules**, presents the anticipated sampling and reporting schedules for the Long-Term Monitoring Plan; followed by technical appendices, including:
- **Appendix A:** Background and Baseline Sampling Data (2004 Sampling and Analysis Plan);
- **Appendix B:** Field Sampling and Handling Protocols;
- **Appendix C:** Quality Assurance/Quality Control Project Plan; and
- **Appendix D:** Data Validation, Management, and Reporting.
- **Appendix E:** Historical Environmental Documentation contains well logs, figures developed to aid Ecology negotiations;also electronic files of Technical Memorandums, and the 2004 SAP.

2 Objectives

2.1 Objectives of RDF Long Term Monitoring

The primary objective of the monitoring plan is to assess the long-term changes, if any, in arsenic concentrations and dynamics in Des Moines Creek and surrounding soil and groundwater as a result of project construction and operation. Since this monitoring program will be commenced during the second phase of construction, the early part of the program will allow for monitoring of potential short-term RDF construction impacts and an evaluation of the effectiveness of remediation components (soil removal and reactive and clean cap performance).

The specific objectives of the long-term monitoring program are summarized as follows:

- Monitor for any project-related arsenic impacts to the West Fork of Des Moines Creek sediments and surface water during the construction phase of the Cell 1 and Cell 2 excavation and after the RDF project becomes operational;
- Continue data collection to support long-term arsenic time trend evaluations in the West Fork;
- Monitor the effectiveness of the remedial design components for containing arsenic remaining in soil;
- Protection of human health and the environment;
- Monitor any potential arsenic migration caused by the RDF project and apply appropriate adaptive management remedial measures; and
- Assess short-term and long-term arsenic mobility and occurrence in surface water, sediments and groundwater to evaluate the application of adaptive management options as necessary.

2.2 Coordination of LTMP with Previous Monitoring Commitments

As described above, the Basin Committee has been in continuous discussion with Ecology since January 2005 to develop this RDF-LTMP program to meet the objectives described above. Also as noted, the Basin Committee previously agreed under the 401 WQC to conduct construction monitoring and to obtain data described in the 2004 SAP. Construction monitoring will continue until the conclusion of Phase II, independent of the monitoring scope described in the RDF-LTMP. Data generated by the construction monitoring program will continue to be submitted to Ecology via the Monthly Status Reports. However, detailed analysis and interpretation of that data is not directly applicable to the primary objectives of the LTMP.

The 2004 *Sampling and Analysis Plan* (Des Monies Creek Basin Committee, 2004) presented a comprehensive monitoring program to assess background and baseline conditions, potential construction and post-construction impacts, and changes of water quality within and downgradient from the project site. The 2004 *Sampling and Analysis Plan* included sampling and analysis of soils, surface water, sediments, and groundwater. To date, the background and baseline monitoring programs of the 2004 SAP have been completed. Current monitoring activities of the RDF are defined as Post-Construction Monitoring in the 2004 SAP. However, once finalized, the scope of this LTMP will preempt the Post-Construction Monitoring program presented in the 2004 SAP.

Data collected as part of the 2004 *Sampling and Analysis Plan* is presented in Appendix A of this document. The LTMP utilizes the results and observations gathered as part of the 2004 SAP; data trend interpretation relies on those data.

3 Previous Monitoring Programs and Results

3.1 Site Characteristics

The Des Moines Creek basin consists of an urbanized watershed that covers 5.8 square miles in the Seattle-Tacoma metropolitan area. Des Moines Creek is approximately 3.5 miles long and discharges to Puget Sound at the Des Moines Creek Beach Park. The creek originates on a low-gradient upland plain near the south end of the Seattle-Tacoma International Airport. Two main tributary branches, the East and West Fork, converge at the Tyee Golf Course at river mile (RM) 2.35. The East Fork flows out of Bow Lake and is channeled through a series of subsurface pipes until it surfaces near 26th Avenue South. The West Fork flows out of the NWPs located to the northwest of the Tyee Golf Course. The creek descends steeply through a ravine located south of South 200th Street and is thought to follow former glacial-age outwash channels to Puget Sound (Booth, 1996). The portion of the RDF project area containing elevated arsenic levels in soil is located beneath and east of the NWPs and along the West Fork of Des Moines Creek.

The geologic history of the Puget Sound Basin and the study area has been dominated by repeated glaciation, followed by glacial and non-glacial cycles of deposition. Sedimentary deposits associated with up to four of these cycles have been identified in the Des Moines Drift Plain. A detailed description of the geologic and hydrogeologic conditions encountered in the upper Des Moines Creek Basin is presented in the *Arsenic Issues Evaluation Report* (Aspect Consulting and others, 2004b).

The geologic unit of particular significance related to the RDF project is the relic lake containing organic rich peat soils observed in the Cell 1 and Cell 2 excavation areas of the RDF project. The peat appears to be up to 16 feet thick near the southern area of Cell 1 and is present throughout the proposed excavation areas.

In addition, two particular groundwater bearing zones--a perched zone and a regional aquifer are of interest to the long-term monitoring of the RDF. The perched water table primarily occurs in the shallow peat, alluvium, and recessional outwash deposits encountered in the upper Des Moines Creek basin. Near the RDF, the perched zone appears to be locally isolated from deeper water bearing units by glacial till. The regional aquifer predominately consists of pre-Frasier sands and gravels from glacial and interglacial time periods.

The topographic low surrounding the RDF facility is a natural discharge zone, as evidenced by the shallow water table, wetland hydrology, and upward groundwater gradients. Static piezometric head in wells completed in the regional unit often exhibit highly confined and even flowing artesian conditions. Although seasonally sensitive, the area surrounding the RDF and much of the upper Des Moines Creek channel serves as the local discharge area for perched and regional groundwater under gaining conditions.

The primary constituent of concern for long-term monitoring of the RDF is arsenic. Arsenic was found to occur in conjunction with peat soils that accumulated in wetland

areas. The geochemistry of arsenic, including speciation, mobility, and biogeochemical cycling is described in detail in the *Arsenic Issues Evaluation Report* (Aspect Consulting and others, 2004b).

3.2 Previous Data Collection

Previous data collection efforts are categorized into four periods:

- Design Investigation Phase I and II soil sampling in the excavation cells;
- 2004 SAP Background monitoring of surface water and sediment in the West Fork of Des Moines Creek;
- 2004 SAP Baseline monitoring of soils, groundwater, and surface water in the RDF area; and
- Construction monitoring during Phase I construction.

In addition, historical surface water monitoring data collected at Northwest Pond influent stations is of interest to the LTMP program.

Pertinent data collected from these investigations are presented in Appendix A, Table A-1 through A-3 for groundwater, surface water, and sediment, respectively. See also Figures A-1 through A-5.

3.2.1 *Initial Phase I & II Soil Sampling in Excavation Cells 1 & 2*

King County conducted a Phase I project design soil investigation, August 19 through 21, 2003, to evaluate the soil chemistry at select locations in the Cell 1 and Cell 2 excavation areas. The Phase I investigation was conducted based on procedures outlined in a Sampling and Analysis Plan prepared by the County (Khan and Ferguson, 2003). Soil sample locations consisted of 15 locations from Cell 1 and Cell 2 excavation areas and three locations along the new Des Moines Creek channel alignment. Hand augers were used to advance soil boreholes to an approximate depth of the proposed excavation grade. Soil samples were composited into a single sample from three sample intervals, which were typically near-surface (0.5 – 1.5 feet below ground surface [ft bgs]), mid-depth (2-3 ft bgs), and bottom (between 2 and 7 ft bgs based on ground surface elevation at a particular sample location).

A suite of analytical parameters was selected by King County, which consisted of metals (arsenic, cadmium, chromium, copper, lead, zinc, and mercury), volatile organic compounds, semivolatile organic compounds (base neutral acids), PCBs, and total petroleum hydrocarbons (TPH-HCID, gasoline range, diesel range, and motor oil range). In addition, the three soil samples collected along the new Des Moines Creek alignment were analyzed for herbicides. Detailed results of the soil chemistry investigation are reported in King County (2003f).

A Phase II soil investigation was conducted by King County, on October 23 and 24, 2003, in order to provided discrete interval soil samples from supplemental soil borings. Twenty additional locations were sampled to evaluate the vertical extent of arsenic, chromium, and mercury. The additional soil boring locations were based on the location of elevated composite samples collected during the Phase I investigation. Samples were

typically collected from 6 inches below the ground surface, mid-depth, and the approximate bottom of the proposed RDF excavation depth. Detailed results of the Phase II soil chemistry investigation are included in King County (2003e).

Relevant conclusions of the Phase I and II sampling efforts identified elevated arsenic concentrations in soils within the proposed RDF footprint. Reported concentrations range from non-detect to 432 mg/kg in Cell 1 and non-detect to 149 mg/kg in Cell 2. The highest concentrations were reported in the northern portion of Cell 1 and the eastern area of Cell 2.

3.2.2 Background Sampling of West Fork Surface Water & Sediment

A 3-month background monitoring program was established to document the pre-construction surface water and sediment quality in the existing West Fork of Des Moines Creek, prior to construction of the new creek alignment. The data were obtained consistent with the 2004 SAP, and serve as benchmarks for the evaluation of surface water and sediment quality data collected from the new West Fork channel.

Aspect Consulting conducted an initial background monitoring of surface water and sediment at three locations (SW-1a, SW-2a, and SW-3a; see Figure 3) along the pre-construction West Fork of Des Moines Creek between the Northwest Pond outlet and the confluence of the West and East Forks of Des Moines Creek. Samples were collected monthly at these three locations from February 13, 2004 to April 22, 2004 using procedures outlined in an initial sampling plan (Aspect Consulting and Glass, 2004). Samples were submitted for total and dissolved arsenic analysis. Results, including water quality field parameter data and laboratory analytical data, are presented in Appendix A.

Maximum arsenic concentration in the stream water was 3.1 micrograms per liter (µg/L), which is below both U.S. EPA and Washington State (MTCA Method A) groundwater standards (10 and 5 µg/L, respectively) and considerably less than the Washington State surface water quality criteria for chronic levels in freshwater (190 µg/L). Total arsenic concentrations in the creek sediments ranged from 6 to 48 mg/kg and were significantly lower at the most downstream location. Average sediment background values were 39, 44, and 9 mg/kg at SW-1a, SW-2a, and SW-3a, respectively. These levels are below the upper bound Apparent Effects Threshold (AET) for freshwater sediments of 50.9 mg/kg.

3.2.3 Baseline Sampling

A 1-year baseline monitoring program was established to gather soil, groundwater, surface water, and sediment chemistry data for investigating the environmental cycling of arsenic before major soil excavation and project-related hydrologic or geochemical changes could occur. Baseline monitoring occurred prior to and concurrent with Phase I Construction activities (see Figure 5). The baseline monitoring program was conducted in accordance with the 2004 *Sampling and Analysis Plan* (Des Moines Creek Basin Committee, 2004) and is described below for the soil, groundwater, and surface water and sediment components.

3.2.3.1 Event I & II Soil Sampling in Cells 1 & 2 Excavation Areas

Soil sampling was conducted in excavation Cells 1 and 2 by King County and Aspect Consulting personnel (S.S. Papadopulos & Associates, 2004). Work occurred in two stages. Event 1 tested the lateral and spatial variability of arsenic concentrations. Event 2 re-sampled a small subset of the Event 1 locations to address data gaps and evaluate the extent and mobility of arsenic in soil within the Cell 1 and Cell 2 area of the RDF.

During Event I, April 19 through 30, 2004, King County personnel advanced 53 borings in the excavation area on an 80-foot grid spacing. Samples were collected at 1-foot intervals to a depth of 2 feet below the planned excavation depth. Peat and/or "organic muck" with thicknesses from 1 to 7 feet were encountered in 44 of the 53 borings. Probing suggested that the peat may be up to 16 feet thick locally. The thickest accumulations appear to be in the southern half of Cell 1.

Arsenic concentrations reported for Event I ranged over three orders of magnitude from 0.6 to 596 mg/kg. For locations where arsenic values were greater than 20 mg/kg, concentrations generally increased from the ground surface downward, with a maximum concentration occurring at between 1 and 6 feet below ground surface. Elevated arsenic levels were strongly correlated with the occurrence of peat or organic-rich soil. The highest arsenic concentrations were found to the northeast of the ponds, with an isolated high near the base of the West Berm.

For Event II, 19 previous and 5 new locations were sampled by Aspect Consulting from July 26 through July 29, 2004. Sampling protocol and methodologies were the similar to those used during Event I.

Laboratory testing to determine arsenic mobility was performed on soil samples from nine Event II locations and one Event I location and on sediment samples from the NWPs and the West Fork of Des Moines Creek (S.S. Papadopulos & Associates, 2005). Thirty samples were analyzed for total organic carbon (TOC), nitrogen, iron, acid-volatile sulfide (AVS), and chromium reducible sulfide (CRS). Seven sediment samples were analyzed for the above parameters, except without AVS and CRS, and adding total aluminum and manganese. A subset consisting of 12 soil, 3 pond sediment, and 3 stream sediment samples were analyzed by sequential extraction to provide information on the forms and potential mobility of arsenic. Aerobic batch leach tests were performed on the 12 soil samples to estimate the arsenic fraction that could be released to surface water from soils exposed during excavation.

The following conclusions were reached based on the laboratory testing results:

- In soils with elevated arsenic levels, most arsenic is present as solid arsenic sulfide, with lesser quantities present as strongly adsorbed and soluble arsenic species;
- In sediments, arsenic appeared to be strongly adsorbed and/or incorporated in iron and aluminum oxides and/or clay minerals;
- A small fraction (<2%) of arsenic in site soils is leachable in-situ;
- Leaching of arsenic from exposed soils could result in a detectable increase in arsenic concentration in Des Moines Creek; and

- Excavated soil is not a dangerous waste, because arsenic concentrations in leachate from the Toxicity Characteristic Leaching Procedure (EPA SW-846 Method 1311) did not exceed 5 milligrams per liter (mg/L) (Washington Administrative Code [WAC] 173-303-909[8][c]).

3.2.3.2 Groundwater Sampling

Groundwater samples were collected from 8 temporary single wells and 7 permanent well pairs (Aspect Consulting, 2004b). The temporary wells were located at the south end of the West Berm and were sampled during a one-time event in April, 2004. The permanent well pairs, each consisting of shallow and deep wells, included 4 pairs within the excavation area and 3 pairs along the pre-construction channel of the West Fork of Des Moines Creek. These wells were sampled quarterly from June 2004 to February 2005 as part of the baseline monitoring program. Quarterly long-term monitoring began in May 2005 (see Figure 5).

Reported dissolved arsenic concentrations ranged from 0.5 to 104 µg/L. This data set, depending on location, can be compared to different regulatory requirements depending on the highest beneficial use of groundwater at each specific monitoring location. Rationale and application of these regulatory standards are presented below Section 5.

Shallow and deep groundwater have very similar chemical signatures – both are characterized as a calcium/magnesium bicarbonate type (Figures A-4 and A-5, respectively).

3.2.3.3 Surface Water and Sediment Sampling

Surface water and sediments were sampled quarterly by personnel from Aspect Consulting and King County as part of the baseline monitoring program.

3.2.3.3.1 West Fork of Des Moines Creek

The West Fork was sampled in three locations between the Northwest Pond outfall and the confluence with the East Fork from June 2004 through February 2005. Quarterly long-term monitoring began in May 2005 (see Figure 5). The monitoring was a continuation of the background sampling that begun in February 2004. On September 30, 2004, stream flow was redirected along a new alignment and sample locations were subsequently moved laterally into the new channel. The initial sample locations are identified by the letter "a", while current locations are designated "b".

Water samples were tested for alkalinity, aluminum, arsenic and speciation compounds, calcium, chloride, iron, magnesium, manganese, nitrate, phosphorous, potassium, sodium, sulfate, sulfide, total organic carbon (TOC), and total suspended solids. The highest arsenic concentration measured in West Fork surface water was 3.1 µg/L.

Sediments were tested for total arsenic, iron, manganese, nitrogen, sulfide, TOC, and total solids. Arsenic concentrations in the new channel averaged 5 mg/kg, which is noticeably less than the 41 mg/kg average for the two original channel upstream locations, but little different from the original channel downstream sample site (8 mg/kg).

3.2.3.3.2 *Northwest Ponds (NWPs)*

Surface water samples were collected quarterly from four NWPs locations, from June 2004 through February 2005. Water quality parameters were measured as a function of depth in fall and winter. Sediments were sampled in September 2004 and February 2005 as representative of dry and wet season conditions.

Vertical gradients of specific conductivity and dissolved oxygen (DO) parameters indicated the thickness of the upper mixing layer and the degree of mixing. This layer was shallow in the fall and deep during the winter. At shallow locations the full water column was mixed during winter, while at the 9-foot deep NWP1 the bottom two feet remained unmixed. DO levels in the upper layer varied from 5 to 11 mg/L and declined with depth to a range of <1 to 4 mg/L. Most conductivity gradients mirrored those of DO, but increased with depth. Near-surface conductivity values were 150 to 200 microsiemens per centimeter (µS/cm); values near the bottom varied from 170 to 650 µS/cm. The highest values were recorded in the deep NWP1 location. Temperatures in the ponds varied seasonally from 3° to 22° Centigrade (C). Measurements of pH were in the range of 6 to 8. Oxygen reduction potential (ORP or redox) values were from -130 to 200 millivolts (mV), with lowest values found in summer and fall at the deep NWP1 sampling site.

Arsenic concentrations in Northwest Pond water were low, ranging from 1.3 to 4.3 µg/L. Arsenic concentrations in pond sediments averaged 36 mg/kg with a range from 20 to 55 mg/kg.

Influent flow into the NWPs was not measured as part of the project, but historical arsenic data are available (Aspect Consulting and others, 2004a). Seattle-Tacoma International Airport NPDES-required sampling in the mid-1990s included collection of arsenic data from certain outfalls discharging into Des Moines Creek. The arsenic concentrations measured during this period ranged from non-detect to 5.1 µg/L in influent stormwater. Based on these findings, arsenic analysis was deleted from the NPDES requirements. These data indicate that the long term presence of arsenic at the project site was not, at least in the mid-1990s, significantly influenced by additional or ongoing input from influent surface water sources.

3.2.4 *Construction Monitoring*

King County, on behalf of the Basin Committee, performs construction monitoring in compliance with the 401 WQC. Construction monitoring is phased to match construction phases.

3.2.4.1 Phase I Construction Monitoring

Phase I construction monitoring was initiated by King County in the summer of 2004. Field sampling procedures and methodologies are presented in the Construction Water Quality Sampling Plan, included in Appendix D of the Stormwater Pollution Prevention Plan for Des Moines Creek Basin Restoration Projects (King County, 2005b).

Surface water samples were collected from six stations, beginning at the Northwest Pond, then down the West Fork of Des Moines Creek to the confluence with the East Fork, just upstream from the construction monitoring point of compliance. In addition, a background sample was collected and analyzed from the Tyee Pond located along the

East Fork. As construction advanced, water quality monitoring stations along the creek were relocated in parallel with creek realignment along the West Fork.

Phase I construction monitoring of surface water included a visual inspection for oil and grease, general water quality parameters (pH, temp, DO, and ORP), turbidity, and arsenic.

Construction monitoring data have been collected since the start of Phase I construction (June 2004), beginning with pre-loading of the West Berm and realignment of the West Fork of Des Moines Creek, and are available in the Monthly Status Reports (King County, 2004 and 2005a) routinely submitted to Ecology.

Typically, arsenic results reported by field testing methods range between 5 µg/L (detection limit) and 20 µg/L. However, during the pre-loading of the soils beneath the West Berm, water from a dewatering trench – referred to as the Unsuitable Trench –was collected and broadcast over an area near the south end of Cell 1 for disposal. Field test kit analysis indicated that arsenic concentrations in the trench ranged from 30 to 125 µg/L. A confirmation sample submitted to the King County Laboratory reported arsenic concentration of 72.9 µg/L, approximately 10 percent lower than the field test kit method measurement of 80 µg/L.

3.2.4.2 Phase II Construction Monitoring

King County will perform surface water construction monitoring in Des Moines Creek during Phase II construction. Construction observations will be conducted and documented on a daily basis for indications of construction-related impacts to the West Fork.

A daily sample will be collected from the outlet of the Northwest Ponds and tested for arsenic using a portable test kit. Additional arsenic samples will also be collected on a daily basis during the major excavation activities, and submitted to a certified laboratory for total and dissolved arsenic analysis. Event-based continuous sampling will occur if observations indicate a construction-related impact to the West Fork of Des Moines Creek. Sampling will occur at station SW-1b, located downstream from the new NWPs outlet control structure. Based on the results at SW-1b, the sampling may expand to include stations SW-2b and SW-3b. The compliance coordinator shall decide on the scope of the additional monitoring.

A second year of Phase II construction monitoring will be implemented, as Phase II RDF construction will extend into 2006 (see Figure 5).

4 Long-Term Monitoring -- Environmental Media

4.1 Environmental Medial of Concern

Current data suggest that arsenic concentrations at the site may reflect an arsenic source interaction with a natural peat environment (See geochemical description of arsenic in the Arsenic Issues Evaluation Report, Aspect Consulting and others, 2004b). While peat age dating has not been performed at the site, Rigg (1958) calculated an average accumulation rate of 1 foot every 500 years for deposits found in the Puget Sound lowlands. Application of this relationship to the observed peat thicknesses (13.5 feet in the southern portion of Cell 1), suggests that the peat deposits located near within the RDF may be up to nearly 7,000 years old.

During construction (especially during excavation of the peat), subsurface horizons that are currently anoxic would be brought to the surface. This could result in a short-term release of arsenic-bearing pore water as well as a slow release of arsenic adsorbed on peat and associated with sulfides by leaching and oxidation. The slow release of arsenic from the excavated peat surfaces will be a temporary phenomenon. After the newly excavated surfaces become exposed to natural weathering processes, conditions in the peat are expected to approach pre-excavation conditions at some point in time after the excavation is complete. However, the RDF project design includes elements to control any such remobilization, such that arsenic will not become any more of an environmental threat at the site after the completion of the RDF than it was before construction.

The RDF long-term monitoring program is designed to make observations and collect data to verify that arsenic is not remobilized at the site as a result of RDF construction or operations, and in ways that could adversely impact human health or the environment.

The environmental media of concern are:

- Soil representative of the upper 2 feet of capping material within the RDF;
- Groundwater downgradient of the RDF along the West Fork of Des Moines Creek;
- Surface water from the West Fork of Des Moines Creek;
- Major influent contributing sources to the RDF;
- Sediment from the streambed of the West Fork of Des Moines Creek; and
- Vegetation reestablishment within the RDF (Qualitative assessment).

Section 4.2 provides the technical bases for the monitoring activity in each of these media and the regulatory standards by which data obtained from each will be assessed. Sampling locations and methodology are presented in detail in Section 5 and Appendix B.

4.2 Site-Specific MTCA VCP Standards

Long-term monitoring plan data will be tabulated and compared to appropriate regulatory standards. Site-specific standards for each medium have been developed through in-depth discussion with Ecology from late January through June 2005. The site-specific standards reflect consideration of relevant exposure pathways, in-situ and downgradient receptors, and highest beneficial use.

Long-term monitoring criteria are summarized in Table 1, below, and described more fully in the subsections that follow.

Table 1: Applicable Regulatory Standards for Long-Term Monitoring of Arsenic

Media/Location	Criteria Source	Criteria	Units
Soil Cap			
Upper 2 feet	Mean As-Built Arsenic concentration	10 to 11	mg/kg
Groundwater			
DMCGW-5s and -5d	WAC 173-201A freshwater chronic criteria (dissolved fraction)	190	µg/L
DMCGW-6d	Statistical trend analysis	N/A	-
DMCGW-8	MCL drinking water criteria	10	µg/L
DMCGW-9s and -9d	MCL drinking water criteria	10	µg/L
Surface Water			
SW-1b, SW-2B, and SW-3b	WAC 173-201A freshwater chronic criteria (dissolved fraction)	190	µg/L
Sediment			
Upper 10 cm: SW 1b, SW-2B, and SW-3b	Freshwater sediment upper bound Apparent Effects Threshold (AET)	50.9	mg/kg
Vegetation			
RDF reactive cap area	Visual (qualitative) Inspection	N/A	-

4.2.1 Soil Cap

Previous results from baseline sampling of Cell 1 and Cell 2 were compared to MTCA Method A unrestricted cleanup level of 20 mg/kg. Although the MTCA standard is protective of human health, an arsenic criterion has not been established to be protective of the wetland ecosystem. On review of available data and regulatory policies, Ecology established a site-specific remediation goal: at the conclusion of construction, arsenic concentrations in the upper 2 feet of site soil over the 2-acre project area may not exceed the MTCA Method A cleanup level (20 mg/kg), and that the mean arsenic concentration

may not exceed the preconstruction site mean arsenic concentration (10-11 mg/kg) for surifical soils.[1]

4.2.2 Groundwater

The locations of the wells to be monitored as part of the RDF-LTMP are illustrated in Figure 2. Groundwater monitoring wells DMCGW-5s and -5d are located downstream of the RDF's West Berm, approximately 120 feet north of the new alignment of Des Moines Creek. Similarly, DMCGW-6d is located on the north side, but approximately 1,000 feet further downstream than the DMCGW-5 well pair. Both of these well pairs were established as part of the 2004 SAP. Due to construction impacts and monitoring rationale (elaborated on below), monitoring wells were located at two additional locations explicitly for the RDF-LTMP. Monitoring well DMCGW-8 was located on the bank of the realigned Des Moines Creek, just downstream of the East Berm. Well pair DMCGW-9s and -9d was located 2,800 feet south of the East Berm, approximately equidistant from Highline Water District's (HWD's) Tyee Well and the wetland delineation encompassing the RDF and the West Fork of Des Moines Creek.

At most locations, the elevation of the stage in Des Moines Creek is lower than in adjacent groundwater monitoring wells, thus indicating a gaining segment of the creek. However, during periods of seasonal low groundwater elevations, the creek elevation may remain higher than adjacent groundwater elevations. This condition creates a seasonally loosing condition in the creek, potentially contributing surface water to the aquifer.

DMCGW-5s and -5d are located within the delineated wetland area. The primary receptor for shallow groundwater within the designated wetland area is surface water. Therefore, sample results from DMCGW-5s (shallow) and -5d (deep) will be evaluated relative to WAC 173-201A freshwater chronic criteria for arsenic of 190 µg/L (dissolved fraction).

DMCGW-6d: This well is located just outside the wetland boundary, and adjacent to the creek. Due to the seasonality of the dynamic between gaining/losing reaches of Des Moines Creek to groundwater near DMCGW-6d, and the resultant uncertainty of the potential receptor/beneficial use (surface water or drinking water) of the groundwater being monitored, arsenic data from this well will be evaluated to determine changes over time, rather than compliance with a specific numerical criterion. Monitoring data will be evaluated using trend analysis to identify any significant increasing arsenic concentration trends. If a significant increasing trend is identified, the Basin Committee will discuss the data with Ecology and jointly determine what, if any, additional evaluative or remedial steps are appropriate.

Wells DMCGW-8, -9s, -9d: Monitoring wells DMCGW-8 and DMCGW-9s and -9d are located outside of the designated wetland boundary, approximately equidistant between the RDF and HWD's Tyee Well. The highest beneficial use of groundwater outside of the wetland boundary is drinking water; therefore, analytical results at these locations

[1] Ecology calculated the pre-construction value by eliminating data points over 20 mg/kg (representing peat excavation), then taking the arithmetic mean of the remaining values in the upper 1-foot soil horizon.

will be evaluated against the Maximum Contaminant Level (MCL) drinking water criterion of 10 µg/L for arsenic.

4.2.3 Surface Water

Sample data from the West Fork of Des Moines Creek and from within the detention facility will be compared to the WAC 173-201A freshwater chronic criterion for arsenic of 190 µg/L (dissolved fraction). Compliance with the surface water criterion will be based on achieving surface water cleanup levels within the RDF surface waters (post-construction) and the segment of the creek located within the project boundary between the RDF outlet and confluence with the East Fork of Des Moines Creek.

4.2.4 Sediments

Sediment samples will be collected from the upper 10 cm at three monitoring stations established in each segment of the creek that is located within the newly established West Fork channel. Data will be compared to freshwater sediment upper bound AET value of 50.9 mg/kg, and trends, if any, will be observed.

4.2.5 Vegetation Monitoring

The health of vegetation planted as part of RDF construction will be monitored by periodic visual inspection by a professional biologist. The cause of observed morbidity or mortality will be evaluated in consultation with Ecology. Vegetation cover and plant growth will be compared across the RDF and to similarly situated plant communities in adjacent areas.

5 Sampling and Analysis Program

This section provides a brief overview of the sampling and analysis program for the LTMP. Additional detail on field sampling methods and handling protocols are found in Appendix B.

5.1 Soil Cap Monitoring

The Basin Committee will establish as-built cap arsenic concentration conditions at the conclusion of cap construction. To verify that arsenic concentrations in the clean soil cap do not increase over time, post-construction cap monitoring events will be performed during the dry season in Years 2, 5, and 10 after the cap is installed. Results of the post-construction sampling will be statistically compared to the as-built data compiled at the completion of cap construction (Year 0).

5.1.1 Soil Cap Sampling Locations – As-Built Conditions

As-built sampling to confirm cap arsenic concentrations will be completed immediately following completion of cap construction. As-built data collection will consist of collection samples from two depths at each of four locations within each of about 30 60-foot by 60-foot grid cells. The four samples from each depth interval (0 to 12 inches and 12 to 21 inches[2]) will be composited to yield 2 samples representative of two different depths for each grid cell.

5.1.2 Soil Cap Sampling Locations – Long-Term Monitoring

Similarly, long-term monitoring of the soil cap will consist of collection of soil samples from four spatially discrete locations distributed within the designated grid cells. At each location, samples will be collected from two discrete depth intervals: one from 0 to 12 inches and the other from 12 to 21 inches. The feasibility of sampling every grid cell will be assessed before each long-term monitoring event. If access to cap monitoring locations is limited due to the successful proliferation of RDF vegetation, sampling may be limited to readily accessible cells (see Figure 1). This variance to the sampling program would minimize damage to the established vegetation and the wetland ecosystem. If a reduced sampling program is implemented, the samples collected from the select grid cells will be composited as described above and will be statistically compared against the as-built data set collected at the same grid location.

Sampling locations will be documented using survey-grade GPS with an accuracy of ±0.1 meters and will be permanently marked in the field with an approximately 3-foot-long section of orange-painted inert pipe marked with 6-inch gradations driven to a depth of no greater than 21 inches. Sample locations within each cell may be adjusted based on

[2] The lower depth limit of 21-inches ensures that a 3-inch protective zone above the geotextile at the bottom of the cap is maintained and that sampling does disturb the reactive layer.

surface access (e.g., presence of thick vegetation) and subsurface obstructions (e.g., root mass).

Each of the composited samples will be submitted for total arsenic analysis by EPA Method 6020. Method details are provided in Table 2.

Soil sample collection protocols are provided in Appendix B.

5.2 Groundwater Monitoring Locations

Groundwater samples will be collected from monitoring wells established during baseline sampling [DMCGW-5s (shallow) and -5d (deep) and DMCGW-6d] and newly installed monitoring wells (DMCGW-8 and DMCGW-9s and -9d), as illustrated by Figure 2.

Since the relocation of Des Moines Creek in September 2004, baseline monitoring wells DMCGW-7s and -7d have not contained the water column required to routinely collect representative groundwater samples and as a result these wells were decommissioned in July 2005. Therefore, DMCGW-8 was located approximately 150 feet south near the south end of the East Berm along the bank of the new West Fork channel and completed in the uppermost saturated zone (Aspect Consulting, 2005).

DMCGW-9s and -9d were located and installed at two different depths to provide data representative of ambient groundwater conditions between the RDF and the HWDs Tyee Well. DMCGW-9s is located just outside of designated wetland boundaries and is completed near the contact of recent alluvium/recessional outwash and the older Pre-Fraser sediments. DMCGW-9d is similarly located, but screened deeper in the older Pre-Fraser sediments. All groundwater monitoring locations were established in accordance with Washington Administrative Code (WAC) Chapter 173-160, Minimum Standards for Construction and Maintenance of Wells.

Groundwater samples will be collected on a quarterly basis for 3 years following the completion of RDF construction and on a semiannual basis during monitoring program years 4 through 10 (see Figure 5). Following the third year of monitoring, Ecology will be consulted to determine if the planned sampling frequency should be modified.

Groundwater samples will be submitted for chemical analysis of total and dissolved arsenic (EPA Method 6020), Total Suspended Solids (TSS – SM 2540-D), and geochemical characterization parameters including dissolved iron (EPA Method 6010B), sulfide (EPA Method 9030), and sulfate (EPA Method 300.0). Samples to be analyzed for dissolved metals will be filtered in the field using a 0.45 micron flow through disposable filter.

Groundwater sampling protocols are provided in Appendix B.

5.2.1 Groundwater-Surface Water Head Measurements

Before water samples have been collected, the differential head between the groundwater monitoring wells and the adjacent surface water in West Fork of Des Moines Creek will be determined by reading the creek stage height via a staff gage. A staff gage will be permanently installed in the creek adjacent to each groundwater monitoring location, and then surveyed relative to the project datum and the top of casing elevation to the

neighboring monitoring well(s). The staff gage will be marked with ticks to allow direct measurement to the nearest 0.1 foot. The staff gage measurement will be compared with the adjacent groundwater elevation to assess gaining or losing stream conditions.

5.3 Surface Water Monitoring

5.3.1 Sampling Locations for Des Moines Creek

Surface water samples will be collected at three locations along the new channel of the West Fork of Des Moines Creek, between the RDF outlet and the confluence with the East Fork. The three monitoring stations[3] are shown on Figure 3 and described below:

- **SW-1b** is located in the new channel approximately 50 feet downstream of the outfall of Outlet Control Structure #2 from the NWPs;
- **SW-3b** is located in the new channel approximately 100 feet downstream of the centerline of the Approach Light Road. SW-3b is approximately 100 feet upstream of the discharge from the Port's stormwater outfall SDS4, which enters Des Moines Creek in the vicinity of the confluence of the West Fork and East Fork; and
- **SW-2b** is located in the new creek channel midway between SW-1b and SW-3b.

Samples will be collected during baseflow or under similarly stable conditions. Des Moines Creek surface water samples will be collected on a quarterly basis for 3 years after construction of the RDF is completed and on a semiannual basis during years 4 through 10. Following the third year of monitoring, Ecology will be consulted to determine if the planned sampling frequency should be modified.

Surface water samples will be submitted for chemical analysis of total and dissolved arsenic (EPA Method 6020) and TSS (SM 2540-D). Samples to be analyzed for dissolved arsenic will be filtered in the field.

Surface water sampling protocols are provided in Appendix B.

5.3.2 NWPs Influent Sampling

The Basin Committee will conduct a limited monitoring program to confirm that current NWPs influent arsenic conditions are consistent with those reported by STIA in the 1990s (see Section 3.2.3.3.2 , above). During the first year after completion of RDF construction, quarterly monitoring of influent surface water discharges into the NWPs system will be conducted. Monitoring will consist of collecting samples from four stormwater events throughout the year, at each of the influent drainage ways discharging into the NWPs. Samples would be composites representing the majority of the storm event. In addition, influent base flows into the system would be monitored twice in the monitoring year during the winter and summer periods.

In order to reduce the cost of the monitoring program, samples would be collected as part of ongoing Seattle-Tacoma International Airport NPDES monitoring program. Because

[3] The "b" following the location identifier denotes the monitoring location in the new creek realignment. Previous surface and sediment monitoring locations are denoted with an "a".

the primary objective of this effort is to verify historic conditions, it is not significant that the influent monitoring events will not be conducted concurrent with the downstream monitoring.

5.4 Sediment Sampling

Sediment sampling locations will be paired with the surface water sampling locations along the West Fork of Des Moines Creek between the RDF outlet and the confluence of West Fork and East Fork (see Figure 3).

Des Moines Creek sediment samples will be collected on a quarterly basis for 3 years after construction of the RDF is completed and on a semiannual basis during years 4 through 10. Following the third year of monitoring, Ecology will be consulted to determine if the sampling frequency should be modified.

Sediment samples will be submitted for chemical analysis of total arsenic (EPA Method 6020) and Total Organic Carbon (TOC) (EPA Method 9060A).

Sediment sampling protocols are provided in Appendix B.

5.5 Vegetation Monitoring

The health of vegetation cover planted as part of RDF construction will be evaluated as part of the post-construction monitoring program. A biologist will conduct visual inspection of the vegetative cover annually for evidence of stress not attributable to other stressors, canopy coverage, and presence of invasive species for a period of 10 years. If stress, morbidity and/or mortality are observed, cause(s) will be discussed with Ecology. Morbidity or mortality attributable to arsenic contamination may require additional remedial actions at the site. Figure 4 presents the planting scheme and planned extent of the proposed vegetation cover for the RDF.

5.6 Laboratory Analysis and Testing

Laboratory analytical methods and required reporting limits for the soil cap, groundwater, surface water, and sediment samples collected for this project are summarized in Table 2.

Table 2: Laboratory Analytical Methods and Required Reporting Limits

Analyte	Method	Method Detection Limit	Required Reporting Limit	Units
Soil Cap				
Total Arsenic	EPA 6020	0.2	0.5	mg/kg
Groundwater				
Total and Dissolved Arsenic	EPA 6020	0.2	0.5	µg/L
Dissolved Iron	EPA 6010B	6	20	µg/L
Sulfate	EPA 300.0	0.04	0.2	mg/L
Sulfide	EPA 9030	0.06	0.1	mg/L
Total Suspended Solids	SM 2540-D	0.5	1	mg/L
Surface Water				
Total and Dissolved Arsenic	EPA 6020	0.2	0.5	µg/L
Total Suspended Solids	SM 2540-D	0.5	1	mg/L
Sediment				
Total Arsenic	EPA 6020	0.2	0.5	mg/kg
Total Organic Carbon	EPA 9060A	0.02	0.05	%
Vegetation				
N/A, criteria are stress, morbidity and/or mortality	-Biologist observation	-N/A	-N/A	-N/A

Notes:
Dissolved water samples will be field filtered with a 0.45 micron flow through disposable filter.

6 QA/QC and Data Validation

This section summarizes the Quality Assurance/Quality Control (QA/QC) elements for all the sampling media and the data evaluation protocols. The protocols are analogous to those used in the 2004 Sampling and Analysis Plan. Detailed QA/QC elements for all monitoring programs are included in Appendix C.

6.1 Soil Cap Quality Control Samples

Field duplicates will be collected from approximately 10 percent of the sample population (approximately 5 samples), and laboratory duplicates will be analyzed from about 5 percent of the sample population. The field duplicate will be submitted as a blind duplicate with a unique sample identifier. Regardless of the stated rate of QC sample collection, at least one of each QC sample type will be processed for every monitoring event.

One equipment rinsate blank will be collected during each day of sampling.

6.2 Groundwater Quality Control Samples

Field duplicates will be collected from approximately 10 percent of the sample population, and laboratory duplicates will be analyzed from about 5 percent of the sample population. The field duplicate will be submitted as a blind duplicate with a unique sample identifier. Regardless of the stated rate of QC sample collection, at least one of each QC sample type will be collected during every monitoring event.

One equipment rinsate blank sample will be collected during each day of sampling.

6.3 Surface Water Quality Sampling

Field duplicates will be collected from approximately 10 percent of the sample population, and laboratory duplicates will be analyzed from about 5 percent of the sample population. The field duplicate will be submitted as a blind duplicate with a unique sample identifier. Regardless of the stated rate of QC sample collection, at least one of each QC sample type will be collected during every monitoring event.

