King County

Department of Natural Resources

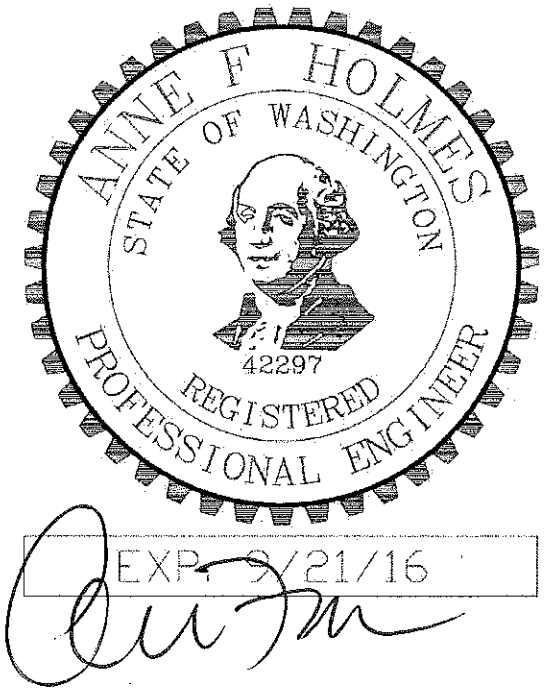
ENVIRONMENTAL MONITORING SAMPLING AND ANALYSIS PLAN AND QUALITY ASSURANCE PROJECT PLAN FOR VASHON ISLAND CLOSED LANDFILL

Prepared by
King County Solid Waste Division
Facility Engineering & Sciences Unit

Seattle, WA
January 2016

Environmental Monitoring Sampling and Analysis Plan
and
Quality Assurance Project Plan
for
Vashon Closed Landfill

I certify in accordance with the requirements of Chapter 18.220 RCW, that the contents of this Groundwater Data Evaluation Report were prepared under my direction under a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Where applicable, some specific and related hydrogeologic portions have been duly certified by the responsible geologist or engineering geologists in accordance with Chapter 18.220.010 (12) RCW. Based on my inquiry of the person(s) directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete.



Name:	Title:	Date:
Anne Holmes, P.E.	Facility Engineering and Science Unit Supervisor	1/29/16
Mailing Address: Solid Waste Division King County Department of Natural Resources & Parks 201 South Jackson Street, Suite 701 Seattle, WA 98104-3855		**Telephone Number:** 206-477-5223

TABLE OF CONTENTS

1 INTRODUCTION 1-1

1.1 PURPOSE 1-1
1.2 RESPONSIBLE AGENCY 1-1
1.3 ORGANIZATION 1-1

2 PROJECT DESCRIPTION AND BACKGROUND 2-1

2.1 LOCATION 2-1
2.2 GEOLOGY AND HYDROGEOLOGY 2-1
2.3 SITE HISTORY 2-2
2.4 EXISTING MONITORING DATA 2-3

3 DATA QUALITY AND FIELD QUALITY CONTROL 3-1

3.1 DATA QUALITY OBJECTIVES 3-1
3.2 DATA QUALITY OBJECTIVES FOR OVERALL PROGRAM 3-1
3.3 SAMPLING PLAN FAILURE RESPONSE ACTIONS 3-3
3.4 QUALITY ASSURANCE 3-3
3.5 QUALITY CONTROL 3-4
3.6 CHANGES IN PROCEDURES 3-4
3.7 FIELD QUALITY CONTROL SAMPLES 3-4
3.7.1 TRIP BLANKS 3-5
3.7.2 FIELD DUPLICATES 3-5
3.7.3 EQUIPMENT/RINSATE BLANKS 3-6
3.8 DATA REVIEW 3-6

4 MONITORING PROGRAM RATIONALE AND GENERAL GUIDELINES 4-1

4.1 PROGRAM DESCRIPTION 4-1
4.2 SELECTION OF ANALYTICAL PARAMETERS 4-1
4.3 SELECTION OF MONITORING LOCATIONS 4-2
4.4 MONITORING FREQUENCY 4-2
4.5 GUIDELINES 4-2
4.5.1 PREPARATION 4-3
4.5.2 SAMPLE CONTAINERS AND PRESERVATION 4-3
4.6 RECORDS 4-3
4.6.1 SAMPLING FIELD RECORDS 4-3
4.6.2 SAMPLING LOGS 4-4
4.6.3 LABELS 4-4
4.6.4 CHAIN-OF-CUSTODY 4-5
4.7 RESIDUALS HANDLING 4-6

5 GROUNDWATER 5-1

5.1 MONITORING NETWORK 5-1
5.2 ANALYTICAL PARAMETERS 5-1
5.3 ASSESSMENT MONITORING 5-1
5.4 GROUNDWATER MONITORING 5-1
5.5 GROUNDWATER SAMPLE COLLECTION 5-2
5.5.1 WELL INSPECTION AND MAINTENANCE 5-2
5.5.2 MEASUREMENT OF DEPTH TO WATER 5-2
5.5.3 LOW-FLOW PURGING 5-2
5.5.4 SAMPLE COLLECTION AND HANDLING 5-3
5.6 ADDITIONAL GROUNDWATER MONITORING 5-3

6 SURFACE WATER 6-1

6.1 SURFACE WATER MONITORING OBJECTIVE 6-1
6.2 MONITORING NETWORK 6-1
6.3 ANALYTICAL PARAMETERS 6-1
6.4 SURFACE WATER SAMPLE COLLECTION 6-1
6.4.1 SAMPLE BOTTLES 6-1
6.4.2 SURFACE WATER MONITORING EQUIPMENT 6-2
6.4.3 SURFACE WATER SAMPLE COLLECTION 6-2

7 LEACHATE 7-1

7.1 LEACHATE MONITORING OBJECTIVE 7-1
7.2 MONITORING NETWORK 7-1
7.3 ANALYTICAL PARAMETERS 7-1
7.4 LEACHATE SAMPLE COLLECTION 7-1
7.4.1 SAMPLE CONTAINERS 7-1
7.4.2 LEACHATE MONITORING EQUIPMENT 7-2
7.4.3 LEACHATE SAMPLE COLLECTION 7-2

8 LANDFILL GAS 8-1

8.1 LANDFILL GAS MONITORING OBJECTIVE AND NETWORK 8-1
8.2 LANDFILL GAS MONITORING 8-1
8.2.1 EQUIPMENT 8-1
8.2.2 PROCEDURES 8-1
8.2.3 MAINTENANCE 8-2
8.2.4 REPLACEMENT 8-2
8.2.5 FREQUENCY 8-2
8.2.6 RECORDKEEPING AND REPORTING 8-2
8.2.7 FACTORS THAT AFFECT PROBE READINGS 8-2
8.2.8 RESPONDING TO MONITORING RESULTS 8-3

9 DATA EVALUATION PROCEDURES 9-1

9.1 DATA WORKFLOW AND MANAGEMENT 9-1
9.2 DATA EVALUATION PARAMETERS 9-2
9.2.1 RETESTING PLAN 9-2
9.2.2 ASSESSMENT MONITORING AND CORRECTIVE ACTIONS 9-3
9.2.3 INDICATOR AND INORGANIC PARAMETERS 9-4
9.2.4 OTHER METAL PARAMETERS 9-6
9.2.5 VOLATILE ORGANIC COMPOUNDS 9-7
9.2.6 ATTENUATION CONSIDERATIONS 9-9
9.3 DATA EVALUATION METHODS 9-9
9.3.1 DATA QUALITY OBJECTIVES 9-9
9.3.2 EVALUATION OF OUTLIERS 9-9
9.3.3 QA/QC REVIEW 9-10
9.3.4 CONSISTENCY REVIEW 9-10
9.3.5 GROUNDWATER ELEVATIONS 9-11
9.3.6 TIME-CONCENTRATION PLOTS 9-11
9.3.7 STATISTICAL SUMMARY TABLES 9-11
9.3.8 PREDICTION LIMITS 9-12
9.3.9 TREND TESTING 9-13
9.4 DATA QUALITY 9-13
9.5 QUARTERLY REPORTS 9-14
9.6 ANNUAL REPORTS 9-14
9.7 EXCEEDANCE REPORTS 9-15