One equipment rinsate blank sample will be collected during each day of sampling.

6.4 Sediment Quality Control Samples

Field duplicates will be collected from approximately 10 percent of the sample population, and laboratory duplicates will be analyzed from about 5 percent of the sample population. The field duplicate will be submitted as a blind duplicate with a unique sample identifier. Regardless of the stated rate of QC sample collection, at least one of each QC sample type will be collected during every monitoring event.

One equipment rinsate blank and one trip blank sample will be collected during each day of sampling.

6.5 Data Validation

All data collected during the Des Moines Creek Long-Term monitoring program will be subject to data validation reviews. The data validation process quantifies technical data quality, verifies that adequate documentation was performed, and determines whether the analytical data are usable and meet project Data Quality Objectives (DQOs). Data validation will be performed in accordance with EPA's National Functional Guidelines for Inorganic Data Review. Detailed data evaluation and reporting guidelines are included in Appendix D.

7 Data Evaluations

Validated data from each sampling event will be reduced and evaluated based on the media type, then compared to the regulatory standard outlined above. The evaluation process for each medium is described below:

7.1 Soil Cap Monitoring

Validated results of the 2, 5, and 10 year sampling events will be statistically evaluated against the Year 0 as-built cap arsenic concentration data set. The intent of the evaluation will be to determine if a statistically significant increase in arsenic is observed. The statistical analysis will likely consist of a two-sample, one-sided test (e.g., Wilcoxon rank sum test or other appropriate methods) to compare the mean/median values of the two sample populations.

7.2 Groundwater Monitoring

Results will be validated, tabulated, and then compared to the standards previously identified. In addition, the evaluation of data from at least well DMCGW-6d will include a temporal trend analysis with comparison/correlation to groundwater and creek stage elevations.

7.3 Surface Water Monitoring

Results will be validated, tabulated, and compared to surface water criteria. Concentration trends over time and spatial distributions will also be presented.

7.4 Sediment Monitoring

Long-term monitoring results will be validated, tabulated, and compared to sediment criteria. Temporal trend analysis and spatial distributions will also be presented.

7.5 Vegetation Monitoring

Vegetation cover and plant growth will be compared across the RDF and to similarly situated plant communities in adjacent areas. Areas that show evidence of high mortality or poor plant growth (not attributable to other stressors) may be added as future soil sample locations to determine whether arsenic is a contributing factor.

If a verified exceedance of a RDF-LTMP criterion occurs, the Basin Committee will notify Ecology, and discuss options and next steps, as described in Sections 8 and 9.

8 Data Management and Reporting

This section addresses issues related to data sources, data processing, and data evaluation. Additional information on data management is provided in Appendix D.

8.1 Field Data Management

Accurate documentation of field activities will be maintained using field log-books, field forms, correspondence forms, and photographs. Entries will be made in sufficient detail to provide an accurate record of field activities without reliance on memory.

Field log entries will be dated and include a chronological description of task activities, names of individuals present, names of visitors, weather conditions, etc. When photographs are taken, the project number, date, picture number, and description of the photograph will be entered on a photograph log.

8.2 Analytical Data Management

Raw data generated in the field or received from analytical laboratories will be reviewed, entered into a computerized spreadsheet, and verified for consistency and correctness. Following data review and validation, all field and analytical data will be transmitted to the Port of Seattle Data Manager in the format of the POS Field Module and Lab Electronic Data Deliverable (EDD) for loading to the Port's EMIS database. In addition, data will be electronically submitted to Ecology within 120 days following completion of each sampling report to Ecology's EIM database utilizing the "Submit Data" web page (https://fortress.wa.gov/ecy/eimimport/submit.htm).

8.3 Reporting

Following each quarterly or semiannual sampling event, a brief Data Summary Report will be prepared detailing the sampling results, and will be submitted as part of the corresponding RDF program periodic status report (current, the Monthly Status Report; we assume the frequency of such reporting will be reduced to quarterly or semiannual as the program proceeds from construction to long term monitoring). The summary reports will include data validation, updated tables and figures, and cursory comparison of results against regulatory standards. Detailed trend and statistical analysis will be included in an Annual Report to be prepared at the conclusion of each monitoring year.

The data validation contractor will report all laboratory results together with any data qualifier flags assigned after data reviews in a format suitable for uploading into the data management program as described in Appendix D. A narrative report shall accompany each data validation deliverable. That narrative report shall identify all data validation review steps that were performed and discuss all assigned data qualifier flags, the basis for their assignment, and implications for data usability. The data validation narrative will be reported as an addendum to the Data Summary Report.

In addition, the third Annual Report will contain an expanded data evaluation of the entire data set collected to date which may provide a basis for considering modification of future monitoring frequency.

8.4 Exceedance Notification

In the event periodic monitoring reports a verified exceedance of criteria established by this RDF-LTMP, the Basin Committee will notify Ecology. Based on then-available information, the Basin Committee and Ecology will discuss if there is a reasonable probability that the exceedance was caused by construction or operation of the RDF; if so, whether the exceedance was a one-time occurrence or represents a change in site conditions, and, in addition, whether the exceedance represents an adverse impact to the receptor. If answers to these questions are affirmative, then the Basin Committee will initiate the contingent action process described in Section 9.

9 Contingent Actions

Due to the inherent variability of environmental data, reported measurements can occasionally exceed project standards even though true changes in environmental media quality have not occurred. The following approach to evaluating an exceedance will involve several sequential steps. The steps are intended to identify whether the data reported by the laboratory are accurate, whether the source causing the exceedance of a regulatory standard is construction or operation of the RDF, to identify the mechanism or pathway contributing to the exceedance, and to determine whether the exceedance represents a change in RDF environmental conditions that poses a significant risk to the environment. If the review results in a negative answer for any of these sequential questions, the inquiry is complete, and routine monitoring will continue. However, if RDF construction or operations are determined (on a more-likely-than-not basis, in consultation with Ecology) to be the cause of a significant threat to human health and/or the environment, actions to identify the most appropriate and effective corrective action will be taken.

In the event of a validated exceedance, following consultation with Ecology described in Section 8, the following steps will be taken.

9.1 Verification Resampling

Statistically, false positives will occur in environmental sampling programs. The primary purpose of verification resampling is to ensure that false positives are not included in the RDF data set. Resampling and validation of the verification sample data will confirm whether the initial exceedance was representative of actual site conditions. Verification sampling will be performed at the earlier of the next regularly scheduled sampling event, or within 60 days of receipt of the exceedant laboratory data.

If the verification sample data are below the RDF–LTMP criterion, then the initial value will be qualified in the data set as not to be used in future analysis (except as may be determined appropriate in the event of additional exceedance(s)) and monitoring will continue as scheduled. Verification monitoring results and the associated technical evaluations will be provided to Ecology as part of the next regular report.

9.2 Exceedance Assessment

A second exceedance following resampling will be considered potential confirmation of the previous exceedance and trigger additional notification to and discussion with Ecology. Data will be considered and discussed by the Basin Committee and Ecology in the context of site- and time-specific conditions (including but not limited to time between exceedances, apparent seasonal data trends, unusual drought, unusual precipitation), as well as receptor risk. If Ecology determines additional evaluation is appropriate, the Basin Committee will initiate an Exceedance Assessment.

The initial focus of the Exceedance Assessment is to determine whether the exceedance is caused by construction or operation of the RDF. If the RDF is not the cause of the exceedance routine monitoring will resume. At the same time, Ecology, with the cooperation of the Basin Committee, will initiate an inquiry to determine the cause of the exceedance and, if appropriate, identify potentially liable parties. This first stage of the Exceedance Assessment could include historical, hydrogeologic, geochemical, etc., reviews of the RDF as a potential source.

If the first part of the Exceedance Assessment concludes that the source of the exceedance is the RDF, then the Exceedance Assessment will continue to review the probable impact of the exceedance on potential receptors. Again, hydrogeologic and geochemical reviews may prove useful, and statistical trend analysis, fate and transport evaluations and modeling could also be used, if appropriate, in this inquiry. If the conditions represented by the exceedance do not have the potential to have a significant adverse impact to human health or the environment, the inquiry will end, and routine monitoring will resume.

If, however, the Exceedance Assessment indicates that the exceedance is caused by the RDF, and that it represents a significant potential threat to human health or the environment, then the Basin Committee, in consultation with Ecology, will proceed to an evaluation and implementation of corrective action.

9.3 Corrective Action

The primary goal of corrective action will be to protect human health and the environment. The scope of the corrective action evaluation is highly dependant on the specific media and pathway identified in the Exceedance Assessment, as well as the site-specific conditions at the time of the inquiry. The Basin Committee will consult closely with Ecology in the event a Corrective Action evaluation might be determined to be appropriate.

10 Schedules

The Long-Term Monitoring Plan presents a sampling scheme for all relevant media for a 10-year period. The long-term monitoring program was provisionally initiated, with Ecology approval, in May 2005, at the conclusion of the baseline monitoring program (2004 SAP).

The post-construction time period is divided into two periods:

- **Post Phase I Construction** includes monitoring activities that start after the Phase I construction is complete, and continues through the end of Phase II construction--approximately May 2005 through the end of the 2006 construction season.
- **Post Phase II Construction** monitoring starts after the RDF becomes operational, and continues to Year 10 (2015), as necessary.

10.1 Sampling Frequency

Figure 5 illustrates the sampling frequency for all media presented in the Long-Term Monitoring Plan. Monitoring of groundwater, surface water, and sediment will occur quarterly for Years 1 through 3. After 3 years of data collection, the sampling frequency will be reduced to semiannually for the remainder of the plan, Year 4 through 10. Visual inspection of the vegetative cover will occur annually for the 10 year long-term monitoring period. Sampling of the soil cap is proposed to occur in Year 0 to establish as-built conditions and in Year 2, Year 5, and Year 10, contingent on access as discussed above. If no significant increases in arsenic are found after the three post-construction sampling events (2, 5, and 10 years), no additional monitoring will be required for the soil cap.

10.2 Evaluations for Revising Frequency

The Year 3 Annual Report will include an evaluation of the data collected to date and determine if the sampling frequency should be reduced or modified. The evaluation will include spatial and temporal trends of groundwater, surface water, and sediment, as well as observations in vegetative cover. If appropriate, the evaluation may also include a statistical evaluation of data to determine if a reduced sampling program can meet the objectives of the Long-Term Monitoring Program.

10.3 Reporting

The Data Summary Reports will be prepared and submitted to Ecology 60 days following each sampling event. Annual Reports will be submitted within 90 days of the end of each monitoring year. The Data Summary reports will be included in the periodic status reports, while the Annual Reports will be submitted under separate cover.

References

Aspect Consulting, LLC, 2004a, Overexcavation/Clean Cap Extent Technical Memorandum, Technical Memorandum 2. October 15, 2004.

Aspect Consulting, LLC, 2004b, Preliminary Groundwater Quality Evaluation. October 28, 2004.

Aspect Consulting, LLC, 2005, Letter Report – June/July 2005 Monitoring Well Installation and Decommissioning, Des Moines Creek Regional Detention Facility. October 25, 2005.

Aspect Consulting, LLC and Glass, G.L. (Environmental Consultant), 2004, West Fork Des Moines Creek, Initial Arsenic Sampling and Analysis. February 2004.

Aspect Consulting, LLC, Glass, G. L. (Environmental Consultant), and S.S. Papadopulos & Associates, Inc., 2004a, Des Moines Creek Regional Retention/Detention Facility, Ecology Presentation, Arsenic Issues – Agenda and presentation handout package. January 29, 2004.

Aspect Consulting, LLC, Glass, G. L. (Environmental Consultant), and S.S. Papadopulos & Associates, Inc., 2004b. Arsenic Issues Evaluation Report. April 14, 2004.

Aspect Consulting, LLC and S.S. Papadopulos & Associates, Inc., 2004, Excavation Materials Segregation & Volume of Clean Materials. Des Moines Creek Regional Retention/Detention Facility. November 20, 2004.

Booth, D., 1996, Geology and Geomorphology of the Des Moines Creek Basin. March 25, 1996.

Des Moines Creek Basin Committee, 1997, Des Moines Creek Basin Plan. November 1997.

Des Moines Creek Basin Committee, 2004, Sampling and Analysis Plan, Des Moines Creek Retention/Detention Facility, March 31, 2004.

EPA, 1994, USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. EPA 540/R-94/013. February 1994.

EPA, 2004, SW-846 On-Line, Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods, www.epa.gov/epaoswer/hazwaste/test/main.htm. February 2004.

Glass, G.L. (Environmental Consulting) and Aspect Consulting, LLC, 2005, Ecology Coordination Meeting Minutes. January through July 2005.

Khan, Z., 2003, Scope of Work, Des Moines Creek Basin Restoration Project Soil Chemistry Investigation. Seattle, Washington: King County Department of

Natural Resources and Parks, Water and Land Resources Division. June 12, 2003.

Khan, Z. and Ferguson, M., 2003, Final Draft Sampling and Analysis Plan, Des Moines Creek Basin Restoration Project, Soil Chemistry Investigation. Seattle, Washington: King County Department of Natural Resources and Parks, Water and Land Resources Division. September 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003a, Des Moines Creek Regional CIP, Regional Retention/Detention Facility, Phase 1, Permit Review Submittal (15 sheets). December 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003b, Des Moines Creek Regional CIP, Regional Retention/Detention Facility, Phase 2, Permit Review Submittal (15 sheets). December 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003c, Des Moines Creek Regional CIP, Bypass Pipe Installation, Tyee Reach Permit Review Submittal (6 sheets). December 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003d, Des Moines Creek Regional CIP, Bypass Pipe Installation, Treatment Plant Reach, Permit Review Submittal (7 sheets). December 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003e, Des Moines Creek Soil Chemistry Investigation Phase II Results. December 4, 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003f, Des Moines Creek Soil Chemistry Investigation Results (Phase I). December 17, 2003.

King County Department of Natural Resources and Parks, Water and Land Resources Division (undated). Value Engineering Report, Des Moines Creek Basin Restoration Project, Development Phase, Soil Sampling Recommendation, Design Sketch and Description, pp. 22-25.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2004, Monthly Status Reports. May 2004 through December 2004.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2005a, Monthly Status Reports. January 2005 through July 2005.

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2005b, Construction Water Quality Sampling Plan, Appendix D, Stormwater Pollution Prevention Plan for Des Moines Creek Basin Restoration Projects, Phase II. May 2005.

King County Department of Transportation, 2003a, Memo from Dennis Armstrong, Engineer, Materials Laboratory, Project Support Services Group, to Zahid Khan, Senior Engineer, Surface Water Engineering Services Unit, Capital Projects and

Open Space Acquisitions Section, regarding Des Moines Regional R/D Pond Environmental Testing. October 17, 2003.

King County Department of Transportation, 2003b, Memo from Dennis Armstrong, Engineer, Materials Laboratory, Project Support Services Group, to Zahid Khan, Senior Engineer, Surface Water Engineering Services Unit, Capital Projects and Open Space Acquisitions Section, regarding Des Moines Regional R/D Pond Environmental Sampling Supplemental, Phase 1. December 23, 2003.

King County Department of Transportation, 2003c, Memo from Dennis Armstrong, Engineer, Materials Laboratory, Project Support Services Group, to Zahid Khan, Senior Engineer, Surface Water Engineering Services Unit, Capital Projects and Open Space Acquisitions Section, regarding Des Moines Regional R/D Pond Environmental Exploration Phase II. December 23, 2003.

Port of Seattle, 2004a, Letter of Transmittal from Paul Agid and enclosed Voluntary Cleanup Program Application. May 21, 2004.

Port of Seattle, 2004b, Letter from Paul Agid to Norm Peck; Response – Ecology Proposed Revisions to Voluntary Cleanup Program Application. June 21, 2004.

Rigg, G. B., 1958, Peat Resources of Washington, Bulletin No. 44, State of Washington, Department of Conservation, Division of Mines and Geology.

S.S. Papadopulos & Associates, Inc., 2004, Des Moines Creek Baseline Soil Boring Sampling Pre-Validated Data Evaluation, Technical Memorandum, June 25, 2004.

S.S. Papadopulos & Associates, Inc., 2005, Technical Memorandum #4: Arsenic Mobility Evaluation, March 21, 2005.

S.S. Papadopulos & Associates, Inc. and Shannon and Wilson (in progress). Technical Memorandum #5 – Soil Amendment/Cap Design.

Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Des Moines Creek Basin Committee and the Department of Ecology for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Cell 2

Cell 1

Northwest Ponds

West Berm

Outlet Control Structure #2

West Fork Des Moines Creek (Abandoned Channel)

West Fork Des Moines Creek (Existing)

N

0 100 200

Feet

Legend

- Extent of Reactive Cap
- Extent of overexcavation and placement of clean backfill
- Side Slope Cap
- Excavation Boundary
- Possible Sample Grid (60')
- 6 — Proposed readily accessible soil cap sampling cells

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Soil Cap Monitoring Locations

Des Moines Creek Regional Retention/Detention Facility
SeaTac, Washington

DATE:	PROJECT NO.
May 2005	040106A
DESIGNED BY: JJS	
DRAWN BY: PMB	FIGURE NO. 1
REVISED BY: PMB (July 2005)	

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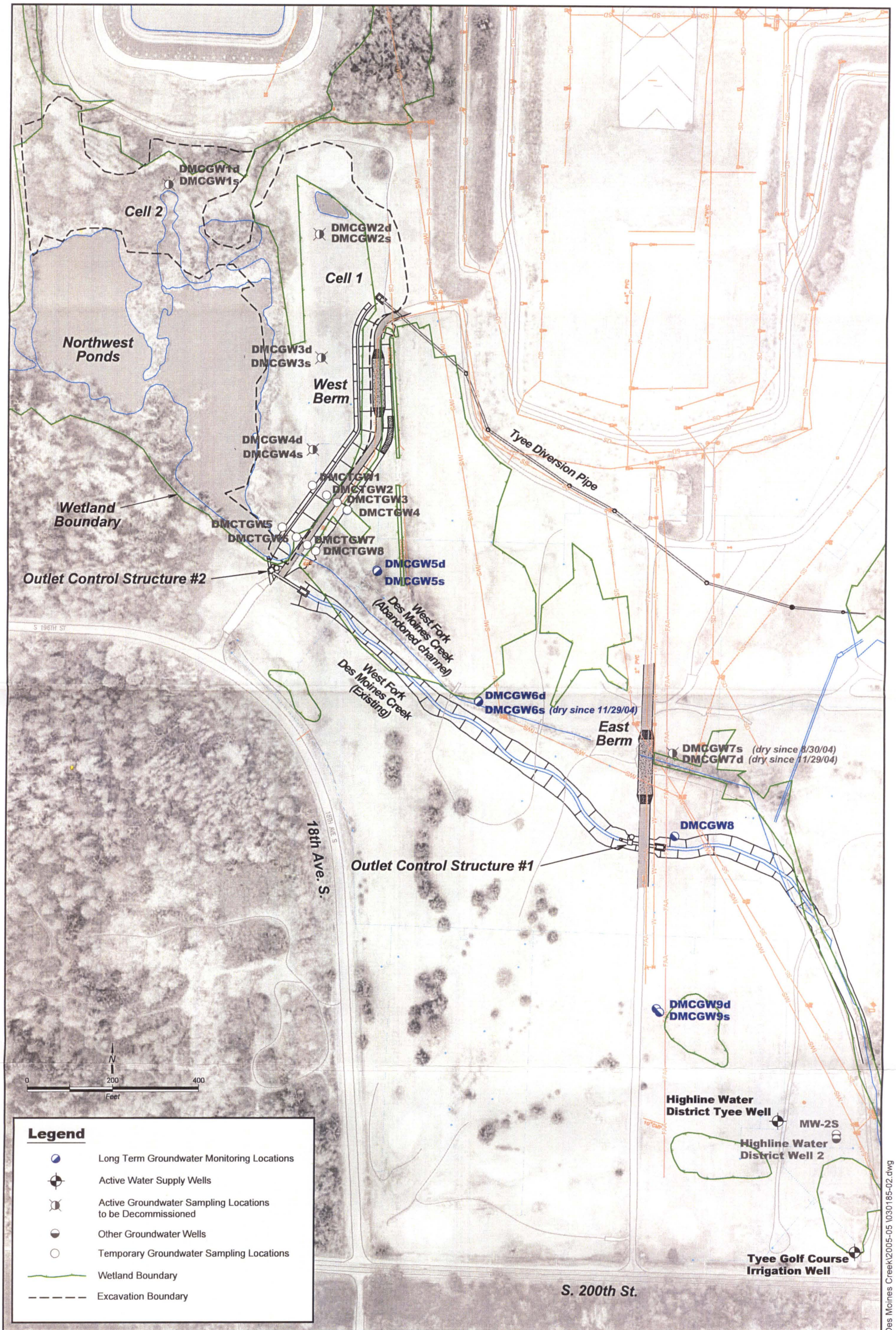

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Groundwater Monitoring Well Locations

Des Moines Creek Regional Retention/Detention Facility
SeaTac, Washington

DATE: May 2005	PROJECT NO. 040106A
DESIGNED BY: JJS	
DRAWN BY: PMB	FIGURE NO. 2
REVISED BY: PMB (July 2005)	

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Legend

- Active Sampling Location for Surface Water Sediment
- Former Sampling Location along Abandoned Creek Channel

Outlet Control Structure #2

SW-1a

SW-1b

West Fork Des Moines Creek (Abandoned Channel)

West Fork Des Moines Creek (Existing)

SW-2a

SW-2b

Tyee Diversion Pipe

East Berm

SW-3a

SW-3b

Outlet Control Structure #1

East Fork Des Moines Creek (Existing)

Tyee Pond

Existing 24" Culvert

S 196TH ST

18TH AVE S

18th Ave. S.

N

0 150 300

Feet

$\Sigma^2\Pi$

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Surface Water and Sediment Sampling Locations

Des Moines Creek Regional Retention/Detention Facility
SeaTac, Washington

DATE: May 2005	PROJECT NO. 040106A
DESIGNED BY: JJS	
DRAWN BY: PMB	FIGURE NO. 3
REVISED BY: PMB (July 2005)	

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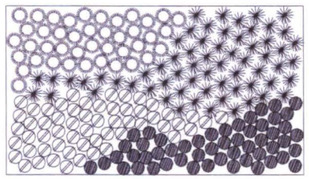
PLANTING SCHEDULE

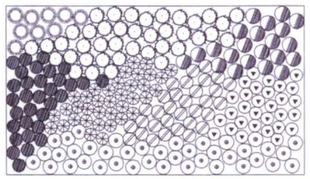
AREA PATTERN	PLANT SYMBOL	SCIENTIFIC NAME	COMMON NAME	SPECIFIED SIZE	SPACING	QTY/100'
		PLANT GROUP A				
		SALIX GEYERIANA	GEYER'S WILLOW	3–4' LIVE STAKES	2'–3' O.C.	3800
		SALIX LASIANDRA	PACIFIC WILLOW	3–4' LIVE STAKES	3' O.C.	3800
		SALIX SITCHENSIS	SITKA WILLOW	3–4' LIVE STAKES	2–3' O.C.	3800
		SPIRAEA DOUGLASII	HARDHACK	3' BAREROOT	3' O.C.	3800
		PLANT GROUP B:				
		CORNUS STOLONIFERA	RED OSIER DOGWOOD	3' BAREROOT	3' O.C.	2200
		PHYSOCARPOS CAPITATUS	PACIFIC NINEBARK	3' BAREROOT	3' O.C.	2200
		ROSA PISOCARPA	CLUSTERED WILD ROSE	2'–3' BAREROOT	3' O.C.	2200
		SALIX GEYERIANA	GEYER'S WILLOW	3–4' LIVE STAKES	2–3' O.C.	2200
		SALIX HOOKERIANA	HOOKER'S WILLOW	3–4' LIVE STAKES	2–3' O.C.	2200
		SALIX LASIANDRA	PACIFIC WILLOW	3–4' LIVE STAKES	3' O.C.	2200
		SALIX SCOULERIANA	SCOULER'S WILLOW	3–4' LIVE STAKES	2–3' O.C.	2200
		SALIX SITCHENSIS	SITKA WILLOW	3–4' LIVE STAKES	2–3' O.C.	2200
		PLANT GROUP C:				
		HOLODISCUS DISCOLOR	OCEAN SPRAY	OCEAN SPRAY	3' O.C.	1300
		PHILADELPHUS LEWISII	MOCK ORANGE	2–3' BAREROOT	3' O.C.	1300
		ROSA NUTKANA	NOOTKA ROSE	2–3' BAREROOT	3' O.C.	2500



PLANT GROUP A

NOTE:
WITHIN EVERY 2,000 SQUARE FEET, ARRANGE THE PACIFIC WILLOW AND HARDHACK NORTH OF THE SITKA WILLOW AND GEYER'S WILLOW.

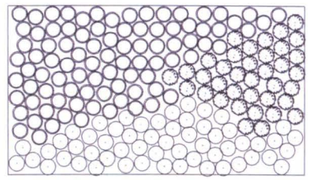
QUANTITY: 60 OF EACH SPECIES.



PLANT GROUP B

NOTE:
WITHIN EVERY 2,000 SQUARE FEET, ARRANGE THE PACIFIC WILLOW, DOGWOOD AND NINEBARK NORTH OF THE OTHER WILLOW. ARRANGE THE CLUSTERED ROSE ALONG THE SOUTH.

QUANTITY: 30 OF EACH SPECIES.



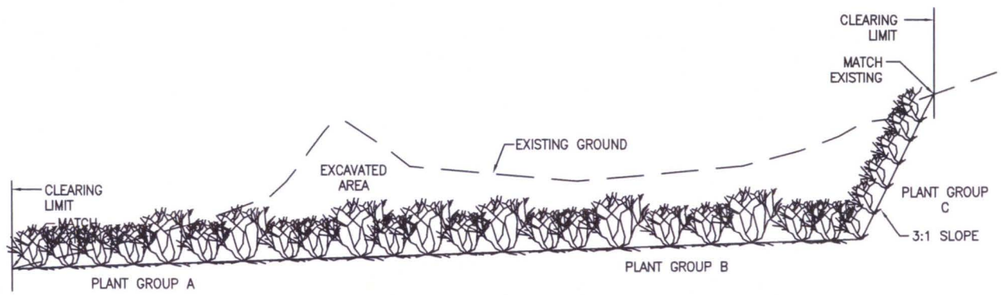
PLANT GROUP C

NOTE:
WITHIN EVERY 2,000 SQUARE FEET, ARRANGE THE OCEAN SPRAY AND ROSE NORTH OF THE MOCK ORANGE.

QUANTITY: 100 ROSE
50 EACH OF MOCK ORANGE AND OCEAN SPRAY.

TYPICAL PLANTING PLANS FOR MODIFIED NORTHWEST POND

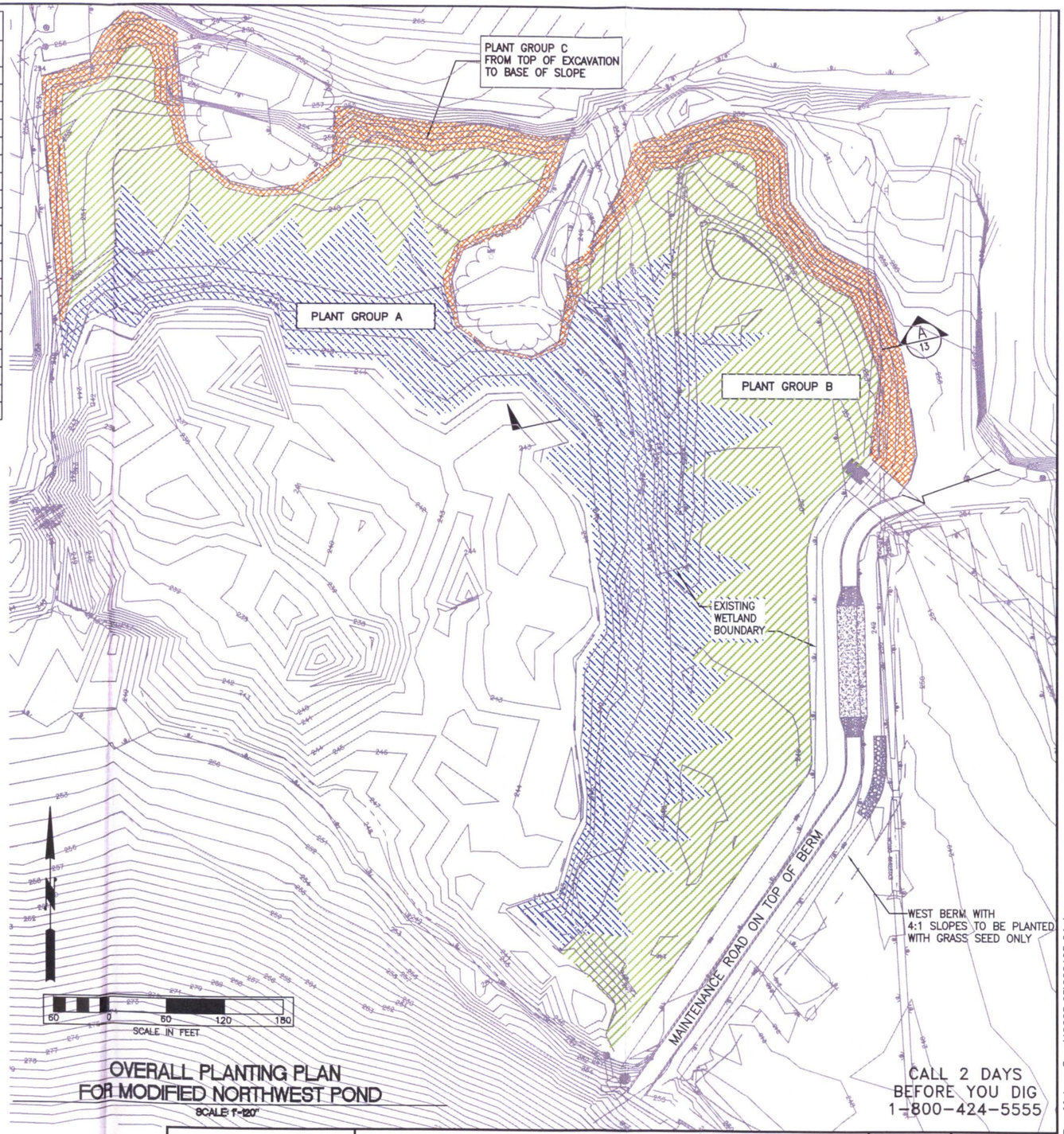
SCALE: 1"=60'



PROPOSED PLANTING MODIFIED NORTHWEST POND SECTION

A / 13

SCALE: 1"=60' HORIZONTALLY
1"=5' VERTICALLY



OVERALL PLANTING PLAN FOR MODIFIED NORTHWEST POND

SCALE: 1"=120'

Source: King County Department of Natural Resources and Parks, Water and Land Resources Division, Des Moines Regional CIPS, Regional RD Facility, MAP-NO 2004-03, Sheet 14 of 15, April 2003

CALL 2 DAYS BEFORE YOU DIG 1-800-424-5555

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Extent of Vegetation Cover

Des Moines Creek Regional Retention/Detention Facility
SeaTac, Washington

DATE: May 2005	PROJECT NO. 040106A
DESIGNED BY: JJS	
DRAWN BY: PMB	FIGURE NO. 4
REVISED BY: -	

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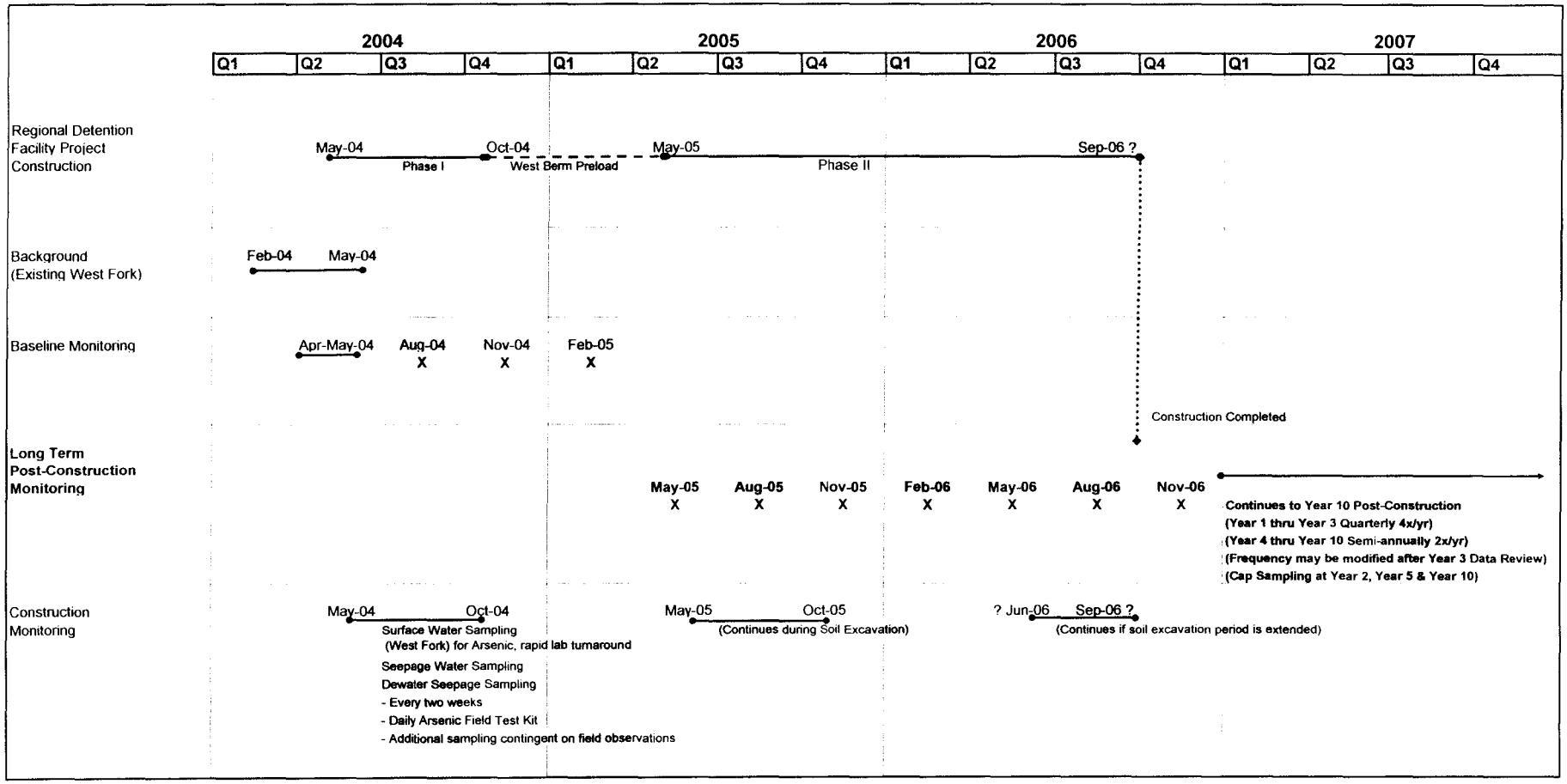
Figure 5: **RDF Construction and Field Sampling Schedules**
Des Moines Creek Regional Detention/Retention Facility



Notes: Components of the Long Term Monitoring Post-Construction Monitoring program are described in text (see Section 5)

APPENDIX A

Background and Baseline Monitoring Data (2004 Sampling and Analysis Plan)

Background and Baseline Monitoring Data

The following tables and figures present the data collected as part of the background and baseline monitoring programs as described in the 2004 Sampling and Analysis Plan. A brief description of the data with respect to long-term monitoring is presented in Section 3.2.

Table A-1
Baseline Groundwater Samples
Des Moines Creek RDF

										Arsenic Speciation								
Well Location	Sample Date / Time	Sample ID	Start Depth	End Depth	Alkalinity, Total (as Caco3) E310.1 mg/l	Aluminum (Total) E200.7 or SW6010B ug/l	Arsenic (Dissolved) SW6020 ug/l	Arsenic (Total) SW6020 ug/l	Arsenic (Dissolved) E1632 ug/L	Arsenic III (As3+) (Dissolved) E1632 ug/l	DiMethyl Arsenic (Dissolved) E1632 ug/L	Monomethyl Arsenic (Dissolved) E1632 ug/L	Calcium Metal (Total) E200.7 or SW6010B ug/l	Chloride E300 mg/l	Iron (Dissolved) E200.7 or SW6010B ug/l	Iron (Total) E200.7 or SW6010B ug/l	Magnesium (Total) E200.7 or SW6010B ug/l	Manganese (Dissolved) E200.7 or SW6010B ug/l
DMCGW1D	6/3/2004 13:15	GW-1D-060304	10.5	11.5	302	88.8 U	4.3	4.3	3.98	3.27	0.133	0.02	57400	4.3	1030	1210	32400	1520
DMCGW1D	8/31/2004 11:35	GW-1D-083104	10.5	11.5	-	-	3.86	3.89	-	-	-	-	-	-	855	981	-	1320
DMCGW1D	11/30/2004 14:32	GW-1D-113004	10.5	11.5	390	40.3 B TR	3.64	3.69	3.4	3.04	0.04 U	0.006 U	70600	4.7	1580	1500	39200	2310
DMCGW1D	2/23/2005 14:03	GW-1D-022305	10.5	11.5	-	-	4.6	4.8	-	-	-	-	-	-	1720	1950	-	2430
DMCGW1D	2/23/2005 14:03	GW-FD-022305	10.5	11.5	-	-	4.8	4.6	-	-	-	-	-	-	1730	1800	-	2410
DMCGW1D	5/23/2005 18:00	GW-1D-052305	10.5	11.5	-	-	*4.5*	*4.8*	-	-	-	-	-	-	-	-	-	-
DMCGW1S	6/3/2004 12:15	GW-1S-060304	4	5	286	44.3 U	1.2	1.2	0.156	0.195	0.04	0.006	66300	4.5	1620	1600	25500	338
DMCGW1S	8/31/2004 12:10	GW-1S-083104	4	5	-	-	0.89	1.04	-	-	-	-	-	-	1110	1130	-	230
DMCGW1S	11/30/2004 13:42	GW-1S-113004	4	5	306	145	0.77	1.03	0.106	0.145	0.04 U	0.006 U	77100	3.9	1050	1080	28000	336
DMCGW1S	2/23/2005 14:54	GW-1S-022305	4	5	-	-	0.9	1.1	-	-	-	-	-	-	687	739	-	331
DMCGW1S	5/23/2005 18:30	GW-1S-052305	4	5	-	-	*0.7*	*0.9*	-	-	-	-	-	-	-	-	-	-
DMCGW2D	6/3/2004 10:00	GW-2D-060304	14	15	94	79.1	4	4.2	3.52	1.96	0.08	0.012	21800	4	1320	1420	11500	246
DMCGW2D	6/3/2004 10:30	GW-FD-060304	14	15	94	51.7 U	4.1	4.2	3.82	2.6	0.133	0.02	22000	4	1290	1360	11700	248
DMCGW2D	8/30/2004 16:15	GW-2D-083004	14	15	-	-	4.51	4.27	-	-	-	-	-	-	1290	1190	-	326
DMCGW2D	8/30/2004 16:15	GW-FD-083004	14	15	-	-	4.37	4.35	-	-	-	-	-	-	1250	1330	-	315
DMCGW2D	11/29/2004 14:00	GW-2D-112904	14	15	124	50 U	3.53	3.5	2.94	2.75	0.04 U	0.006 U	37200	4.9	1530	1600	19300	471
DMCGW2D	11/29/2004 14:00	GW-FD-112904	14	15	126	47.5 B TR	3.56	3.5	2.91	3.09	0.04 U	0.006 U	37400	5	1520	1580	19500	479
DMCGW2D	2/22/2005 13:37	GW-2D-022205	14	15	-	-	3.41	3.41	-	-	-	-	-	-	2440	2520	-	813
DMCGW2D	2/22/2005 13:37	GW-FD-022205	14	15	-	-	3.39	3.43	-	-	-	-	-	-	2410	2570	-	804
DMCGW2D	5/23/2005 15:20	GW-2D-052305	14	15	-	-	*2.8*	*2.9*	-	-	-	-	-	-	-	-	-	-
DMCGW2D	5/23/2005 15:20	GW-FD-052305	14	15	-	-	*2.8*	*2.8*	-	-	-	-	-	-	-	-	-	-
DMCGW2S	6/2/2004 15:00	GW-2S-060204	7	8	84	1470	1.1	3.93	0.89	0.462	0.04	0.006	19800	3.8	2350	4520	10500	202
DMCGW2S	8/31/2004 10:15	GW-2S-083104	7	8	-	-	5.13	7.78	-	-	-	-	-	-	3120	3710	-	341
DMCGW2S	11/29/2004 15:15	GW-2S-112904	7	8	131	166	11.5	12.9	10.9	9.14	0.04 U	0.006 U	37900	4.4	3840	4140	16700	362
DMCGW2S	2/22/2005 13:36	GW-2S-022205	7	8	-	-	9.2	10.1	-	-	-	-	-	-	3870	3930	-	374
DMCGW2S	5/23/2005 16:00	GW-2S-052305	7	8	-	-	*11.8*	*12.2*	-	-	-	-	-	-	-	-	-	-
DMCGW3D	6/2/2004 13:30	GW-3D-060204	12.5	13.5	185	50 U	0.5	0.54	0.269	0.167	0.04	0.015 TR	41200	6.3	1240	1220	14300	447
DMCGW3D	8/30/2004 14:55	GW-3D-083004	12.5	13.5	-	-	0.43 B TR	0.45 B TR	-	-	-	-	-	-	1230	1220	-	464
DMCGW3D	11/29/2004 12:30	GW-3D-112904	12.5	13.5	190	53.3	0.41 B TR	0.38 B TR	0.079	0.062	0.04 U	0.006 U	43200	6.2	962	1020	15000	435
DMCGW3D	2/22/2005 11:17	GW-3D-022205	12.5	13.5	-	-	0.38 B TR	0.43 B TR	-	-	-	-	-	-	1070	1160	-	471
DMCGW3D	5/23/2005 13:30	GW-3D-052305	12.5	13.5	-	-	*0.4 B TR*	*0.4 B TR*	-	-	-	-	-	-	-	-	-	-
DMCGW3S	6/2/2004 13:50	GW-3S-060204	5.5	6.5	114	138	1.23	1.29	0.12	0.139	0.04	0.006	32000	4.3	1920	2000	11500	194
DMCGW3S	8/30/2004 17:05	GW-3S-083004	5.5	6.5	-	-	1.54	1.5	-	-	-	-	-	-	1930	2050	-	182
DMCGW3S	11/29/2004 13:30	GW-3S-112904	5.5	6.5	116	101	1.3	1.33	0.198	0.18	0.04 U	0.006 U	33100	4.4	1930	1970	12000	181
DMCGW3S	2/22/2005 13:06	GW-3S-022205	5.5	6.5	-	-	1.3	1.35	-	-	-	-	-	-	2070	2050	-	198
DMCGW3S	5/23/2005 14:25	GW-3S-052305	5.5	6.5	-	-	*1.2*	*1.3*	-	-	-	-	-	-	-	-	-	-
DMCGW4D	6/2/2004 12:30	GW-4D-060204	11.5	14	334	193	45.6	47	55	41.6	2	0.3	74400	4.1	24800	25400	28700	8190
DMCGW4D	8/31/2004 14:35	GW-4D-083104	11.5	14	-	-	62.9	67.7	-	-	-	-	-	-	25000	25600	-	8230
DMCGW4D	11/29/2004 16:00	GW-4D-112904	11.5	14	346	398	66.4	63	64	67.8	0.04 U	0.006 U	73400	3.7	26900	28600	27500	8020
DMCGW4D	2/22/2005 14:26	GW-4D-022205	11.5	14	-	-	54.7	55	-	-	-	-	-	-	30900	32100	-	8800
DMCGW4D	5/23/2005 11:33	GW-4D-052305	11.5	14	-	-	*48.4*	*48.6*	-	-	-	-	-	-	-	-	-	-
DMCGW4S	6/2/2004 10:50	GW-4S-060204	4.5	7	428	144	56.6	57.3	66.4	48.9	2	0.3	90100	4.4	20700	20600	37400	9510
DMCGW4S	8/31/2004 10:22	GW-4S-083104	4.5	7	-	-	82.2	83.8	-	-	-	-	-	-	21900	21900	-	11200
DMCGW4S	11/30/2004 11:00	GW-FD-113004	4.5	7	460	543	49.1	54.4	50.7	47.4	0.04 U	0.006 U	99200	3.8	19600	23100	41000	9370
DMCGW4S	11/30/2004 11:10	GW-4S-113004	4.5	7	462	698	60.2	57.3	53.6	47.1	0.04 U	0.006 U	84500	3.7	21100	20100	35100	9410
DMCGW4S	2/22/2005 14:35	GW-4S-022205	4.5	7	-	-	42.7	42	-	-	-	-	-	-	22000	21700	-	9610
DMCGW4S	5/23/2005 12:35	GW-4S-052305	4.5	7	-	-	*38.1*	*41.1*	-	-	-	-	-	-	-	-	-	-

Table A-1
Baseline Groundwater Samples
Des Moines Creek RDF

										Arsenic Speciation								
Well Location	Sample Date / Time	Sample ID	Start Depth	End Depth	Alkalinity, Total (as Caco3) E310.1 mg/l	Aluminum (Total) E200.7 or SW6010B ug/l	Arsenic (Dissolved) SW6020 ug/l	Arsenic (Total) SW6020 ug/l	Arsenic (Dissolved) E1632 ug/L	Arsenic III (As3+) (Dissolved) E1632 ug/l	DiMethyl Arsenic (Dissolved) E1632 ug/L	Monomethyl Arsenic (Dissolved) E1632 ug/L	Calcium Metal (Total) E200.7 or SW6010B ug/l	Chloride E300 mg/l	Iron (Dissolved) E200.7 or SW6010B ug/l	Iron (Total) E200.7 or SW6010B ug/l	Magnesium (Total) E200.7 or SW6010B ug/l	Manganese (Dissolved) E200.7 or SW6010B ug/l
DMCGW5D	6/1/2004 14 45	GW-5D-060104	13	14	109	7790	0.61 U	1.97	0.549	0.44	0.16	0.024	21000	3.1	16.2 U	10800	14500	146
DMCGW5D	8/31/2004 15 50	GW-5D-083104	13	14	-	-	1.11	4.82	-	-	-	-	-	-	2300	22200	-	201
DMCGW5D	11/30/2004 13 30	GW-5D-113004	13	14	108	441	0.44 B TR	0.56	0.602	0.526	0.04 U	0.006 U	18600	3	25	569	10900	194
DMCGW5D	2/23/2005 14 20	GW-5D-022305	13	14	-	-	0.3 B TR	0.5 B TR	-	-	-	-	-	3.2	29.6	983	-	181
DMCGW5D	5/23/2005 15 50	GW-5D-052305	13	14	-	-	*0.2 B TR*	*0.8*	-	-	-	-	-	-	-	-	-	-
DMCGW5S	6/1/2004 16 00	GW-5S-060104	3	4	107	30.8 J	55.9	56.3	65.3	57.9	0.334 TR	0.24	30100	3.1	477	489	16700	298
DMCGW5S	8/31/2004 16 10	GW-5S-083104	3	4	-	-	40	44.1	-	-	-	-	-	-	723	780	-	326
DMCGW5S	11/30/2004 10 45	GW-5S-113004	3	4	147	50 U	22.5	28.4	19.7	19.7	0.04 U	0.006 U	37900	3	614	721	21500	376
DMCGW5S	2/23/2005 14 38	GW-5S-022305	3	4	-	-	18.5	19	-	-	-	-	-	-	554	689	-	361
DMCGW5S	5/23/2005 16 55	GW-5S-052305	3	4	-	-	*14.4*	*15.8*	-	-	-	-	-	-	-	-	-	-
DMCGW6D	6/1/2004 12 35	GW-6D-060104	14	15	140	320 J	0.4 U	0.97	0.348	0.362	0.04	0.006	36400	3.7	23.3 U	479	14500	88.1
DMCGW6D	8/30/2004 13 40	GW-6D-083004	14	15	-	-	1.48	3.35	-	-	-	-	-	-	40.7	892	-	159
DMCGW6D	11/29/2004 12 00	GW-6D-112904	14	15	242	121	3.44	4.45	3.99	3.2	0.04 U	0.006 U	53000	3.7	63.4	214	20200	183
DMCGW6D	2/22/2005 12 30	GW-6D-022205	14	15	-	-	5.84	6.13	-	-	-	-	-	-	110	230	-	257
DMCGW6D	5/23/2005 12 50	GW-6D-052305	14	15	-	-	*7.9*	*8.7*	-	-	-	-	-	-	-	-	-	-
DMCGW6S	6/1/2004 15 45	GW-6S-060104	4	5	184	914	4.63	3.99	4.02	0.664	0.114	0.017	36900	3.7	2480	2860	16500	1350
DMCGW6S	8/30/2004 17 42	GW-6S-083004	4	5	-	-	6.32	5.91	-	-	-	-	-	-	1700	5280	-	1400
DMCGW6S	11/29/2004 12 00	GW-6S-112904 Not Sampled	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW6S	2/22/2005	GW-6S-022205 Not Sampled	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW6S	5/23/2005	GW-6S-052305 Not Sampled	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW7D	6/1/2004 11 00	GW-7D-060104	21	22	271	85.2 U	3.14	3.49	3.02	0.928	0.053	0.008	52400	4.9	2190	2440	33900	155
DMCGW7D	8/30/2004 10 12	GW-7D-083004	21	22	-	-	4.43	4.52	-	-	-	-	-	-	3270	3280	-	225
DMCGW7D	11/29/2004 12 00	GW-7D-112904 Not Sampled	21	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW7D	2/22/2005	GW-7D-022205 Not Sampled	21	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW7D	5/23/2005 10 15	GW-7D-052305	21	22	-	-	*3.9*	*3.4*	-	-	-	-	-	-	-	-	-	-
DMCGW7S	6/1/2004 13 45	GW-7S-060104	11	12	371	2260	7.09	8.37	6.18	3.59	0.16	0.034 TR	69300	6.4	11900	15200	45000	721
DMCGW7S	8/30/2004	GW-7S-083004 Not Sampled	11	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW7S	11/29/2004 12 00	GW-7S-112904 Not Sampled	11	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW7S	2/22/2005	GW-7S-022205 Not Sampled	11	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCGW7S	5/23/2005	GW-7S-052305 Not Sampled	11	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DMCTGW1	4/19/2004 14 30	TGW-1-GW-041904	5	7.5	-	-	65.9	60	-	-	-	-	-	-	-	-	-	-
DMCTGW2	4/19/2004 14 05	TGW-2-GW-041904	5	7.5	-	-	0.49 B	0.77	-	-	-	-	-	-	-	-	-	-
DMCTGW3	4/20/2004 8 55	TGW-3-GW-042004	5	7.5	-	-	1.98	2	-	-	-	-	-	-	-	-	-	-
DMCTGW4	4/19/2004 13 45	TGW-4-GW-041904	5	7.5	-	-	2.85	3.39	-	-	-	-	-	-	-	-	-	-
DMCTGW5	4/20/2004 10 40	TGW-5-GW-042004	5	7.5	-	-	0.76	0.83	-	-	-	-	-	-	-	-	-	-
DMCTGW6	4/20/2004 15 00	TGW-6-GW-042004	2.8	5.3	-	-	104	104	-	-	-	-	-	-	-	-	-	-
DMCTGW7	4/20/2004 14 45	TGW-7-GW-042004	4.5	7	-	-	33.8	34.6	-	-	-	-	-	-	-	-	-	-
DMCTGW8	4/20/2004 13 20	TGW-8-GW-042004	2.5	5	-	-	5.93	7.01	-	-	-	-	-	-	-	-	-	-
DMCTGW8	4/20/2004 13 30	TGW-9-GW-042004	2.5	5	-	-	6.51	6.39	-	-	-	-	-	-	-	-	-	-

Notes: 1. Result values in italic type are PREVALIDATED data.
2. "-" = Not Analyzed

Table A-1
Baseline Groundwater Samples
Des Moines Creek RDF

Well Location	Sample Date / Time	Sample ID	Manganese (Total) E200.7 or SW6010B ug/l	Nitrate E300 mg/l	Phosphorus E365.3 mg/l	Potassium (Total) E200.7 or SW6010B ug/l	Sodium (Total) E200.7 or SW6010B ug/l	Sulfate E300 mg/l	Sulfide E376.2 mg/l	Total Organic Carbon E415.1 mg/l
DMCGW1D	6/3/2004 13:15	GW-1D-060304	1560	0.2 U	0.12	7100	17500	2.7	0.05 U	6.2
DMCGW1D	8/31/2004 11:35	GW-1D-083104	1310	0.1 U	0.08	-	-	3.5	0.05 U	4.4
DMCGW1D	11/30/2004 14:32	GW-1D-113004	2130	0.1 U	0.08	7070	18800	5.1	0.05 U	8.3
DMCGW1D	2/23/2005 14:03	GW-1D-022305	2540	0.08 J TR	0.08	-	-	5.7	0.007 J TR	9.3
DMCGW1D	2/23/2005 14:03	GW-FD-022305	2380	0.1 U	0.07	-	-	5.8	0.05 U	9.7
DMCGW1D	5/23/2005 18:00	GW-1D-052305	-	-	-	-	-	-	-	-
DMCGW1S	6/3/2004 12:15	GW-1S-060304	334	0.2 U	0.34	3560	13700	0.6	1.08	17.8
DMCGW1S	8/31/2004 12:10	GW-1S-083104	231	0.1 U	0.14	-	-	0.2 U	0.05 U	16.9
DMCGW1S	11/30/2004 13:42	GW-1S-113004	321	0.1 U	0.1	3910	14800	28.4	0.98	20.4
DMCGW1S	2/23/2005 14:54	GW-1S-022305	342	0.1 U	0.07	-	-	31.4	0.65	20.2
DMCGW1S	5/23/2005 18:30	GW-1S-052305	-	-	-	-	-	-	-	-
DMCGW2D	6/3/2004 10:00	GW-2D-060304	251	0.2 U	0.04 J	6080	5690	20.9	0.05 U	6
DMCGW2D	6/3/2004 10:30	GW-FD-060304	253	0.2 U	0.06 J	6220	5820	20.6	0.05 U	6.1
DMCGW2D	8/30/2004 16:15	GW-2D-083004	328	0.1 U	0.04	-	-	3.6	0.05 U	5.8
DMCGW2D	8/30/2004 16:15	GW-FD-083004	327	0.1 U	0.03	-	-	3.8	0.05 U	5.5
DMCGW2D	11/29/2004 14:00	GW-2D-112904	490	0.1 U	0.03	7750	8210	59.7	0.05 U	13.5
DMCGW2D	11/29/2004 14:00	GW-FD-112904	495	0.1 U	0.03	7620	8220	58.4	0.05 U	13.9
DMCGW2D	2/22/2005 13:37	GW-2D-022205	818	0.1 U	0.03	-	-	210	0.05 U	6.8
DMCGW2D	2/22/2005 13:37	GW-FD-022205	845	0.1 U	0.03	-	-	206	0.05 U	6.9
DMCGW2D	5/23/2005 15:20	GW-2D-052305	-	-	-	-	-	-	-	-
DMCGW2D	5/23/2005 15:20	GW-FD-052305	-	-	-	-	-	-	-	-
DMCGW2S	6/2/2004 15:00	GW-2S-060204	223	0.1 U	0.3	6150	5910	16.7	0.01 J	8.4
DMCGW2S	8/31/2004 10:15	GW-2S-083104	352	0.1 U	0.15	-	-	60.8	0.05 U	13.9
DMCGW2S	11/29/2004 15:15	GW-2S-112904	362	0.1 U	0.19	7590	9000	47.9	0.35	19
DMCGW2S	2/22/2005 13:36	GW-2S-022205	368	0.1 U	0.19	-	-	52.4	0.3	16.4
DMCGW2S	5/23/2005 16:00	GW-2S-052305	-	-	-	-	-	-	-	-
DMCGW3D	6/2/2004 13:30	GW-3D-060204	448	0.1 U	0.49	3540	12100	0.2 U	0.12	19.9
DMCGW3D	8/30/2004 14:55	GW-3D-083004	462	0.1 U	0.49	-	-	0.2 U	0.05 U	20
DMCGW3D	11/29/2004 12:30	GW-3D-112904	455	0.1 U	0.47	3190	12200	0.2 U	0.14	22.2
DMCGW3D	2/22/2005 11:17	GW-3D-022205	474	0.1 U	0.5	-	-	0.3	0.15	21.4
DMCGW3D	5/23/2005 13:30	GW-3D-052305	-	-	-	-	-	-	-	-
DMCGW3S	6/2/2004 13:50	GW-3S-060204	193	0.1 U	0.42	2920	8990	12.5	1.19	45.2
DMCGW3S	8/30/2004 17:05	GW-3S-083004	191	0.1 U	0.39	-	-	16.6	0.04 J TR	46.7
DMCGW3S	11/29/2004 13:30	GW-3S-112904	184	0.1 U	0.4	2850	11200	21.9	0.92	49.7
DMCGW3S	2/22/2005 13:06	GW-3S-022205	199	0.1 U	0.37	-	-	18.3	0.89	45.8
DMCGW3S	5/23/2005 14:25	GW-3S-052305	-	-	-	-	-	-	-	-
DMCGW4D	6/2/2004 12:30	GW-4D-060204	8470	0.1 U	1.14	3450	12000	0.2 U	0.005 U	12.8
DMCGW4D	8/31/2004 14:35	GW-4D-083104	8140	0.09 J TR	1.38	-	-	0.2 U	0.05 U	12.8
DMCGW4D	11/29/2004 16:00	GW-4D-112904	8370	0.1 U	1.42	4600	12000	0.2 U	0.05 U	14.1
DMCGW4D	2/22/2005 14:26	GW-4D-022205	9080	0.1 U	1.36	-	-	0.8	0.007 J TR	13.4
DMCGW4D	5/23/2005 11:33	GW-4D-052305	-	-	-	-	-	-	-	-
DMCGW4S	6/2/2004 10:50	GW-4S-060204	9680	0.1 U	2.03	6690	13500	9	0.005 U	29.3
DMCGW4S	8/31/2004 10:22	GW-4S-083104	10700	0.1 U	2.21	-	-	1.5	0.01 J TR	31.3
DMCGW4S	11/30/2004 11:00	GW-FD-113004	10000	0.1 U	1.98	6740	33100	13.8	0.05 U	26.3
DMCGW4S	11/30/2004 11:10	GW-4S-113004	9060	0.1 U	2.01	6300	31100	16.4	0.05 U	26.1
DMCGW4S	2/22/2005 14:35	GW-4S-022205	9520	0.1 U	1.84	-	-	15.2	0.05 U	23.4
DMCGW4S	5/23/2005 12:35	GW-4S-052305	-	-	-	-	-	-	-	-

Table A-1
Baseline Groundwater Samples
Des Moines Creek RDF

Well Location	Sample Date / Time	Sample ID	Manganese (Total) E200.7 or SW6010B ug/l	Nitrate E300 mg/l	Phosphorus E365.3 mg/l	Potassium (Total) E200.7 or SW6010B ug/l	Sodium (Total) E200.7 or SW6010B ug/l	Sulfate E300 mg/l	Sulfide E376.2 mg/l	Total Organic Carbon E415.1 mg/l
DMCGW5D	6/1/2004 14:45	GW-5D-060104	328	0.1 U	1.02	4980	8580	3.6	0.05 U	1.2
DMCGW5D	8/31/2004 15:50	GW-5D-083104	550	0.1 U	0.19	-	-	0.8	0.66	0.9
DMCGW5D	11/30/2004 13:30	GW-5D-113004	177	0.1 U	0.08	3850	7780	0.6	0.18	1
DMCGW5D	2/23/2005 14:20	GW-5D-022305	195	0.1 U	0.08	-	-	0.5	0.27	1
DMCGW5D	5/23/2005 15:50	GW-5D-052305	-	-	-	-	-	-	-	-
DMCGW5S	6/1/2004 16:00	GW-5S-060104	303	0.1 U	0.14	5290	10600	54.6	0.05 U	10.2
DMCGW5S	8/31/2004 16:10	GW-5S-083104	330	0.1 U	0.07	-	-	53.1	1.21	11.4
DMCGW5S	11/30/2004 10:45	GW-5S-113004	373	0.1 U	0.07	4230	11000	57.3	0.99	11.9
DMCGW5S	2/23/2005 14:38	GW-5S-022305	358	0.1 U	0.07	-	-	48.5	1.17	13.5
DMCGW5S	5/23/2005 16:55	GW-5S-052305	-	-	-	-	-	-	-	-
DMCGW6D	6/1/2004 12:35	GW-6D-060104	111	0.1 U	0.14	5420	10200	24.6	0.05 U	0.8
DMCGW6D	8/30/2004 13:40	GW-6D-083004	191	0.1 U	0.14	-	-	4.5	0.05 U	5.6
DMCGW6D	11/29/2004 12:00	GW-6D-112904	195	0.1 U	0.13	6720	9410	2.2	0.02 J TR	5.8
DMCGW6D	2/22/2005 12:30	GW-6D-022205	256	0.1 U	0.1	-	-	54.5	0.006 J TR	7
DMCGW6D	5/23/2005 12:50	GW-6D-052305	-	-	-	-	-	-	-	-
DMCGW6S	6/1/2004 15:45	GW-6S-060104	1360	0.1 U	0.15	6320	8010	0.2 U	0.005 U	6
DMCGW6S	8/30/2004 17:42	GW-6S-083004	1480	0.1 U	0.08	-	-	1.1	0.05 U	7.3
DMCGW6S	11/29/2004 12:00	GW-6S-112904 Not Sampled	-	-	-	-	-	-	-	-
DMCGW6S	2/22/2005	GW-6S-022205 Not Sampled	-	-	-	-	-	-	-	-
DMCGW6S	5/23/2005	GW-6S-052305 Not Sampled	-	-	-	-	-	-	-	-
DMCGW7D	6/1/2004 11:00	GW-7D-060104	153	0.1 U	0.06	5620	11900	18.2	0.05 U	3.9
DMCGW7D	8/30/2004 10:12	GW-7D-083004	231	0.1 U	0.07	-	-	25.7	0.05 U	7.8
DMCGW7D	11/29/2004 12:00	GW-7D-112904 Not Sampled	-	-	-	-	-	-	-	-
DMCGW7D	2/22/2005	GW-7D-022205 Not Sampled	-	-	-	-	-	-	-	-
DMCGW7D	5/23/2005 10:15	GW-7D-052305	-	-	-	-	-	-	-	-
DMCGW7S	6/1/2004 13:45	GW-7S-060104	796	0.1 U	0.85	8010	27700	12.8	0.06	-
DMCGW7S	8/30/2004	GW-7S-083004 Not Sampled	-	-	-	-	-	-	-	-
DMCGW7S	11/29/2004 12:00	GW-7S-112904 Not Sampled	-	-	-	-	-	-	-	-
DMCGW7S	2/22/2005	GW-7S-022205 Not Sampled	-	-	-	-	-	-	-	-
DMCGW7S	5/23/2005	GW-7S-052305 Not Sampled	-	-	-	-	-	-	-	-
DMCTGW1	4/19/2004 14:30	TGW-1-GW-041904	-	-	-	-	-	-	-	-
DMCTGW2	4/19/2004 14:05	TGW-2-GW-041904	-	-	-	-	-	-	-	-
DMCTGW3	4/20/2004 8:55	TGW-3-GW-042004	-	-	-	-	-	-	-	-
DMCTGW4	4/19/2004 13:45	TGW-4-GW-041904	-	-	-	-	-	-	-	-
DMCTGW5	4/20/2004 10:40	TGW-5-GW-042004	-	-	-	-	-	-	-	-
DMCTGW6	4/20/2004 15:00	TGW-6-GW-042004	-	-	-	-	-	-	-	-
DMCTGW7	4/20/2004 14:45	TGW-7-GW-042004	-	-	-	-	-	-	-	-
DMCTGW8	4/20/2004 13:20	TGW-8-GW-042004	-	-	-	-	-	-	-	-
DMCTGW8	4/20/2004 13:30	TGW-9-GW-042004	-	-	-	-	-	-	-	-

Notes:
1. Result values in italic type are PREVALIDATED data.
2. "-" = Not Analyzed

Table A-2
NW Ponds Baseline and West Fork Des Moines Creek Background and Baseline Surface Water Samples
Des Moines Creek RDF

							Arsenic Speciation										
Sample Location	Sample Date / Time	Sample ID	Alkalinity, Total (as Caco3) E310.1 mg/l	Aluminum (Total) E200.7 or SW6010B ug/l	Arsenic (Dissolved) SW6020 ug/l	Arsenic (Total) SW6020 ug/l	Arsenic (Dissolved) E1632 ug/L	Arsenic III (As3+) (Dissolved) E1632 ug/L	DiMethyl Arsenic (Dissolved) E1632 ug/L	Monomethyl Arsenic (Dissolved) E1632 ug/L	Calcium Metal (Total) E200.7 or SW6010B ug/l	Chloride E300 mg/l	Iron (Dissolved) E200.7 or SW6010B ug/l	Iron (Total) E200.7 or SW6010B ug/l	Magnesium (Total) E200.7 or SW6010B ug/l	Manganese (Dissolved) E200.7 or SW6010B ug/l	Manganese (Total) E200.7 or SW6010B ug/l
NWP1	6/2/2004 13:50	NWP1-SW-S-060204	76	50 U	1.37	1.3	1.03	0.449	0.065 TR	0.04	15900	3.1	151	256	7330	103	109
NWP1	6/2/2004 14:28	NWP1-SW-D-060204	241	101	3.62	4.23	0.007 U	0.007 U	0.4	0.006 U	42900	5.1	14700	15600	15700	1610	1630
NWP1	8/31/2004 18:14	NWP1-SW-S-083104	-	50 U	1.37	1.62	-	-	-	-	-	-	203	502	-	327	351
NWP1	8/31/2004 18:25	NWP1-SW-D-083104	-	50 U	1.5	4.05	-	-	-	-	-	-	2070	11400	-	2290	2300
NWP1	12/1/2004 14:00	NWP1-SW-D-120104	131	209 U	1.59	3.36	-	-	-	-	41500	5.9	1290	3830	16600	588	787
NWP1	12/1/2004 14:15	NWP1-SW-S-120104	76	111 U	0.78	1.33	-	-	-	-	19500	4.3	165	1060	8540	218	222
NWP1	2/16/2005 13:00	NWP1-SW-D-021605	-	61.7	2.06	2.91	-	-	-	-	-	-	1340	2620	-	522	502
NWP1	2/16/2005 13:00	NWP1-SW-S-021605	-	75.9	1.00 B TR	1.4	-	-	-	-	-	-	248	659	-	162	174
NWP2	6/2/2004 12:40	NWP2-SW-S-060204	86	50 U	4.18	1.68	2.01	0.379	0.4	0.066	17800	2.5	163	288	7160	72.7	75.3
NWP2	6/2/2004 13:10	NWP2-SW-D-060204	107	50 U	1.87	1.96	1.19	0.326	0.05 TR	0.042	24100	2.2	398	592	8400	373	345
NWP2	8/31/2004 14:25	NWP-SW-FD-083104	-	50 U	1.75	2.12	-	-	-	-	-	-	271	553	-	211	216
NWP2	8/31/2004 18:30	NWP2-SW-S-083104	-	50 U	1.57	1.66	-	-	-	-	-	-	138	417	-	123	119
NWP2	8/31/2004 18:40	NWP2-SW-D-083104	-	86.4	3.51	4.07	-	-	-	-	-	-	2820	3180	-	870	915
NWP2	11/30/2004 12:00	NWP2-SW-S-113004 Not Sampled	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NWP2	11/30/2004 14:00	NWP2-SW-D-113004	76	71.4	1.18	1.42	-	-	-	-	18800	4	523	847	8060	193	182
NWP2	2/16/2005 12:00	NWP2-SW-D-021605	-	50 U	1.16	1.43	-	-	-	-	-	-	99.6	248	-	101	90.2
NWP2	2/16/2005 12:00	NWP2-SW-S-021605	-	74.1	1.29	1.54	-	-	-	-	-	-	264	509	-	141	143
NWP3	6/2/2004 23:10	NWP3-SW-S-060204	78	50 U	1.35	1.55	1.97	0.425	0.057 TR	0.057	17500	2.6	150	295	7400	87.7	95.1
NWP3	6/2/2004 23:55	NWP3-SW-D-060204	84	50 U	1.63	1.91	2	0.37	0.052 TR	0.055	18500	2.2	431	836	6760	250	302
NWP3	8/31/2004 14:25	NWP3-SW-S-083104	-	50 U	1.92	2.05	1.08	0.676	0.142	0.094	-	-	277	561	-	200	220
NWP3	8/31/2004 14:25	NWP-FD-083104	-	-	-	-	1.17	0.795	0.159	0.115	-	-	-	-	-	-	-
NWP3	8/31/2004 14:35	NWP3-SW-D-083104	-	52.2	2.38	2.56	1.18	1.42	0.088	0.062	-	-	719	1020	-	791	791
NWP3	11/30/2004 12:00	NWP3-SW-D-113004 Not Sampled	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NWP3	11/30/2004 13:30	NWP3-SW-S-113004	82	73.3	1.17	1.44	0.796	0.223	0.04 U	0.014 U	21100	3.3	315	671	7970	152	173
NWP3	11/30/2004 13:30	NWP-FD-SW-113004	84	71.4	1.15	1.45	0.817	0.237	0.04 U	0.018 U	21300	3.2	296	639	7910	160	160
NWP3	2/16/2005 11:00	NWP3-SW-S-021605	-	111	1.24	1.57	0.669 H	0.382 H	0.04 U	0.012 U	-	-	169	501	-	128	132
NWP3	2/16/2005 11:00	NWP-FD-SW-021605	-	93.2	1.24	1.55	0.681 H	0.311 H	0.04 U	0.016 B	-	-	182	512	-	132	134
NWP3	2/16/2005 12:00	NWP3-SW-D-021605 Not Sampled	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NWP4	6/1/2004 15:15	NWP4-SW-S-060104	73	50 U	1.74	1.65	0.957 U	0.376 U	0.048 U TR	0.028 U	16100	2.3	195	243	6320	34.8	36.7
NWP4	6/1/2004 15:55	NWP4-SW-D-060104	76	414	1.57	2.88	2.99 U	2.65	0.082 U TR	0.012 U	17000	2.3	310	1460	6510	97.8	228
NWP4	8/31/2004 12:20	NWP4-SW-S-083104	-	50 U	1.93	2.23	1.33	1.08	0.187	0.094	-	-	173	638	-	442	369
NWP4	8/31/2004 12:30	NWP4-SW-D-083104	-	154	2.54	3.22	1.33	1.4	0.196	0.094	-	-	365	1480	-	894	924
NWP4	11/30/2004 12:00	NWP4-SW-D-113004	74	98.3	1.1	1.48	0.778	0.282	0.04 U	0.014 U	19400	3.2	206	641	7300	164	173
NWP4	11/30/2004 12:00	NWP4-SW-S-113004 Not Sampled	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NWP4	2/16/2005 11:00	NWP4-SW-S-021605	-	158	1.26	1.69	0.778 H	0.334 H	0.04 U	0.018 B	-	-	201	547	-	131	140
NWP4	2/16/2005 12:00	NWP4-SW-D-021605 Not Sampled	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SW-1A	2/13/2004 12:19	SW1A-SW-021304	-	-	-	2.5	-	-	-	-	-	-	-	-	-	-	-
SW-1A	2/13/2004 12:19	SW1A-SW-D-021304	-	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-
SW-1A	3/30/2004 13:50	SW-1A-SW-033004	-	-	-	1.61	-	-	-	-	-	-	-	-	-	-	-
SW-1A	3/30/2004 13:50	SW-1A-SW-D-033004	-	-	1.33	-	-	-	-	-	-	-	-	-	-	-	-
SW-1A	4/22/2004 10:30	SW1A-SW-042204	-	-	-	1.97	-	-	-	-	-	-	-	-	-	-	-
SW-1A	4/22/2004 10:30	SW1A-SW-D-042204	-	-	1.76	-	-	-	-	-	-	-	-	-	-	-	-
SW-1A	6/1/2004 14:00	SW1A-SW-060104	70	50 U	1.69	1.8	0.889 U	0.41 U	0.067 U TR	0.044 U	15800	2.2	192	289	6190	45.2	51.4
SW-1A	8/30/2004	SW1A-SW-083004	-	42.7 B TR	2.27	2.52	1.34	1.21	0.071	0.045	-	-	240	555	-	286	304
SW-1B	11/29/2004 13:30	SW1B-SW-112904	85	62.2	1.1	1.64	-	-	-	-	20300	3.5	143	636	7890	202	195

Table A-2
NW Ponds Baseline and West Fork Des Moines Creek Background and Baseline Surface Water Samples
Des Moines Creek RDF

							Arsenic Speciation										
Sample Location	Sample Date / Time	Sample ID	Alkalinity, Total (as Caco3) E310.1 mg/l	Aluminum (Total) E200.7 or SW6010B ug/l	Arsenic (Dissolved) SW6020 ug/l	Arsenic (Total) SW6020 ug/l	Arsenic (Dissolved) E1632 ug/L	Arsenic III (As3+) (Dissolved) E1632 ug/L	DiMethyl Arsenic (Dissolved) E1632 ug/L	Monomethyl Arsenic (Dissolved) E1632 ug/L	Calcium Metal (Total) E200.7 or SW6010B ug/l	Chloride E300 mg/l	Iron (Dissolved) E200.7 or SW6010B ug/l	Iron (Total) E200.7 or SW6010B ug/l	Magnesium (Total) E200.7 or SW6010B ug/l	Manganese (Dissolved) E200.7 or SW6010B ug/l	Manganese (Total) E200.7 or SW6010B ug/l
SW-1B	2/15/2005 13:00	SW1B-SW-021505	-	117	1.23	1.44	0.786 H	0.323 H	0.04 U	0.012 U	-	-	265	445	-	117	129
SW-1B	5/23/2005 12:00	SW1B-SW-052305	-	-	*1.8*	*1.9*	-	-	-	-	-	-	-	-	-	-	-
SW-2A	2/13/2004 11:25	SW2A-SW-021304	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-	-
SW-2A	2/13/2004 11:25	SW2A-SW-D-021304	-	-	2.8	-	-	-	-	-	-	-	-	-	-	-	-
SW-2A	3/30/2004 11:25	SW-2A-SW-033004	-	-	-	2.85	-	-	-	-	-	-	-	-	-	-	-
SW-2A	3/30/2004 11:25	SW-2A-SW-D-033004	-	-	2.39	-	-	-	-	-	-	-	-	-	-	-	-
SW-2A	4/22/2004 9:40	SW2A-SW-042204	-	-	-	2.6	-	-	-	-	-	-	-	-	-	-	-
SW-2A	4/22/2004 9:40	SW2A-SW-D-042204	-	-	2.3	-	-	-	-	-	-	-	-	-	-	-	-
SW-2A	6/1/2004 13:20	SW2A-SW-060104	74	50 U	2.83	2.83	0.984 U	0.564 U	0.07 U TR	0.034 U	17100	2.2	203	308	6760	48.7	51.2
SW-2A	8/30/2004	SW2A-SW-083004	-	50 U	2.69	2.9	1.57	0.561	0.044	0.066	-	-	156	316	-	82.9	90.5
SW-2B	11/29/2004 12:30	SW2B-SW-112904	83	72	1.18	1.63	-	-	-	-	20000	3.5	145	620	7820	191	182
SW-2B	2/15/2005 12:15	DMC-FD-SW-021505	-	75.1 J	1.1	1.4	0.636 H	0.274 H	0.04 U	0.013 B	-	-	164	392	-	75	80.3
SW-2B	2/15/2005 12:15	SW2B-SW-021505	-	90.8 J	1.2	1.46	0.66 H	0.289 H	0.04 U	0.012 U	-	-	162	423	-	103	113
SW-2B	5/23/2005 23:40	SW2B-SW-052305	-	-	*1.8*	*1.9*	-	-	-	-	-	-	-	-	-	-	-
SW-3A	2/13/2004 10:20	SW3A-SW-021304	-	-	-	3.1	-	-	-	-	-	-	-	-	-	-	-
SW-3A	2/13/2004 10:20	SW3A-SW-D-021304	-	-	2.7	-	-	-	-	-	-	-	-	-	-	-	-
SW-3A	3/30/2004 10:20	SW-3A-SW-033004	-	-	-	2.72	-	-	-	-	-	-	-	-	-	-	-
SW-3A	3/30/2004 10:20	SW-3A-SW-D-033004	-	-	2.32	-	-	-	-	-	-	-	-	-	-	-	-
SW-3A	4/22/2004 8:50	SW3A-SW-042204	-	-	-	2.84	-	-	-	-	-	-	-	-	-	-	-
SW-3A	4/22/2004 8:50	SW3A-SW-D-042204	-	-	2.31	-	-	-	-	-	-	-	-	-	-	-	-
SW-3A	6/1/2004 12:00	SW3A-SW-060104	77	33.5 B	2.9	3.13	1.03 U	0.17 U	0.079 U TR	0.051 U	17500	2.3	208	274	7000	47	48.4
SW-3A	6/1/2004 12:55	DMC-SW-FD-060104	78	50 U	2.66	3.1	1.2 U	0.73 U	0.041 U TR	0.02 U TR	17600	2.3	202	278	7070	47.9	49.9
SW-3A	8/30/2004	SW3A-SW-083004	-	45.5 B TR	2.76	2.95	1.66	0.593	0.1	0.04	-	-	134	246	-	83.1	83
SW-3A	8/30/2004	SW-FD-083004	-	62.8	2.79	3	-	-	-	-	-	-	133	246	-	83.9	83.2
SW-3A	8/31/2004	SW3A-SW-083104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SW-3A	8/31/2004	SW-FD-083104	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SW-3B	11/29/2004 11:45	DMC-FD-SW-112904	81	90.2	1.18	1.67	-	-	-	-	20900	3.6	154	715	8300	187	195
SW-3B	11/29/2004 11:45	SW3B-SW-112904	80	106	1.19	1.66	-	-	-	-	20800	3.6	145	707	8270	187	194
SW-3B	2/15/2005 11:30	SW3B-SW-021505	-	110	1.11	1.43	0.66 H	0.222 H	0.04 U	0.014 B	-	-	155	412	-	74.8	81.8
SW-3B	5/23/2005 10:00	DMC-FD-SW-052305	-	-	*1.6*	*1.9*	-	-	-	-	-	-	-	-	-	-	-
SW-3B	5/23/2005 10:00	SW3B-SW-052305	-	-	*1.7*	*1.9*	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. Result values in italic type are PREVALIDATED data.
2. "-" = Not Analyzed

Table A-2
NW Ponds Baseline and West Fork Des Moines Creek Background and Baseline Surface Water Samples
Des Moines Creek RDF