10 HEALTH AND SAFETY 10-1

11 REFERENCES 11-1

LIST OF TABLES

TABLE 3-2 QUALITY ASSURANCE SAMPLES 3-5

LIST OF FIGURES

FIGURE 1 SITE VICINITY MAP
FIGURE 2 SITE MAP
FIGURE 3 CROSS SECTIONS
FIGURE 4 CROSS SECTION A-A'
FIGURE 5 CROSS SECTION B-B'
FIGURE 6 CROSS SECTION C-C'
FIGURE 7 CROSS SECTION D-D'
FIGURE 8 CROSS SECTION E-E'
FIGURE 9 DOMESTIC WELLS MAP
FIGURE 10 MONITORING WELL LOCATION MAP
FIGURE 11 SURFACE WATER SAMPLING LOCATION MAP
FIGURE 12 LEACHATE SAMPLING LOCATION MAP
FIGURE 13 GAS PROBE LOCATION MAP

APPENDICES

A MONITORING PARAMETERS

LIST OF TABLES ..... APPENDIX A
TABLE 5-2 GROUNDWATER ANALYTICAL PARAMETERS
TABLE 6-2 SURFACE WATER ANALYTICAL PARAMETERS
TABLE 6-5 FRESHWATER TOXICS SUBSTANCES CRITERIA
TABLE 7-2 LEACHATE ANALYTICAL PARAMETERS

B SAMPLE CONTAINERS AND PRESERVATION

LIST OF TABLES ..... APPENDIX B
TABLE 4-1 SAMPLE CONTAINER, PRESERVATION AND STORAGE CONDITIONS

C SAMPLING EQUIPMENT

LIST OF TABLES ..... APPENDIX C
TABLE 5-3 GROUNDWATER SAMPLING EQUIPMENT
TABLE 6-3 SURFACE WATER SAMPLING EQUIPMENT
TABLE 7-3 LEACHATE SAMPLING EQUIPMENT
TABLE 8-2 LANDFILL GAS MONITORING EQUIPMENT

D SAMPLING PROCEDURES

LIST OF TABLES ..... APPENDIX D
TABLE 3-1 SAMPLING PLAN PROBLEM RESPONSE ACTIONS
TABLE 5-4 MEASUREMENT OF DEPTH TO WATER
TABLE 5-5 GROUNDWATER WELL EVACUATION
TABLE 5-6 GROUNDWATER SAMPLE COLLECTION
TABLE 6-4 SURFACE WATER SAMPLE COLLECTION
TABLE 7-4 LEACHATE SAMPLE COLLECTION
TABLE 8-3 GEM 2000 FIELD CALIBRATION PROCEDURES
TABLE 8-4 GAS MONITORING PROCEDURES
TABLE 9-1 LIST OF QUALIFIERS

E DATA QUALITY OBJECTIVES
LIST OF TABLES ..... APPENDIX E
TABLE 9-2 KCSWD DATA QUALITY OBJECTIVES

F MONITORING NETWORK
LIST OF TABLES ..... APPENDIX F
TABLE 5-1 GROUNDWATER MONITORING NETWORK
TABLE 6-1 SURFACE WATER MONITORING NETWORK
TABLE 7-1 LEACHATE MONITORING NETWORK
TABLE 8-1 LANDFILL GAS MONITORING NETWORK

1 INTRODUCTION

1.1 PURPOSE

The goal of the Sampling and Analysis plan is to describe the steps to follow to produce quality environmental monitoring data for the Vashon Island Closed Landfill (VLF) and to meet regulatory requirements set forth in WAC 173-351-410. This document describes the environmental monitoring and quality assurance/quality control (QA/QC) procedures used at the VLF. The procedures presented here include:

- sample collection and handling;
- sample preservation and transport;
- analytical procedures;
- chain-of-custody control; and
- field quality assurance and quality control.

1.2 RESPONSIBLE AGENCY

King County Solid Waste Division (SWD) is responsible for environmental monitoring at the facility. A trained field crew collects the samples and delivers them to a contract laboratory. The data review and analysis is performed by SWD staff. Reports are prepared quarterly and annually to present the data.

The activities presented in this Sampling and Analysis Plan (SAP) are intended to replace any other environmental monitoring guidance previously developed for the facility and to replace the Quality Assurance Project Plan (QAPP). The previous QAPP document applied to all King County Solid Waste Division facilities that are monitored. The protocols and procedures for sampling described herein supersede those in the QAPP and apply specifically to the Vashon Landfill. The SAP is based on currently available data regarding environmental characteristics at the facility and incorporates recently installed wells.

This SAP also provides a brief description of the partial closure and site improvements that were completed in 1989 and mentions the site investigations conducted at the landfill in 1995 and 1999 and the final closure construction completed in 2002.

1.3 ORGANIZATION

Implementation of this SAP is coordinated by an interdisciplinary team of KCSWD employees. The team consists of staff from KCSWD's Facilities Engineering and Science Unit (FESU), Operations, and Recycling and Environmental Services Section (RES). Team members possess expertise related to landfill operations, monitoring and sampling field methods, environmental chemistry and data analysis, and regulatory compliance. Team members work together to coordinate sample event scheduling, sample collection, quality assurance/quality control (QA/QC), data analysis, compliance analysis, and reporting.

2 PROJECT DESCRIPTION AND BACKGROUND

2.1 LOCATION

The Vashon Landfill is located at 18900 Westside Hwy SW, Vashon, WA (Figure 1).

The Vashon Landfill includes a 24-acre refuse fill area, located on three contiguous parcels totaling 59.29 acres in the west central portion of Vashon Island that is also the site of the Vashon Island Transfer Station (Figure 2). Most of the property exists in sparsely to unwooded, gently rolling terrain at elevations of 300 to 400 feet. The western portion of the property (west of Westside Highway SW) is undeveloped, forested land that slopes steeply towards Colvos Passage and includes an additional 4.8 acre parcel.

The Vashon Landfill site is within the Judd Creek drainage area with surface water draining towards the south. The undeveloped portion of the property west of 130th Avenue SW drains westward. Judd Creek discharges to Quartermaster Harbor and is one of Vashon Island's largest creeks. It has a drainage area of 3,149 acres with midsummer low flows of about 224 gpm (Carr, 1983).

The aquifer system underlying Vashon & Maury Islands is a designated sole source aquifer.

2.2 GEOLOGY AND HYDROGEOLOGY

Surficial till, which corresponds to Vashon till, mantles the site. The weathered till has a thickness of 15-50 feet throughout most of the landfill, but is absent in southern portions of the site. No wells monitor the Vashon till.

The outwash is underlain by a lacustrine silt layer that is interpreted to be laterally continuous beneath the site. This lacustrine silt is incised by fluvial sands and gravels. These sands and gravels are interpreted as channel deposits. Perched saturated zones identified beneath the Vashon Landfill occur in channel deposits (Cc1 & Cc2) within the uppermost lacustrine silt (Unit C). Groundwater in the deeper saturated zone occurs in sands and gravels within the lowermost Unit C channel deposits (Cc3) and within Units D and F. This deeper saturated zone is apparently hydraulically continuous with the regional aquifer. Units D and F are generally separated by an aquitard (Unit E). However, this aquitard has likely been removed by erosion beneath at least some portions of the site (specifically, at MW 25 and MW 26, see Figure 6). A deeper aquitard, Unit G, was encountered in only one boring (MW 7, see Figures 5, 7, and 8). Due to its limited distribution, the hydrogeologic effect of the Unit G aquitard beneath the Vashon Island Landfill site is limited.

Groundwater perched in or adjacent to the upper Unit C channel deposits (Cc1) is evaluated using wells MW 3, MW 4, MW 10, MW 13, and MW 24 (see Figures 4 through 8). All wells measure water levels within the Cc1 deposits, but not all wells produce sufficient water for sampling. Wells typically producing sufficient water include MW 10, MW 13, and periodically MW 3.

Wells MW 2, MW 9, MW 20, and MW 21 are completed within the middle channel deposits (Cc2) (see Figures 4 and 8). Well MW 8 is installed in silty sands that are beneath the middle channel deposits and are laterally equivalent with and adjacent to the lower channel deposits (Cc3) (see Figures 4 and 8). Groundwater in well MW 8 does not appear hydraulically connected with groundwater within the middle channel deposits (Cc2) nor the lower channel deposits (Cc3).

Four borings (MW 7, MW 12, and MW 19) were advanced to elevations between 8 and 40 feet to evaluate site stratigraphy at depth (CH2M HILL, 1996). These borings were completed as wells screened to intercept groundwater in Unit D (see Figures 4 through 8).

Five additional borings were advanced into Unit D and completed as monitoring wells during 2003 (B&H and UES, 2003a and 2003b). Of these, wells MW 25, MW 26, MW 29 were installed to screen groundwater in Unit D. Well MW 27 is constructed to screen the lower Unit C channel deposits (Cc3); the base of the well screen also penetrates the upper few feet of underlying Unit D deposits. Groundwater in MW 27 is interpreted as being equivalent with groundwater in saturated Unit D soils and therefore with the regional aquifer. Well MW 28 was installed to screen the contact between Unit D and Unit E; the elevation of this contact exceeds the water table elevation in Unit D at this location (see Figure 6).

Geologic cross-sections of the landfill (Figures 4 to 8) show the relationship of the geologic units beneath the site and the identified water-bearing zones. Channel Cc2 and the regional aquifer are the only water bearing units with sufficient information to produce potentiometric maps. Direction of groundwater flow within channel Cc2 was determined in the 2004 Update and subsequent quarterly potentiometric reports to be primarily westward. The direction of groundwater flow within the regional aquifer is indeterminate, with flow components potentially northward, westward and southward.

2.3 SITE HISTORY

Solid waste disposal operations have been ongoing at the landfill since the early 1900s. Operation of the landfill was taken over by the Solid Waste Division by the late 1950's (R.W. Beck and Associates, 1983) and daily cover, record keeping, and other updated solid waste management practices were initiated. In 1983, the first four groundwater monitoring wells were installed at the landfill. An analysis of various leachate collection system alternatives was performed in order to meet King County Solid Waste Regulations (KCSWR - Regulation No. 8). The selected design consisted of installing an impermeable cap and double liner over the existing refuse area, a passive gas collection system under this liner, a leachate collection and conveyance system, an aerated pretreatment lagoon, storm water control facilities (ditches, culverts, and siltation and detention ponds), and a venting and treatment system of flares. A bottom liner for the future refuse area was installed. These improvements were completed in 1989. The northwest 2.3 acres of the landfill received final cover in 1988-1990. Two piezometers were installed in 1992.

The existing groundwater monitoring network was supplemented by the installation of eight groundwater monitoring wells during the summer of 1995. Eight gas probes were installed around the perimeter of the refuse area to determine if gas migration was occurring at the landfill in 1995. Other improvements to the gas collection system included converting the system from passive to active and the conveyance and treatment system change from flares to activated carbon in 1996.

During fall 1998, two more wells were installed to provide supplementary monitoring of an extensive sand bed in the lacustrine silt. The interpretation of the site hydrogeology is presented in the Vashon Island Landfill Hydrogeologic Report (Berryman & Henigar et. al., 2000). This report addresses the requirements in Chapter 173-351-490 of the Washington Administrative Code.

In the summer of 2003, MW-6D, MW-6S, and MW-11 were decommissioned due to damage from the Nisqually Earthquake and four new wells and one piezometer were installed. The data from these wells was incorporated into the hydrogeologic interpretation in the Vashon Island Landfill Draft Hydrogeologic Report Update (Berryman & Henigar and UES, 2004). In April

2015 four additional wells were decommissioned: MW-1 had a broken casing, MW-5D and MW-5S due to poor construction, and MW-14 due to a stuck pump.

2.4 EXISTING MONITORING DATA

Groundwater, surface water, and leachate have been monitored at the site under the previous SAP/QAPP for an extensive list of parameters since 1986. Existing groundwater data includes analysis results for all WAC 173-351-990 Appendix I and Appendix II parameters dating back to 1995. Additional constituents have been analyzed for during regular monitoring under the previous SAP. This additional data consists of an extended list of inorganics, metals, and volatile organic compounds; and herbicides, pesticides, bacterial, and radiological parameters.

In 2003, Health and Ecology required that wells MW-20, MW-21, MW-2, and MW-5D (decommissioned in April 2015), - and MW-4be placed in assessment monitoring. Specifically, the Division was required to test for Appendix III parameters for two sampling rounds, one at seasonal high water and one at seasonal low water. To comply, the Division set up the 2003 sampling schedule for the Appendix III list for the second and fourth quarter sampling.

Analytes of concern in these wells have been volatile organics. No additional analytes have been identified in the Appendix III list. The predominant volatile organics seen are vinyl chloride and precursors cis- and trans- 1,2-dichloroethene, benzene and two freons, dichlorodifluoromethane and trichlorofluoromethane. The vinyl chloride is sporadically detected in two of the hillslope seeps as well.

Neighboring Wells

Several private drinking supply wells are located in the general vicinity of the landfill. In February 2002, the SWD conducted a survey and sampling of these wells. No landfill impacts were detected. As a precautionary measure the SWD continues to monitor two of these wells, potentially located downgradient of the landfill, twice per year starting in 2010. The wells are sampled using the groundwater sample collection procedures listed in Table 5-6 of Appendix D. No landfill impacts have been detected. The locations of these wells are shown in Figure 9.

3 DATA QUALITY AND FIELD QUALITY CONTROL

A sound quality assurance/quality control (QA/QC) program is essential to obtaining high-quality and well-documented measurement data. The objectives of QA are: a) to collect, process and analyze with consistent and correct techniques; b) to minimize the number of lost, damaged, and uncollected samples; c) to maintain and document the integrity of the data from sample collection to entry into the data record; d) to obtain comparable data; e) to obtain reproducible results.

3.1 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) are established to measure the success of the monitoring program. These measure accuracy, precision, representativeness, completeness and comparability. Each of these is evaluated in terms of criteria defined by laboratory results and adherence to established procedures both in the lab and in the field.

To maintain the quality of data collected at the site, this SAP incorporates Data Quality Objectives (DQOs) outlined below. To monitor the groundwater, samples will be collected from listed monitoring wells. Data Quality Objectives were considered during the design of the monitoring program to ensure that the data accurately and precisely represent the groundwater conditions at the site. Data Quality Objectives were previously discussed in detail in Quality Assurance Project Plan for Environmental Monitoring for King County Solid Waste Facilities (QAPP). This document supersedes the QAPP.

3.2 DATA QUALITY OBJECTIVES FOR OVERALL PROGRAM

Accuracy

Accuracy is defined as the degree of agreement between a measurement and an accepted or true value. Accuracy is frequently expressed either as percent recovery (R) or as percent bias (R-100). Accuracy is measured by the percent recovery of an analyte in a reference standard or spiked sample.

Accuracy is calculated by the following formula:

$$\%R = (Yi \div Xi) \times 100\%$$

where:

%R = percent recovery (accuracy) for compound i

Yi = measured spike concentration for known standard and measured - original sample concentration for matrix spike (analytical value)

Xi = known spike concentration of compound i (true value)

The calculated %R is compared to criteria and deviations from the specified criteria will be noted. The lab will provide an explanation of any deviation from the criteria and appropriate actions taken and noted. Percent recoveries are evaluated during data review and the reviewer will make any necessary comments on the effects on the reported data. See Appendix A for accuracy goals. Accuracy cannot be delimited for all parameters because of the nature of the measurements. Measurement of accuracy requires the use of reference materials which are not available for certain parameters. For some other parameters, spiking samples may not be practical.

Precision

Precision is the measure of reproducibility of individual measurements. Laboratory precision is calculated from duplicate measurements in the lab, including matrix spike duplicates. Field duplicates provide information on the entire sampling and analysis processes. Precision is measured by the relative percent difference between duplicate analyses. Laboratory duplicates provide for short term instrumental changes and therefore should be performed within a two hour period.

Precision may be expressed as relative percent difference (RPD) or relative standard deviation (RSD).

Precision will be calculated as the relative percent different (RPD) as follows:

$$RPDi = \frac{|Oi - Di|}{(Oi + Di) * 0.5}$$

where:

RPDi = *Relative percent difference for compound I*
Oi = *Value of compound i in original sample*
Di = *Value of compound I in duplicate sample*

The calculated RPD is compared to criteria and any deviations are reported. If the criteria are exceeded, the lab will provide an explanation of causes and a report of actions taken.

King County Solid Waste Division has not established quality control objectives for field duplicates. Field duplicates measure both lab and field precision and therefore may have greater variability than lab duplicates, which measure only lab precision. See Appendix A for precision goals. Precision cannot be delimited for all parameters because of the nature of the measurements.

Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population or parameter concentration at a sampling point or environmental condition of a site. Sample site selection, sampling methods, and analytical technique contribute to representativeness.

Representativeness is not quantified. Representativeness is determined by a comparison of quality control data to criteria and by confirming that sampling and analytical methods conform to established plans and procedures.

Sample representativeness is the extent to which a set of samples reflects the characteristics of a population, where each sample has an equal probability of yielding the same result.

Completeness

Completeness is a measure of planned versus actual valid results. The completeness of field activities will be calculated by representing the number of samples actually delivered to the laboratory as a percentage of the planned samples. Analytical completeness is the percentage of valid analytical results obtained compared with the total number of analytical results planned.