Sample Location	Sample Date / Time	Sample ID	Nitrate E300 mg/l	Phosphorus E365.3 mg/l	Potassium (Total) E200.7 or SW6010B ug/l	Sodium (Total) E200.7 or SW6010B ug/l	Sulfate E300 mg/l	Sulfide E376.2 mg/l	Total Organic Carbon E415.1 mg/l	Total Suspended Solids E160.2 mg/l
NWP1	6/2/2004 13:50	NWP1-SW-S-060204	0.1 U	0.04	2870	5060	5.1	0.05 U	7.3	5 U
NWP1	6/2/2004 14:28	NWP1-SW-D-060204	0.1 U	2.81	36700	12500	0.4	0.24	20.2	56
NWP1	8/31/2004 18:14	NWP1-SW-S-083104	0.1 U	0.05	-	-	7.5	0.05 U	8.1	-
NWP1	8/31/2004 18:25	NWP1-SW-D-083104	0.1 U	1.64	-	-	2.7	0.14	23.2	-
NWP1	12/1/2004 14:00	NWP1-SW-D-120104	0.1 U	0.25	1880 B TR	10700	58.8	0.05 U	11.6	7
NWP1	12/1/2004 14:15	NWP1-SW-S-120104	0.2	0.08	2230	6860	11.5	0.05 U	6.8	5 U
NWP1	2/16/2005 13:00	NWP1-SW-D-021605	0.1	0.14	-	-	17.1	0.05 U	10	5 U
NWP1	2/16/2005 13:00	NWP1-SW-S-021605	0.3	0.04	-	-	10.7	0.05 U	6.4	5 U
NWP2	6/2/2004 12:40	NWP2-SW-S-060204	0.1 U	0.06	3290	6090	5.2	0.05 U	7.5	5 U
NWP2	6/2/2004 13:10	NWP2-SW-D-060204	0.1 U	0.13	4360	6860	6.5	0.05 U	6.4	5 U
NWP2	8/31/2004 14:25	NWP-SW-FD-083104	0.1 U	0.07	-	-	6.8	0.05 U	8.9	-
NWP2	8/31/2004 16:30	NWP2-SW-S-083104	0.1 U	0.08	-	-	7.4	0.05 U	8.8	-
NWP2	8/31/2004 16:40	NWP2-SW-D-083104	0.1 U	0.26	-	-	11.5	0.41	8.4	-
NWP2	11/30/2004 12:00	NWP2-SW-S-113004 Not Sampled	-	-	-	-	-	-	-	-
NWP2	11/30/2004 14:00	NWP2-SW-D-113004	0.2	0.07	2390	6300	11.7	0.05 U	6.9	5 U
NWP2	2/16/2005 12:00	NWP2-SW-D-021605	0.06 J TR	0.04	-	-	15.4	0.05 U	4.4	5 U
NWP2	2/16/2005 12:00	NWP2-SW-S-021605	0.3	0.04	-	-	11.4	0.05 U	6.2	5 U
NWP3	6/2/2004 23:10	NWP3-SW-S-060204	0.1 U	0.05	3170	6200	5.2	0.05 U	7.4	5 U
NWP3	6/2/2004 23:55	NWP3-SW-D-060204	0.1 U	0.13	3640	5740	4.5	0.05 U	7.2	5 U
NWP3	8/31/2004 14:25	NWP3-SW-S-083104	0.1 U	0.07	-	-	6.5	0.05 U	8.9	-
NWP3	8/31/2004 14:25	NWP-FD-083104	-	-	-	-	-	-	-	-
NWP3	8/31/2004 14:35	NWP3-SW-D-083104	0.1 U	0.12	-	-	6.4	0.01 J TR	9.5	-
NWP3	11/30/2004 12:00	NWP3-SW-D-113004 Not Sampled	-	-	-	-	-	-	-	-
NWP3	11/30/2004 13:30	NWP3-SW-S-113004	0.1	0.06	2830	6310	12	0.05 U	6.2	5 U
NWP3	11/30/2004 13:30	NWP-FD-SW-113004	0.1	0.06	2880	6230	12	0.05 U	6.1	5 U
NWP3	2/16/2005 11:00	NWP3-SW-S-021605	0.2	0.04	-	-	11.5	0.05 U	6.3	5 U
NWP3	2/16/2005 11:00	NWP-FD-SW-021605	0.2	0.04	-	-	11.5	0.05 U	6.1	5 U
NWP3	2/16/2005 12:00	NWP3-SW-D-021605 Not Sampled	-	-	-	-	-	-	-	-
NWP4	6/1/2004 15:15	NWP4-SW-S-060104	0.1 U	0.05	3280	5570	4.8	0.05 U	7.3	5 U
NWP4	6/1/2004 15:55	NWP4-SW-D-060104	0.1 U	0.19	3740	6380	4.9	0.05 U	7.4	5 U
NWP4	8/31/2004 12:20	NWP4-SW-S-083104	0.1 U	0.06	-	-	6.4	0.05 U	9.2	-
NWP4	8/31/2004 12:30	NWP4-SW-D-083104	0.1 U	0.13	-	-	5.2	0.02 J TR	10.4	-
NWP4	11/30/2004 12:00	NWP4-SW-D-113004	0.1	0.08	2430	5830	10.8	0.05 U	6.6	5 U
NWP4	11/30/2004 12:00	NWP4-SW-S-113004 Not Sampled	-	-	-	-	-	-	-	-
NWP4	2/16/2005 11:00	NWP4-SW-S-021605	0.2	0.05	-	-	11.7	0.05 U	6.2	6
NWP4	2/16/2005 12:00	NWP4-SW-D-021605 Not Sampled	-	-	-	-	-	-	-	-
SW-1A	2/13/2004 12:19	SW1A-SW-021304	-	-	-	-	-	-	-	-
SW-1A	2/13/2004 12:19	SW1A-SW-D-021304	-	-	-	-	-	-	-	-
SW-1A	3/30/2004 13:50	SW-1A-SW-033004	-	-	-	-	-	-	-	-
SW-1A	3/30/2004 13:50	SW-1A-SW-D-033004	-	-	-	-	-	-	-	-
SW-1A	4/22/2004 10:30	SW1A-SW-042204	-	-	-	-	-	-	-	-
SW-1A	4/22/2004 10:30	SW1A-SW-D-042204	-	-	-	-	-	-	-	-
SW-1A	6/1/2004 14:00	SW1A-SW-060104	0.1 U	0.07	3310	5470	4.8	0.05 U	6.9	5 U
SW-1A	8/30/2004	SW1A-SW-083004	0.1 U	0.06	-	-	7	0.05 U	9.3	-
SW-1B	11/29/2004 13:30	SW1B-SW-112904	0.1	0.08	3010 J	5950	11.8	0.05 U	6.7	5 U

Table A-2
NW Ponds Baseline and West Fork Des Moines Creek Background and Baseline Surface Water Samples
Des Moines Creek RDF

Sample Location	Sample Date / Time	Sample ID	Nitrate E300 mg/l	Phosphorus E365.3 mg/l	Potassium (Total) E200.7 or SW6010B ug/l	Sodium (Total) E200.7 or SW6010B ug/l	Sulfate E300 mg/l	Sulfide E376.2 mg/l	Total Organic Carbon E415.1 mg/l	Total Suspended Solids E160.2 mg/l
SW-1B	2/15/2005 13:00	SW1B-SW-021505	0.2	0.04	-	-	11.4	0.05 U	6.4	5 U
SW-1B	5/23/2005 12:00	SW1B-SW-052305	-	-	-	-	-	-	-	*5 U*
SW-2A	2/13/2004 11:25	SW2A-SW-021304	-	-	-	-	-	-	-	-
SW-2A	2/13/2004 11:25	SW2A-SW-D-021304	-	-	-	-	-	-	-	-
SW-2A	3/30/2004 11:25	SW-2A-SW-033004	-	-	-	-	-	-	-	-
SW-2A	3/30/2004 11:25	SW-2A-SW-D-033004	-	-	-	-	-	-	-	-
SW-2A	4/22/2004 9:40	SW2A-SW-042204	-	-	-	-	-	-	-	-
SW-2A	4/22/2004 9:40	SW2A-SW-D-042204	-	-	-	-	-	-	-	-
SW-2A	6/1/2004 13:20	SW2A-SW-060104	0.057 J	0.06	3350	5650	5.4	0.05 U	7.4	5 U
SW-2A	8/30/2004	SW2A-SW-083004	0.1 U	0.07	-	-	6.5	0.05 U	9	-
SW-2B	11/29/2004 12:30	SW2B-SW-112904	0.1	0.08	2700	5800	12	0.05 U	6.6	5 U
SW-2B	2/15/2005 12:15	DMC-FD-SW-021505	0.2	0.04	-	-	11.7	0.05 U	6.2	5 U
SW-2B	2/15/2005 12:15	SW2B-SW-021505	0.2	0.05	-	-	11.7	0.05 U	6.4	5 U
SW-2B	5/23/2005 23:40	SW2B-SW-052305	-	-	-	-	-	-	-	*5 U*
SW-3A	2/13/2004 10:20	SW3A-SW-021304	-	-	-	-	-	-	-	-
SW-3A	2/13/2004 10:20	SW3A-SW-D-021304	-	-	-	-	-	-	-	-
SW-3A	3/30/2004 10:20	SW-3A-SW-033004	-	-	-	-	-	-	-	-
SW-3A	3/30/2004 10:20	SW-3A-SW-D-033004	-	-	-	-	-	-	-	-
SW-3A	4/22/2004 8:50	SW3A-SW-042204	-	-	-	-	-	-	-	-
SW-3A	4/22/2004 8:50	SW3A-SW-D-042204	-	-	-	-	-	-	-	-
SW-3A	6/1/2004 12:00	SW3A-SW-060104	0.085 J	0.06	3370	5570	5.6	0.05 U	7.5	5 U
SW-3A	6/1/2004 12:55	DMC-SW-FD-060104	0.067 J	0.06	3400	5650	5.7	0.05 U	7.3	5 U
SW-3A	8/30/2004	SW3A-SW-083004	0.1 U	0.05	-	-	5.6	-	9	-
SW-3A	8/30/2004	SW-FD-083004	0.1 U	0.05	-	-	5.5	-	8.8	-
SW-3A	8/31/2004	SW3A-SW-083104	-	-	-	-	-	0.05 U	-	-
SW-3A	8/31/2004	SW-FD-083104	-	-	-	-	-	0.05 U	-	-
SW-3B	11/29/2004 11:45	DMC-FD-SW-112904	0.2	0.08	2950 J	6350	11.6	0.05 U	7	5 U
SW-3B	11/29/2004 11:45	SW3B-SW-112904	0.2	0.08	2970 J	6250	11.6	0.05 U	7	5 U
SW-3B	2/15/2005 11:30	SW3B-SW-021505	0.2	0.04	-	-	11.8	0.05 U	6.3	5 U
SW-3B	5/23/2005 10:00	DMC-FD-SW-052305	-	-	-	-	-	-	-	*5 U*
SW-3B	5/23/2005 10:00	SW3B-SW-052305	-	-	-	-	-	-	-	*5 U*

Notes: 1. Result values in italic type are PREVALIDATED data.
2. "-" = Not Analyzed

Table A-3
NW Ponds Baseline and West Fork Des Moines Creek Background and Baseline Sediments Samples
Des Moines Creek RDF

Sample Location	Sample Date / Time	Sample ID	Soil Type	Aluminum (Total) E200.7 or SW6010B mg/kg	Arsenic (Total) SW8020 mg/kg	Arsenic (Total) SW7060A SE Ins* mg/kg	Arsenic (Total) SW7062 SE Am* mg/kg	Arsenic (Total) SW7062 SE Cry* mg/kg	Arsenic (Total) SW7062 SE Ex* mg/kg	Arsenic (Total) SW7062 SE Sol* mg/kg	Chromium Reducible Sulfide CRSO-FJ mg/kg	Iron (Total) E200.7 or SW6010B mg/kg	Iron (Total) SW6010B SE Am* mg/kg	Iron (Total) SW6010B SE Cry* mg/kg	Iron (Total) SW6010B SE Ins* mg/kg
NWP1	9/1/2004 13:00	NWP1-SD-1.75-090104	0-0.75: Very soft , dark brown, organic MUCK, with weeds, roots and twigs 0.75-1.4: soft, brown, PEAT 1.4-1.6: Gray ASH layer 1.6-1.75 soft, brown, PEAT; fibrous	36000	55.1	2.24	12.4	2.5 U	23.9	4.6	2650 J	49500	1160	8770	10400
NWP1	9/1/2004 13:00	NWP1-SD-3.5-090104	1.75-3.5 soft, brown, PEAT; fibrous	-	-	-	-	-	-	-	-	-	-	-	-
NWP1	2/24/2005 13:05	NWP1-SD-1.8-022405	0-0.4: Very soft, dark brown to gray, organic MUCK, with weeds, roots and twigs 0.4-1.8: Soft, brown, PEAT; fibrous	32000	46.2	-	-	-	-	-	4110	40500	-	-	-
NWP2	9/1/2004 12:30	NWP2-SD-1.3-090104	0-1.3: Very soft , dark brown, organic MUCK; plant roots and twigs	11300	19.6	1.74	13.5	2.5 U	35.2	3.5	1560 J	15300	1400	5090	8650
NWP2	9/1/2004 12:30	NWP2-SD-2.6-090104	1.3-1.5: Gray ASH layer 1.5-2.6: Brown, fibrous PEAT	-	-	-	-	-	-	-	-	-	-	-	-
NWP2	2/24/2005 12:40	NWP2-SD-1.7-022405	0-1.7: Very soft , dark brown, organic MUCK, with weeds, roots and twigs	25900	43.8	-	-	-	-	-	2740	34300	-	-	-
NWP2	2/24/2005 12:40	NWP2-SD-3.4-022405	1.7-1.8: Very soft , dark brown, organic MUCK, with weeds, roots and twigs 1.8-2.2: Very soft, medium brown, organic MUCK 2.2-3.4: soft, brown, PEAT	-	-	-	-	-	-	-	-	-	-	-	-
NWP3	9/1/2004 12:10	NWP3-SD-1.6-090104	0-1.2: Very soft, dark brown, organic MUCK 1.2-1.5: Soft, brown, PEAT 1.5-1.6: Gray ASH layer	13800	21.8	3.97	13.8	2.5 U	81.7	7.2	3860 J	17700	4060	17100	10200
NWP3	9/1/2004 12:10	NWP3-SD-3.2-090104	1.6-3.2: Soft, brown, PEAT	-	-	-	-	-	-	-	-	-	-	-	-
NWP3	2/24/2005 11:45	NWP3-SD-1.8-022405	0-1.4: Very soft , dark brown, organic MUCK; plant roots and twigs 1.4-1.8: Brown, fibrous PEAT with gray smear at 1.5 possible ASH layer	27900	34.6	-	-	-	-	-	4700	33000	-	-	-
NWP3	2/24/2005 11:45	NWP3-SD-3.0-022405	1.8-3.0: Brown, fibrous PEAT	-	-	-	-	-	-	-	-	-	-	-	-
NWP4	9/1/2004 11:15	NWP4-SD-1.5-090104	0-1.4: Very soft , dark brown, organic MUCK, with weeds, roots and twigs 1.4-1.5 Gray ASH layer	19100	35.5	-	-	-	-	-	2130 J	22500	-	-	-
NWP4	9/1/2004 11:15	NWP4-SD-3.0-090104	1.5-1.6: Gray ASH layer 1.6-3.0: soft, brown, PEAT; fibrous	-	-	-	-	-	-	-	-	-	-	-	-
NWP4	2/24/2005 11:00	NWP4-SD-0.9-022405	0-0.9: Very soft , dark brown, organic MUCK, with weeds, roots and twigs	20800	32.1	-	-	-	-	-	11100	26700	-	-	-
NWP4	2/24/2005 11:00	NWP4-SD-2.4-022405	0.9-1.1: Very soft , dark brown, organic MUCK, with weeds, roots and twigs 1.1-2.0 Turns light brown 2.0-2.4 Soft, brown, PEAT; fibrous with gray smear about 1.5	-	-	-	-	-	-	-	-	-	-	-	-
SW-1A	2/13/2004 12:35	SW1A-SD-021304	Not Available	-	38.3	-	-	-	-	-	-	-	-	-	-
SW-1A	3/30/2004 14:00	SW-1A-SD-033004	Not Available	-	40.8	-	-	-	-	-	-	-	-	-	-
SW-1A	4/22/2004 11:00	SW1A-SD-042204	Not Available	-	38.5	-	-	-	-	-	-	-	-	-	-
SW-1A	6/3/2004 12:20	SW1A-SD-060304	Not Available	33200	49.4	3.32	13.2	2.5 U	83	3	-	35900	3380	13700	14200
SW-1A	9/1/2004 11:30	SW1A-SD-090104	Not Available	13600	38.7	-	-	-	-	-	1450	12900	-	-	-
SW-1B	12/1/2004	SW1B-SD-120104	Not Available	6860	3.22	-	-	-	-	-	26.9	10200	-	-	-
SW-1B	2/23/2005 12:00	SW1B-SD-022305	Not Available	5530	1.69 J	-	-	-	-	-	155	8730	-	-	-
SW-1B	5/23/2005 18:15	SW1B-SD-052305	Not Available	-	3.74	-	-	-	-	-	-	-	-	-	-
SW-2A	2/13/2004 11:45	SW2A-SD-021304	Not Available	-	47.6	-	-	-	-	-	-	-	-	-	-
SW-2A	3/30/2004 11:45	SW-2A-SD-033004	Not Available	-	41.5	-	-	-	-	-	-	-	-	-	-
SW-2A	4/22/2004 10:05	SW2A-SD-042204	Not Available	-	42.9	-	-	-	-	-	-	-	-	-	-
SW-2A	6/3/2004 11:30	SW2A-SD-060304	Not Available	14400	19.9	0.86	8.1	2.5 U	8.5	2.5	-	19400	1170	13900	6610
SW-2A	9/1/2004 11:00	SW2A-SD-090104	Not Available	25000	51.6	-	-	-	-	-	3440	25800	-	-	-
SW-2B	12/1/2004	SW2B-SD-120104	Not Available	14500	4.72	-	-	-	-	-	21.6	19600	-	-	-
SW-2B	2/23/2005 11:00	SW2B-SD-022305	Not Available	11900	4.59 J	-	-	-	-	-	88	15100	-	-	-
SW-2B	5/23/2005 17:35	SW2B-SD-052305	Not Available	-	6.42	-	-	-	-	-	-	-	-	-	-
SW-3A	2/13/2004 10:45	SW3A-SD-021304	Not Available	-	6.19	-	-	-	-	-	-	-	-	-	-
SW-3A	3/30/2004 10:45	SW-3A-SD-033004	Not Available	-	13.2	-	-	-	-	-	-	-	-	-	-
SW-3A	4/22/2004 9:00	SW3A-SD-042204	Not Available	-	6.2	-	-	-	-	-	-	-	-	-	-
SW-3A	6/3/2004 10:15	SW3A-SD-060304	Not Available	14000	8.9	0.45	1.8	2.5 U	10.5	1.2	-	17400	1850	5020	7690
SW-3A	9/1/2004 9:50	SW3A-SD-090104	Not Available	12300	6.46	-	-	-	-	-	32 J TR	14300	-	-	-
SW-3B	12/1/2004	SW3B-SD-120104	Not Available	17900	2.4	-	-	-	-	-	11.9	20400	-	-	-
SW-3B	2/23/2005 10:00	SW3B-SD-022305	Not Available	15800	2.13 J	-	-	-	-	-	29	21300	-	-	-
SW-3B	5/23/2005 16:55	SW3B-SD-052305	Not Available	-	10.8	-	-	-	-	-	-	-	-	-	-

Notes: 1. Result values in italic type are PREVALIDATED data. 2. "-" = Not Analyzed

Table A-3
NW Ponds Baseline and West Fork Des Moines Creek Background and Baseline Sediments Samples
Des Moines Creek RDF

Sample Location	Sample Date / Time	Sample ID	Manganese (Total) E200.7 or SW6010B mg/kg	Nitrogen E351.4 mg/kg	Sulfide EPA DRAFT 1991 mg/kg	Total Organic Carbon SW9060 percent	Total Solids E160.3 percent
NWP1	9/1/2004 13:00	NWP1-SD-1.75-090104	913	8540	575 J	7.83	14.6
NWP1	9/1/2004 13:00	NWP1-SD-3.5-090104	-	-	-	-	-
NWP1	2/24/2005 13:05	NWP1-SD-1.8-022405	716	8140	1590	13	23.2
NWP2	9/1/2004 12:30	NWP2-SD-1.3-090104	260	4110	393 J	6.47	34
NWP2	9/1/2004 12:30	NWP2-SD-2.6-090104	-	-	-	-	-
NWP2	2/24/2005 12:40	NWP2-SD-1.7-022405	566	13300	42.7	14.8	15.7
NWP2	2/24/2005 12:40	NWP2-SD-3.4-022405	-	-	-	-	-
NWP3	9/1/2004 12:10	NWP3-SD-1.6-090104	474	10600	805 J	15	12.6
NWP3	9/1/2004 12:10	NWP3-SD-3.2-090104	-	-	-	-	-
NWP3	2/24/2005 11:45	NWP3-SD-1.6-022405	781	9430	745	14.4	19.5
NWP3	2/24/2005 11:45	NWP3-SD-3.0-022405	-	-	-	-	-
NWP4	9/1/2004 11:15	NWP4-SD-1.5-090104	673	11700	88 J	14.5	19.6
NWP4	9/1/2004 11:15	NWP4-SD-3.0-090104	-	-	-	-	-
NWP4	2/24/2005 11:00	NWP4-SD-0.9-022405	750	13200	729	17.8	21
NWP4	2/24/2005 11:00	NWP4-SD-2.4-022405	-	-	-	-	-
SW-1A	2/13/2004 12:35	SW1A-SD-021304	-	-	-	-	15.8
SW-1A	3/30/2004 14:00	SW-1A-SD-033004	-	-	-	-	9.52
SW-1A	4/22/2004 11:00	SW1A-SD-042204	-	-	-	-	6.66
SW-1A	6/3/2004 12:20	SW1A-SD-060304	1150	11400 J	-	19.1 J	13.2
SW-1A	9/1/2004 11:30	SW1A-SD-090104	1260	12900	111	20	12.5
SW-1B	12/1/2004	SW1B-SD-120104	188	2530	2.3	4.72	41.3
SW-1B	2/23/2005 12:00	SW1B-SD-022305	177	1430	0.7 J TR	1.12	69.8
SW-1B	5/23/2005 18:15	SW1B-SD-052305	-	-	-	-	65.8
SW-2A	2/13/2004 11:45	SW2A-SD-021304	-	-	-	-	12.7
SW-2A	3/30/2004 11:45	SW-2A-SD-033004	-	-	-	-	14.6
SW-2A	4/22/2004 10:05	SW2A-SD-042204	-	-	-	-	9.83
SW-2A	6/3/2004 11:30	SW2A-SD-060304	826	4820 J	-	9.34 J	21.9
SW-2A	9/1/2004 11:00	SW2A-SD-090104	1580	15300	508	18.8	4.18
SW-2B	12/1/2004	SW2B-SD-120104	267	512	1.3 U	0.94	72.2
SW-2B	2/23/2005 11:00	SW2B-SD-022305	244	807	0.8 U	1.1	70.3
SW-2B	5/23/2005 17:35	SW2B-SD-052305	-	-	-	-	72.1
SW-3A	2/13/2004 10:45	SW3A-SD-021304	-	-	-	-	54.3
SW-3A	3/30/2004 10:45	SW-3A-SD-033004	-	-	-	-	45.3
SW-3A	4/22/2004 9:00	SW3A-SD-042204	-	-	-	-	62.3
SW-3A	6/3/2004 10:15	SW3A-SD-060304	301	1990 J	-	2.53 J	60.9
SW-3A	9/1/2004 9:50	SW3A-SD-090104	255	1260	6.4 J TR	2.18	61.4
SW-3B	12/1/2004	SW3B-SD-120104	159	841	1.3 U	0.74	80.7
SW-3B	2/23/2005 10:00	SW3B-SD-022305	241	731	0.8 U	1.43	68.1
SW-3B	5/23/2005 16:55	SW3B-SD-052305	-	-	-	-	51.6

Notes 1. Result values in italic type are PRE

Table A-4
Groundwater Field Parameters
Des Moines Creek RDF

Location	Sample Date/Time	Meas Date/Time	Dissolved Oxygen in mg/L	pH in pH units	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C	Turbidity in NTU
GW1D	8/31/04 11:35	8/31/04 11:15	0.46	7.05	70.1	501	12.20	4.73
GW1D	11/30/04 14:32	11/30/04 14:27	1.28	6.96	-48.3	638	10.68	3.11
GW1D	2/23/05 14:03	2/23/05 13:23	0.62	7.01	-54.6	793	11.41	2.64
GW1D	5/23/05 18:00	5/23/05 5:47	0.57	6.93	-107.0	715	10.95	8.08
GW1S	6/3/04 12:15	6/3/04 12:03			-62.5			
GW1S	8/31/04 12:10	8/31/04 11:51	0.58	6.36	-35.5	473	1454	1.41
GW1S	11/30/04 13:42	11/30/04 13:37	0.95	6.37	-13.5	598	10.39	0.70
GW1S	2/23/05 14:54	2/23/05 14:33	1.12	6.45	-57.0	632	9.02	6.16
GW1S	5/23/05 18:30	5/23/05 6:19	0.93	6.29	-117.5	627	11.01	1.6
GW2D	6/3/04 10:00	6/3/04 9:50						4.83
GW2D	8/30/04 16:15	8/30/04 15:43	0.55	6.49	-53.5	278	15.04	1.06
GW2D	11/29/04 14:00	11/29/04 13:58	0.98	6.17	-3.3	382	11.93	3.94
GW2D	2/22/05 13:37	2/22/05 13:08	0.32	6.21	10.3	587	12.99	7.65
GW2D	5/23/05 15:20	5/23/05 15:06	0.50	6.40	10.5	476	13.75	1.7
GW2S	6/2/04 15:00	6/2/04 14:57						23.3
GW2S	8/31/04 10:15	8/31/04 9:54	0.68	6.17	-5.0	419	15.55	6.20
GW2S	11/29/04 15:15	11/29/04 14:57	1.00	5.98	-17.7	385	12.02	
GW2S	2/22/05 13:36	2/22/05 14:16	0.65	6.29	-94.7	379	12.76	3.47
GW2S	5/23/05 16:00	5/23/05 15:38	0.52	6.19	-9.2	368	13.13	1.39
GW3D	6/2/04 13:30	6/2/04 13:13						7.26
GW3D	8/30/04 14:55	8/30/04 14:26	0.95	6.29	-57.1	371	16.94	
GW3D	11/29/04 12:30	11/29/04 12:19	1.30	6.22	0.8	382	11.40	12.4
GW3D	2/22/05 11:17	2/22/05 10:50	0.93	6.44	-62.5	380	11.93	4.2
GW3D	5/23/05 13:30	5/23/05 13:24	0.81	6.41	-15.9	390	14.00	5.54
GW3S	6/2/04 13:50	6/2/04 13:31						4.12
GW3S	8/30/04 17:05	8/30/04 15:16						12.7
GW3S	2/22/05 13:06	2/22/05 11:49	1.02	5.86	-93.4	304	11.66	2.2
GW3S	5/23/05 14:25	5/23/05 14:00	2.02	6.09	-18.2	311	13.85	3.54
GW4D	6/2/04 12:30	6/2/04 12:10						9.82
GW4D	8/31/04 14:35	8/31/04 14:13	0.76	6.18	-85.6	683	17.55	10.4
GW4D	11/29/04 16:00	11/29/04 15:49	0.95	6.30	-76.0	673	11.83	3.46
GW4D	2/22/05 14:26	2/22/05 13:51	0.69	6.37	-84.8	686	11.76	6.32
GW4D	5/23/05 11:33	5/23/05 11:28	0.83	6.42	-104.0	682	12.93	3.43
GW4S	6/2/04 10:50	6/2/04 10:40			-121.4			
GW4S	8/31/04 10:22	8/31/04 10:00	0.93	6.23	-80.8	941	19.14	31.3
GW4S	11/30/04 11:10	11/30/04 11:05	0.72	6.37	-69.6	866	11.61	15.4
GW4S	2/22/05 14:35	2/22/05 15:13	0.47	6.38	-73.6	832	9.47	2.28
GW4S	5/23/05 12:35	5/23/05 12:26	0.90	6.44		788	13.70	25.0
GW5D	6/1/04 14:45	6/1/04 14:32			-136.5			
GW5D	8/31/04 15:50	8/31/04 13:27	1.11	7.54	1.09	232	16.22	
GW5D	11/30/04 13:30	11/30/04 12:39	2.05	7.52	-66.2	233	10.43	100
GW5D	2/23/05 14:20	2/23/05 11:10	1.71	7.27	-101.1	241	12.13	25.1
GW5D	5/23/05 15:50	5/23/05 14:53	2.36	7.68	-137.7	252	16.95	53.9
GW5S	6/1/04 16:00	6/1/04 15:58			-35.5			
GW5S	8/31/04 16:10	8/30/04 13:38	3.40	6.40	-8.9	378	19.45	
GW5S	11/30/04 10:45	11/30/04 10:33	1.39	6.18	-6.8	396	10.50	17.6

Table A-4
Groundwater Field Parameters
Des Moines Creek RDF

Location	Sample Date/Time	Meas Date/Time	Dissolved Oxygen in mg/L	pH in pH units	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C	Turbidity in NTU
GW5S	2/23/05 14:38	2/23/05 10:03	1.54	6.25	-80.2	406	9.17	3.27
GW5S	5/23/05 16:55	5/23/05 16:16	1.79	6.45	-124.9	415	15.67	8.14
GW6D	6/1/04 12:35	6/1/04 12:31			-179.4			
GW6D	8/30/04 13:40	8/30/04 11:41	1.38	7.90	-105.8	322	17.27	6.39
GW6D	11/29/04 12:00	11/29/04 11:19	3.72	7.58	-22.3	401	9.89	17.2
GW6D	2/22/05 12:30	2/22/05 10:21	1.75	7.68	-35.8	508	9.67	21.1
GW6D	5/23/05 12:50	5/23/05 12:03	1.34	7.56	-102.5	542	13.37	6.27
GW6S	6/1/04 15:45	6/1/04 13:45			-101.7			
GW6S	8/30/04 17:42	8/30/04 11:20	5.23	7.04	-109.5	423	19.89	40.1
GW7D	6/1/04 11:00	6/1/04 10:57			-34.9			
GW7D	8/30/04 10:12	8/30/04 10:07	1.51	6.54	-54.0	684	14.8	5
GW7S	6/1/04 13:45	6/1/04 11:51			-93.7			

Table A-5
Surface Water Field Parameters
Des Moines Creek RDF

Location	Meas Date/Time	Depth / Comments	Dissolved Oxygen in mg/L	pH in pH units	Purge Rate in ml/mn	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C
SW1A	8/30/04 17:38	~10' downstream from pond pump outlet. Disturbed soil up to silt fence by channel.	8.4	7.10	860	-13	197	23.1
SW1B	11/29/04 13:21		5.5	6.70	780	154	202	5.6
SW1B	2/15/05 12:55	0.4'	8.1	6.8	700	216	195	5.1
SW1B	5/23/05 12:00		10.8	6.7		152	144	18.1
SW2A	8/30/04 16:52	water clear, slow velocity, aquatic veg. in channel. Heavy equip. operating near channel during sampling.	3.6	7.00	800	82	195	22.5
SW2B	11/29/04 12:29		6.3	6.80	660	186	202	5.2
SW2B	2/15/05 12:05	0.6'	8.4	6.7	700	227	195	5.6
SW2B	5/23/05 11:45	water clear, velocity ~1fps	10.8	6.7	1000	149	146	17.7
SW3A	8/30/04 14:08	Water clear, low velocity, pool ~1.4 ft.	2.1	6.90	750	100	196	20
SW3B	11/29/04 11:35		6.7	6.60	750	205	197	4.3
SW3B	2/15/05 11:22	0.4'	8.1	6.5	700	244	195	4.6
SW3B	5/23/05 9:45	water clear, velocity ~1fps	8.6	6.7	1000	147	140	14.4

Table A-6
NW Ponds Surface Water Profile and Field Parameters
Des Moines Creek RDF

Location	Meas Date/Time	Depth / Comments	Dissolved Oxygen in mg/L	pH in pH units	Purge Rate in ml/mn	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C
NWP1	8/31/04 17:05	0.9'	6.4	7.0	860	78	180	23.6
NWP1	8/31/04 17:07	0.9'	6.4	7.1	860	82	180	24.0
NWP1	8/31/04 17:10	0.9'	6.5	7.0	860	86	180	23.4
NWP1	8/31/04 17:12	1.8'	6.4	7.1	860	89	182	21.5
NWP1	8/31/04 17:15	1.8'	6.0	7.1	860	90	180	21.5
NWP1	8/31/04 17:17	1.8'	6.0	7.1	860	90	181	21.5
NWP1	8/31/04 17:20	2.7'	5.1	7.0	860	91	176	21.1
NWP1	8/31/04 17:23	2.7'	4.9	7.0	860	93	175	21.2
NWP1	8/31/04 17:24	2.7'	4.8	6.9	860	93	175	21.2
NWP1	8/31/04 17:26	3.6'	5.4	7.0	860	94	169	20.5
NWP1	8/31/04 17:28	3.6'	5.1	7.0	860	94	168	20.5
NWP1	8/31/04 17:30	3.6'	5.4	6.9	860	95	168	20.6
NWP1	8/31/04 17:32	4.5'	5.2	6.9	860	95	169	20.1
NWP1	8/31/04 17:34	4.5'	4.5	6.8	860	96	169	20.3
NWP1	8/31/04 17:36	4.5'	4.8	6.9	860	96	169	20.3
NWP1	8/31/04 17:38	5.4'	5.0	6.9	860	97	180	19.7
NWP1	8/31/04 17:40	5.4'	4.8	6.9	860	97	178	20.0
NWP1	8/31/04 17:42	5.4'	4.3	6.8	860	97	177	20.0
NWP1	8/31/04 17:43	5.4'	4.7	6.9	860	97	179	20.0
NWP1	8/31/04 17:45	6.3'	5.5	6.7	860	99	209	19.8
NWP1	8/31/04 17:47	6.3'	5.2	6.7	860	99	214	19.8
NWP1	8/31/04 17:49	6.3'	5.4	6.8	860	100	216	19.9
NWP1	8/31/04 17:51	7.2'; green with algae	5.0	6.5	860	100	309	19.4
NWP1	8/31/04 17:53	7.2'; green with algae	4.7	6.6	860	99	312	19.4
NWP1	8/31/04 17:56	7.2'; green with algae	4.5	6.5	860	98	305	19.5
NWP1	8/31/04 17:58	8.1'; sulpher smell, less green	4.2	6.3	860	-34	533	18.4
NWP1	8/31/04 18:00	8.1'	4.2	6.4	750	-35	544	18.4
NWP1	8/31/04 18:02	8.1'	4.0	6.5	750	-35	544	18.4
NWP1	8/31/04 18:04	9.0'; sulpher smell, less green	4.0	6.5	750	-25	649	17.4
NWP1	8/31/04 18:06	9.0'	3.8	6.5	750	-25	652	17.4
NWP1	8/31/04 18:09	9.0'	3.7	6.5	750	-25	652	17.4
NWP1	12/1/04 12:10	0.4	5.8	6.5	840	63	190	7.2
NWP1	12/1/04 12:13	0.4	5.4	6.6	680	16	190	7.3
NWP1	12/1/04 12:15	0.4	5.4	6.6	680	35	191	7.3
NWP1	12/1/04 12:17	0.4	5.3	6.6	600	37	187	7.3
NWP1	12/1/04 12:20	1.4	5.3	6.6	600	29	189	7.3
NWP1	12/1/04 12:23	1.4	5.3	6.6	750	45	190	7.3
NWP1	12/1/04 12:25	1.4	5.4	6.6	600	52	190	7.3
NWP1	12/1/04 12:28	2.4	5.5	6.6	600	58	191	7.3
NWP1	12/1/04 12:31	2.4	5.4	6.6	600	60	192	7.3
NWP1	12/1/04 12:33	2.4	5.5	6.6	600	64	191	7.3
NWP1	12/1/04 12:37	3.4	5.4	6.6	600	64	190	7.3
NWP1	12/1/04 12:40	3.4	5.3	6.6	600	60	188	7.2
NWP1	12/1/04 12:42	3.4	5.2	6.6	600	60	190	7.3
NWP1	12/1/04 12:50	4.4	5.1	6.5	670	30	190	7.2
NWP1	12/1/04 12:52	4.4	5.2	6.5	670	35	186	7.1

Table A-6
NW Ponds Surface Water Profile and Field Parameters
Des Moines Creek RDF

Location	Meas Date/Time	Depth / Comments	Dissolved Oxygen in mg/L	pH in pH units	Purge Rate in ml/mn	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C
NWP1	12/1/04 12:55	4.4	5.4	6.5	670	38	187	7.1
NWP1	12/1/04 13:00	5.4	5.3	6.6	860	42	188	7.1
NWP1	12/1/04 13:03	5.4	5.3	6.6	860	43	187	7.1
NWP1	12/1/04 13:05	5.4	5.3	6.6	860	45	187	7.1
NWP1	12/1/04 13:08	6.4	5.1	6.6	750	47	188	7.1
NWP1	12/1/04 13:15	6.4	4.9	6.6	860	48	187	7.1
NWP1	12/1/04 13:16	6.4	5.0	6.6	860	49	188	7.1
NWP1	12/1/04 13:18	7.4	4.4	6.6	860	52	210	7.3
NWP1	12/1/04 13:21	7.4	4.4	6.6	860	52	203	7.2
NWP1	12/1/04 13:25	7.4	4.3	6.5	860	53	206	7.3
NWP1	12/1/04 13:30	8.4	3.2	6.4	860	39	330	7.8
NWP1	12/1/04 13:35	8.4; color a bit green	2.8	6.4	860	29	339	7.8
NWP1	12/1/04 13:38	8.4	2.7	6.4	860	28	352	7.9
NWP1	12/1/04 13:41	8.4	2.5	6.4	860	21	357	7.9
NWP1	12/1/04 13:45	9	3.4	6.4	860	8	386	8.2
NWP1	12/1/04 13:50	9	3.3	6.4	860	7	411	8.2
NWP1	12/1/04 13:53	9	3.1	6.4	860	6	405	8.2
NWP1	12/1/04 13:56	9	3.0	6.4	860	5	408	8.2
NWP1	2/16/05 12:00	0.4'	7.2	6.8	700	194	194	5.4
NWP1	2/16/05 12:03	0.4'	6.7	6.7	700	195	195	5.5
NWP1	2/16/05 12:05	0.4'	6.6	6.7	700	196	194	5.6
NWP1	2/16/05 12:06	1.4'	6.5	6.8	700	192	195	5.4
NWP1	2/16/05 12:08	1.4'	6.4	6.8	700	193	194	5.4
NWP1	2/16/05 12:11	1.4'	6.3	6.8	700	193	194	5.3
NWP1	2/16/05 12:12	2.4'	6.3	6.7	700	195	194	5.2
NWP1	2/16/05 12:14	2.4'	6.3	6.7	700	196	194	5.2
NWP1	2/16/05 12:16	2.4'	6.3	6.6	700	199	194	5.2
NWP1	2/16/05 12:17	3.4'	6.3	6.7	700	194	194	5.0
NWP1	2/16/05 12:19	3.4'	6.2	6.7	700	198	194	5.0
NWP1	2/16/05 12:22	3.4'	6.2	6.7	700	198	194	5.0
NWP1	2/16/05 12:23	4.4'	6.2	6.7	700	195	194	5.0
NWP1	2/16/05 12:25	4.4'	6.2	6.6	700	198	194	5.0
NWP1	2/16/05 12:28	4.4'	6.2	6.6	700	199	194	5.0
NWP1	2/16/05 12:29	5.4'	6.0	6.6	700	198	196	4.9
NWP1	2/16/05 12:31	5.4'	5.9	6.6	700	199	197	4.9
NWP1	2/16/05 12:34	5.4'	6.0	6.6	700	199	197	4.9
NWP1	2/16/05 12:35	6.4'	5.5	6.6	700	199	201	5.0
NWP1	2/16/05 12:37	6.4'	5.3	6.6	700	198	202	5.0
NWP1	2/16/05 12:40	6.4'	5.5	6.6	700	197	201	5.0
NWP1	2/16/05 12:42	7.4'	4.7	6.7	700	196	207	5.2
NWP1	2/16/05 12:45	7.4'	4.8	6.7	700	194	205	5.1
NWP1	2/16/05 12:48	7.4'	4.9	6.7	700	195	204	5.1
NWP1	2/16/05 12:49	8.4'	3.4	6.5	700	194	246	5.7
NWP1	2/16/05 12:51	8.4'	2.9	6.6	700	196	263	5.9
NWP1	2/16/05 12:53	8.4'	2.3	6.6	700	191	268	6.0