Completeness is calculated as follows:

$$C = A \div I \times 100\%$$

where:

C = Percent Completeness
A = Actual number of samples collected or analyses received

I = Planned number of samples or analyses

If the completeness goal is not met, the QA/QC officer and the sampling coordinator will use professional judgment to determine if the data are sufficient for the site objectives and the planned use of data. If the data are judged inadequate, additional field samples may be collected to accomplish the project goals. Decisions to repeat sample collection and analysis will be made by the laboratory services project manager. Some circumstances that can invalidate samples include: holding times, sample storage, sample preservation, insufficient sample volumes and breakage. See Appendix A for completeness goals.

Comparability

Comparability is the confidence with which one data set can be compared to another. Data are comparable if sample collection techniques, measurement procedures, analytical methods and reporting are equivalent.

Comparability is ensured by:

- Use of National Bureau of Standards or EPA traceable standards;
- Use of standard methodologies;
- Application of appropriate quality control; and
- Participation in interlaboratory studies to document laboratory performance.

Comparability is difficult to quantify; therefore a qualitative comparability assessment will be made for applicable data sets.

3.3 SAMPLING PLAN FAILURE RESPONSE ACTIONS

The appropriate staff person shall take failure response actions anytime errors, deficiencies, or out-of-control circumstances occur. Failure response action can be an immediate response to remedy a spontaneous or non-recurring problem such as equipment failure. Long-term response action is necessary to correct recurring problems. Any recurring or unresolved problem will be brought to the immediate attention of the appropriate supervisor or manager. Table 3-1 of Appendix D lists common problems and preventative response actions.

The interdisciplinary team will review the results of the failure response action and determine if further action is required. The interdisciplinary team supervisor or manager will notify the interdisciplinary team if sampling protocols require modification.

3.4 QUALITY ASSURANCE

Quality Assurance (QA) is a system of documented checks that validate the reliability of a data set. QA procedures are used to verify that field and laboratory measurement systems operate within acceptable limits. There is no substitute for high quality sampling and field measurements. A high quality set of hydrologic and chemical data is accurate, precise, representative, comparable, and complete.

All sampling activities will be traceable to the person collecting the sample and to the specific piece of sampling equipment used to collect that sample. All records (sampling logs, calibration logs, chain of custody, and field sheets) shall be kept so that they are traceable. The subsequent procedures will be followed:

- proper calibration of all sampling and field measurement equipment;

- use of field sheet to record field measurements and other pertinent information necessary to document what was done;
- review of field records including sampling logs by the field engineering project manager to assure that procedures are being followed;
- strict adherence to established field sampling protocols by the field engineers;
- proper preservation of all samples preserved immediately upon collection in the field;
- after collection, all sample handling will be minimized;
- follow chain of custody procedures.

3.5 QUALITY CONTROL

Quality control is the system of technical actions that measures the attributes and performance of field activities to control the quality of the measurement data. The aim is to provide quality that is satisfactory, adequate, dependable, and economical.

Detailed procedures for sample preparation, including preservation methods, sample storage, packing and shipment, sample designation, and sample records are discussed in the field protocols section (Section 4).

Quality assurance samples, excluding volatile trip blanks, make up 10 percent of all samples. Blank samples should be collected so that laboratory analysis can be performed to show that no container contamination occurred. Quality assurance samples include trip blanks, field blanks, duplicate samples, and equipment blanks.

3.6 CHANGES IN PROCEDURES

Any changes or deviations from procedures as outlined in this section will be documented on the field sampling sheet. Modifications of field procedures must be approved in advance by the interdisciplinary team..

3.7 FIELD QUALITY CONTROL SAMPLES

Quality control (QC) and quality assurance (QA) samples will be analyzed by a Washington State-certified environmental laboratory. The QA/QC samples originating in the field are field blanks, field duplicates, and equipment blanks. VOA trip blanks originate from the lab and travel from and back to the lab with the sample bottle set. QC samples, excluding VOA trip blanks, make up 10 percent of all samples. VOA trip blanks are collected at the rate of one sample per chain of custody.

VOA Trip blanks, field blanks, and field duplicates will be collected and submitted to the analytical laboratory to provide a way of assessing the quality of data resulting from the field sampling. Trip and field blank samples will be used to check for procedural contamination, cross-contamination, and contamination during shipment and storage of samples. All the blanks, duplicates will be submitted blind to the laboratory with sample labels that are indistinguishable from primary.

Specific field QC sample descriptions and sample collection frequency are discussed in the following sections. Table 3-2 summarizes the type and frequency of field quality control samples to be collected.

Table 3-2
Quality Assurance Samples

Sample Type	Frequency		
	Groundwater	Surface water	Leachate
Field Blank	Every 20 samples	Every 20 samples	Every 20 samples
VOA trip blank	Every sample cooler that contains VOA sample containers	Every sample cooler that contains VOA sample containers	Every sample cooler that contains VOA sample containers
Field duplicates	Every 20 samples	Every 20 samples	Every 20 samples
Equipment/ Rinsate blanks	Every quarter	NA	NA

3.7.1 TRIP BLANKS

3.7.1.1 VOLATILE ORGANIC ANALYSIS (VOA) TRIP BLANKS

VOA trip blanks are analyzed to determine if contamination has occurred during sample handling, shipping, or storage. VOA trip blanks are a sample set that is filled with organic-free water at the analytical laboratory. This set travels unopened with the volatile organic compound (VOC) bottles from the lab, and remains with the VOC samples during sampling and returning shipment to the lab. VOA Trip blanks are used for VOC analysis only. Each VOA trip blank will be inspected for bubbles and noted in the field sheet if any are present. Each VOA trip blank will be given a sample ID in accordance with the labeling protocol in order to identify which primary samples it accompanies. The sample ID will be recorded on the field sheet and chain-of-custody form. They are collected at the rate of one set per trip, per landfill per matrix to be analyzed for volatile organic compounds for all aqueous matrices.

3.7.1.2 FIELD BLANKS

Field blanks are analyzed to establish the effectiveness of decontamination procedures and to check for contamination resulting from sample collection, handling and shipping. At the end of the sampling event, field blanks are prepared in the field by filling the sampling bottles with distilled water and handled identically to samples. Field blanks are analyzed for the same parameters as primary samples. These blanks are collected across matrices at a frequency of one per every 20 samples to be analyzed. Each field blank will be given a sample ID in agreement with the labeling protocol in order to identify which primary samples it accompanies. The sample ID will be recorded in the field sheet and on the chain-of-custody form.

3.7.2 FIELD DUPLICATES

Field duplicates are used to evaluate precision, and to evaluate degree of contaminant variability within the sample matrix for non-homogeneous sample matrices. Field duplicates are collected from the same sample source and device by alternately filling like sample bottles for two sample sets until all containers are full. Samples are preserved, stored and analyzed under identical conditions. Duplicate frequency should equal or exceed 5% of primary samples collected across all aqueous matrices.

3.7.3 EQUIPMENT/RINSATE BLANKS

Equipment or rinsate blanks are distilled water used to rinse pre-cleaned sampling equipment prior to sampling operations. The rinsate blanks are handled identically as primary samples collected with that piece of equipment. This blank is used to determine if contaminants have been introduced by contact of the sample medium with sample equipment. Equipment blanks measure possible contamination of non-dedicated sampling equipment. When dedicated equipment is used, these blanks are not needed. If needed, equipment/rinsate blanks will be collected quarterly.

3.8 DATA REVIEW

Data is reviewed as received for accuracy, precision, representativeness, completeness, and comparability. Each of these is evaluated in terms of criteria defined by laboratory results and adherence to established procedures both in the lab and in the field.

Reports received from the lab provide laboratory QA/QC sample results including method blanks, duplicates, matrix spike/matrix spike duplicates, standard reference materials, surrogate recoveries, and blank spikes. At a minimum approximately 10 % of the QA/QC reports are comprehensively reviewed.

High quality data collection requires strict adherence to proven well construction, sampling, and analytical protocols developed with due precautions against bias, imprecision, contamination, or chemical alteration of the water sample. In this respect all field measurements involved in water sample collection are considered part of the sampling protocol. Quality control procedures built into sampling and analytical protocols will guard against the loss of data by minimizing both systematic and random error.

The overall effectiveness of the quality control checks in reducing errors should be audited by a person or technique outside of the normal sampling and analytical operations. In this way, the QA program will ensure that quality control (QC) procedures are followed on a daily basis to reduce variability and errors, identify and correct measurement problems, and provide a documented statistical measure of data quality. The effectiveness of the overall program demands that all personnel be aware of the QA/ QC requirements for the investigation and that the quality control objectives be understood.