Table A-6
NW Ponds Surface Water Profile and Field Parameters
Des Moines Creek RDF

Location	Meas Date/Time	Depth / Comments	Dissolved Oxygen in mg/L	pH in pH units	Purge Rate in ml/mn	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C
NWP1	2/16/05 12:56	8.4'	2.2	6.6	700	188	262	6.0
NWP1	2/16/05 12:57	8.4'	2.1	6.5	700	181	271	6.1
NWP1	2/16/05 12:58	8.4'	2.0	6.4	700	184	276	6.1
NWP1	2/16/05 13:00	9.0'	.0	6.5	700	180	290	6.3
NWP1	2/16/05 13:02	9.0'	0.8	6.5	700	175	296	6.4
NWP1	2/16/05 13:05	9.0'	0.9	6.5	700	167	282	6.3
NWP2	8/31/04 15:15	0.3'	9.8	7.5	860	103	180	26.7
NWP2	8/31/04 15:17	0.3'	9.0	7.6	860	102	173	26.8
NWP2	8/31/04 15:20	0.3'	8.6	7.4	860	121	178	26.5
NWP2	8/31/04 15:22	0.3'	9.0	8.0	860	95	169	26.8
NWP2	8/31/04 15:25	0.3'; wind picking up, mixing pond near surface.	9.2	8.1	860	101	175	27.0
NWP2	8/31/04 15:27	0.6'	5.6	7.3	860	113	193	23.9
NWP2	8/31/04 15:30	0.6'	5.1	6.9	860	111	196	23.7
NWP2	8/31/04 15:32	0.6'	5.5	6.9	860	110	195	23.8
NWP2	8/31/04 15:34	0.9'	3.7	6.8	860	106	200	23.0
NWP2	8/31/04 15:36	0.9'	3.5	6.8	860	107	196	23.6
NWP2	8/31/04 15:43	0.9'; wind picking up, mixing pond near surface	3.6	6.7	860	101	193	23.6
NWP2	8/31/04 15:48	1.2'	1.6	6.6	860	-4	225	21.2
NWP2	8/31/04 15:50	1.2'; readings unstable	2.0	6.7	860	27	224	21.4
NWP2	8/31/04 15:53	1.2'; readings unstable	1.9	6.7	860	19	229	21.3
NWP2	8/31/04 15:55	1.2'; readings unstable	2.0	6.6	860	19	215	21.7
NWP2	8/31/04 15:58	1.5'; readings unstable	1.6	6.6	860	-27	256	20.8
NWP2	8/31/04 16:01	1.5'	1.7	6.6	860	-71	254	20.5
NWP2	8/31/04 16:03	1.5'; stable readings	1.6	6.6	860	-65	254	20.4
NWP2	8/31/04 16:06	1.8"; stable readings	3.0	6.7	860	-63	262	19.1
NWP2	8/31/04 16:09	1.8'	2.9	6.6	860	-69	262	19.2
NWP2	8/31/04 16:11	1.8'	2.9	6.7	860	-73	262	19.1
NWP2	8/31/04 16:14	2.1'	2.8	6.6	860	-84	275	18.9
NWP2	8/31/04 16:17	2.1'	2.7	6.6	860	-83	270	18.9
NWP2	8/31/04 16:20	2.1'	1.4	6.7	860	-94	285	18.8
NWP2	8/31/04 16:22	2.1'	1.4	6.7	860	-92	283	18.8
NWP2	8/31/04 16:24	2.1'	1.4	6.7	860	-93	283	18.8
NWP2	11/30/04 13:30	0.4	5.0	6.7	600	170	185	7.5
NWP2	11/30/04 13:33	0.4	4.6	6.7	600	109	180	7.4
NWP2	11/30/04 13:36	0.4	4.6	6.7	550	80	175	7.3
NWP2	11/30/04 13:39	0.4	4.5	6.7	550	60	186	7.3
NWP2	11/30/04 13:42	0.4	4.3	6.7	550	55	186	7.3
NWP2	2/16/05 11:00	0.2'	7.5	6.8	680	199	235	4.9
NWP2	2/16/05 11:03	0.2'	7.3	6.8	680	198	216	4.9
NWP2	2/16/05 11:05	0.2'	6.9	6.7	680	198	211	4.9
NWP2	2/16/05 11:06	0.6'	6.6	6.8	680	196	210	5.0
NWP2	2/16/05 11:09	0.6'	6.6	6.8	680	195	208	5.0
NWP2	2/16/05 11:12	0.6'	6.6	6.8	680	197	204	4.9
NWP2	2/16/05 11:13	1.0'	6.7	6.7	680	198	220	4.8

Table A-6
NW Ponds Surface Water Profile and Field Parameters
Des Moines Creek RDF

Location	Meas Date/Time	Depth / Comments	Dissolved Oxygen in mg/L	pH in pH units	Purge Rate in ml/mn	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C
NWP2	2/16/05 11:15	1.0'	6.8	6.7	680	198	210	4.9
NWP2	2/16/05 11:18	1.0'	6.7	6.7	680	199	220	4.9
NWP2	2/16/05 11:20	1.4'	6.8	6.7	680	199	262	4.9
NWP2	2/16/05 11:22	1.4'	6.8	6.7	680	201	258	5.0
NWP2	2/16/05 11:25	1.4'	6.9	6.6	680	202	255	5.0
NWP2	2/16/05 11:26	1.8'	6.9	6.7	680	200	271	5.1
NWP2	2/16/05 11:28	1.8'	6.7	6.7	680	200	267	5.0
NWP2	2/16/05 11:31	1.8'	6.9	6.7	680	197	253	5.0
NWP3	8/31/04 13:15	0.2'	7.70	7.30	700	127	193	25.0
NWP3	8/31/04 13:20	0.2'	7.50	7.30	700	130	192	25.0
NWP3	8/31/04 13:21	0.2'	7.60	7.30	700	132	191	25.1
NWP3	8/31/04 13:22	0.4'	7.80	7.30	700	133	191	25.2
NWP3	8/31/04 13:25	0.4'	7.50	7.30	700	135	191	25.2
NWP3	8/31/04 13:28	0.4'	7.10	7.20	700	130	191	25.3
NWP3	8/31/04 13:30	0.6'	4.40	7.00	700	116	199	22.2
NWP3	8/31/04 13:33	0.6'	3.70	6.90	700	120	199	22.3
NWP3	8/31/04 13:39	0.6'	3.70	6.60	750	144	199	22.1
NWP3	8/31/04 13:41	0.6'	3.80	6.80	750	144	198	22.1
NWP3	8/31/04 13:43	0.6'	3.80	6.80	750	145	197	22.3
NWP3	8/31/04 13:45	0.8'	4.00	6.80	750	143	200	21.1
NWP3	8/31/04 13:47	0.8'	3.90	6.80	750	142	200	21.2
NWP3	8/31/04 13:50	0.8'	3.80	6.80	750	139	200	21.4
NWP3	8/31/04 13:52	1.0'	5.30	6.80	750	133	202	21.0
NWP3	8/31/04 13:55	1.0'	3.80	6.80	750	139	200	21.6
NWP3	8/31/04 13:57	1.0'	3.80	6.80	750	139	200	21.4
NWP3	8/31/04 14:00	1.2'	3.90	6.80	750	106	204	21.1
NWP3	8/31/04 14:03	1.2'	4.00	6.80	750	101	203	21.2
NWP3	8/31/04 14:05	1.2'	3.80	6.80	750	113	205	21.0
NWP3	8/31/04 14:07	1.4'	3.90	6.70	750	107	208	20.8
NWP3	8/31/04 14:10	1.4'	3.60	6.70	750	104	208	20.9
NWP3	8/31/04 14:12	1.4'	3.40	6.70	750	102	208	20.9
NWP3	8/31/04 14:14	1.6'	4.10	6.80	750	93	208	20.8
NWP3	8/31/04 14:17	1.6'	3.80	6.70	750	101	208	20.9
NWP3	8/31/04 14:20	1.6'	3.70	6.70	750	97	208	20.9
NWP3	11/30/04 12:28	0.4	5.50	6.80	750	138	196	7.3
NWP3	11/30/04 12:41	0.4	5.10	6.80	750	119	194	7.3
NWP3	11/30/04 12:43	0.4	5.00	6.70	750	99	192	7.3
NWP3	11/30/04 12:45	0.4	5.10	6.70	750	77	195	7.3
NWP3	11/30/04 12:48	0.4	5.10	6.70	750	70	198	7.3
NWP3	2/16/05 10:15	0.2'	8.7	6.5	700	211	208	3.7
NWP3	2/16/05 10:17	0.2'	8.4	6.5	700	210	208	3.7
NWP3	2/16/05 10:20	0.2'	8.2	6.5	700	208	208	3.7
NWP3	2/16/05 10:22	0.6'	8.8	6.5	700	213	208	3.7
NWP3	2/16/05 10:24	0.6'	8.2	6.5	700	209	207	3.8
NWP3	2/16/05 10:28	0.6'	8.2	6.5	700	209	207	3.7

Table A-6
NW Ponds Surface Water Profile and Field Parameters
Des Moines Creek RDF

Location	Meas Date/Time	Depth / Comments	Dissolved Oxygen in mg/L	pH in pH units	Purge Rate in ml/mn	Redox (ORP) in mV	Specific Conductance in us/cm	Temperature in °C
NWP3	2/16/05 10:30	1.0'	8.3	6.5	700	210	207	3.8
NWP3	2/16/05 10:32	1.0'	8.3	6.6	700	208	207	3.8
NWP3	2/16/05 10:35	1.0'	8.1	6.6	700	208	208	3.8
NWP4	8/31/04 11:14	0.4'	4.70	7.20	860	107	194	20.6
NWP4	8/31/04 11:16	0.4'	4.50	7.10	860	114	189	21.3
NWP4	8/31/04 11:18	0.4'	5.00	7.00	860	123	191	21.5
NWP4	8/31/04 11:19	0.4'	4.80	6.90	860	125	190	21.2
NWP4	8/31/04 11:20	0.8'	5.00	6.90	860	125	190	20.8
NWP4	8/31/04 11:22	0.8'	4.8	6.90	860	123	192	20.8
NWP4	8/31/04 11:24	0.8'	4.70	6.90	860	120	192	20.5
NWP4	8/31/04 11:36	1.2'	5.00	6.90	860	132	191	20.2
NWP4	8/31/04 11:38	1.2'	3.30	6.80	860	129	193	20.2
NWP4	8/31/04 11:40	1.2'	3.10	6.80	860	126	193	20.2
NWP4	8/31/04 11:41	1.6'	3.40	6.80	860	50	197	19.8
NWP4	8/31/04 11:43	1.6'	3.50	6.80	860	32	197	19.8
NWP4	8/31/04 11:45	1.6'	3.80	6.70	860	32	197	19.8
NWP4	8/31/04 11:47	2.0'	3.90	6.80	860	-1	203	19.5
NWP4	8/31/04 11:50	2.0'	3.80	6.80	860	-6	202	19.5
NWP4	8/31/04 11:52	2.0'	3.60	6.90	860	-1	203	19.6
NWP4	8/31/04 11:54	2.4'	4.00	6.80	860	-1	206	19.3
NWP4	8/31/04 11:56	2.4'	2.80	6.80	860	-13	207	19.3
NWP4	8/31/04 11:58	2.4'	2.70	6.80	860	-4	207	19.3
NWP4	8/31/04 12:00	2.4'	2.60	6.80	860	-3	207	19.3
NWP4	8/31/04 12:02	2.8'	5.00	6.90	860	-48	210	19.4
NWP4	8/31/04 12:05	2.8'	4.00	6.90	860	-41	208	19.5
NWP4	8/31/04 12:07	2.8'	1.20	7.00	860	-30	207	19.4
NWP4	8/31/04 12:09	2.8'	2.60	6.90	860	-33	207	19.4
NWP4	8/31/04 12:12	2.8'	2.50	6.90	860	-34	207	19.4
NWP4	11/30/04 10:17	0.4	6.30	6.40	660	193	185	6.7
NWP4	11/30/04 10:21	0.4	6.10	6.50	600	80	185	6.7
NWP4	11/30/04 10:24	0.4	6.10	6.50	550	54	186	6.8
NWP4	11/30/04 10:30	0.4	6.00	6.60	660	28	186	6.8
NWP4	11/30/04 10:33	0.4	5.90	6.60	660	32	186	6.8
NWP4	2/16/05 9:25	0.4'	9.2	5.9	700	232	205	2.6
NWP4	2/16/05 9:27	0.4'	9.1	6.0	700	229	205	2.6
NWP4	2/16/05 9:30	0.4'	9.2	6.1	700	223	205	2.6
NWP4	2/16/05 9:31	0.8'	9.1	6.1	700	226	205	2.7
NWP4	2/16/05 9:33	0.8'	9.1	6.1	700	224	206	2.7
NWP4	2/16/05 9:36	0.8'	9.0	6.1	700	224	205	2.7
NWP4	2/16/05 9:38	1.2'	9.1	6.2	700	222	205	2.8
NWP4	2/16/05 9:40	1.2'	9.0	6.2	700	218	205	2.8
NWP4	2/16/05 9:43	1.2'	9.0	6.2	700	217	205	2.8
NWP4	2/16/05 9:44	1.4'	9.0	6.3	700	219	206	2.9
NWP4	2/16/05 9:46	1.4'	8.9	6.3	700	218	205	2.9
NWP4	2/16/05 9:50	1.4'	9.0	6.3	700	218	206	2.9

Figure A-1
Groundwater Quality - Arsenic
Des Moines Creek Regional Detention Facility

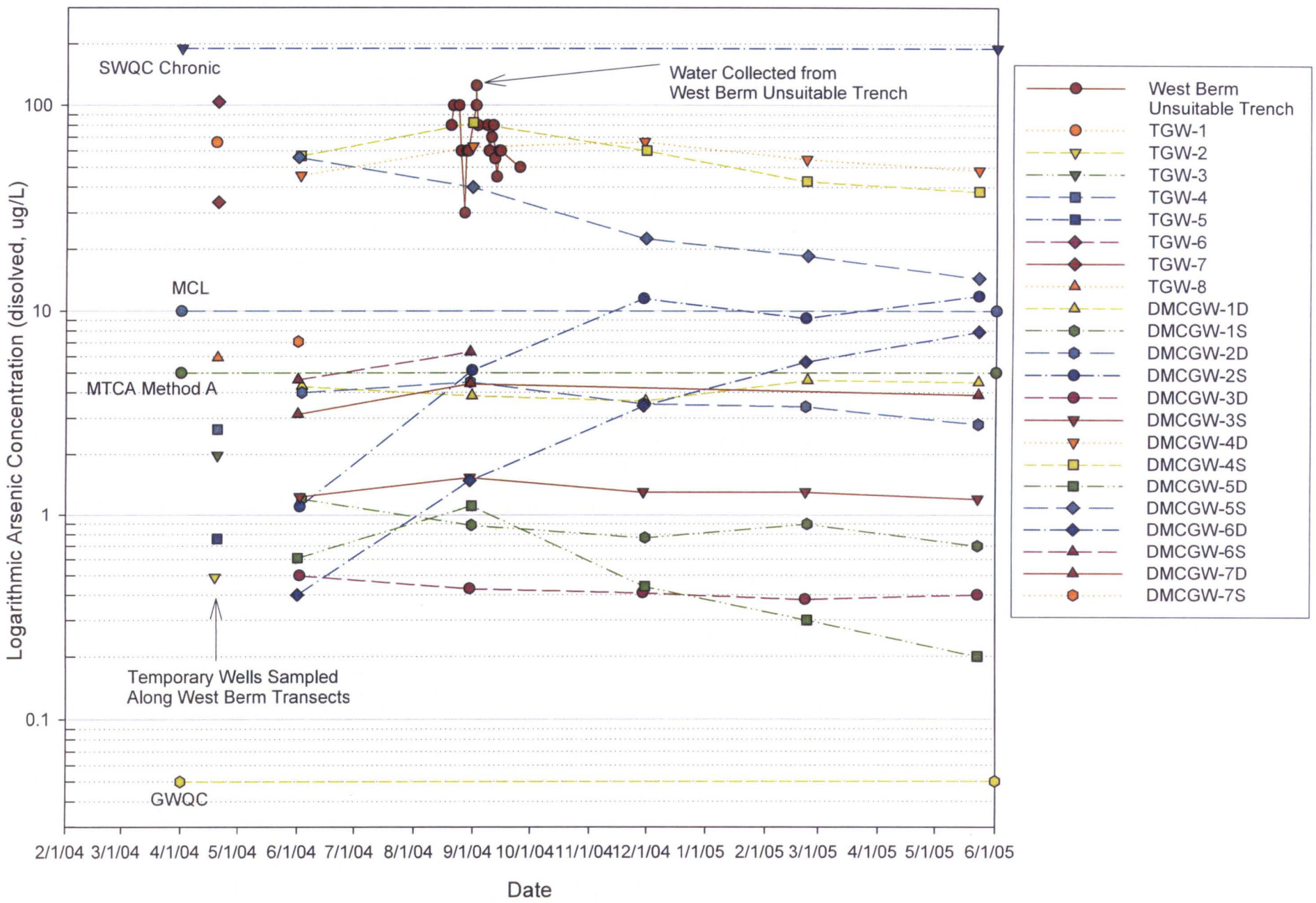


Figure A-2
Surface Water Quality - Arsenic
Des Moines Creek Regional Detention Facility

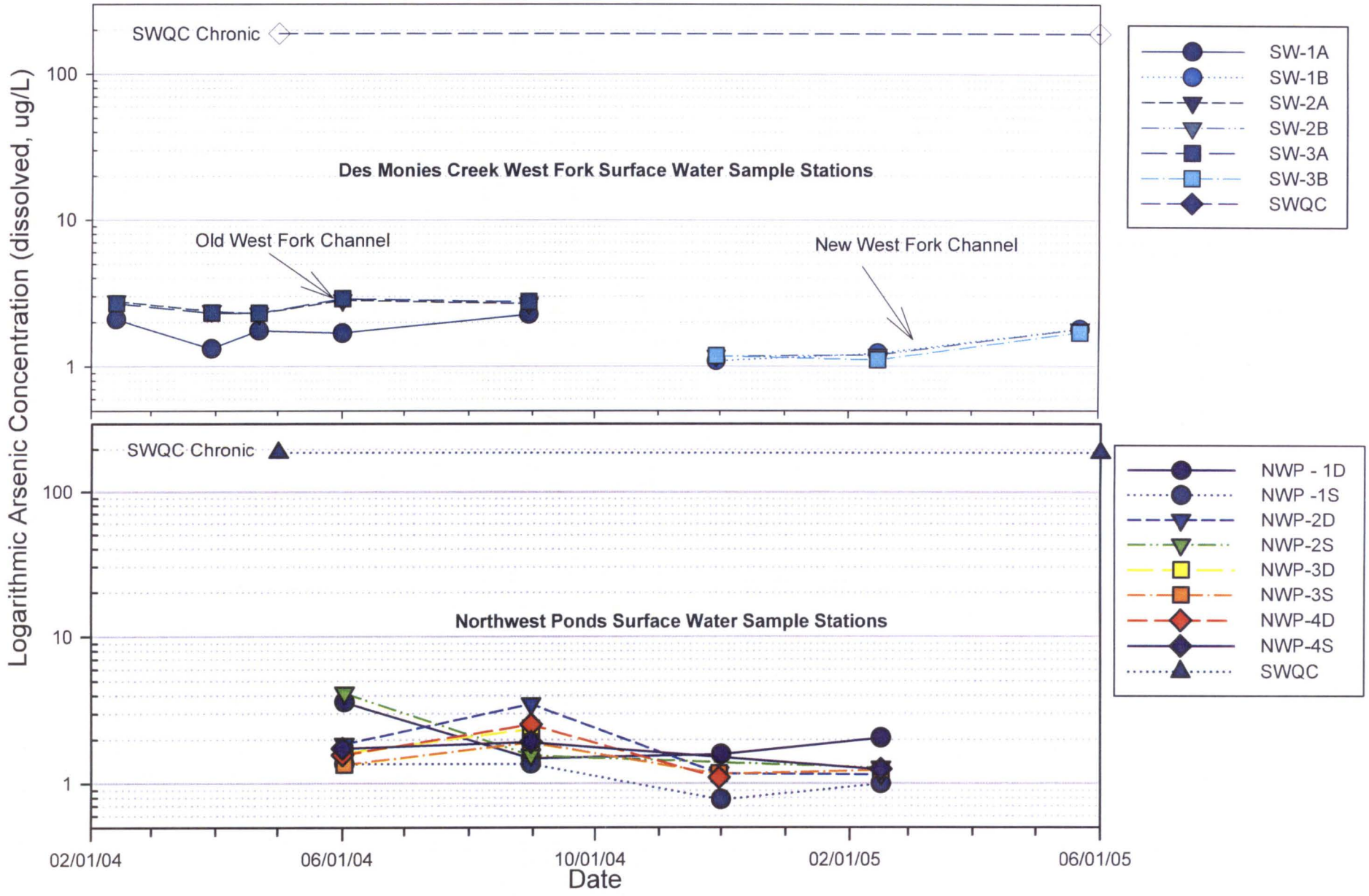


Figure A-3
Sediment Quality - Arsenic
Des Moines Creek Regional Detention Facility

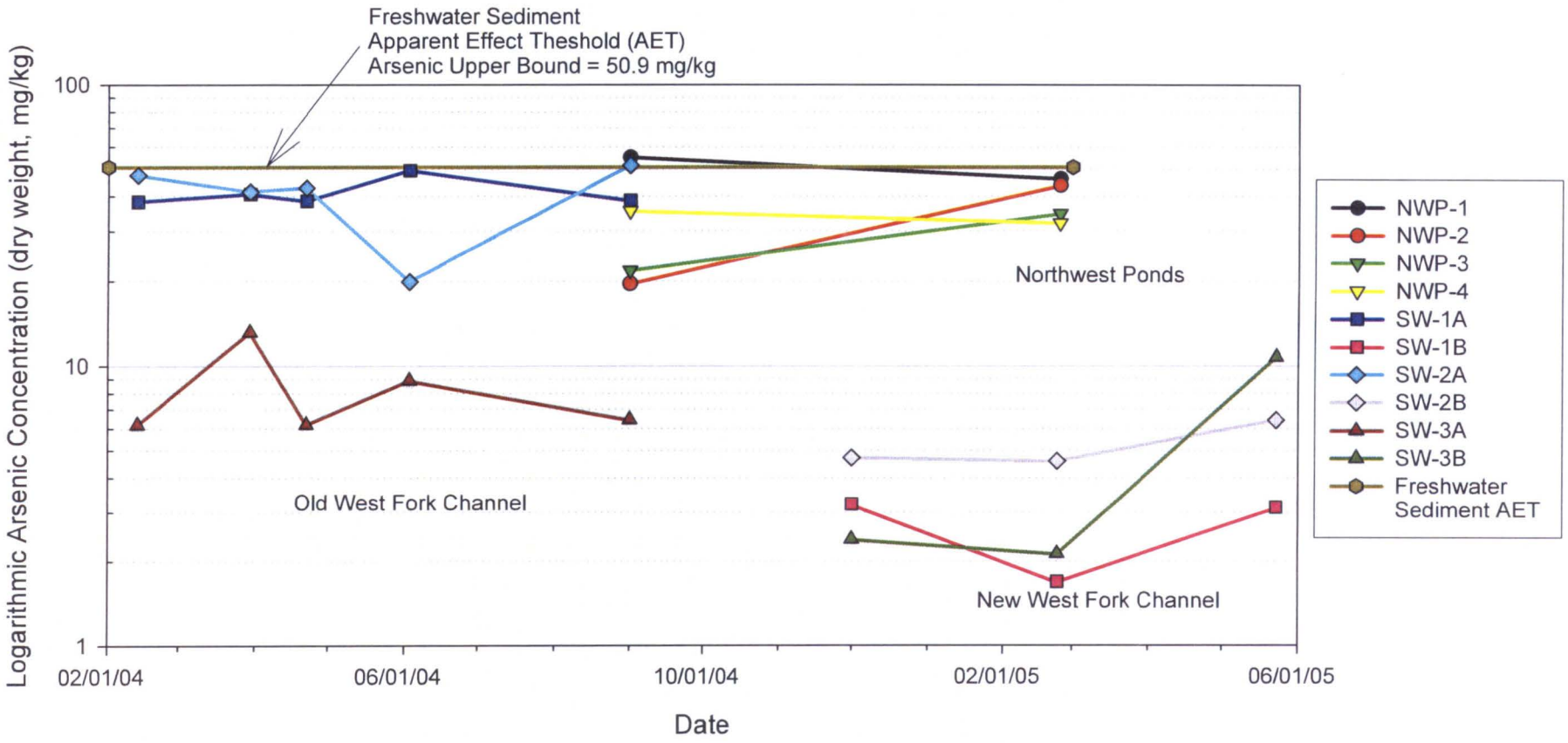


Figure A-4
Des Moines Creek RDF
Perched Groundwater Shallow Wells
Groundwater Quality
Piper Plot

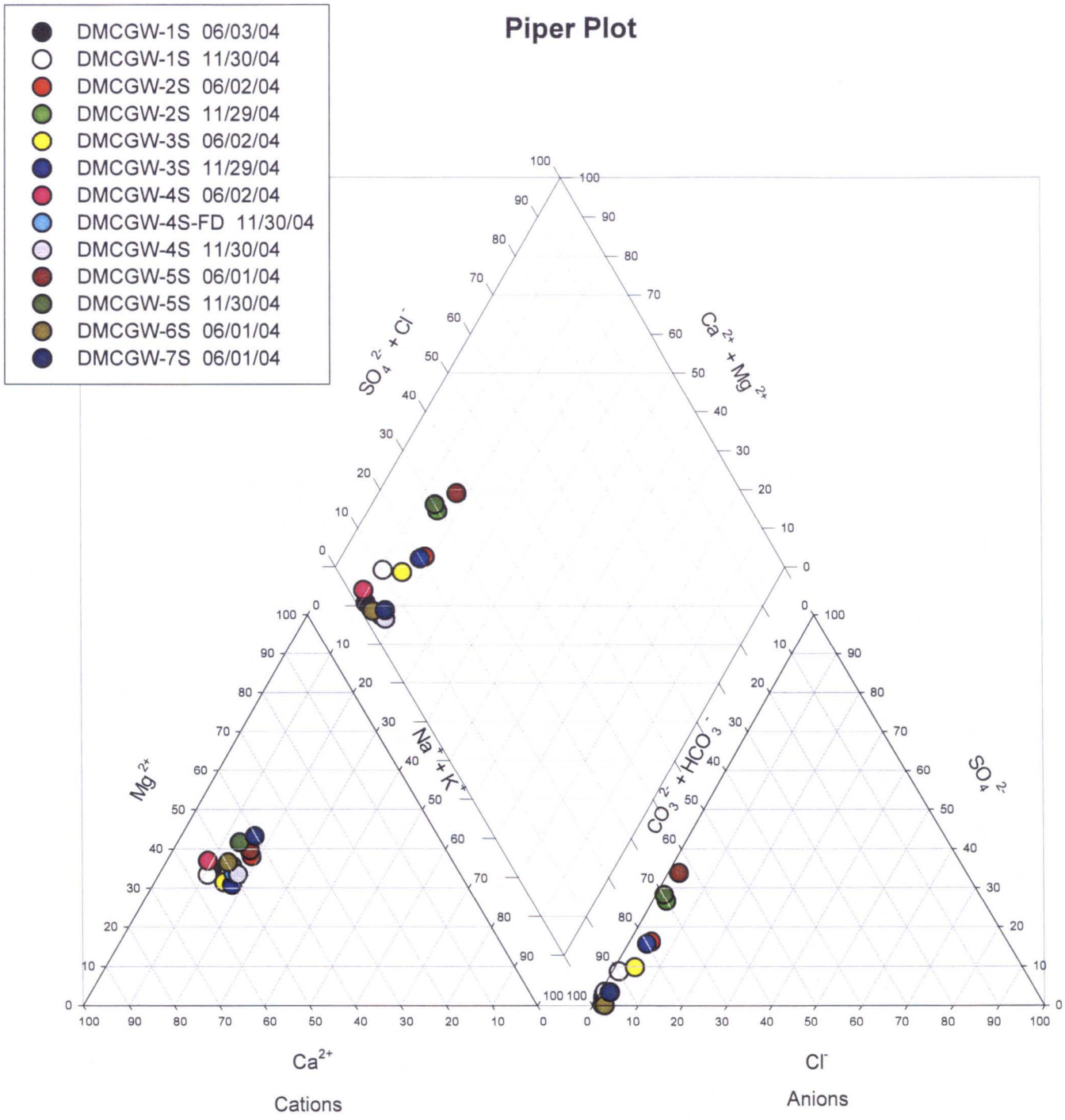
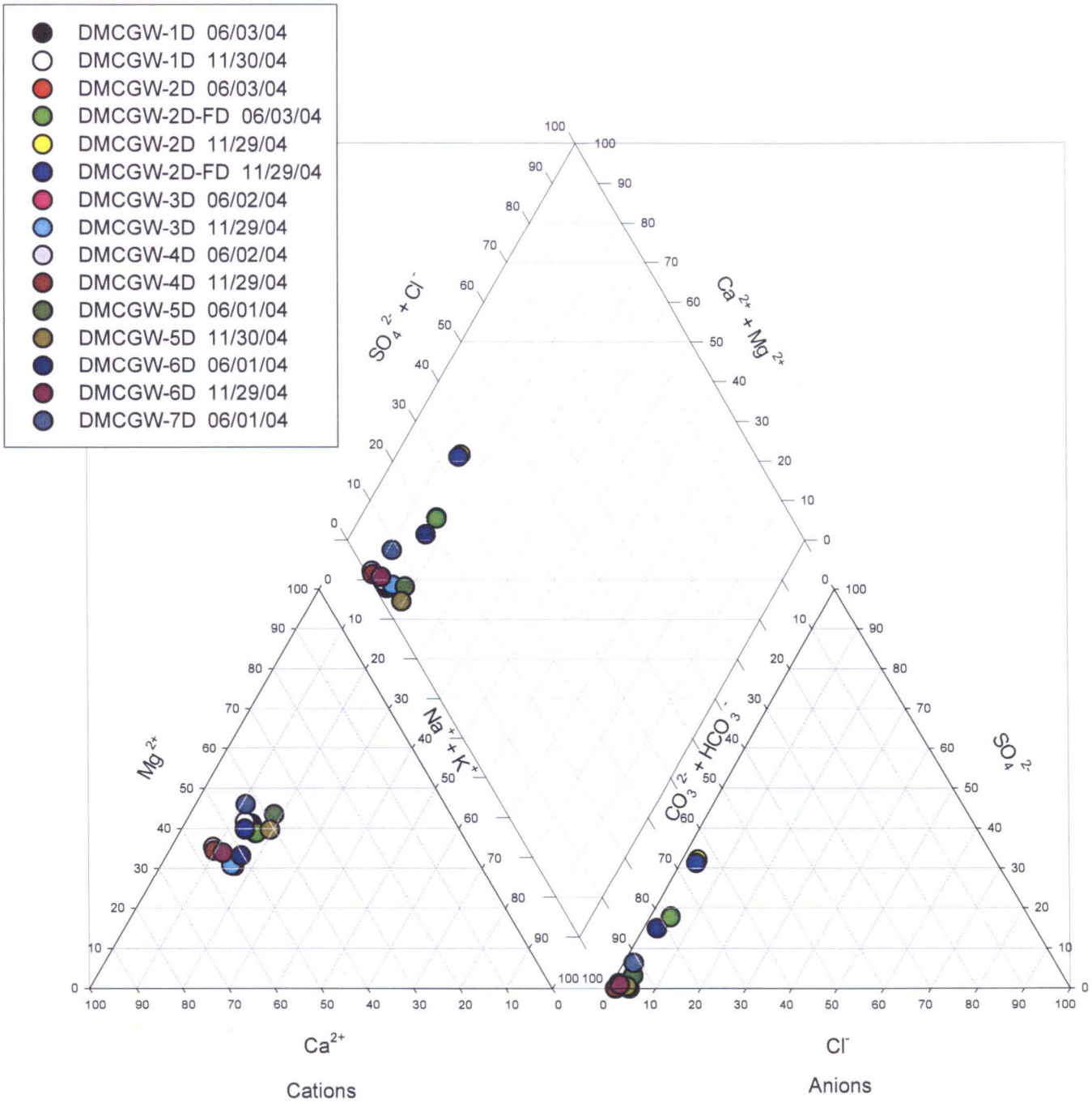


Figure A-5
Des Moines Creek RDF
Perched Groundwater Deep Wells
Groundwater Quality
Piper Plot



APPENDIX B

Field Sampling and Handling Protocols

The following Appendix describes the protocols that will be employed for the collection and handling of field samples under the Long-Term Monitoring Plan.

B.1 Field Sampling

B.1.1 Soil Sample Collection Protocols

The following standard operating procedures will be followed for the soil sampling:

1. Field sampling staff will notify and coordinate access requirements with the property owners before sample collection.
2. Decontaminate all sampling equipment following the equipment decontamination procedure described in Appendix B.
3. Identify the sample location stake.
4. Clear the area to be sampled of any debris (for example, twigs, rocks, litter, etc.).
5. Estimate the cap thickness based on stake stickup above ground surface.
6. Take precautions to avoid damaging the cap reactive layer and geotextile by preventing sample tool entry into the bottom 3 inches of the cap material.
7. Collect two discrete soil samples at each location. Collect the first sample from the interval 0 to 12 inches, and the second from 12 inches to 21 inches (but not less than 3 inches above the estimated cap depth).
8. Collect the samples using an auger or a thin-wall tube sampler, as appropriate.
9. Transfer the samples directly into properly labeled, laboratory-supplied sample containers using a precleaned plastic spoon.
10. During boring, control accidental brushing of loose material back down the borehole by periodically removing and depositing soils into a plastic sheet spread near the hole.
11. During boring, the licensed professional geologist or geotechnical engineer will take notes and photographs and prepare soil boring logs. Details will be presented on the soil material observed at specific depth, change in soil contacts, presence and depth of groundwater, hydrogen sulfide odor (if present), and any other pertinent information.
12. After reaching the sample collection depth, slowly and carefully remove the auger from the hole and lower the precleaned tube sampler to collect samples.
13. If a tube sampler is used, discard the top 1 inch of the core and quickly seal the ends of the sample tube.
14. Based on site conditions, the licensed professional geologist or geotechnical engineer may decide to collect samples directly from the auger.

15. A clean auger and/or sampling device shall be used for each sample interval.

16. Field notes shall be collected at each sample location and include date, time, sample identification, personnel, and sample collection method.

17. All samples collected with the auger shall be placed in laboratory-supplied sample jars. Samples shall be labeled with a unique identification using the convention for soil samples outlined in Appendix B. Furthermore, samples will be handled under procedures described in Appendix B.

18. All sampling tools must be decontaminated prior to collecting samples from another borehole according to the methods described in Appendix B.

19. After collecting samples, the boreholes should be backfilled with the removed soil material or as determined by the geologist or engineer.

20. All soil samples must be stored and delivered to the laboratory according to the guidelines of this plan.

B.1.2 Groundwater Collection Protocols

Groundwater samples will be sampled using low flow (that is, flow rates at or less than 0.5 liter/minute) purging and sampling techniques. The following section describes the sampling procedures using this method.

The static groundwater level will be measured with an electric tape to the nearest 0.01 foot and referenced from the top of the well casing.

A portable peristaltic pump, with disposable LDPE and silicon tubing, will be used for this groundwater sampling. Position the ¼-inch OD LDPE tubing intake at the approximate midpoint of the screen for both purging and sampling. Connect the discharge to the intake of a flow-through cell for measuring water quality parameters.

Purge the well at low flow rates not to exceed approximately 0.5 liter (or 16 ounces) per minute. Allow the discharge to run into the flow-through cell. The purge water discharging from the flow-through cell should be directed away from the well. Determine the flow rate by measuring the time to fill a container of known volume and adjust the flow rate as necessary.

During purging, measure and record field parameters (DO, ORP, temperature, pH, and conductivity) until they stabilize. Of these parameters, DO and ORP are considered most important since they determine redox conditions of the groundwater. Because DO and ORP are also expected to take the longest to stabilize, stabilization is defined as three successive readings where DO varies by less than 10 percent, and ORP varies by less than 10 milliVolts (mV). Additional stability criteria are 0.5° C for temperature, 10 percent for conductivity, and 0.1 units for pH. However, no more than three well casing volumes need be purged prior to groundwater sample collection. Flow rate (and depth to water, if possible) should also be measured every 2 to 4 minutes. Record the time and all measurements on the field log for each set of readings.

The groundwater sample will be collected directly from the pump discharge line upstream of the flow-through cell by filling the lab-provided bottles, while maintaining the same low flow rate as during purging.

B1.3 Surface Water Collection Protocols

Samples shall be collected starting with the most downstream location and proceeding upstream. All samples shall be collected in the course of 1 day. Water samples shall be collected prior to the collection of sediment samples.

Surface water samples shall be collected using a peristaltic pump at flow rates between 500 and 1,000 ml/min. New ¼-inch OD by 0.17-inch ID LDPE tubing, new silicon tubing, and new filters shall be used at each sampling location. The polyethylene tubing will be attached to a support and extended to the approximate center of the creek. The intake depth of the LDPE tubing should be approximately halfway between the sediment and the creek surface.

Water quality parameters shall be measured in the field prior to the collection of surface water samples. These field parameters are temperature, conductivity, dissolved oxygen (DO), pH, and oxygen reduction potential (ORP or redox). The parameters will be measured using a peristaltic pump and a flow-through cell with a multi-parameter water quality meter (YSI 556 Multi Probe System or equivalent). Flow rate should also be measured every 3 to 5 minutes, preferably just before recording the field parameters. Measurements will be recorded at 3- to 5-minute intervals until the readings have stabilized. Readings will be considered stable when changes between consecutive readings are less than 0.5° C for temperature, 10 percent for conductivity and DO, 0.1 units for pH, and 10 mV for ORP. A minimum of three readings must be recorded. Sample location, personnel, date and times of measurement, and field parameter values will be recorded on a field log for each set of readings.

The surface water sample will be collected by directly filling the lab-provided bottles from the pump discharge line at the same flow rate that was maintained during measurement of field parameters. New sampling tubing will be used at each location, which will eliminate the need for equipment decontamination between sample stations. However, rinsate blank samples of the pump tubing will be collected at the end of each water sampling event or at least for each batch of sample tubing.