4 MONITORING PROGRAM RATIONALE AND GENERAL GUIDELINES

4.1 PROGRAM DESCRIPTION

The overall objective of the monitoring program is to obtain quality data of sufficient and representative conditions to adequately monitor groundwater, surface water, leachate, and landfill gas at the Vashon Landfill. To achieve these goals, monitoring networks and parameter lists have been developed. Standard Operating Procedures (SOPs) have been established to conduct the field testing. These SOPs are presented in Appendix D of this SAP. The sampling program is also used to determine whether compliance with applicable regulations and permit conditions has been met.

4.2 SELECTION OF ANALYTICAL PARAMETERS

Parameter selection for chemical measurements is very important to the effective planning of sampling and analytical protocols. Groundwater, leachate and surface water have been sampled and analyzed for a comprehensive suite of inorganic and organic constituents since 1986. These monitoring efforts have provided extensive data, more chemical data than that required by the needs of the program.

The additional data has been used to further define site conditions and to characterize potential contaminants.

This revised Sampling and Analysis Plan incorporates what has been learned throughout the monitoring history. Existing data have demonstrated the extent of site-wide spatial variability and provided the basis to focus analytical efforts.

The parameters selected for the monitoring program consist of general groundwater quality parameters and specific chemical constituents, giving consideration to the relative mobility and persistence of the known components, as well as the potential transformation products. Additional parameters may be added to the list either to address water quality questions or to evaluate operational efficiencies. The removal of any parameters from this list requires a revision to this document.

The parameters selected for the monitoring program consist of inorganics, metals, and a suite of volatile organic compounds (VOCs), including compounds that were detected in leachate samples. Parameter lists for each matrix are included in the appropriate chapter. All analytes defined in Appendix I and Appendix II of WAC 173-351 are found included for groundwater or leachate as appropriate, with the exception of bicarbonate. Bicarbonate ion concentrations are derived from equilibria constants, pH and total alkalinity results. Speciation of carbonate forms by these means is done quarterly when calculating ion balances.

The analytes chosen provide an internal consistency check on major ionic constituents, field determinations, and the potential effects of unusually high levels of metals or nutrient anions. Major ion solution chemistry is valuable in obtaining an overall picture of the subsurface system of interest. The major ion chemistry determines the inorganic background and potential for matrix effects in analysis.

Leachate is one appropriate medium to characterize in order to define the potential for groundwater contamination. Understanding the character of leachate is critical for detection monitoring. The parameters chosen for leachate consist of all groundwater parameters listed in Appendices II and III of WAC 173-351.

Parameter lists were developed to achieve the following objectives:

- meet the requirements of WAC 173-351 and Wastewater Discharge Permit 7675-03,
- characterize the nature and variability of upgradient water quality,
- determine whether or not the operation of the landfill results in the contamination of groundwater, and
- determine whether concentrations of specific chemical constituents are within prescribed limits, and can be used to measure the effectiveness of corrective actions.

The analyte lists provide a degree of analytical detail that can be used to internally check for analytical error. They also provide a broad screening approach, which will detect a wide variety of chemical compounds that could reasonably be derived from Municipal Solid Waste (MSW) or as a result of interactions with MSW.

4.3 SELECTION OF MONITORING LOCATIONS

The monitoring networks for groundwater, surface water, leachate, and landfill gas have been established to meet the requirements of WAC 173-351 and to meet the terms of the Wastewater Discharge Permit issued by the King County Wastewater Treatment Division. The groundwater monitoring network was developed by a licensed hydrogeologist, as the result of several groundwater investigation efforts. The surface water monitoring locations have been selected to monitor run-on and run-off from the site. Surface expression of the groundwater along the western slope of the property is also monitored. The leachate locations provide characterization, treatment assessment and permit compliance. The landfill gas probe network was developed by professional engineers to detect any off site migration of methane. More specific discussion of these networks is included under each matrix section.

4.4 MONITORING FREQUENCY

Groundwater samples will be collected from designated monitoring wells on a quarterly basis. Frequency of monitoring will be increased to monthly in the event of new monitoring well installations in order to obtain an adequate sample population for statistical evaluation of data within one year of installation.

Surface water samples and leachate samples will be collected quarterly. Samples may be collected more frequently to further characterization or for evaluation of operational efficiencies. Any reduction of frequency in monitoring requires a modification to this document.

4.5 GUIDELINES

The value of any sampling program depends on the quality of the samples collected. The objectives of the sampling procedures are to minimize changes in the water chemistry during sample collection, transportation to the laboratory, and short-term storage (under 24 hours) and to maximize the probability of obtaining representative groundwater surface water and leachate monitoring data. The various physical parameters, measured before and during sampling, provide both scientific and legal evidence that the sample is representative of site conditions.

4.5.1 PREPARATION

The following procedures shall be performed before commencing field work:

- Check and calibrate equipment to make sure it is all there, it works, and is clean.
- Make sure all sample containers, coolers, ice, and other supplies are in good condition and ready for use. Check sample containers for loose, cracked, or missing lids and confirm that preservatives are present where required and have not leaked.
- Have recent historical information, permit information, and procedures available for reference.
- Before starting any sampling run, identify the constituents to be tested. This will allow efficient planning for equipment and materials. It is the Division's practice to pre-label sample bottles in order to ensure that all bottles are present in the sample kit. Pre-labeling of sample bottles helps to avoid confusion when testing more than one station at a time.
- Fill out the labels on each bottle with the following information: name of client (KCSWD), location, date, time, database sample ID, and field engineer's initials. Write legibly when filling out the labels, field records, and other information.

4.5.2 SAMPLE CONTAINERS AND PRESERVATION

All sample containers will be supplied by the Contract Laboratory. Sample containers will be provided in accordance with guidelines noted in Table 4-1 of Appendix B. These containers will be pre-washed and prepared for sampling and contain appropriate preservatives in accordance with standard operating practice of the Laboratory. Samples must be collected, filtered (for dissolved metals in groundwater, surface water and leachate), preserved, and delivered to the laboratory within 24 hours of collection. Per update to WAC 175-351 8 sampling rounds will be collected for both total and dissolved metals. Subsequent samples will be collected for total metals.

4.6 RECORDS

Adequate records must be maintained for each sample collected. All information should be legible. Preciseness and thoroughness in all paperwork and bottle labeling is important.

4.6.1 SAMPLING FIELD RECORDS

Sampling Field Records are used to record a variety of information regarding samples collected and items noted in the field. Field sampling information may help to identify unusual field conditions which can affect both the sampling and the condition of the samples. The following items should be noted during field sampling activities:

- Weather conditions
- Sample station
- Sample location
- Sample type and sample number
- Time and date of sampling
- Sampling method used (i.e., "grab" or dedicated pump)

- Sampling information regarding each specific sample
- Size, type, and quantity of sample containers
- Note if field filtration of the sample is performed
- Preservations (if any) used
- Thermal preservation (i.e., ice)
- Field parameters

Field Parameters monitored during the sampling typically include: pH, temperature, specific conductance, dissolved oxygen, redox, and turbidity. Any unusual conditions noted in the collected samples should also be recorded. The following conditions could indicate a change in water quality at the sample location:

- Sample color
- Sedimentation or turbidity in the sample
- Oil or sheen on the surface
- Separate phases
- Odor, etc.

Other information included on the field records or significant at the time sampling should be noted, including:

- Reason for sampling:
  - Routine scheduled sampling
  - QC samples (blanks, duplicates)
  - Resampling following constituent exceedance
  - Etc.
- Special problems due to unusual conditions (spills, undocumented flow, etc.)
- Other side data, such as well depth and depth to water surface

4.6.2 SAMPLING LOGS

Records describing observations made at the site and other information may be very helpful in interpreting sample results. Describe the sample location and any unusual conditions at the station. This information can be helpful in refreshing the sampling technician's memory later.

4.6.3 LABELS

Place a label on each sample container with the following information: name of client (KCSWD), location, date, time, database sample ID, and field engineer's initials. Write legibly when filling out the labels, field records, and other information. Sample IDs will be according to KCSWD standards, which consist of an 11-digit labeling convention:

- Digits 1-4: Consist of the media type and sampling location.
  - Media type is typically the first digits, and includes groundwater (W), surface water (S), or leachate (L).

    - The sampling location is typically a 3-digit number (digits 2-4); however, shallow or deep sampling locations are distinguished by “S” or “D” respectively. If the sampling location is only a 2-digit number, a “-“ is used for the third digit.
    - “VTRP” is used for the media type and sampling location for volatile organic compound trip blanks.
- Digits 5-10: Consist of the sampling date.
    - Digits 5-6 are the 2-digit year.
    - Digits 7-8 are the 2-digit month.
    - Digits 9-10 are the 2-digit day.
- Digit 11: Is indicative of field duplicates or trip blanks.
    - A “-“ is used if the sample is not a field duplicate or a trip blank.
    - A”D” is used if the sample is a field duplicate.
    - Either an “-“, “B”, or “C” is used if the sample is a volatile organic trip blank.
    - A “F” is used if the same is a field blank
    - Q is for Quarterly samples (only used for surface water and leachate)
    - P is for Permit samples (used for leachate samples).