B1.4 Sample Collection of Sediment

Samples shall be collected starting with the most downstream location and proceeding upstream. All samples shall be collected in the course of one day. Water samples shall be collected prior to the collection of sediment samples.

Both the initial and the most recent collection point of sediments at each location shall be clearly marked. Sample locations at a particular station will move slightly upstream from the previous sample event to avoid collecting sediment from a previous sampled area. After a period of 1 year, the sample location will be reset near the original position.

Sediment samples will be collected from the near vicinity of the surface water locations after surface water samples are collected, containerized, and processed. The field supervisor shall determine what method of sampling will be used, depending on the nature of the sediments to be sampled. The sample should be collected in an area of sediment accumulation, such as the inside of stream meanders, quiet shallow areas, or low velocity zones. Channel reaches of evidence of net erosion, such as high-velocity or turbulent zones will be avoided. As described above, the sediment sample needs to be collected with minimal disturbance so as not to allow sediment agitation. If possible, the sampling personnel will collect the sediment sample by standing on the bank of the creek. If sample personnel must enter the creek, they will do so from the downstream end of the sample location, using care to avoiding sediment disturbance. Field notes shall be collected at each sample location, including date, time, sample identification, personnel, sample collection method, stream description, estimated stream flow, depth of stream, and sediment description.

Sediment samples will be collected by hand by either one of two methods, as described below, which are dependent on conditions that are observed in the field.

1) Core Sample

Core samples shall be collected using 3-inch-diameter decontaminated polycarbonate clear tubing. The sample tube shall be precut to approximately 0.5-foot lengths. Using clean nitrile gloves, the sampling personnel shall push the sample into sediment until top of tubing is almost flush with the sediment. A plastic cap shall be placed over the core tube. Using a clean decontaminated trowel, sediment shall be excavated around the core tube and a plastic cap fitted to the bottom of the tube. The sample shall then be removed from the stream substrate taking care to keep sample upright. Both end caps shall be taped and up arrows marked on the core. The core tube will be dried off to ensure that a proper sample label can be securely attached. The core tube will be stored securely in the upright position in a cooler.

2) Grab Sample

Grab samples shall be collected from the creek bed if field conditions prevent a core sample from being collected. The grab sample procedure will collect the sediment sample by using a stainless steel trowel to collect sediment in the creek substrate. Sampling will be attempted to minimize the loss of fine material winnowed from the samples by moving water. The sample will be placed in a stainless steel bowl and gently mixed with a stainless steel spoon. Laboratory supplied sample jars will be affixed with a sample label and will be filled with the sediment. The sample jars will be stored securely in a cooler.

B.2 Sample Handling Protocols

B2.1 Sample Naming Convention

This section of the Des Moines Creek Long-Term Monitoring Plan describes the sample identification naming convention that shall be used in all sample programs. The naming convention is to be used for all samples that are collected for submittal to a laboratory for

analysis. In general, the naming convention is designed to reference the sample media, identify the sample location, and date the sample was collected. Other pertinent information such as depth and total and dissolved analysis will be identified as appropriate. The following sections provide an example of the sample naming convention for each sample media:

- Soil Cap Samples

Grid No. / Media ID (SC) / Depth / Date (as MMDDYY).

For example, a sample collected from 12 to 21 inches from Grid No. 30 collected on 2/29/05 would be labeled *G30-SB-1224-022905*.

- Groundwater Samples

Monitoring Well ID / Sample Date (MMDDYY)

For example, a typical label would be *GW5S-021305*.

- Surface Water Samples

Sample Station / Media ID (SW) / Total or Dissolved Indicator (T or D) / Sample Date (MMDDYY)

A sample to be analyzed for total metals would be labeled *SW1A-SW-T-021305*. A sample to be analyzed for dissolved metals would be labeled *SW1A-SW-D-021305*.

- Sediment Samples

Sample Station / Media ID (SD) / Sample Date (MMDDYY)

For example, a sample collected at station SW-1b on 2/13/05 is designated as follows: *SW1B-SD-021305*.

B2.2 Sample Handling

Upon collection, samples will be stored securely in a cooler with ice in order to maintain the samples at a temperature of approximately 4 degrees Celsius until delivery to the laboratory. The cooler containing redox sensitive soil and sediment samples will also be purged with an inert gas (argon) to maintain an oxygen-free atmosphere so as not to change the redox conditions of the samples.

A Chain-of-Custody form will be completed for each sample location indicating the sample identification, date and time of collection, and analysis to be performed at the laboratory.

If samples are not delivered to a laboratory at the end of a field working day, they should be properly stored and secured under a containing Chain of Custody.

B.3 Instrument Calibration

Calibration of the multi-parameter water quality meter will be performed in accordance with the manufacturer's instructions twice a day. Calibration will occur prior to the daily use of the instrument and once during the day to evaluate any shift in the readings. An Instrument Calibration Form (Form 5) will be filled out by the field personnel for each calibration event. An instrument supplied calibration cup or laboratory supplied glassware should be used for the calibration process. Care should be given to ensure that all probe sensors are immersed in calibration solutions according to manufacturer's instructions. Standard calibration solutions supplied with the instruments or commercially available should be used.

B.4 Field Documentation

B.4.1 Field Boring Log

Pertinent information from soil cap sample collection will be recorded on field boring logs (Form 1) as follows:

- A data block containing grid number and location, date, geologist or engineer collecting the sample, and a sketch of the approximate boring location within the grid.
- A data block filled with sample information such as sample number, depth of sample, sample type, total inches of sampler advancement, and total inches of sample recovered.
- Soil descriptions written in general accordance with ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

B.4.2 Daily Report

Written Daily Report record (Form 2) will be prepared each day that field personnel are on-site. Information recorded on Daily Reports will be factual and include documentation of relevant activities and events observed throughout the work day. Daily Reports will contain, at a minimum, the following information:

- Project name and number, client name, day and date, weather conditions and temperature ranges, time of arrival and departure to/from site.
- Contractor time of arrival and departure, contractor personnel, and equipment inventory.
- Client field representative, and other site visitors, time of arrival and departure at the site.
- Interruptions in work, listed by item (such as problems that develop accidents, or equipment malfunctions), time of shutdown and restart, and information about the cause of interruption.

- Report of salient details of conversations, including suggestions and instructions to contractors, and program alterations as directed by the project manager or field supervisor.

B.4.3 Groundwater Sampling Data Sheet

Groundwater sampling data sheets (Form 3) will be recorded during sampling of each monitoring well. Groundwater sampling data recorded will include:

- Project name and number, field personnel, well or sample station number, date and time, weather conditions.
- Purging and sampling device, groundwater level measurements, well geometry measurements.
- Calculated purge volume, actual purge volume, water quality field parameters.
- Number and type of sample containers used, date and time of sample collection, sample analytes submitted for laboratory analysis.

B.4.5 Chain-of-Custody Forms

Chain-of-Custody forms (Form 4) will be filled out and accompany the soil, sediment, or water samples at all times. Appendix D contains detailed descriptions of information to be present on Chain-of-Custody forms, and procedures employed in Chain-of-Custody protocol.

B.4.6 Instrument Calibration Forms

Documentation of daily field instrument calibration will be performed and recorded on Instrument Calibration Forms (Form 5). Instrument identification, calibration methods, and salient comments will be documented daily. Calibration will occur twice a day, prior to the daily use of the instrument and once during the day.

B.4.7 Photographs

Digital photographs will be taken on a regular basis to document all field aspects of the sample program. The Daily Report will be updated with information regarding the photo frame ID and a brief description of the content. The general physical site features, sampling processes, field equipment, soil materials, and other pertinent information will be photo-documented. All digital photographs will be downloaded into a subdirectory in the main project computer directory.

B.5 Equipment Decontamination

B.5.1 Sampling Equipment

Hand augers, post-hole diggers, and other soil sample collection tools used for this project will be cleaned prior to advancement of the first boring and between borings

thereafter. Soil sampling equipment will be decontaminated according to the following procedures:

1. Rinse and preclean in potable water.
2. Wash in a solution of laboratory grade, non-phosphate soap (for example, Liquinox) and potable water.
3. Rinse with distilled water.

Decontamination solutions will be renewed as needed. Sponges and nylon scrubbers will be used during steps 1 through 3. When possible, equipment will be air-dried and placed in clean plastic bags between uses. Once per sampling day an aliquot of rinsate water will be collected as an equipment blank and analyzed for arsenic. This blank will be stored and delivered to the lab in the same manner as the samples.

Decontamination of the flow-through cell and water quality multi-parameter probe will be performed between water sample locations by the same method as described above.

Silicon and LDPE tubing will be replaced between each surface water and groundwater sample location, which prevents the need to decontaminate water sampling equipment. Water level meters and manometer board tubing will be decontaminated between wells by the procedure described above.

B.6. Onsite Generated Waste

All soil cuttings, development water, purge water, and decontamination water shall be collected and sealed in U.S. Department of Transportation (DOT) Type 17H 55-gallon steel barrels. All drums will be labeled with the site name, boring numbers, liquid or solid content, and date. The drums will be transported to a secure area of the site upon coordination with Port of Seattle and Tyee Golf Course representatives. The Des Moines Creek Basin Committee is responsible for the proper management and disposal of all on-site waste generated during this program.

B.7 Field Documentation Forms

- Field Boring Log—Form 1
- Daily Report—Form 2
- Groundwater Sampling Data Sheet—Form 3
- Chain-of-Custody Form—Form 4
- Instrument Calibration Form—Form 5

FORM 1 FIELD BORING LOG

SHEET _____ OF _____

LOCATION OF BORING	PROJECT NO.	BORING NO.
	PROJECT NAME	
SKETCH OF LOCATION	DRILLING METHOD:	
	LOGGED BY:	
	DRILLER:	
	SAMPLING METHOD:	
	HAMMER WEIGHT/SAMPLER DIAMETER	

OBSERVATION WELL INSTALL YES _____ NO _____					START	FINISH
WATER LEVEL					TIME	TIME
TIME						
DATE					DATE	DATE
CASING DEPTH						

DATUM

GRADE ELEV.

SURFACE CONDITION

SIZE (%)			SAMPLE NO. / SAMPLE TYPE	SAMPLE DEPTH	INCHES DRIVEN / INCHES RECV'D	DEPTH IN FEET	PENETRATION RESISTANCE	USCS SUMMARY	DESCRIPTION: Density, moisture, color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc. DRILL ACTION
GRAVEL	SAND (SIZE RANGE)	FINES							
						1			
						2			
						3			
						4			
						5			
						6			
						7			
						8			
						9			
						0			
						1			
						2			
						3			
						4			
						5			
						6			
						7			
						8			
						9			
						0			

DAILY REPORT
FORM 2

DATE:	PROJECT NO.	WEATHER:
PROJECT NAME:	CLIENT:	
EQUIPMENT USED:	PROJECT LOCATION:	

THE FOLLOWING WAS NOTED:

COPIES TO:	PROJECT MANAGER:
	FIELD REP.:

FORM 3

GROUNDWATER SAMPLING DATA SHEET | **WELL NUMBER:** _____ | **Page:**___ of ___

Project Name: _____ Project Number: _____

Date: _____

Developed by: _____

Measuring Point of Well: _____

Screened Interval (ft. BGS)_____

Filter Pack Interval (ft. BGS) _____

Starting Water Level (ft TOC): _____

Casing Stickup (ft): _____

Total Depth (ft TOC): _____

Casing Diameter (inches): _____

Casing Volume _____ ft Water x _____ Lpf = _____

Casing volumes: 2" = 0.16 gpf 4" = 0.65 gpf 6" = 1.47 gpf

2" = 0.62 Lpf 4" = 2.46 Lpf 6" = 5.56 Lpf

Sample Intake Depth (ft TOC): _____

PURGING MEASUREMENTS

Time	Cumul. Vol. (gallons) (liters)	Purge Rate (Lpm)	Temp. (C or F)	Specific Conductance (umhos/cm)	Dissolved Oxygen (mg/L)	pH	Eh (ORP)	Turbidity (NTU)	Comments

Total Gallons Purged: _____ Total Casing Volumes Removed: _____

Ending Water Level (ft TOC): _____ Ending Total Depth (ft TOC): _____

SAMPLE INVENTORY

Time	Volume	Bottle Type	Quantity	Filtration	Preservation	Appearance		Remarks
						Color	Turbidity & Sediment	

METHODS

Decon Equipment _____

Purging Equipment: _____ Sampling Equipment: _____

Disposal of Discharged Water: _____

Observations/Comments: _____

_____

FORM 4

CHAIN OF CUSTODY

							Project #											WSG = Composition Water; Soil; or Gas
							Project Name:											G/C = Grab or Composite
							Requested Laboratory Analysis											NUM = Number of Containers
Sampled By:																		Bill To:
Sample #	Date	Time	WSG	G/C	Location	NUM												Remarks
Relinquished By:							Received By:											8 Hour Rush
Date: Time:							Date: Time:											24 Hour Rush
Relinquished By:							Received By;											2 - 3 Day Rush
Date: Time:							Date: Time:											5 Day Rush
Relinquished By:							Received By:											10 Day Standard
Date: Time:							Date: Time:											

FORM 5

INSTRUMENT CALIBRATION FORM

Project:	Project No.:
Date:	Technician:
Instrument:	
Serial No.:	
Calibration Period:	
Calibration Method:	
Comments:	

APPENDIX C

Quality Assurance/Quality Control Project Plan

C.1 Introduction

This Quality Assurance Project Plan (QAPP) presents, in specific terms, the quality assurance (QA) and quality control (QC) objectives, organization, and functional activities associated with the sampling and analysis of the soil cap, groundwater, surface water, and sediment, as part of the long-term monitoring program for the Des Moines Creek Regional Detention/Retention Facility (RDF).

The sampling and analyses are intended to produce data of sufficient technical quality to monitor potential long-term RDF operational impacts to the soil cap, sediment, and water quality within the project area.

The following sections discuss proper sample preservation, containers, handling, and documentation.

C.2 Sample Containers, Preservation, and Holding Times

Table C-1 lists the sample matrix, analytes of interest, analysis method, container type, sample volume, holding time, and preservation used for each of the analyses. The analytical laboratory will supply the field personnel with clean sample containers that will include appropriate preservative. The samples collected for chemical analysis will be stored only in these containers. The objective of the sample preservation is to prevent or hinder the loss or degradation of the chemicals in the samples during transit and storage.

Table C-1: Sample Bottles, Preservatives, and Holding Times by Method

Analyte	Method	Sample Bottle	Preservative	Holding Time
Soil Cap				
Total Arsenic	EPA 6020	4 oz.	None	6 months
Groundwater				
Total and Dissolved Arsenic	EPA 6020	500 mL poly	Ultra HNO_3	6 months
Dissolved Iron	EPA 6010B		Ultra HCl	6 months
Sulfate	EPA 300.0		None	7 days
Total Suspended Solids	SM 2540-D		None	7 days
Sulfate	EPA 300.0		None	7 days
Sulfide	EPA 9030	250 mL poly	Zn-acetate + NaOH	7 days
Surface Water				
Total and Dissolved Arsenic	EPA 6020	500 mL poly	Ultra HNO_3	6 months
Total Suspended Solids	SM 2540-D		None	7 days
Sediment				
Total Arsenic	EPA 6020	4 oz.	None	6 months
Total Organic Carbon	EPA 9060A	4 oz.	None	28 days

C.3 Sample Handling

Samples are to be collected and handled in such a manner as to minimize the possibility of sample contamination occurring or samples being lost. All samples are to be kept chilled at a maximum temperature of 4 degrees Celsius from the time of collection until time of analysis by the laboratory. Field personnel will keep samples cold using blue ice and coolers, in which samples are to be stored until delivery to the analytical laboratory. After receipt of the samples, it is the laboratory's responsibility to store the samples at a maximum temperature of 4 degrees Celsius until analysis is begun. In addition, the soil cap cores collected from the RDF are to be frozen upon retrieval for shipment to the laboratory to minimize any changes to the natural redox state of the sediments prior to sample analysis.

C.4 Sample Documentation

The following information for each sample collected in the field will be recorded in the appropriate sample field log and an appropriate subset of information on the sample label:

- Project number;
- Project name;
- Location from which sample was collected;
- A sample description;
- A unique sample number;
- Date and time of collection;
- Sampling personnel;
- Preservative added, if any;
- Analysis requested; and
- Any special observations or problems pertaining to the sample.

In order to prevent misidentification of samples, each sample will be securely labeled on-site with a plastic-coated, waterproof, non-disintegrating label that will retain waterproof ink markings when wet.

C.5 Sampling Quality Control Checks

Collection and analyses of trip blanks, rinsate blanks and field duplicates are used as quality control checks of any possible contamination introduced in transit to the laboratory.

A trip blank shall consist of a reagent grade water sample prepared by the laboratory and handled/transported in the same manner as if it was obtained as a sample collected from a sample location. The primary purpose of a trip blank is to check for contamination

introduced during shipment of the samples. The trip blank will be prepared by the laboratory and accompany samples collected at the site.

A rinsate blank will be collected during the soil and water investigation phase of the project to evaluate decontamination procedures. One rinsate blank per day of sampling will be collected.

Field duplicates will be collected from 10 percent of the total soil sample population and at least one per sample media per sample event.

C.6 Transfer of Custody

The Chain-of-Custody record will document the history of sample custody from the time of collection to the time of final disposition. When transferring the possession of samples, the individuals relinquishing and receiving the sample will sign, date, and note the time on the record.

Samples will be properly packaged and delivered by field personnel to the laboratory for analysis. The labeled samples will be packaged in coolers containing ice to keep the samples cool. A copy of the Chain-of-Custody record will accompany each cooler, another copy will be retained by the field personnel delivering the samples for inclusion in project records, and one copy will be sent to the project manager's office accompanying the laboratory report. The method of shipment and other pertinent information is to be entered in the "Comments" section on the custody record.

A designated laboratory sample custodian will accept custody of the shipped samples and verify that the information on the sample labels matches that on the Chain-of-Custody records. The custodian will enter the sample label data into the sample tracking system of the laboratory. Samples will then be transferred to the proper analyst or stored in the appropriate secure area at the laboratory. When sample analysis and the necessary quality assurance checks have been completed in the laboratory, the unused portion of the sample and the sample container must be disposed of properly. All identifying tags, data sheets, Chain-of-Custody, and laboratory records shall be retained as documentation. Laboratory personnel are responsible for the care and custody of samples from the time they are received until the sample is exhausted or discarded.

C.7 Data Quality Objectives

Data quality objectives, including precision, accuracy (bias), representativeness, completeness, comparability, and data reporting limits are dictated by the project requirements and intended uses of the data. U.S. Environmental Protection Agency (USEPA) and Washington Department of Ecology regulations and guidance documents such as EPA SW-846 Methods (EPA, 2004) were used to select the appropriate analytical levels, analytical methods, and QA/QC procedures for characterizing environmental quality to meet the intended data uses.

An assessment of data quality is based upon quantitative (precision, accuracy, and completeness) and qualitative (representativeness and comparability) quality assurance

objectives. Definitions of these parameters and the applicable quality control procedures are given below. Table 2 provides a tabulation of laboratory reporting limits.

C.7.1 Sensitivity (Reporting Limits)

Reporting limits will be adequate to identify target analytes to compare data to minimize the frequency of non-detected results, and applicable reporting limits are listed in Section4, Table 1.

C.7.2 Precision

Precision measures the scatter in the data resulting from random error. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average values. Analytical precision is measured through matrix spike/matrix spike duplicate (MS/MSD) samples, laboratory control spikes and spike duplicates, and through laboratory duplicate samples. Analytical precision is quantitatively expressed as the relative percent difference (RPD) between the MS/MSD or duplicates.

Analytical precision measurements will be conducted at a minimum frequency of one per analytical batch. Laboratory precision will be evaluated against quantitative RPD performance criteria presented with the laboratory results in each technical memorandum.

Field duplicates will be carried out at a minimum frequency of one per sampling event for all arsenic analysis or 10 percent of the sample population. However, no data will be qualified based solely on field duplicate precision.

C.7.3 Accuracy (Bias)

Accuracy measures the closeness of the measured value to the true value. Analytical accuracy is assessed by "spiking" samples with known standards (surrogates or matrix spikes) and establishing the percent recovery. Accuracy measurements on matrix spikes will be carried out at a minimum frequency of one in 20 samples per matrix analyzed. Laboratory accuracy will be evaluated against quantitative matrix spike performance criteria.

C.7.4 Representativeness

Representativeness measures how closely the measured results reflect the actual concentration or distribution of the chemical compounds in the matrix sampled. The sampling plan design, sampling techniques, and sample handling procedures (for example, storage, preservation, and transportation) have been developed to ensure representative samples.

Representativeness also reflects the degree to which accumulative data sets characterize variability associated with time, space, or other conditions (for example, stream discharge).

C.8 Analytical Procedures

The analytical methods proposed for the baseline sample program are summarized below. The laboratory reporting limits for analyses water samples are provided in Section 4, Table 1.

Chemical analyses of samples collected during the baseline program will be performed by a certified laboratory.

Testing and analysis methods for this project (listed below) were selected on the basis of quantitation limits and the level of analytical quality control necessary to meet the intended data uses. The reporting limits are typically achieved by the laboratory methods listed below; however, matrix interference and dilutions may result in higher sample quantitation limits (SQLs).

C.9 Data Reduction, Review, and Reporting

All data will undergo two levels of QA/QC evaluation: one at the laboratory, and one by an independent data validator, as described in Appendix D.

Initial data reduction, evaluation, and reporting at the laboratory will be carried out as described in the appropriate analytical protocols and the laboratory's QA Manual. Quality control data resulting from methods and procedures described in this document will also be reported.

C.9.1 Minimum Data Reporting Requirements

The following describes the minimum data reporting requirements necessary to ensure sufficient reporting of analytical data to allow proper QA/QC reporting.

C.9.1.1 Sample IDs

Sample identification for each sample media will include the conventions described in Appendix B of the Long Term Monitoring Plan. Records will be produced that clearly match all blind field duplicate QA samples with laboratory sample IDs and the actual sample location the blind duplicate was collected from.

C.9.1.2 Sample Receipt

Chain-of-custody forms will be filled out for all sample shipments to document problems in sample packaging, custody, and sample preservation.

C.9.1.3 Reporting

For each analytical method run, all analytes for each sample will be reported as a detected concentration or as less than the specific reporting limit. The laboratories will also report dilution factors for each sample as well as date of extraction (if applicable) and date of analysis. Standard data packages will consist of a case narrative, sample results, QA sample results, and Chain-of-Custody forms. Electronic Data Deliverables (EDD) will be

required from the laboratory and submitted to the data manager for input into the data management system.

C.9.2 Internal Quality Control Reporting

Internal quality control samples will be analyzed at the rates specified in the applicable analytical method.

- **Laboratory Blanks.** All analytes will be reported for each laboratory blank. All non-blank sample results shall be designated as corresponding to a particular laboratory blank in terms of analytical batch processing.
- **Matrix Spike Samples.** Matrix spike recoveries will be reported for all inorganic analyses. All general sample results will be designated as corresponding to a particular matrix spike sample. The report will indicate what sample, if any, was spiked. The report will also specify the control limits for matrix spike results for each method and matrix.
- **Laboratory Duplicates and/or Matrix Spike Pairs.** Relative percent differences will be reported for all duplicate pairs as well as analyte/matrix specific control limits.
- **Laboratory Control Samples (LCS).** When run for internal quality control, LCS results will be reported with the corresponding sample data. Control limits for LCS will be reported as specified.

C.10 Quality Control Procedures

Quality control procedures provide the means of controlling the precision and bias of the results. Adherence to established procedures for sample collection, preservation, and storage will minimize errors due to sampling and sample instability. Analytical and measurement systems must be in statistical control, which means that errors have been reduced to acceptable levels and then documented.

C.10.1 Field Quality Control Procedures

Field quality control procedures used for this project will consist of the collection of field duplicate samples at a minimum of 10 percent of the sample population or one per day per sample media.

Rinsate blanks will be collected at the end of each day of soil sampling (1x/day) to evaluate decontamination procedures proposed for soil sampling equipment.

C.10.2 Laboratory Quality Control Procedures

The laboratories' quality control officer is responsible for ensuring that all routine internal quality assurance and quality control procedures are implemented by the laboratory. The laboratory quality control procedures used for this project will consist of the following, at a minimum:

- Instrument calibration and standards as defined in EPA SW-846 Methods (EPA, 2004), or in Chemical Analysis of Water and Waste (USEPA, 1983).
- Laboratory blank measurements at a minimum frequency of 5 percent or one per 20 samples.
- Accuracy and precision measurements at a minimum frequency of 5 percent or one per 20 samples.

C.11 Preventative Maintenance Procedures

C.11.1 Field Preventative Maintenance

Preventative maintenance on water quality field instruments and equipment will follow the operations manuals. Field meters, including pH, conductivity, dissolved oxygen, turbidity, and temperature probes, will be calibrated and maintained by field staff when in use. All routine maintenance will be recorded in the daily report or directly on the instrument calibration form as appropriate.

C.11.2 Laboratory Preventative Maintenance

Preventative maintenance in the laboratory will be the responsibility of the laboratory personnel and analysts. This maintenance includes routine care and cleaning of instruments and inspection and monitoring of carrier gases, solvents, and glassware used in analyses. Details of the maintenance procedures are addressed in the respective laboratory's Standard Operating Procedures and Methods manuals.

Precision and accuracy data are examined for trends and excursions beyond control limits to determine evidence of instrument malfunction. Maintenance will be performed when an instrument begins to change as indicated by the degradation of peak resolution, shift in calibration curves, decrease in sensitivity, or failure to meet one or another of the method-specific quality control criteria.

C.12 Data Assessment Procedures

The analytical data will be reviewed with regard to the following indicators, as appropriate to the particular analysis:

- Sample custody;
- Holding times;

- Method blank contamination;
- Reporting limits;
- Field and laboratory duplicate precision;
- Matrix spike and surrogate accuracy; and
- Completeness.

Reported analytical results will be qualified by the laboratory to identify quality control concerns in accordance with the specifications of USEPA published methods. Additional laboratory data qualifiers may be defined and reported for the laboratory to more completely explain quality control concerns regarding a particular sample result. All additional data qualifiers will be defined in the laboratory's narrative reports associated with each case.

A third party data validator will also perform data validation as described in Appendix D.

C.12.1 Specific Routine Procedures to be Used to Assess Data Precision, Accuracy, and Completeness

Data assessment will be based on the data quality objectives and data review procedures described above. The quantitative definitions of precision, accuracy, and completeness will be developed in conjunction with the contract laboratory and regulatory requirements.

C.13 Corrective Action

The program sponsor reserves the right to conduct an onsite lab audit during the monitoring program. If routine QC audits result in detection of unacceptable conditions or data, the Project Manager, working in conjunction with the Data Validator and Project Geochemist, will be responsible for implementing procedures to correct these conditions. Specific corrective actions are outlined in each respective EPA method used and include but are not limited to the following:

- Identifying the source of the violation;
- Re-analyzing samples if holding time criteria permits;
- Resampling and analyzing;
- Evaluating and amending sampling and analytical procedures; and/or
- Accepting data and flagging to indicate the level of uncertainty.

C.14 Quality Assurance Reports

Technical memoranda and reports generated for this sampling program will include a summary of all data quality information gathered as part of this project. This information will be included in an appendix as part of the data validation package and laboratory reports.

APPENDIX D

Data Validation, Management, and Reporting

D.1 Data Management Plan

The objective of this plan is to provide complete and representative data in a consistent readily accessible format to facilitate decision making throughout the term of this project. The data will be stored in a relational database or spreadsheet. All data processing routines will be accomplished through programmed functions to eliminate errors caused by copy, cut, and paste techniques as well as to ensure that data are processed efficiently and consistently. The database and related files will be backed up daily to tape and stored off-site, so that data recovery is possible if necessary.

Sampling event and analysis requirements will be loaded into the database to be used to verify that all expected data have been collected. All data collected in the field via handwritten field logs, electronic equipment, and Chain-of-Custody transmittals to laboratories will be processed immediately upon completion of the field work, assessed for inclusion in the database, and loaded to the database. Immediate processing of the field data provides an immediate QC check to uncover omissions or errors in field procedures and preparation of Chain-of-Custody and instructions to the laboratory.

Analytical laboratory data will be processed via a standard electronic data deliverable (EDD) format agreed upon by the participating laboratories and program sponsor. The lab EDDs will be verified electronically before loading into the database. Checks for data conformity to defined valid values, completeness, and application of correct analytical methods and detection limits will be performed. EDDs not meeting the verification checks will be returned to the laboratory for correction and resubmittal. When the lab data have passed verification, the data will be loaded into the database and flagged as pending validation and the EDD will be forwarded to a third party data validator for validation. The validator will update the EDD with qualifiers, notes, and corrected values where appropriate. The validated EDD will be processed, updating qualifiers and changes in the database and flagging data as validated.

Data will be made available for reporting in tables and graphics through direct data exchange between the database and presentation and evaluation tools wherever possible.

D.1.1 Data Validation

D.1.1.1 Independent Data Validation

All data collected during the long-term monitoring of the Des Moines Creek RDF will be subject to independent data validation reviews. The data validation process quantifies technical data quality, verifies that adequate documentation was performed, and determines whether the analytical data are usable and meet project Data Quality Objectives (DQOs). For the background, baseline and post-construction monitoring programs in this project, 100 percent of the analytical data will be evaluated for compliance with DQOs and specified analytical requirements. Data validation will be performed in accordance with EPA's National Functional Guidelines for Inorganic Data Review (USEPA 1994).

The analytical laboratory (or laboratories) will submit all data packages with sufficient details to support the required data validation process. Specific formats for data delivery (electronic and hard copy) and required data reporting elements shall be developed through consultation between the data validation contractor and the analytical lab(s) at the start of the program. The program sponsor shall oversee coordination of laboratory reporting, data validation, and data management protocols and data transfers.

D.1.1.2 Technical Validation

Technical validation involves comparison of QC standards and instrument performance results to required control limits. Data validation will include evaluation of field QA/QC sample analysis results (for example, for field blanks). Two levels of validation will be performed: a full validation (EPA Level IV) and a summary (EPA Level III) validation. When available, a data quality screening tool (computer software program) will be used to initially evaluate the laboratory electronic data deliverable (EDD). The following QC elements will be reviewed for data packages undergoing summary (EPA Level III) validation:

- Analytical holding times (from summary forms);
- Chain-of-Custody and sample handling (from summary forms);
- Preparation Blank contamination (from summary forms);
- Initial and continuing calibration (from summary forms);
- Continuing calibration blanks (CCB) (from summary forms and raw data);
- Interference check samples results (from summary forms and raw data);
- Internal standards, ICP/MS only (from summary forms);
- Instrument tuning standards, ICP/MS only (from summary forms);
- Analytical accuracy {matrix spike compounds and standard reference materials (SRMs)}, expressed as percent recovery (%R) (from summary forms);
- Analytical precision (comparison of duplicate sample results) expressed as relative percent difference (RPD) (from summary forms); and
- Reported detection limits (from sample result summaries).

Full validation (EPA Level IV) will include review of all the items listed above for summary validation, plus the following QC elements:

- Compound identification (from raw data);
- Compound quantitation, transcription, and calculation checks (from raw data); and
- Transcription and calculation checks performed at a frequency of 10 percent. If an error is noted, 100 percent of the calculations and transcriptions for that data set will be verified.

For each laboratory performing analyses, and for each of the two monitoring programs (baseline and post-construction), full validation will be performed on the initial data package for each sampling medium and on approximately 10 percent, randomly selected, of all additional data packages. If no significant deviations from required protocols and QC criteria are noticed, the remaining data (approximately 90 percent) will receive a summary validation. If the summary validation results reveal problems or suspected problems, full validation will be performed on additional selected data packages, focusing on those data packages that appear to have problems based on the summary validation.

In the long-term monitoring program, the need for continued data validation may be reviewed at the time a proposal is made to reduce the frequency of sampling (for example, after 3 years of quarterly sampling). Continued use of the same analytical laboratory and a record of performance resulting in minimal data qualifier flags from validation reviews are factors that may support a proposal to reduce or eliminate further data validation reviews during the remainder of the post-construction monitoring period.

D1.2 Data Usability

The data validation contractor will attach appropriate Data Qualifier flags to reported results to indicate possible limits on data usability or rejection of the results based on the data validation findings. Calculation of quantitative measures of data quality is discussed in the following subsections.

D1.3 Quantitative Calculation of Precision

The results from field duplicate analyses and laboratory duplicate analyses will be used to determine the relative percent difference (RPD) between the pair of analyses. The RPD for field duplicates will be used as a measure of combined field and analytical precision, and the RPD for laboratory duplicates will be used as a measure of analytical precision. The RPDs will be calculated as follows:

$$RPD\ (\%) = 100\ (C1 - C2) / [(C1 + C2) / 2]$$

Where:

RPD	=	relative percent difference
C1	=	the higher concentration measured for the duplicate samples
C2	=	the lower concentration measured for the duplicate samples

D.1.4 Quantitative Calculation of Bias

For spiked samples and standard reference materials with known concentrations, the percent recovery (%R) and percent difference (%D) will be used as the measures of accuracy and are calculated as follows:

$$\% R = [100 (Cs - Cn)] / Csa$$

Where:

%R = percent recovery

Cs = measured concentration in spiked aliquot

Cn = measured concentration in non-spiked aliquot

Csa = actual concentration due to spike added

The percent difference (% D) for analysis of SRM samples will be used as an additional measure of accuracy and is calculated as follows:

$$\% D = [100 (CSRM - Cm)] / CSRM$$

Where:

% D = percent difference

Cm = measured concentration in SRM aliquot

CSRM = certified SRM concentration

D.1.5 Quantitative Calculation of Completeness

The measure of completeness will be based on the number of environmental soil samples submitted to the laboratory for analysis and the number of non-rejected, usable results after data validation reviews. Completeness will be calculated as follows:

$$C (\%) = 100 [(\text{Number of acceptable measurements}) / (\text{Number of samples submitted})]$$

Where:

C (%) = completeness percentage

Completeness will be further assessed against the project DQOs and sampling objectives, and included in the final report.

D.1.6 Data Validation Reporting

Data validation reports and data packages shall accompany each Data Summary Report as described in Section 8. These reports will be submitted according to the reporting schedule specified in Section 10.

In almost all cases, data evaluation and reporting activities will be based only on data sets obtained from the single QA-reviewed, secure database of final validated results. Any preliminary data evaluations or data reports that, for special scheduling reasons, need to be prepared using unvalidated data shall be clearly marked as "Preliminary, Based on Unvalidated Data."

APPENDIX E

Historical Environmental Documentation

Documentation in this appendix consists of the major deliverables developed to address the arsenic environmental issues and satisfy Ecology WQC and VCP program requirements.

Well Logs

Regional Plan View (Figure 3)

Regional Geologic Cross Section (Figure 4)

Project Area Cross Section (Figure 6)

Sampling Locations for Surface Water and Sediment in Des Moines Creek (Figure 4)

Predicted Flood Boundaries (Figure 9)

Capture Zone – Tyee Well (Figure 8)

Setbacks and Flood Zone Boundary (Figure 7)

Wetland Buffers and Port of Seattle Restrictive Covenant Areas (Figure 1)

Des Moines Creek Regional CIP Average Annual Inundation - 48 Years of Record

Vertical and Horizontal Distribution of Arsenic in soil (Figure 1)

Historical Environmental Documentation on Accompanying CD

Aspect Consulting, LLC, 2004, Overexcavation/Clean Cap Extent Technical Memorandum, Technical Memorandum 2. October 15, 2004.
Tech Memo 2 Soil Volume 101504.pdf

Aspect Consulting, LLC, 2005, Letter Report – June/July 2005 Monitoring Well Installation and Decommissioning, Des Moines Creek Regional Detention Facility. October 25, 2005. **Letter Rpt MW Installation 102405.pdf**

Aspect Consulting, LLC, Glass, G. L. (Environmental Consultant), and S.S. Papadopulos & Associates, Inc., 2004b. Arsenic Issues Evaluation Report. April 14, 2004.
Arsenic Issues Evaluation Report 041404.pdf

Aspect Consulting, LLC and S.S. Papadopulos & Associates, Inc., 2004. Preliminary Groundwater Quality Evaluation, Technical Memorandum 6, October 28, 2004.
Tech Memo 6 GW Qual 102804.pdf

Aspect Consulting, LLC and S.S. Papadopulos & Associates, Inc., 2004. Excavation Materials Segregation & Volume of Clean Materials, Technical Memorandum 3, November 20, 2004.
Tech Memo 3 Soil Segregation 112004.pdf

Des Moines Creek Basin Committee, 2004, Sampling and Analysis Plan, Des Moines Creek Retention/Detention Facility, March 31, 2004.
Des Moines Creek Sampling & Analysis Plan 033104.pdf

Des Moines Creek Basin Committee, 2004, Memorandum by David Masters to Anne Kenny, Department of Ecology., responding to Ecology comments regarding Des Moines Creek Regional Detention Facility Sampling Plan. May 27, 2004.
Ecology Response Memo 052704.pdf

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003, Des Moines Creek Soil Chemistry Investigation Results (Phase I). December 2003. **Phase1 Soil Chemistry Results.pdf**

King County Department of Natural Resources and Parks, Water and Land Resources Division, 2003, Des Moines Creek Soil Chemistry Investigation Results (Phase II). December 2003. **Phase I1 Soil Chemistry Results.pdf**

S.S. Papadopulos & Associates, Inc., 2004, Des Moines Creek Baseline Soil Boring Sampling Pre-Validated Data Evaluation, Technical Memorandum, June 25, 2004. **Tech Memo 1 DMC RDF 062504.pdf**

S.S. Papadopulos & Associates, Inc., 2005, Soil Treatability Work Plan Des Moines Creek Regional Retention Facility - Draft, January 11, 2005.
DMC Soil Treatability Work Plan - Draft 011105.pdf

S.S. Papadopulos & Associates, Inc., 2005, Technical Memorandum #4: Arsenic Mobility Evaluation, March 21, 2005.
Tech Memo 4 Arsenic Mobility 032105.pdf

Well Logs for Tyee Golf Course Well

A_PW106 1/2

22/4 4F1

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT

WELL LOG

No. Appli. #1065
Permit #1006

Date November 22, 1949

Record by F. C. Yatt

Source well driller's record

Location: State of WASHINGTON

County King

Area

Map

SW¼ SE ¼ NW ¼ sec 4 T 22 N., R 4 E. W.M.

Diagram of Section

Drilling Co. N. C. Janssen Drilling & Mfg. Co.

Address Seattle, Washington

Method of Drilling drilled Date November, 1949

Owner King County Water District #75

Address Midway, Washington

Land surface, datum ft. above / below

Correlation	Material	Thickness (feet)	Depth (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Sandy clay	10	10
	Brown sand	20	30
	Coarse gravel, dry	53	83
	Sand & gravel, water	67	150
	Sand & clay, wet	10	160
	Blue clay	30	190
	Clay, little gravel	20	210
	Sand & gravel, water	33	243
	Sand, clay, gravel	27	270
	Fine sand & clay	240	510
	Coarse sand, water	35	545
	Pump Test:		
	Dim: 545' x 18"		
	SWL: at ground level		
	Dd: 43' Yield: 150 g.p.m. (permit)		
	Casing: 12" standard steel from 0-245'		

Turn up

Sheet of sheets over

11A-PW106/1 2/2

WELL LOG.—Continued No. 22/4-4F1

CORRELATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	Depth forward		
	8" standard steel from 245 to 545'		
	Shoe: 8" to 12" increaser & 12" pipe		
	total length 3'-6"-bottom at 545		
	Perfor: $\frac{1}{4}$" x 4" from 72 to 160'		
	" " " from 190 to 243'		
	sand cup screen from 511 to 541'		
	Pump: 12" deep well turbine		
	Motor: 60 h.p. Elec. motor - standby		
	gas engine		

34F1	Marvin Tracy	1,222	Dr	106	6	98.65	8-20-62	S	--	D	Cp
	T. 22 N., R. 4 E.										
1A1	Lambath Sill & Co.	20	Dr	260	30	+66	1961	--	--	NU	Flows 55 gpm. Casing: 3-inch, 0-255 ft; screen, 255-260 ft.
1H1	Kent Farm Dairy	22	Dr	209	6	+69	4-20-61	S	10	Ind	Flows 19 gpm; pumps 40 gpm.
2D1	F. Gunter	40	Dr	123	8	Flowing	1960	S	1	S	Flows 5 gpm; pumps 60 gpm, dd 30 ft. L.
2H1	The Boeing Company, boring 6	21	Dr	80	--	8.0	11-19-63	--	--	Ex	Topsoil 2 ft, fine brown and gray sand, 2-80 ft.
2P1	The Boeing Company, boring 4	21	Dr	72	--	11.0	11-15-63	--	--	Ex	L.
2P2	The Boeing Company, boring 5	22	Dr	100	--	5.0	11-15-63	--	--	Ex	L.
2R1	The Boeing Company, boring 1	21	Dr	158	--	1.0	11-18-63	--	--	Ex	L.
3G1	State Highway Dept.	250	Dr	128	6	--	--	--	--	Ex	Test hole for bridge piling. L.
3L1	King County Water Dist. 53, well 1	410	Dr	270	8	90	1955	T	10	PS	Yields 90 gpm.
3M1	S. A. Tombs	397	Dg	73	24	64.34	9- 5-62	J	2	D	Yields 20 gpm.
3N1	Andy Matelich	365	Dg	25	30	14.30	9- 5-62	N	--	NU	
4B1	Highline Public School Dist. 401	395	Dr	190	8-6	143	1945	T	3	Irr	Pumped 20 gpm for 4 hr, dd 37 ft. L.
4B2	A. H. Heidenreich	378	Dr	90	5½	50	--	J	1	D,S	Noticeable iron content.
4C1	King County Water Dist. 75, well 3	315	Dr	314	16-8	44	1955	--	--	De	Pumped 290 gpm for 22 hr, dd 29 ft. Destroyed for extension of Sea-Tac Airport runway. L.
4D1	Mrs. R. Mazo	265	Dr	78	4	5.67	9-24-62	C	1	D	Well flows occasionally.
4J1	Harry Johnson	390	Dg	35	48	16.44	9- 5-62	N	--	NU	Formerly supplied 5 families.
4L1	King County Water Dist. 75, well 1	248	Dr	593	18-12-8	0	1952	--	--	De	Yields 420 gpm, dd 41 ft. Destroyed for extension of Sea-Tac Airport runway. C, L.
4L2	King County Water Dist. 75, well 2	248	Dr	133	16	0	1954	--	--	De	Pumped 1,085 gpm for 5½ hr, dd 92 ft. Destroyed for extension of Sea-Tac Airport runway. L.
4N1	King County Water Dist. 75, well 7	248	Dr	270	12	73	1958	T	75	PS	Yields 500 gpm, dd 47 ft. Cp, L.
4Q1	King County Water Dist. 75, well 4	295	Dr	202	20	54	1956	T	--	PS	Pumped 1,050 gpm for 6 hr, dd 49 ft. L.

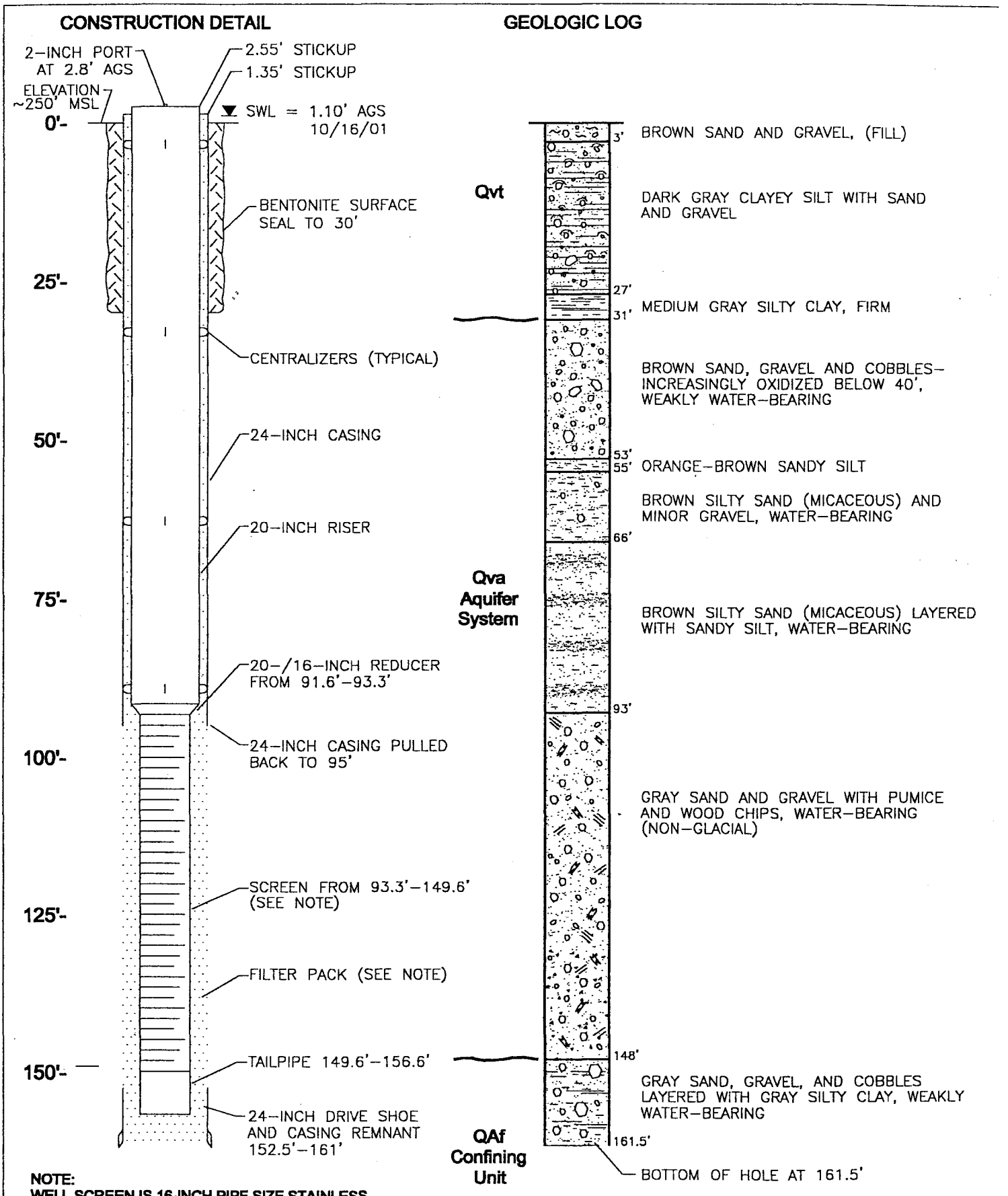
22N4E 4F1 > (sic)

Luzier, J.E., 1969, Geology and Ground Water Resources of Southwestern King County, Washington, Washington Department of Water Resources Water Supply Bulletin No. 28, 260 p.

Table 10 - Drillers' logs - Continued

Materials	Thickness (feet)	Depth (feet)
22/4-4B1 - Continued		
Sand and gravel	6	117
Hardpan, loose, brown	18	135
Hardpan, loose, blue, layers of silt, water-bearing	13	148
Clay, blue, and gravel	10	158
Sand and gravel, brown, water-bearing, yields 15 gpm	7	165
Sand and gravel, brown, water-bearing, yields 20 gpm	25	190
22/4-4C1. King County Water Dist. 75, well 3. Drilled by N. C. Jannsen, 1955. Altitude 315 ft. Casing: 16-inch to 235 ft; 8-inch, 195-241 ft; 20-slot screen, 241-279 ft; 50-slot screen, 279-314 ft.		
Gravel and sand	68	68
Boulders and sand	20	88
Boulder, hard	2	90
Gravel, boulders, and sand	37	127
Clay, sandy	49	176
Sand	71	247
Sand, coarse, contains boulders	13	260
Gravel, boulders, and sand	10	270
Gravel and sand	28	298
Sand	11	309
Clay, contains sand	5	314
22N4E 4F1> 22/4-4L1. King County Water Dist. 75, well 1. Drilled by N. C. Jannsen. Altitude 248 ft. Rotary drilled well: 24-inch to 60 ft; 18-inch, 60-485 ft; 8-inch, 485-593 ft. Casing: 12-inch to 246 ft; 8-inch to 246 ft; 8-inch, 246-512 ft; perforated 70-156 ft and 187-240 ft; screened 512-543 ft. Concrete grout to 60 ft; gravel pack, 60-485 ft.		
Sand and clay	10	10
Sand	20	30
Gravel, coarse	53	83
Sand and gravel	67	150
Sand and clay	10	160
Clay, blue	30	190
Clay, contains gravel	20	210
Sand and gravel	33	243
Sand, clay, and gravel	27	270
Sand and clay	30	300
Sand, fine	50	350
Sand and clay	100	450
Sand, fine	60	510
Sand, coarse	20	530
Sand, medium	63	593
22/4-4L2. King County Water Dist. 75, well 2. Drilled by L. R. Gaudio, 1952. Altitude 248 ft. Casing: 16-inch to 110 ft; 12-inch, 100-slot screen, 107-133 ft.		
Topsoil, black	1	1

Well Logs for Tyee Well
(Highline Water District)



NOTE:
WELL SCREEN IS 16-INCH PIPE SIZE STAINLESS STEEL, 40-SLOT (0.040-INCH). FILTER PACK IS 8X12 COLORADO SILICA SAND PRODUCT.

FIGURE 3

ROBINSON & NOBLE, INC.	PM: J. HAY JOB NO. 00-091F NOVEMBER 2001	T 22 N/R 4 E -04F UNIQUE WELL ID. AFR835	**CONSTRUCTION DETAIL AND GEOLOGIC LOG FOR TYEE WELL** **HIGHLINE WATER DISTRICT**

File Original and First Copy with Department of Ecology

Second Copy- Owner's Copy
Third Copy- Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Start Card No. 137544
Unique Well ID # AFR835
Water Right Permit No. C2191-A

(1) OWNER: Name Highline Water District Address P.O. Box 3867, Kent, WA 98032

(2) LOCATION OF WELL: County King - SE ¼ NW ¼ Sec 4 T 22 N, R 04E W.M.
(2a) STREET ADDRESS OF WELL (or nearest address)

(3) PROPOSED USE: ☐ Domestic ☐ Industrial ☐ Municipal ■ ☐ Irrigation ☐ Test Well ☐ Other ☐ ☐ Dewater

(4) TYPE OF WORK: Owner's number of well (if more than one) Type Well (formerly 2R)
■ Abandoned New well ■ Method: ☐ Dug ☐ Bored ☐ Deepened ☐ Cable ■ Driven ☐ Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches. Drilled 161.5 feet. Depth of completed well 156.6 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 24" Diam. from +1.35 ft. to 95 ft.
Welded ■ 20" (riser) Diam. from +2.55 ft. to 93 ft.
Liner installed ☐ Diam. from ft. to ft.
Threaded ☐

Perforations: Yes ☐ No ☐
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ■ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 16" Slot size 0.040 from 93 ft. to 149 ft.
Diam. Slot size from ft. to ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ■ No ☐ Size of gravel 4X8 gravel
Gravel placed from 160 ft. to land surface ft.

Surface Seal: Yes ■ No ☐ To what depth? 30 ft.
Material used in seal high solids bentonite
Did any strata contain unusable water? Yes ☐ No ■
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 250 ft.
Static level +1.10 ft. below top of well Date 10/16/01
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water is lowered below static level
Was a pump test made? Yes ■ No ☐ If yes, by whom? R & N
Yield: 800 gal./min. with 65 ft. drawdown after 24 hrs.
" " " " " "
" " " " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
1.0	34.8	15.0	16.9	71.0	8.83
5.0	23.0	20.0	15.3	110.0	7.10
10.0	19.2	30.0	12.98	150.5	6.15

Date of Test 10/16/01
Bailer test gal./min. with ft. drawdown after hrs.
Airtest gal./min. with stem at ft. for hrs.
Artesian flow g.p.m. Date
Temperature of water 56.3°F Was a chemical analysis made? Yes ■ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formations Described by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	From	To
Brown sand and fine gravel (golf course fill)	0	3
Dark grey, clayey silt with sand and gravel (glacial till)	3	27
Medium grey silty clay (firm)	27	31
Brown to orange-brown sand, gravel, and cobbles (locally oxidized below 40')—weakly water-bearing	31	53
Orange-brown sandy silt	53	55
Brown, silty sand (calcareous) and minor gravel—water bearing	55	66
Brown, silty sand (calcareous) layered with sandy silt—water-bearing	66	93
Gray sand and gravel with pumice and wood chips—water-bearing	93	148
Gray sand, gravel, and cobbles layered with gray silty clay—weakly water-bearing	148	161.5

Prepared by: Robinson & Noble, Inc.
5320 Orchard Street West
Tacoma, Wa 98467
253.475.7711

(Additional pump test and water quality data available)

Work started August 20, 20 01 Completed October 19, 20 01

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Drilling Inc
(PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address PO Box 1840 Milton, Wa 98354
(Signed) Ricky Holt License No. 1099
(WELL DRILLER)
Contractor's Registration No. HOLTDI136OG Date 12/26/01, 19

Well Logs
(TWG-1 to -8 and
GW-1s/d to -7s/d, 8, -9s/d)

Coarse-Grained Soils - More than 50%[1] Retained on No. 200 Sieve	Gravels - More than 50%[1] of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines[5]	GW	Well-graded gravel and gravel with sand, little to no fines
			GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥15% Fines[5]	GM	Silty gravel and silty gravel with sand
			GC	Clayey gravel and clayey gravel with sand
	Sands - 50%[1] or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines[5]	SW	Well-graded sand and sand with gravel, little to no fines
			SP	Poorly-graded sand and sand with gravel, little to no fines
		≥15% Fines[5]	SM	Silty sand and silty sand with gravel
			SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50%[1] or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT[2] blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT[2] blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

[3] Estimated Percentage

Component	Percentage by Weight
Trace	<5
Few	5 to 10
Little	15 to 25
With	- Non-primary coarse constituents: ≥ 15% - Fines content between 5% and 15%

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch

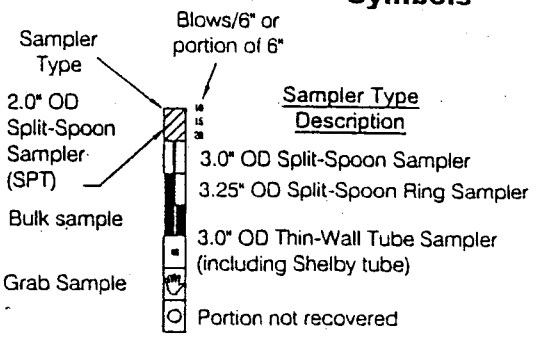
Slightly Moist - Perceptible moisture

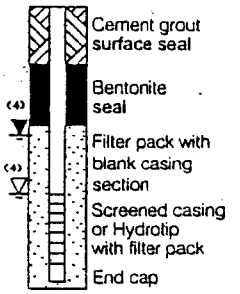
Moist - Damp but no visible water

Very Moist - Water visible but not free draining

Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of groundwater
▼ ATD = At time of drilling
▽ Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 15%

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Aspect consulting
IN-DEPTH PERSPECTIVE
179 Madrone Lane North, Bainbridge Island, WA 98110, (206) 780-9370
811 First Avenue #480, Seattle, WA 98104, (206)-328-7443

Exploration Log Key

DATE:
DESIGNED BY:
DRAWN BY:
REVISED BY:

PROJECT NO.

FIGURE NO.
A-1

Q:_ACAD Standards\Standard Drawings\Exploration Log Key.dwg

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	TGW-1	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	248.92
Location	SeaTac, Washington	Static water level (ft bgs)	2
Drilling Method	Direct push soil probe	Start Date	April 19, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 19, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
1 248				1.0/1.0	100		Grass and topsoil cover
2 247	4/19/04	3					Loose, brown, moist to wet SAND with SILT (SP-SM), trace fine gravel; sand fine to coarse, predominantly medium
3 246				4.0/2.0	50		
4 245		5					Becomes gray
5 244	Temporary well installed; riser pipe surface - 5', 3/4" ID PVC prepack screen assembly, 10-slot, with 20-40 sand filter 5' - 7.5'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						
6 243				2.5/0.2	8		No recovery - loose, saturated sand
7 242							
8 241				1.5/0	0		
9 240							Boring terminated at 9.0 feet. Abandoned by backfilling with granular bentonite.
239							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 2

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	TGW-2	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	247.86
Location	SeaTac, Washington	Static water level (ft bgs)	0.71
Drilling Method	Direct push soil probe	Start Date	April 19, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 19, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
247	4/19/04			1.0/1.0	100		Grass and topsoil cover
1							Loose, dark brown, moist to wet silty SAND (SM), trace gravel, organics; sand fine to coarse
246							
2							Very soft, dark brown, moist to wet, fibrous PEAT (PT)
245							
3		5		4.0/1.8	45		
244							
4							Silty interbed 4' - 4.5'
243							
5	Temporary well installed; riser pipe surface - 5', 3/4" ID PVC prepack screen assembly, 10-slot, with 20-40 sand filter 5' - 7.5'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						
242		6.3					
6				2.5/2.8	112		
241		7.5					
7							
240							Boring terminated at 7.5 feet. Abandoned by backfilling with granular bentonite.
8							
239							
9							
238							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 3

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	TGW-3	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	248.45
Location	SeaTac, Washington	Static water level (ft bgs)	1.75
Drilling Method	Direct push soil probe	Start Date	April 19, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 19, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
248				1.0/1.0	100		Grass and topsoil cover
1							
247							Loose, brown, moist, fine to coarse SAND (SP); grades finer with depth
2	4/20/04	3					Soft, brown, very moist, clayey SILT (ML)
246							
3				4.0/3.4	85		
245	4/19/04						Very soft, dark brown, wet, fibrous PEAT (PT)
4		5					
244							
5	Temporary well installed; riser pipe surface - 5', 3/4" ID PVC prepack screen assembly, 10-slot, with 20-40 sand filter 5' - 7.5'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						
243		6					
242				2.5/2.5	100		
7		7.5					
241							Boring terminated at 7.5 feet. Abandoned by backfilling with granular bentonite.
8							
240							
9							
239							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 4

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	TGW-4	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.04
Location	SeaTac, Washington	Static water level (ft bgs)	2.31
Drilling Method	Direct push soil probe	Start Date	April 19, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 19, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
0 249				1.0/1.0	100		Grass and topsoil cover
1 248							Medium dense, brown, moist, fine to medium SAND (SP)
2 247	4/19/04						
3 246		5		4.0/1.7	43		
4 245							Soft, brown, wet, clayey SILT (ML)
5 244	Temporary pre-packaged well installed; riser pipe surface - 5' 10-slot screen 5' - 7.5'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						Very soft, brown, wet, fibrous PEAT (PT)
6 243		7.5		2.5/1.3	52		
7 242							
8 241							Boring terminated at 7.5 feet. Abandoned by backfilling with granular bentonite.
9 240							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 5

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	TGW-5	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	248.44
Location	SeaTac, Washington	Static water level (ft bgs)	1.72
Drilling Method	Direct push soil probe	Start Date	April 20, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 20, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
248				1.0/1.0	100		Grass and topsoil cover
1							
247	4/20/04						Very soft, brown, moist to wet SILT (ML), few fine sand and clay
2							
246							
3		5		4.0/0.7	18		
245							Loose, brown, wet, silty SAND (SM); sand fine to medium
4							
244							
5	Temporary pre-packaged well installed; riser pipe surface - 5' 10-slot screen 5' - 7.5'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						
243		6.1					
6							Very soft, dark brown, wet, fibrous PEAT (PT)
242				2.5/2.1	84		
7		7.5					
241							Boring terminated at 7.5 feet. Abandoned by backfilling with granular bentonite.
8							
240							
9							
239							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 6

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	TGW-6	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.47
Location	SeaTac, Washington	Static water level (ft bgs)	3.23
Drilling Method	Direct push soil probe	Start Date	April 20, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 20, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
249							Grass and topsoil cover
1							Loose, brown to dark brown, moist, silty SAND (SM); sand fine to medium
248							
2		3					
247							
3	4/20/04			4.0/3.5	88		
246	Temporary pre-packaged well installed; riser pipe surface - 2.8', 10-slot screen 2.8' - 5.3'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						
4		5					
245							Very soft, dark brown, wet, fibrous PEAT (PT)
5							
244		5.5		0.5/0.5	100		
6							Boring terminated at 5.5 feet. Abandoned by backfilling with granular bentonite.
243							
7							
242							
8							
241							
9							
240							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 7

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	TGW-7	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	250.05
Location	SeaTac, Washington	Static water level (ft bgs)	3.24
Drilling Method	Direct push soil probe	Start Date	April 20, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 20, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
250							Grass and topsoil cover
1 249							Loose, brown to dark brown, moist SAND (SP), trace silt and organics
		2.5					
2 248							Increasing brown silt content, grades to SAND with SILT (SP-SM)
3 247	4/20/04			4.0/3.8	95		Dark brown, wet, silty SAND (SM), organics
		4					
4 246							Grades to light gray, fine sand
	Temporary pre-packaged well installed; riser pipe surface - 4.5', 10-slot screen 4.5' - 7.0'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling	5					
5 245							
6 244		7		2.0/2.0	100		Very soft, dark brown, wet PEAT (PT)
7 243							Boring terminated at 7.0 feet. Abandoned by backfilling with granular bentonite.
8 242							
9 241							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

▼ Water Level ATD
▽ Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 8

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	TGW-8	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	247.50
Location	SeaTac, Washington	Static water level (ft bgs)	0.52
Drilling Method	Direct push soil probe	Start Date	April 20, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 20, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
247	4/20/04	1.5		3.5/2.1	60		Loose, wet, dark brown SAND with SILT (SP-SM), frequent organics and woody debris, trace clay, trace gravel; fine to coarse sand, fine gravel
1							
246							
2							
245		3.5					Loose, wet, light brown to light gray, silty SAND (SM); fine to coarse sand
3	Temporary pre-packaged well installed; riser pipe surface - 2.5', 10-slot screen 2.5' - 5.0'; well withdrawn and boring abandoned with granular bentonite after groundwater sampling						
244							
4		5		1.5/1.8	120		
243							Very soft, dark brown, wet, fibrous PEAT (PT)
5							Boring terminated at 5.0 feet. Abandoned by backfilling with granular bentonite.
242							
6							
241							
7							
240							
8							
239							
9							
238							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: RRH/TCB
Approved by: JJS

Figure No. A - 9

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-1d	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	248.21
Location	SeaTac, Washington	Static water level (ft bgs)	0.83
Drilling Method	Hand Auger	Start Date	April 26, 2004
Sampling Method	Hand Auger	Drilling Contractor: Holt Drilling	Finish Date April 26, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.90' ags Concrete seal 0'-0.3'						**MARSH DEPOSITS**
	4/26/04						Soft, dark brown, moist PEAT
	4/26/04						Wet
245	Granular bentonite seal 0.3'-7'						
5		6		1.0/1.0	100		
		7		1.0/1.0	100		
	20-40 Sand filter pack 6.8' - 7.0'	8		1.0/1.0	100		
240	10-20 Sand filter pack 7'-9.5'	9		1.0/1.0	100		Soft, gray, wet SILT with fine sand
10	Slough 9.5' - 11.5'	10		1.0/1.0	100		Sand grades fine to medium
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 10.5' - 11.5'	11		1.0/1.0	100		Loose to medium dense, gray, wet SAND with silt and gravel; sand fine to coarse, gravel fine Well graded SAND, little silt, fine to coarse gravel
		11.5		0.5/0.5	100		
							Bottom of boring at 11.5 feet (refusal).
235							
15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

▼ Water Level ATD
▽ Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 10

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-1s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	248.37
Location	SeaTac, Washington	Static water level (ft bgs)	0.93
Drilling Method	Direct push soil probe	Start Date	April 26, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 26, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 3.20' ags Concrete seal 0'-0.3' 4/26/04 Granular bentonite seal 0.3'-3'	2		4.0/2.2	55		**MARSH DEPOSITS** Soft, dark brown, moist PEAT
245	20-40 Sand filter pack 3'-4'	4					
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 4' - 5'	5		1.0/1.0	100		
5							Bottom of boring at 5 feet.
240							
10							
235							
15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 11

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-2d	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	250.58
Location	SeaTac, Washington	Static water level (ft bgs)	2.97
Drilling Method	Direct push soil probe	Start Date	April 22, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 22, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
250	4" Steel monument 2.60' ags Concrete seal 0'-0.3'						**TOPSOIL**
							Loose, dark brown, moist, silty SAND, frequent organics and roots; grass cover
		2		2.0/1.4	70		**MARSH DEPOSITS**
							Soft, dark brown, moist to wet PEAT; fibrous with woody debris
	4/26/04	4		4.0/3.1	78		
	Granular bentonite seal 0.3'- 8'						
5		6					
245							
		7					Soft, gray to brown, moist SILT WITH CLAY AND SAND; sand fine
		8.5		4.0/4.0	100		Loose to medium dense, gray, wet SAND, few gravel; sand fine to coarse, gravel fine
10		10					
240	20-40 Sand filter pack 7.8' - 8'; slough 8' - 15'						*No recovery 10' - 15'
			○	4.0/0	0		
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 14' - 15'		○	1.0/0	0		
15							
235							Bottom of boring at 15 feet.

Sample Type (ST):
- ■ Continuous Core
- ⊠ Grab Sample
- ○ No Recovery

▼ Water Level ATD
▽ Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 12

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-2s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	250.78
Location	SeaTac, Washington	Static water level (ft bgs)	2.74
Drilling Method	Direct push soil probe	Start Date	April 22, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 22, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
250	4" Steel monument 2.60' ags Concrete seal 0'-0.3'			2.5/2.5	100		**TOPSOIL** Loose, dark brown, moist, silty SAND, frequent organics and roots; grass cover **MARSH DEPOSITS** Soft, dark brown, moist to wet PEAT; fibrous with woody debris
	SWL 4/26/04 Granular bentonite seal 0.3'-5.8'			3.5/3.5	100		
5 245	20-40 Sand filter pack 5.8'-6' Hole slough 6'-7'			2/0	0		No recovery - driller reports gravel
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 7' - 8'						Bottom of boring at 8 feet.
10 240							
15 235							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 13

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-3d	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.34
Location	SeaTac, Washington	Static water level (ft bgs)	1.36
Drilling Method	Direct push soil probe	Start Date	April 21, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 21, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
0	4" Steel monument 2.80' ags Concrete seal 0'-0.3'						**TOPSOIL** Loose, dark brown, moist, silty SAND, organics and roots; grass cover
	4/26/04	2		2.0/1.5	75		**MARSH DEPOSITS** Soft, dark brown, moist PEAT; occasional wood fragments
245		4		4.0/2.9	73		
5	Granular bentonite seal 0.3'-11.5'	6					
		7		4.0/4.0	100		
240		8.5					
10		10					
		11.75		3.5/4.0	114		
	20-40 Sand filter pack 11.5' - 12.5'	13.5					
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 12.5' - 13.5'						Bottom of boring at 13.5 feet. NOTE: Riser pipe damaged during monument installation; unable to repair, abandoned well per WAC 173. Redrilled well 5' north of original well and 3' north of GW-3s. 1' screen installed 12.5' - 13.5'. No samples collected.
235							
15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 14

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-3s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.37
Location	SeaTac, Washington	Static water level (ft bgs)	1.37
Drilling Method	Direct push soil probe	Start Date	April 21, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 21, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
0	4" Steel monument 2.55' ags Concrete seal 0'-0.3'						**MARSH DEPOSITS**
	4/26/04						Soft, dark brown, moist, silty PEAT; grass cover Decreasing silt content
	Granular bentonite seal 0.3'- 4'			3.5/1.6	46		
	10-20 Sand filter pack 4' - 6.5'						
245 5				3.0/3.4	113		
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 5.5' - 6.5'						Bottom of boring at 6.5 feet.
240 10							
235 15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 15

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-4d	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.91
Location	SeaTac, Washington	Static water level (ft bgs)	2.92
Drilling Method	Direct push soil probe	Start Date	April 21, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 21, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.23' ags Concrete seal 0'-0.3'						**TOPSOIL** Loose, brown, moist, silty SAND, frequent roots and organics
		3		4.0/3.2	80		Loose, brown, moist, silty SAND, trace gravel, trace organics; sand fine to coarse; gravel fine
	4/26/04						Wet
	Granular bentonite seal 0.3'- 8'	5					**MARSH DEPOSITS** Soft, dark brown, wet PEAT Loose, gray, wet, silty SAND; predominantly fine to medium sand
245				5.0/0	0		No recovery 5' - 10'
240	10-20 Sand filter pack 8' - 14'						
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 11.5' - 14'	14		4.0/3.2	80		Wet sample falls out during first attempt at retrieval
235							Bottom of boring at 14 feet.
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 16

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-4s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.78
Location	SeaTac, Washington	Static water level (ft bgs)	2.8
Drilling Method	Direct push soil probe	Start Date	April 20, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 20, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.55' ags Concrete seal 0'-0.3'						**TOPSOIL** Topsoil and grass cover
	Granular bentonite seal 0.3'- 4' 4/26/04			4.0/2.9	73		Loose, brown to dark brown, moist SAND, trace to few silt, trace fine gravel; fine to coarse sand; silt increasing with depth Brown sand with silt
245 5	10-20 Sand filter pack 4' - 7'						
	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 4.5' - 7'			2.0/1.4	70		
240 10							Bottom of boring at 7 feet.
235 15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 17

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	GW-5d	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	247.90
Location	SeaTac, Washington	Static water level (ft bgs)	0.95
Drilling Method	Direct push soil probe	Start Date	April 22, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 22, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.60' ags Concrete seal 0'-0.3'						**TOPSOIL** Loose, dark brown, moist, silty SAND, frequent organics and roots; grass cover
	4/28/04	2		2.0/1.3	65		**MARSH DEPOSITS** Soft, dark brown, moist to wet PEAT; fibrous with woody debris
245		3.5					
	Granular bentonite seal 0.3'- 9'	5		4.0/4.0	100		
5		6					
		8					Brown to dark brown
240				4.0/3.1	78		
	20-40 Sand filter pack 8.8' - 9'	10					
10							
		12					Grading to brown
	Slough 9' - 14'			4.0/3.3	83		
	4/22/04 (ATD)						
235	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 13' - 14'	14					Loose, gray, wet, silty SAND; fine to coarse sand
							Bottom of boring at 14 feet.
15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 18

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	GW-5s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	248.00
Location	SeaTac, Washington	Static water level (ft bgs)	1.16
Drilling Method	Direct push soil probe	Start Date	April 22, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 22, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl Graphic	Description
	4" Steel monument 2.50' ags Concrete seal 0'-0.3'						**TOPSOIL** Loose, dark brown, moist, silty SAND with organics and roots; grass cover
	4/26/04 Granular bentonite seal 0.3'-2.2' 20-40 Sand filter pack 2.0' - 2.2'			2.5/1.5	60		**MARSH DEPOSITS** Soft, dark brown, moist, fibrous PEAT
245	10-20 Sand filter pack 2.2' - 4' 3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 3' - 4'			1.5/1.4	93		Increasing woody debris
							Bottom of boring at 4 feet.
5							
240							
10							
235							
15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 19

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-6d	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.63
Location	SeaTac, Washington	Static water level (ft bgs)	3.15
Drilling Method	Direct push soil probe	Start Date	April 23, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 23, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.55' ags Concrete seal 0'-0.3'	2		2.0/1.7	85		Loose, brown, moist, silty SAND, few gravel, with organics and roots, grass, topsoil; sand fine to coarse, gravel fine
	4/26/04	4					
245 5	Granular bentonite seal 0.3'-8.8'	6		4.0/3.6	90		Gray, moist to wet, fine to medium sand
		7					Fine to coarse sand, few fine gravel
		8.5		4.0/4.0	100		
	20-40 Sand filter pack 8.8' - 9.0'	10					
240 10	4/23/04 (ATD)						
		12		2.0/1.8	90		Loose to medium dense, gray, wet SAND, few silt, few gravel; sand fine to coarse, gravel fine to coarse
	Slough 9'-15'	14					Soft, gray, wet SILT; nonplastic
				3.0/2.9	97		
235 15	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 14' - 15'	15					
							Bottom of boring at 15 feet.
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 20

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-6s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	249.32
Location	SeaTac, Washington	Static water level (ft bgs)	2.91
Drilling Method	Direct push soil probe	Start Date	April 23, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 23, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.50' ags Concrete seal 0'-0.3'			2.0/1.4	70		Loose, brown, moist, silty SAND with organics and roots, grass, topsoil, few clay Increasing fines, gray and brown 4" layer of white to light gray volcanic ash
	Granular bentonite seal 0.3'-2.8'						
	4/26/04 20-40 Sand filter pack 2.8' - 3.0' 10-20 Sand filter pack 3'-5'			3.0/1.8	60		Loose, gray to brown, moist to wet SAND, few to with silt, trace fine gravel
245 5	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 4' - 5'						
240 10							Bottom of boring at 5 feet.
235 15							
230							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 21

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-7d	1 of 2

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	255.11
Location	SeaTac, Washington	Static water level (ft bgs)	7.48
Drilling Method	Direct push soil probe	Start Date	April 23, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 23, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
255	4" Steel monument 2.5' ags Concrete seal 0'-0.3'	2		2.0/1.2	60		Loose, brown, moist, silty SAND to SAND with silt, with roots and organics; sand fine to coarse •Trace organics
		6		2.0/1.9	95		•Grades to coarse, silty sand with gravel; sand fine to coarse, gravel fine to coarse
5 250	Granular bentonite seal 0.3'-15.75'						
	4/26/04	7.5					Soft, dark brown, moist PEAT
		9		4.0/4.0	100		Soft, gray to dark gray, moist SILT, little fine sand
		10					
10 245		11.5					
		13		4.0/4.0	100		
		14					
		15					
15 240	20-40 Sand filter pack 15.75' - 16'	16.5		4.0/4.0	100		
		18					
	Slough 16' - 22'	19					

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 22

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
030185	GW-7d	2 of 2

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	255.11
Location	SeaTac, Washington	Static water level (ft bgs)	7.48
Drilling Method	Direct push soil probe	Start Date	April 23, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 23, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
235	3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 21' - 22'	20.5		4.0/4.0	100		
		22					Loose, gray, wet, silty, fine to medium SAND
							Bottom of boring at 22 feet.
230							
225							
220							

Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 22

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004

Geologic & Monitoring Well Construction Log

Aspect consulting — IN-DEPTH PERSPECTIVE

Project Number	Well Number	Sheet
030185	GW-7s	1 of 1

Project Name	Des Moines Creek Regional Retention/Detention Facility	Ground surface elevation (NAVD88)	254.98
Location	SeaTac, Washington	Static water level (ft bgs)	7.61
Drilling Method	Direct push soil probe	Start Date	April 23, 2004
Sampling Method	1-1/2" core	Drilling Contractor: Holt Drilling	Finish Date April 23, 2004

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Mtl. Graphic	Description
	4" Steel monument 2.55' ags Concrete seal 0'-0.3'			2.0/1.2	60		Loose, brown, moist, silty SAND with roots, grass and organics, topsoil
							Decreasing fines, fine to medium sand
				4.0/2.5	63		Fine to coarse sand, little fine gravel
5 250	Granular bentonite seal 0.3'-10'						Increasing silt, frequent organics
	4/26/04						2" peat layer
				4.0/4.0	100		Soft, gray, moist SILT with clay; low plasticity, slow dilatancy
10245	20-40 Sand filter pack 10'-10.4'						
	10-20 Sand filter pack 10.4' - 12' 3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 11' - 12'			2.0/2.5	125		
							Bottom of boring at 12 feet.
15240							

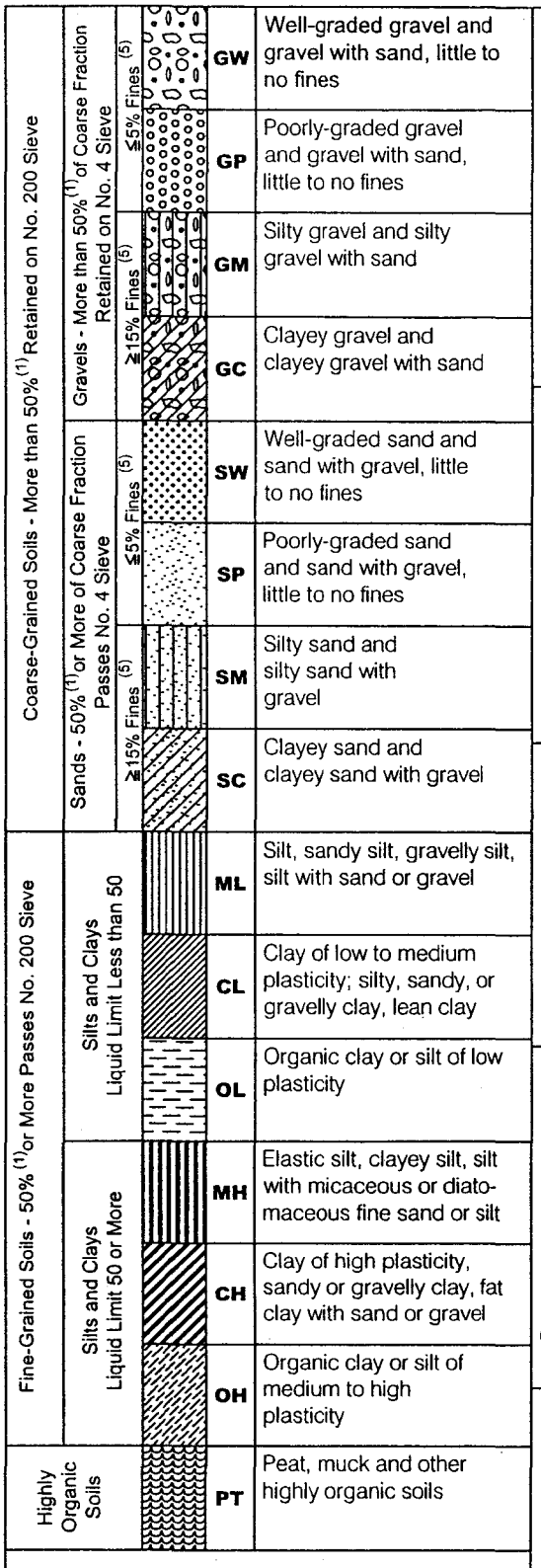
Sample Type (ST):
- Continuous Core
- Grab Sample
- No Recovery

▼ Water Level ATD
▽ Static Water Level

Logged by: TCB
Approved by: JJS

Figure No. A - 23

DES MOINES MW DES MOINES CREEK.GPJ October 18, 2004



Terms Describing Relative Density and Consistency

	Density	SPT[2] blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT[2] blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

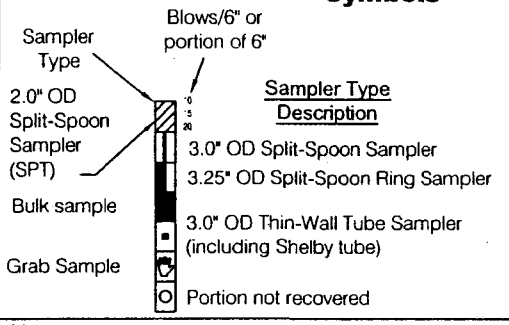
[3] Estimated Percentage

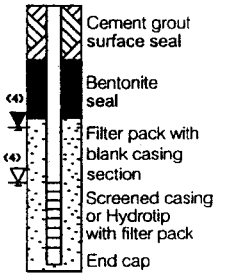
Percentage by Weight	Modifier
<5	Trace
5 to 15	Slightly (sandy, silty, clayey, gravelly)
15 to 30	Sandy, silty, clayey, gravelly)
34 to 49	Very (sandy, silty, clayey, gravelly)

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





(1) Percentage by dry weight
(2) (SPT) Standard Penetration Test (ASTM D-1586)
(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)
(4) Depth of groundwater ▼ ATD = At time of drilling ▽ Static water level (date)
(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

Aspect consulting
IN-DEPTH PERSPECTIVE
179 Madrone Lane North
Bainbridge Island, WA 98110
(206) 780-9370
811 First Avenue #480
Seattle, WA 98104
(206)-328-7443

Exploration Log Key

DATE: October 2005
DESIGNED BY:
DRAWN BY:
REVISED BY:
PROJECT NO.
FIGURE NO. C-1

Q:_ACAD Standards\Standard Details\Exploration Log Key.dwg

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-8	1 of 2

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 254.18
Ground surface elevation (NAVD88): 251.98
Northing/ Easting (NAD83): N: 158734.48; E: 1275469.79
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
	12" Steel monument 2.2' ags Concrete seal 0' - 1.5'							**TOPSOIL** Topsoil and grass cover.
								RECENT ALLUVIUM
		1		1.5/1.5	100	1 1 1		Soft, moist, gray-blue, slightly sandy, very silty clay (CL); some organics and wood, fine to coarse sand. 1" red-brown sand lenses.
5		2		1.5/0.2	13	1 1 1		Soft, moist, gray-blue, slightly sandy, very clayey SILT, trace organics and wood; fine to coarse sand (ML)
	2" Sch 40 PVC Casing							
		3		1.5/0.5	33	1 1 1		
10	Granular bentonite seal 1.5' - 22'	4		1.5/1.5	100	1 1 1		1/4" sand lenses.
		5		1.5/1.5	100	12 14 18		Soft, moist, gray-blue, slightly sandy, very clayey SILT; poorly graded, well sorted, fine to coarse 6" sand lenses.
15								**RECESSIONAL OUTWASH**
		6		1.5/1.0	67	11 13 14		Medium dense, moist, gray-blue, slightly silty SAND, trace gravels, trace organics, fine to coarse sand, fine to coarse gravel (SM).
		7		1.5/1.5	100	6 11 12		Soft, moist, gray-blue, sandy SILT, fine to coarse sand (ML). Medium dense, moist, gray-blue, slightly silty SAND, fine to coarse sand (SP).
	6/27/05							

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-2

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-8	2 of 2

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 254.18
Ground surface elevation (NAVD88): 251.98
Northing/ Easting (NAD83): N: 158734.48; E: 1275469.79
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
		8		1.5/1.5	100	6 6 12		Medium dense, wet, gray-blue, slightly silty SAND; fine to coarse sand (SP).
	ATD							
		9		1.5/1.2	80	8 13 14		Trace fine to coarse gravels.
25		10		1.5/1.5	100	13 15 19		
	10 - 20 Sand filter pack							
	2" Sch 40 PVC 20-slot screen 24.75' - 29.75'	11		1.5/1.5	100	17 18 19		
30	3" Threaded PVC Cap							Bottom of boring = 30.0 Feet
		12		1.5/1.5	100	9 19 26		Increase in quantity of fine gravels.
35								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-2

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9s	1 of 2

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 251.21
Ground surface elevation (NAVD88): 251.36
Northing/ Easting (NAD83): N: 158325.11; E: 1275437.12
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
	12" Flush steel monument Concrete seal 0'-1.5'							**TOPSOIL** Topsoil and grass cover
								RECENT ALLUVIUM Very soft, moist, gray-blue, slightly sandy, very silty CLAY (CL).
		1		1.5/1.5	100	1 1 1		
5								
	2" Sch 40 PVC Casing							
		2		1.5/1.5	100	12 17 16		**RECESSIONAL OUTWASH** Dense, moist, gray-blue, silty SAND (SM); trace organics, fine to coarse sand.
10	Granular bentonite seal 1.5'-25'							
		3		1.5/0.7	44	7 14 23		
15								
		4		1.5/0.7	44	17 18 21		Dense, moist, yellow-red, slighty silty, very sandy GRAVEL (GW), rounded to sub rounded, fine to coarse gravel, fine to coarse sand.