4.6.4 CHAIN-OF-CUSTODY

The field engineer is responsible for the care and custody of the samples collected until properly delivered to the receiving laboratory. The team must ensure that each container is:

- In their physical possession,
- In their view at all times, or
- Stored in a locked place where nobody can tamper with the containers.

A chain-of-custody form must be filled out by the Field Engineer Team and laboratory personnel to assign responsibility for possession of the sample at all times. This procedure tracks the sample status from the point of sample collection to completion of the laboratory analyses. Most importantly, responsibility for sample integrity is placed on a single individual at all times. This procedure becomes particularly important if the sampling protocol and analytical determination are ever challenged in litigation.

Proper chain-of-custody procedures play a crucial role in enforcement cases. The following are some basic guidelines of legal significance:

- As few people as possible should handle the sample.
- Chain-of-custody records must accompany the sample. The chain-of–custody record should contain the sample I.D., date and time the sample is collected, the sample location, analysis required, the name of the person(s) collecting the sample, and the time, names and signatures of each individual who had possession of the sample.
- The Field Engineer Team is responsible for the care and custody of the samples collected until custody has be relieved and documented by laboratory personnel.

A four-part chain-of-custody document is used. The lab keeps all original chain-of-custody documents.

4.7 RESIDUALS HANDLING

All waste generated during Environmental monitoring will be managed appropriately. Miscellaneous disposable equipment will be placed in plastic trash bags and disposed of at Cedar Hills.

Water generated during well purging and sampling will be discharged to ground away from the well head. Purge water from wells with landfill impacts will be stored in drums for disposal to a wastewater treatment facility or can be disposed of in the on-site leachate pond.

5 GROUNDWATER

5.1 MONITORING NETWORK

Groundwater monitoring well networks are recommended in the Vashon Island Hydrogeologic Report Update. Table 5-1 of Appendix F lists the monitoring wells to be included in the program in the 2004 Hydrogeologic Report Update. Figure 10 shows the locations.

5.2 ANALYTICAL PARAMETERS

Analytical parameters are selected in compliance with WAC 173-351, Appendices I & II. Additional parameters have been added. These include mercury, for consistency with historical data, and dichlorodifluoromethane as the single Appendix III compound detected during assessment monitoring. Specific conductance, pH, oxidation reduction potential (ORP), dissolved oxygen (DO), turbidity, and temperature are measured in the field. Analytical methods used by the contract lab and method detection limits are listed in Table 5-2 of Appendix A.

5.3 ASSESSMENT MONITORING

Assessment monitoring is required when evaluation of the groundwater data indicates the presence of an analyte at a statistically higher concentration than background. WAC 173-351-440 calls out the requirements for assessment monitoring. The parameter list is expanded to encompass all of Appendix III analytes. After the initial sampling rounds, WAC 351-440 (3) requires that testing continue for all Appendix I and II parameters, and any Appendix III parameters that were detected. For the assessment monitoring wells at Vashon, dichlorodifluoromethane was the only Appendix III analyte detected, and has been added to the parameter list as reflected in Table 5-2 of Appendix A. All the same field protocols are required. The following wells at Vashon Landfill have been determined to be in assessment monitoring:

- MW-20
- MW-21
- MW-2
- MW-4

Since 2000, MW-4 has only produced enough water to sample twice, once in May and November of 2007, and will be sampled for the assessment monitoring parameter list if water levels rise sufficiently.

Surface water samples collected from surface water site SW-E and seeps SW-W1, SW-W2 and SW-W3 are also analyzed using the assessment monitoring parameter list.

5.4 GROUNDWATER MONITORING

Prior to initiating a groundwater sampling trip, review the most recent field sheets for the wells being sampled. Note which wells recover from pumping slowly and plan to sample those wells first.

Sample Bottles

Sample bottles used for groundwater sampling are listed on the Groundwater Sampling Field Record (refer to Appendix C). This field record also lists the bottle type and required preservatives.

It is the Division's practice to provide the testing laboratory with a monthly schedule of sampling events. Check with the lab to be certain bottles will be available when needed.

Groundwater Monitoring Equipment

The equipment needed for sampling a groundwater monitoring well is summarized in Table 5-3 of Appendix C. The Field Engineering Unit is responsible for maintaining sampling equipment and supplies.

5.5 GROUNDWATER SAMPLE COLLECTION

A number of steps must be completed prior to collection of groundwater samples. These include inspection of the well, measurement of the depth to water in the well, and stabilization of specified parameters via low-flow sampling techniques.

5.5.1 WELL INSPECTION AND MAINTENANCE

After arriving at a well, observe the condition of the well's exterior. Verify that the steel casing is intact, the well is identified, and the casing is locked. If not found as expected, make notes on the field sheets. Open the casing lock and check the condition of the well. Record any evidence of insects, spiders, slugs, etc. Also note if there is water in the annulus (the space between the PVC and protective steel casing). Record maintenance performed and any maintenance required on the field sheet. Care must be exercised to ensure maintenance procedures do not create possibility of introducing contaminants to the well or sample. However, if the well or the pump used for sample collection requires maintenance that cannot be performed at the time of sampling, notify the interdisciplinary team. If the problem can be fixed in a timely manner, the well will be resampled prior to the following quarter. A sample is not to be collected if the equipment is compromised.

5.5.2 MEASUREMENT OF DEPTH TO WATER

Water level measurements are used to evaluate water-level fluctuations over time and the groundwater flow system. Table 5-4 of Appendix D summarizes the procedure for measuring the depth to water in a well. Measure the static water level of all wells prior to initiating sampling at the first well, on the first day at the facility. This provides the water levels for the quarterly potentiometric mapping.

5.5.3 LOW-FLOW PURGING

Wells will be sampled using low-flow sampling techniques. Low-flow (minimal drawdown) sampling was developed in order to minimize well and aquifer disturbance, sampling time, the amount of wastewater generated, and specifically identify when steady-state conditions have been reached, in order to collect a representative groundwater sample. Detailed procedures for low-flow sampling are provided by Puls, et al. (1996) and the American Society for Testing and Materials (ASTM) D6771-02. Table 5-6 of Appendix D summarizes the stabilization requirements needed to identify when steady-state conditions have been reached during well purging prior to groundwater sample collection using low-flow techniques.

Stabilization is defined as three successive readings taken 3 minutes apart within the above specifications. Turbidity is not listed in the ASTM method and will be measured prior to the

collection of the groundwater sample. Temperature will also be monitored, but can be affected by air temperature and solar radiation. During well purging, the flow rate will be monitored and the total volume of water purged will be calculated. All field parameters will be recorded electronically. Groundwater field parameters must be measured and confirmed as stable before the well is sampled.

5.5.4 SAMPLE COLLECTION AND HANDLING

Groundwater sample collection will take place immediately following stabilization of the specified parameters via low-flow sampling techniques. Table 5-6 of Appendix D summarizes the procedure for collection of groundwater samples using low-flow sampling techniques.

5.6 ADDITIONAL GROUNDWATER MONITORING

Any additional groundwater quality data collected at the Facility during other activities also will be appended to the Annual Report. A synchronic set of water level measurements will be taken from the entire monitoring well network on a quarterly basis, at a minimum, but not necessarily coincident with water quality sampling intervals. The synchronic water level measurements will be taken prior to the quarterly monitoring. Measurements will be taken at all wells on the same day. If any problems at a well restrict the ability to take the water level measurement, the measurement will be taken at the next monitoring event after the problem is addressed. The results of quarterly, as well as any additional water level measurements, will be reported as elevation data and selected intervals plotted on contour maps in the Quarterly Report.

Two domestic private water supply wells are monitored in the vicinity of the landfill (Figure 9). The monitoring is conducted by SWD field engineers, and follows the groundwater protocols of this SAP. These wells have shown no landfill impacts.

6 SURFACE WATER

6.1 SURFACE WATER MONITORING OBJECTIVE

The objective of the surface monitoring program is to comply with surface water requirements of WAC 173-351.