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-3

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9s	2 of 2

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 251.21
Ground surface elevation (NAVD88): 251.36
Northing/ Easting (NAD83): N: 158325.11; E: 1275437.12
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	ST	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
	6/27/05							
		5		1.5/0.5	33	17 18 23		
25								
	10-20 Sand filter pack 25'-32.5'	6		0.5/0.1	17	50/6"		**PRE-FRASER NON GLACIAL** Very dense, wet, yellow-red, slighty silty sandy GRAVEL (GW); fine to coarse gravel, fine to coarse sand.
30	2" Sch 40 PVC 20-slot screen 27.25' - 32.25'							
	3" Threaded PVC cap	7		1.0/1.0	100	28 50/6"		Bottom of Boring = 32.5 Feet 1.0' thick, slightly silty SAND; lense with trace gravel.
35								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-3

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9d	1 of 3

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 252.31
Ground surface elevation (NAVD88): 252.56
Northing/ Easting (NAD83): N: 158333.24; E: 1275429.77
Start/Finish Date: 7/11/2005; 7/11/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
	12" Flush steel monument Concrete seal 0'-1.0' Bentonite slurry seal 1.0'-32.0'							**TOPSOIL** Topsoil and grass cover.
		1		1.5/1.5	100	2 2 4		**RECENT ALLUVIUM** Very soft, dry-moist, red-brown, slighty sandy, very clayey SILT (ML) to very silty clay (CL) with organics. 1/4 - 2" fine to coarse sand lense.
5	2" Sch 40 PVC Casing							
		2		1.5/1.0	67	6 7 14		**RECESSIONAL OUTWASH** Loose, moist, light gray, slightly silty SAND (SP); trace organics; poorly graded, well sorted fine to medium sand.
10								
		3		1.5/1.2	78	7 12 14		Fine sand with brown staining and trace gravels.
15								
		4		1.5/0.8	50	12 15 12		Dense, moist-wet, yellow-red, slightly silty, very sandy GRAVEL (GP); fine to coarse sand, predominantly medium to coarse gravel.
	7/11/05 SWL							

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-4

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9d	2 of 3

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling
Top of Casing (NAVD88): 252.31
Ground surface elevation (NAVD88): 252.56
Northing/ Easting (NAD83): N: 158333.24; E: 1275429.77
Start/Finish Date: 7/11/2005; 7/11/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
		5		1.5/1.0	67	17 18 21		Grades to slightly silty, very sandy GRAVEL (GP-GM).
25	ATD							
		6		1.0/1.0	100	28 50/6"		**PRE-FRASER NON GLACIAL** Very dense, wet, yellow-red, slightly silty sandy GRAVEL (GP-GM); fine to coarse sand, fine to coarse gravel, large clasts of volcanics.
30	Granular bentonite seal 32.0'-36.0'							
		7		1.5/0.7	44	12 34 50/5"		Grades to silty, sandy GRAVEL.
35	10-20 Sand filter pack 36.0'-45.0'							
		8		0.5/0.5	100	50/6"		Grades back to slightly silty sandy GRAVEL.

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-4

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9d	3 of 3

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Hollow-Stem Auger
Sampling Method: 18" Split-Spoon
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 252.31
Ground surface elevation (NAVD88): 252.56
Northing/ Easting (NAD83): N: 158333.24; E: 1275429.77
Start/Finish Date: 7/11/2005; 7/11/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
	2" Sch 40 PVC 20-slot screen 39.75'-44.75'							
		9		0.9/0.5	55	32 50/5"		
	3" Threaded PVC cap							Bottom of boring = 45.0 FEET
45		10		1.5/0.2	11	7 2 4		Loose, wet, yellow, slightly gravelly SAND (SP); fine gravel, fine to coarse sand, predominantly medium.
50								
55								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. C-4

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Well Decommission Logs
(GW-7s/d, GW-8, GW9s/d)

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-7s	1 of 1

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Well Decommission
Sampling Method:
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 257.23
Ground surface elevation (NAVD88): 254.98
Northing/ Easting (NAD83): N: 158927.91; E: 1275460.80
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
5 250	Granular bentonite seal 0.3'-10'							Well Abandonment: On 6/27/05 the well was filled to a depth of 12 feet with bentonite chips (~10 lbs). The well monument and bollards were removed. Any concrete used in the construction of the well was also removed.
10 245	20-40 Sand filter pack 10'-10.4' 10-20 Sand filter pack 10.4' - 12' 3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 11' - 12'							
15 240								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. A-1

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-7d	1 of 2

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Well Decommission
Sampling Method:
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 257.39
Ground surface elevation (NAVD88): 255.11
Northing/ Easting (NAD83): N: 158926.66; E: 1275463.53
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
255								Well Abandonment: On 6/27/05 the well was filled to a depth of 22 feet with bentonite chips (~15 lbs). The well monument and bollards were removed. Any concrete used in the construction of the well was also removed.
5 250	Granular bentonite seal 0.3'-15.75'							
10 245								
15 240	20-40 Sand filter pack 15.75' - 16'							
	Slough 16' - 22'							

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. A-2

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-7d	2 of 2

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Well Decommission
Sampling Method:
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88): 257.39
Ground surface elevation (NAVD88): 255.11
Northing/ Easting (NAD83): N: 158926.66; E: 1275463.53
Start/Finish Date: 6/27/2005; 6/27/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
235	SWL of 20.88 ft on 6/27/05 3/4" ID PVC prepack screen assembly; 10-slot, with 20-40 filter 21' - 22'							Well Abandonment: On 6/27/05 the well was filled to a depth of 22 feet with bentonite chips (~15 lbs). The well monument and bollards were removed. Any concrete used in the construction of the well was also removed.
25 230								
30 225								
35 220								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. A-2

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9d	1 of 3

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Well Decommission
Sampling Method:
Drilling Contractor: Holt Drilling
Top of Casing (NAVD88):
Ground surface elevation (NAVD88):
Northing/Easting (NAD83):
Start/Finish Date: 7/11/2005; 7/11/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
5	Granular bentonite 1.5'-37.0'							DMC GW-9d was damaged during construction and a new well was completed (see Appendix C-4 for well log). Well Abandonment: On 7/11/05 the well was filled to a depth of 43.25 feet with bentonite chips (~75 lbs). The well monument and concrete used in the construction of the well was removed.
10								
15								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. A-3

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9d	2 of 3

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Well Decommission
Sampling Method:
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88):
Ground surface elevation (NAVD88):
Northing/
Easting (NAD83):
Start/Finish Date: 7/11/2005; 7/11/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
								Well Abandonment: On 7/11/05 the well was filled to a depth of 43.25 feet with bentonite chips (~75 lbs). The well monument and concrete used in the construction of the well was removed.
25								
30								
35	10-20 Sand filter pack 37'-43'							

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. A-3

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Aspect consulting
IN-DEPTH PERSPECTIVE

Geologic & Monitoring Well Construction Log

Project Number	Well Number	Sheet
04016A	DMC GW-9d	3 of 3

Project Name: Des Moines Creek Regional Retention/Detention Facility
Location: SeaTac, Washington
Drilling Method: Well Decommission
Sampling Method:
Drilling Contractor: Holt Drilling

Top of Casing (NAVD88):
Ground surface elevation (NAVD88):
Northing/
Easting (NAD83):
Start/Finish Date: 7/11/2005; 7/11/2005

Depth/ Elevation (ft)	Well Construction	Sample ID	S T	Feet driven/ recovered	% Recovery	Blow Count	Mtl. Graphic	Description
	3" Threaded PVC cap							Well Abandonment: On 7/11/05 the well was filled to a depth of 43.25 feet with bentonite chips (~75 lbs). The well monument and concrete used in the construction of the well was removed.
45								
50								
55								

Sample Type (ST):
- 18" Split Spoon
- Grab Sample
- No Recovery

Water Level ATD
Static Water Level

Logged by: JMS
Approved by: JJS

Figure No. A-3

DES MOINES MW DES MOINES CREEK.GPJ October 25, 2005

Excavation Boundary

IWSLG_B-12
IWSLG_KJ-3
DMCGW1d/s
DMCGW2d/s
DMCGW3d/s
DMCGW4d/s
DMCTGW1
KCB-1
DMCTGW7
DMCTGW8
DMCGW5d/s
DMCGW6d/s
B-9
KCB-7
DMCGW7d/s
B-10
KCB-6
B-11
B-12
KCB-8
22N4E4F3
22N4E4F4
MW-2S
22N4E4F2
22N4E4F1
KCB-2
B-4

Cell 1
Cell 2
Northwest Ponds
West Berm
East Berm
Outlet Control Structure #2
Outlet Control Structure #1
Tyee Diversion Pipe
Tyee Pond
East Fork Des Moines Creek (Old Channel)
West Fork Des Moines Creek
24" Culvert
Highline Water District Tyee Well 22N4E4F1

S. 196th St.
18th Ave. S.
S. 200th St.

Legend

- Excavation Boundary
- Line of Geologic Cross Section
- Monitoring Well

N

0 300 600

Feet

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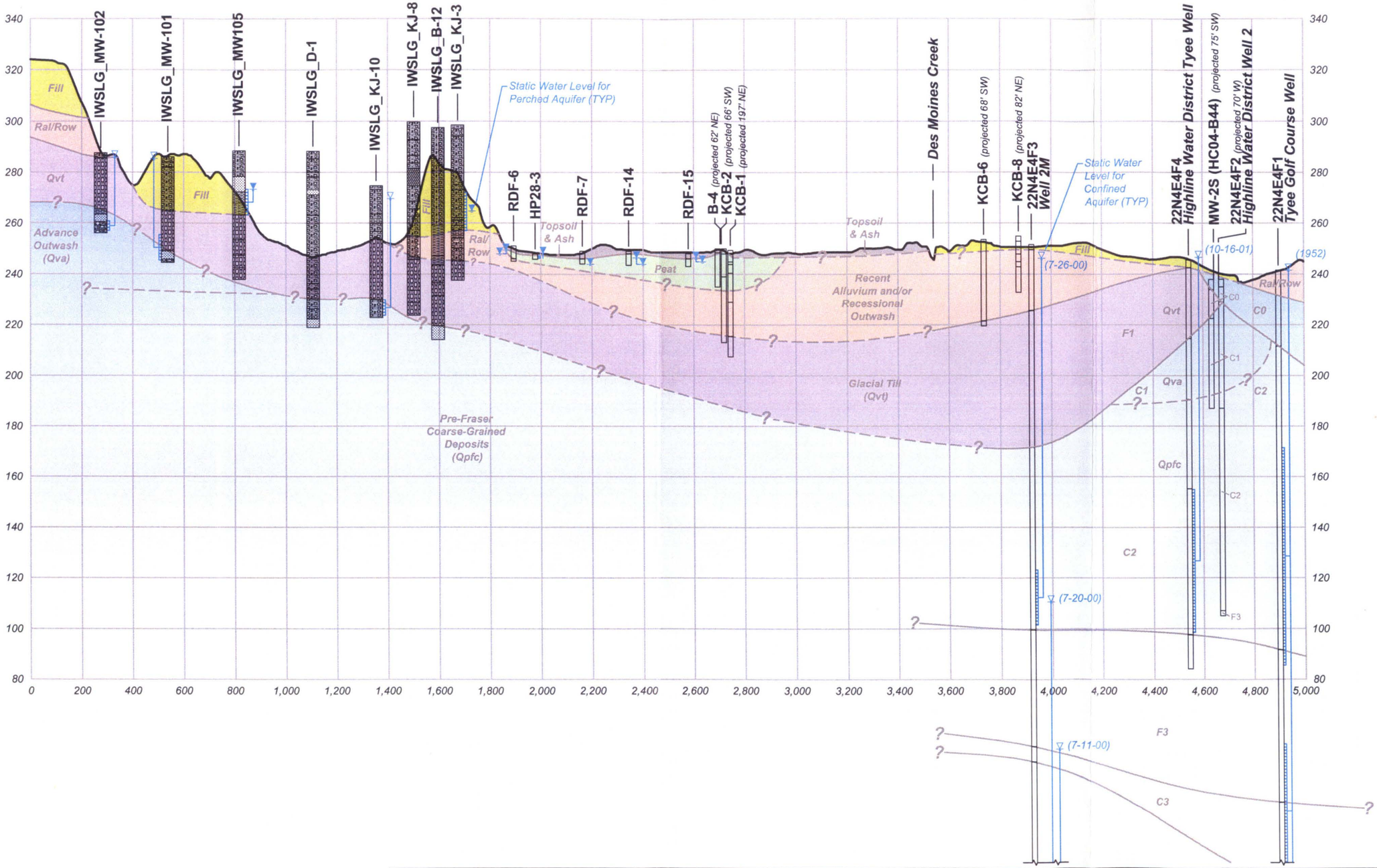
NORTH **SOUTH**

IWS LAGOON 3

DES MOINES REGIONAL RETENTION/DETENTION FACILITY

TYEE WELL FIELD



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NORTH

SOUTH

IWSLG_B-12

DMCGW-1d April 2004

DMCGW-2d April 2004

DMCGW-3d April 2004

DMCGW-4d April 2004

DMCTGW-1 April 2004

KCB-1

DMCTGW-7 April 2004

DMCTGW-8 April 2004

DMCGW-5d April 2004

DMCGW-6d April 2004

DMCGW-7d April 2004

KCB-6

22N4E4F3

Ground Surface

Des Moines Creek (Former Channel)

Des Moines Creek (New Channel)

Fill

Topsoil

Peat

Ral/Row

F1

Qvt

C2

Qpfc

Screens at multiple positions

320 300 280 260 240 220 200 180 160

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800

Note:
Water levels for DMCGW and DMCTGW wells taken in April 2004.

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Project Area Cross Section

Des Moines Regional Detention/Retention Facility
SeaTac, Washington

DATE: Feb 2005	PROJECT NO. 030185
DESIGNED BY: JJS	
DRAWN BY: PMB	FIGURE NO. 6
REVISED BY:	

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Legend

Proposed Sampling Locations for Surface Water & Stream Bed Sediments

Outlet Control Structure #2

SW-1a

SW-1b

West Fork Des Moines Creek (Phase 1)

West Fork Des Moines Creek (Existing)

SW-2a

SW-2b

Tyee Diversion Pipe

East Berm

SW-3a

SW-3b

Outlet Control Structure #1

Existing 24" Culvert

Tyee Pond

East Fork Des Moines Creek (Existing)

S 196TH ST

18th Ave. S.

18TH AVE S

48" CONC

2" PVC

N

0 150 300

Feet

$\Sigma^2\Pi$

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Sampling Locations for Surface Water and Sediment in Des Moines Creek

Des Moines Regional Retention/Detention Facility

SeaTac, Washington

DATE: March 2004	PROJECT NO. 030185
DESIGNED BY: JSL	
DRAWN BY: SDM	FIGURE NO. 4
REVISED BY: -	

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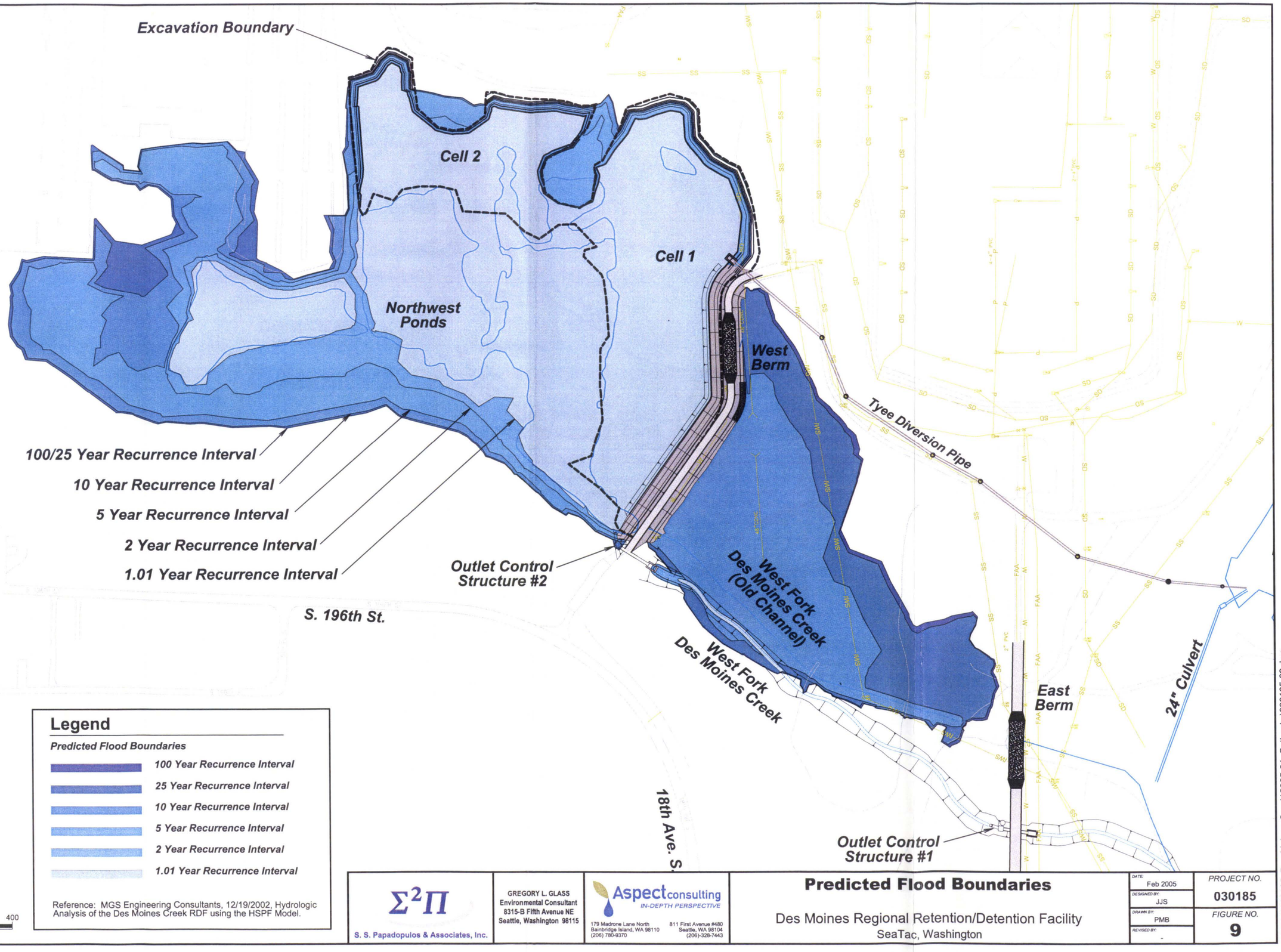

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Predicted Flood Boundaries

Des Moines Regional Retention/Detention Facility
SeaTac, Washington

DATE: Feb 2005	PROJECT NO. 030185
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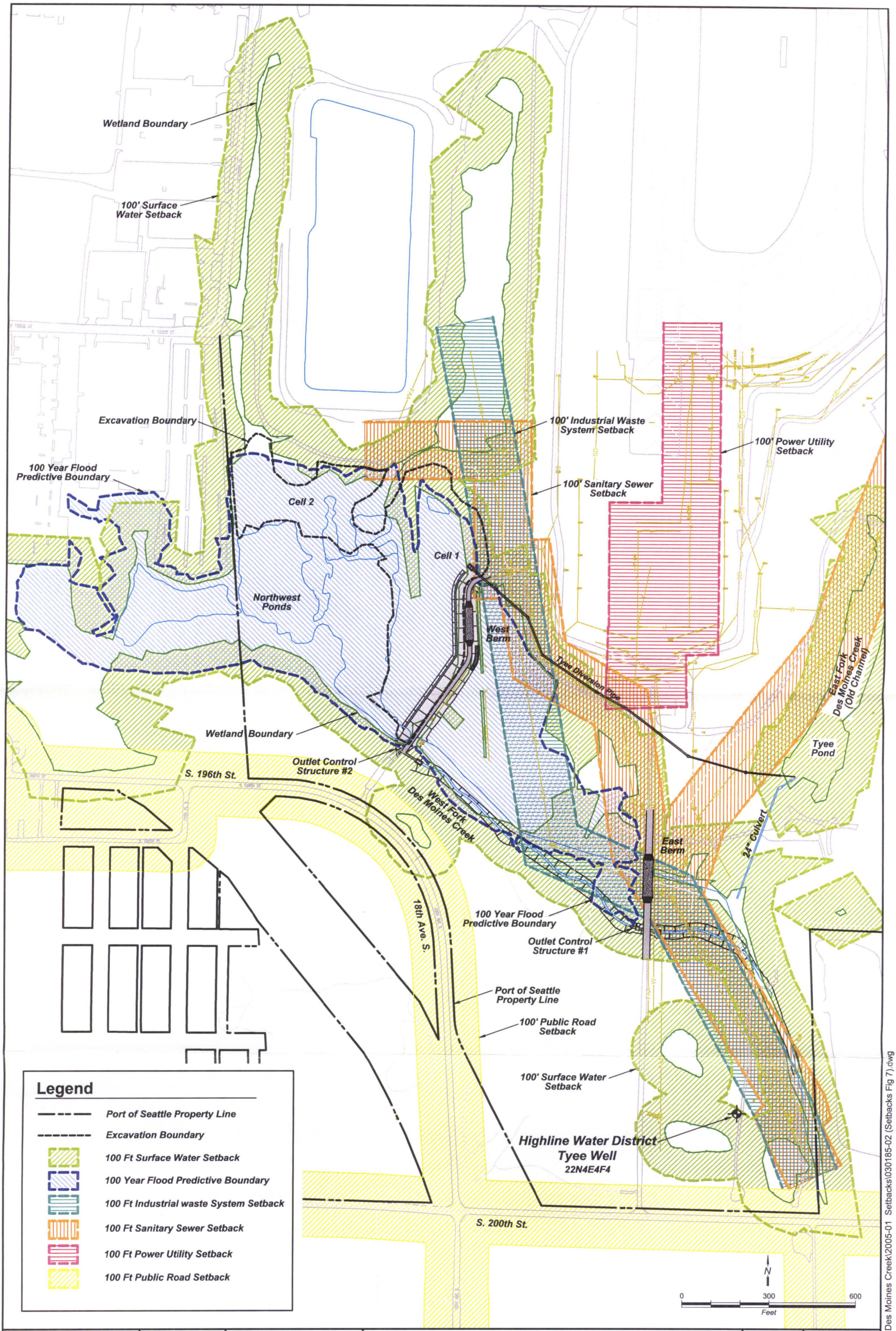

Setbacks and Flood Zone Boundary

Des Moines Regional Retention/Detention Facility
SeaTac, Washington

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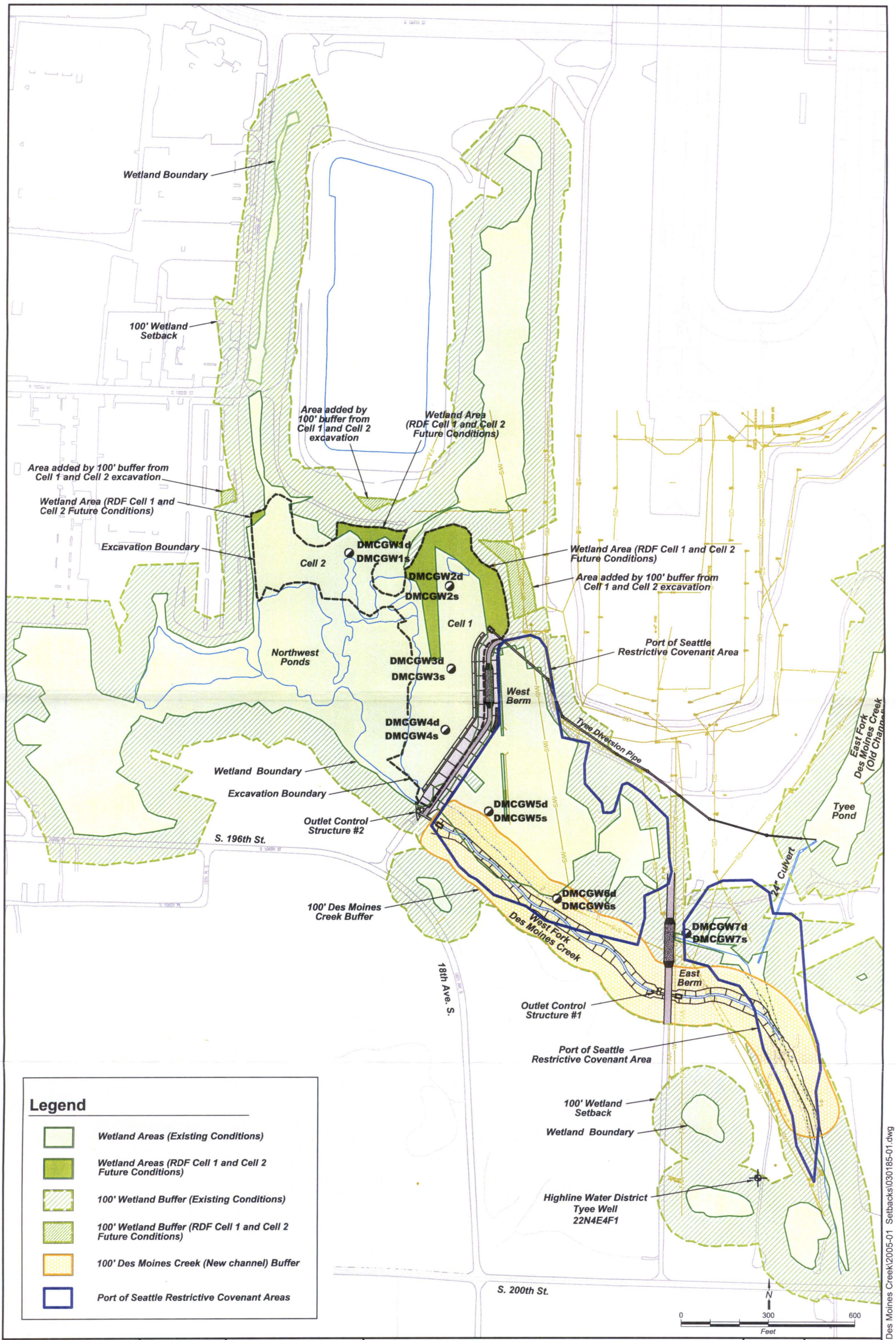

Legend

- Wetland Areas (Existing Conditions)
- Wetland Areas (RDF Cell 1 and Cell 2 Future Conditions)
- 100' Wetland Buffer (Existing Conditions)
- 100' Wetland Buffer (RDF Cell 1 and Cell 2 Future Conditions)
- 100' Des Moines Creek (New channel) Buffer
- Port of Seattle Restrictive Covenant Areas

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Wetland Buffers and Port of Seattle Restrictive Covenant Areas

Des Moines Regional Retention/Detention Facility

SeaTac, Washington

DATE:	PROJECT NO.
Feb 2005	030185
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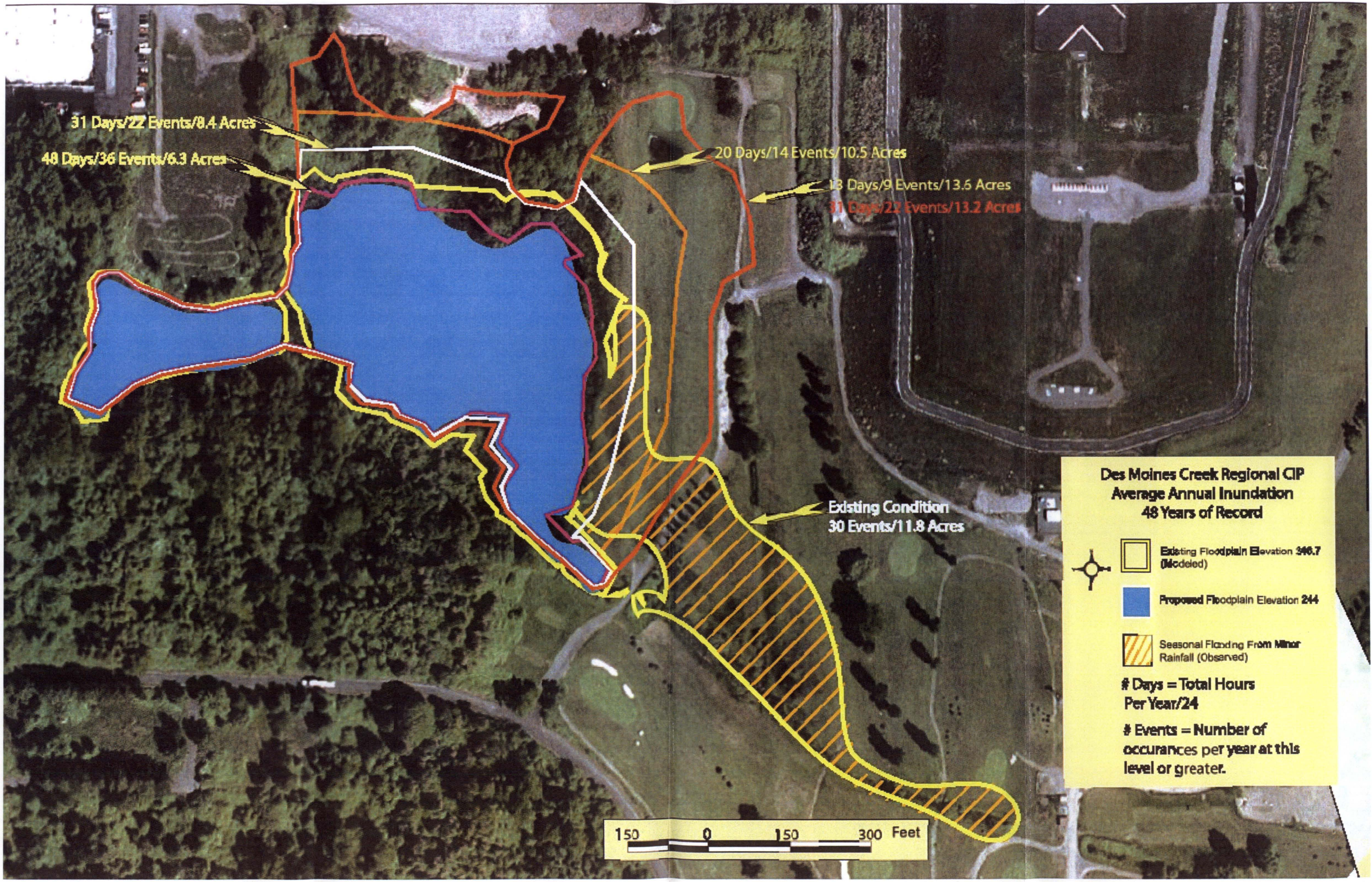
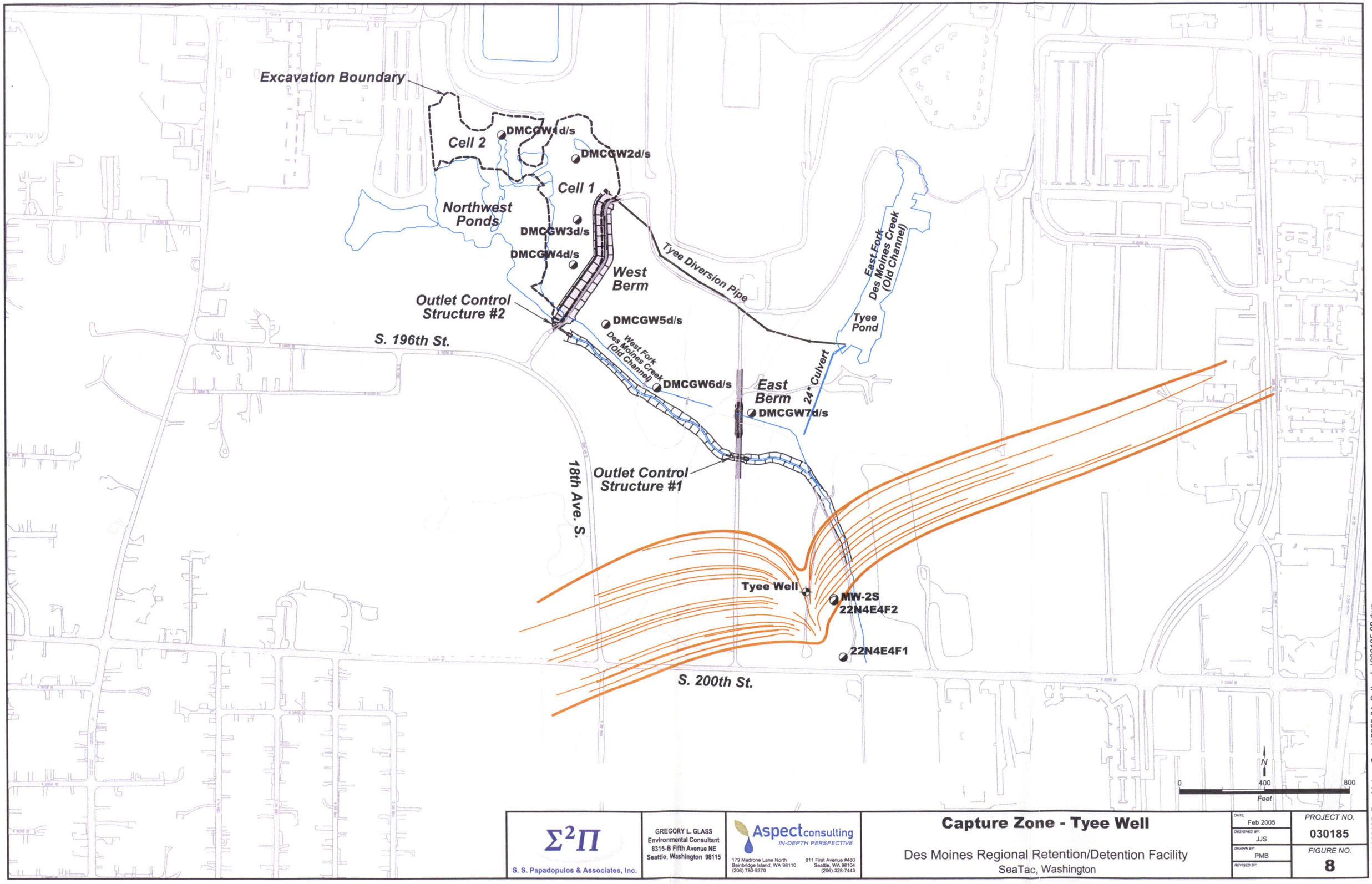

31 Days/22 Events/8.4 Acres
48 Days/36 Events/6.3 Acres
20 Days/14 Events/10.5 Acres
13 Days/9 Events/13.6 Acres
31 Days/22 Events/13.2 Acres
Existing Condition
30 Events/11.8 Acres
150 0 150 300 Feet
Des Moines Creek Regional CIP
Average Annual Inundation
48 Years of Record
Existing Floodplain Elevation 246.7 (Modeled)
Proposed Floodplain Elevation 244
Seasonal Flooding From Minor Rainfall (Observed)
Days = Total Hours Per Year/24
Events = Number of occurances per year at this level or greater.



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