6.2 MONITORING NETWORK

Run-on collects in a detention pond at the north end of the landfill area, identified as the "Borrow Area Stormwater Pond" in Figure 11. This pond discharges to surface channels that also collect the surface runoff from the closed landfill and flows to a detention pond in the southwest corner of the site. Surface water from the transfer station is routed through a series of three detention ponds on the transfer station property and is then discharged to the pond in the southwest corner. From the pond, it is routed underground to a discharge point at the south end of the site into a tributary of Judd Creek.

Discharge from undeveloped springs, referred to as seeps, occurs along the hillside to the west of the site. These discharges represent groundwater and must also be protective of the surface water of the unnamed stream into which they flow. These seeps are referred to as Spring 1, 2, or 3 in Section 2.2, Hydrogeology, and as monitoring locations SW-W1, SW-W2, and SW-W3 in the monitoring program.

In order to adequately monitor the surface water at the site, monitoring stations have been established. SW-W1, SW-W2, and SW-W3 monitor the seeps on the slope to the west of the landfill. SW-E monitors the potential downstream impacts on the unnamed stream into which they flow. Table 6-1 of Appendix F identifies the monitoring locations and purposes. Figure 11 shows the locations.

6.3 ANALYTICAL PARAMETERS

The analytical parameters are selected to be consistent with groundwater parameters for comparison at the seeps along the hillside. Additional parameters for comparison with surface water standards are included. Sampling is completed for both total and dissolved metals. The parameters analyzed by the contract lab for total metals are listed in Table 6-2 of Appendix A. The parameters analyzed by the contract lab for dissolved metals are calculated with Table 6-5 of Appendix A. The measuring of pH and specific conductance are completed as field parameters.

6.4 SURFACE WATER SAMPLE COLLECTION

6.4.1 SAMPLE BOTTLES

Sample bottles used for surface water sampling are listed on the Surface Water Sampling Field Record (refer to Appendix C).

It is the Division's practice to provide the testing laboratory with a monthly schedule of sampling events. Check with the lab to be certain bottles will be available when needed.

6.4.2 SURFACE WATER MONITORING EQUIPMENT

The equipment needed for sampling surface water is summarized in Table 6-3 of Appendix C. The field engineer is responsible for maintaining sampling equipment and supplies.

6.4.3 SURFACE WATER SAMPLE COLLECTION

Surface water sampling techniques and equipment are designed to minimize effects on the chemical and physical integrity of the sample. If the guidance that is provided in this section is followed, a representative sample of the surface water will be obtained.

It is important to minimize the disturbance of sediments from the bank or stream bed, because this may bias sample analysis. It is also important to note the clarity conditions of the water prior to collection.

- Determine the location for sample collection.
- Evaluate a stable surface near the sample collection location to place field notebook, sample jars, field forms, any meters or probes, and other miscellaneous equipment.
- Put on new, clean, disposable nitrile gloves. Move to the sample collection location and face upstream. Allow any sediment to pass the collection point prior to collecting a sample. A plastic container will be used to collect samples for field parameters and for transfer to sample bottles. The container should be rinsed twice with the sample water prior to collection of the sample. Use of a transfer container prevents overfilling and loss of preservatives in sample containers.
- Avoid allowing sediment, algae, weeds, etc., to enter the sample container.
- When sample vial is filled, replace cover and fill next vessel if required.

Table 6-4 of Appendix D summarizes the procedure for collection of surface water samples.

7 LEACHATE

7.1 LEACHATE MONITORING OBJECTIVE

The leachate monitoring program is designed to address several objectives. Monitoring requirements are defined in WAC 173-351, and in the Wastewater Discharge Permit 7675-03 issued by King County Wastewater Treatment Division. The monitoring program additionally provides data to evaluate the leachate pretreatment aeration and provides characterization data for characterization of groundwater impacts.

7.2 MONITORING NETWORK

The objective of leachate monitoring is threefold. The leachate is delivered to the King County wastewater treatment system and needs to comply with permit conditions. Additionally, leachate is monitored for characterization and aid in identification of any impacts. Leachate is monitored after aeration pretreatment to assess treatment effectiveness.

Leachate is monitored at three locations at the site. Characterization monitoring samples are drawn from a system junction box, prior to aeration. Leachate samples are also collected post aeration and again at tanker discharge, for permit compliance. Table 7-1 of Appendix F describes the leachate monitoring locations. Figure 12 shows the locations.

7.3 ANALYTICAL PARAMETERS

The analytical parameters for leachate are summarized in Table 7-2 of Appendix A. The table includes analytical parameters that are selected for characterization and comparison with groundwater, to comply with WAC 173-351 Appendices II and III. and to comply with the wastewater discharge permit. The metals are analyzed for total and dissolved factions for leachate characterization purposes. The measuring of pH and specific conductance are completed as field parameters.

7.4 LEACHATE SAMPLE COLLECTION

Leachate is sampled quarterly at station B for characterization and quarterly at station P for pretreatment evaluation. Station T is monitored for compliance with permit conditions quarterly, when the leachate is delivered to Metro. Leachate monitoring procedures, including sample bottles, monitoring equipment, and sample collection, are described in this section.

Prior to initiating a leachate sampling trip, examine the previous field test results. Highlight significant inconsistencies in current and previous field test results on the field sheet.

7.4.1 SAMPLE CONTAINERS

Sample containers required for leachate sampling are listed on the Leachate Sampling Field Record (refer to Appendix C).

It is the Division’s practice to provide the testing laboratory with a monthly schedule of sampling events. Check with the lab to be certain bottles will be available when needed.

7.4.2 LEACHATE MONITORING EQUIPMENT

The equipment needed for sampling leachate is summarized in Table 7-3 of Appendix C. The Field Engineer is responsible for maintaining sampling equipment and supplies.

7.4.3 LEACHATE SAMPLE COLLECTION

Leachate sampling techniques and equipment are designed to minimize effects on the chemical and physical integrity of the sample. If the guidance that is provided in this section is followed, a representative sample will be obtained.

A plastic container can be used to collect samples and transfer to sample bottles. The container should be rinsed twice with the sample water prior to collection of the sample.

Avoid allowing debris, vegetation, insects, sediment, etc., to enter the sample container. If sample containers are preserved, avoid overfilling containers, and coming in contact with the preservative. When sample vial is filled, replace cover and fill next vessel if required. Table 7-4 of Appendix D summarizes the procedures for collection of leachate samples.

8 LANDFILL GAS

8.1 LANDFILL GAS MONITORING OBJECTIVE AND NETWORK

The objective of landfill gas monitoring is to detect any offsite migration of explosive levels of methane and to ensure that explosive levels of methane are not present in onsite structures. Landfill gas is monitored by landfill gas technicians at perimeter probes surrounding the site and at established ambient air locations. Testing of the landfill gas collection system is also done by the landfill gas technicians but is not explicitly covered in this SAP. Table 8-1 of Appendix F lists the landfill gas monitoring compliance probes and ambient stations. Figure 13 shows the locations.

The monitoring of LFG probes is necessary to determine compliance with regulations established by the Washington State Department of Ecology (Ecology) and Public Health – Seattle & King County (Public Health). The regulations state that methane concentrations at the property boundary or beyond shall not exceed the lower explosive limit (LEL) for methane (typically five percent, by volume) and shall not exceed 25 percent of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components).

Site compliance is determined by the concentration of combustible gas (measured as methane) detected at the LFG probes located along the property boundary. Only qualified personnel trained in the proper use and calibration of the monitoring instruments should perform probe monitoring.

The transfer station and facility structures were built to comply with the Board of Health Solid Waste Regulations Title 10.09.060 for construction standards for methane control. A landfill gas barrier is installed beneath the facility structures, to prevent methane intrusion into the structures.

Monitoring data from the probes are also used to evaluate the performance of the LFG collection system and will indicate if any operational adjustments to the system are required. This document does not discuss the monitoring that is performed to evaluate the LFG extraction system performance.

8.2 LANDFILL GAS MONITORING

8.2.1 EQUIPMENT

The equipment needed for LFG monitoring is presented in Table 8-2 of Appendix C. Because probe data are used to evaluate and determine site compliance, monitoring equipment must be routinely maintained and calibrated in accordance with the manufacturer's recommendations.

The Landtec GEM 2000 meter should be calibrated prior to each use and checked immediately following each use. If used continuously over several hours, the instrument's calibration should be checked at least once during the monitoring period. The procedures for calibrating the Landtec GEM 2000 meters are presented in Table 8-3 of Appendix D.

8.2.2 PROCEDURES

Table 8-3 of Appendix D presents the step-by-step procedures for calibrating the gas meters. Table 8-4 of Appendix D presents the procedures for monitoring the LFG probes and the procedures for on-site monitoring. The monitoring procedures are appropriate when using a

Landtec GEM 2000 portable combustible gas/oxygen meter. Other manufacturers may have their own recommended procedures. Always refer to the instrument manufacturer's manual for operational instructions.

8.2.3 MAINTENANCE

Ecology and Public Health regulations suggest a minimum post-closure period of as long as necessary for the landfill to become functionally stable for LFG control monitoring. LFG probes would likely remain in place several decades past the landfill's final closure. Maintaining the physical integrity of the gas probes is essential to the success of the monitoring program. LFG probes generally require very little maintenance. Most of the probe is below ground, making the only portion requiring attention the security casing and its surrounding area.

The security casings used on the LFG probes are fabricated from cold steel. Because they are constantly exposed to the elements, rust can be a concern over time. All probes should be inspected yearly and the following tasks performed as needed:

Probes showing evidence of deterioration should be cleaned, rust deposits removed, primed, and coated with a rust-inhibiting paint.

Identification numbers should be re-painted and kept legible at all times.
Security locks should be kept clean and key assemblies lubricated.
Excess vegetation should be cleared around the probes to allow for easy access.
Vehicular access to the probe locations must be maintained.

8.2.4 REPLACEMENT

If a probe is destroyed and must be replaced or relocated, Public Health and other regulatory agencies having jurisdiction should be notified. Before replacing the probe, a letter should be submitted to Public Health identifying the probe being replaced, the reasons for its replacement, and its new proposed location and details. Following work completion, a second notification should be sent showing the probe's new location and completion details.

8.2.5 FREQUENCY

Parameters typically measured at the LFG monitoring probes include methane concentration, oxygen concentration, carbon dioxide concentration and static pressure. Compliance monitoring of the LFG monitoring probes is performed quarterly.

8.2.6 RECORDKEEPING AND REPORTING

Field record forms are used to record a variety of information regarding the samples collected and items noted in the field. All collected monitoring data should be field-recorded for later transfer onto permanent forms or for entry into a computerized database. Currently, copies of monitoring data are submitted to KCSWD Facility, Engineering and Science Unit staff so that quarterly and annual reports can be prepared. Immediately following probe monitoring, the data collected should be evaluated and any corrective actions determined. These actions are based on the methane concentrations measured at the probes.

8.2.7 FACTORS THAT AFFECT PROBE READINGS

In general, two factors can affect LFG migration and probe readings. They are barometric pressure and the operation of an active LFG extraction system within the landfill. Changes to either of these can impact lateral LFG movement within the soils.

Barometric Pressure

At most landfills, changes in barometric pressure, either diurnal or weather-based, can impact LFG migration. Typically, probe static pressures change between relatively high positive pressure to negative pressure of equal magnitude with changes to barometric conditions. LFG migration due to changes in barometric pressure can be controlled using the LFG extraction system.

8.2.8 RESPONDING TO MONITORING RESULTS

If monitoring probe methane concentrations are below the LEL (five percent, by volume), the landfill complies with the regulations for methane concentrations at the property boundary. Monitoring probe methane concentrations that are greater than the LEL require the LFG Crew to make same day corrections to the LFG collection system based on the monitoring session data. The Operations Supervisor and the LFG Crew will make same day corrections to the LFG collection system based on the monitoring session data prior to the end of the day. As required by WAC 173-351, the Operations or FESU Supervisor will immediately notify the SKCDPH, provide them with the methane concentration, location of the probe and next steps for mitigation. The LFG control system shall be monitored to determine if further mitigation steps are needed. After each event the notification process followed shall be documented for the landfill gas probe monitoring program files, and provided to the Operations and FESU Supervisors.

Since probe monitoring results may need to be incorporated into outside agency reports or reformatted for other purposes, all data needs to be recorded in an electronic format including but not limited to Routine Field Notes, instrument logged readings, calibration sheets, equipment inventory sheets, and equipment maintenance logs. Electronic format data files will be transmitted to supervisors and site engineers within one business day.

9 DATA EVALUATION PROCEDURES

Environmental samples are collected, analyzed, and evaluated by the procedures described in the Sampling and Analysis Plan for Environmental Monitoring at Vashon Landfill. This document describes the review of the results for data quality, the selection of parameters for further analysis, and the statistical analysis of those selected parameters. These procedures are used for sample results for groundwater, surface water, and leachate.

This document describes the data reports that are regularly generated and responsibilities for those reports.

9.1 DATA WORKFLOW AND MANAGEMENT

This section briefly describes the flow of data from initial sample collection to entry into the environmental database.

The samples are collected and delivers to the lab. The lab sends a sample receipt acknowledgement to FESU. After verifying that the sample identification and parameter list are correct, the sample information is entered into a spreadsheet, which is used to track samples. If any inconsistencies or errors are identified, corrective actions are taken, potentially leading to rejection of the sample and re-sampling. Any corrections are coordinated with and transmitted to both FESU and the lab. Copies of the chain of custody (COC) and field data sheets are submitted for data entry into the environmental database. The data is received as an Electronic Data Deliverable (EDD) in addition to a PDF format copy of the result. The EDDs are visually scanned for errors and then uploaded into the database. The database has checks in place to minimize the potential for entry of erroneous data and verifies that all reference values exist in the database. The database also requires parent records, to prohibit entry of unassociated data. If errors are found, corrections are requested from the lab and are entered after receipt. After all the data for the quarter, including corrections, has been entered or uploaded, data export reports are generated for further evaluation.

Data export reports for groundwater sample results are reviewed and compared with standards and criteria. Any exceedances are tabulated for the next quarterly report. More in-depth analysis is performed for parameters of importance. The selected parameters and justification for their selection is described in Section 9-3 and the specific analyses and methods are described in Section 9-4.

Laboratory QA/QC data is reported electronically. The QA/QC sample results are uploaded into the database along with the sample results. Any inconsistencies in the data, unusual exceedances, or values that are observed to be inconsistent with historical data trigger a review of the associated QA/QC data. If this review does not explain the inconsistency, the lab is contacted. The lab will then verify the result and make any appropriate corrections. This same process is employed any time during the data evaluation when a result is inconsistent with historical data or other data from the same sample.

Data is exported from the database for the requested time period for the rest of the data evaluation methods.

Ecology maintains its own database Environmental Information Management (EIM). Uploading data to Ecology’s EIM has been postponed due on-going EIM database upgrades.

9.2 DATA EVALUATION PARAMETERS

This section discusses the analytes used to characterize the groundwater and to indicate whether landfilling impacts the groundwater quality. Also, the graphical methods used to represent the data are described. The statistical methods used to evaluate the analytical data are described in the following section.

Environmental samples are routinely analyzed for chemical constituents including conventionals, metals, and volatile organic compounds (VOCs) as prescribed by WAC 173-351 Appendix I & II. Field measurements include depth to water, well purge volume, pH, specific conductance, and temperature. Some of these analytes are useful in characterizing groundwater quality, as indicators of impacts to groundwater from landfill gas and leachate, or in screening for potentially harmful effects to human health and the environment. It is these analytes that the data evaluation focuses on.

Indicator parameters evaluated for groundwater quality include pH, specific conductance, total dissolved solids (TDS), total alkalinity as $CaCO_3$, ammonia-nitrogen, nitrate-nitrogen, chloride, sulfate, dissolved iron, and dissolved manganese. The evaluation of these parameters includes presentation of descriptive statistics and results of trend testing.

Calcium, magnesium, potassium, and sodium are regularly detected, common constituents found in groundwater in contact with native lithology. Their primary value is for general groundwater quality characterization and analytical correctness (ion balance). A secondary use is as an adjunct to contaminant fate and transport evaluation. A statistical summary and trend testing results are presented for these parameters as well. This information will most likely be redundant to the findings based on indicator parameters.

Arsenic is evaluated because of occasional exceedances of water quality standards. Arsenic occurs naturally in local soils and was widely dispersed in surficial soils in the Puget Sound area from stack emissions of the former Asarco smelter in Ruston, WA. Vashon Landfill lies approximately 10 miles north of the former smelter site.

Volatile organic compounds are evaluated on a case by case basis after confirming that their presence in groundwater is not the result of laboratory or field contamination.

The following descriptions discuss the value of analytes used in the evaluation of ground water quality.

The evaluation of these parameters includes detection frequency presentation of median concentrations and results of trend testing. Evaluation of parameters with associated regulatory limits includes comparison to those standards.

9.2.1 RETESTING PLAN

In the event that a foreground concentration exceeds the UPL in the detection monitoring program, then a retesting plan is implemented to confirm that the detection was not a false positive. The most common type of retesting plan is a 1-of-m retesting plan, which indicates that if the initial analytical result exceeds the UPL, then up to (m-1) resamples may need to be collected in order to verify that the initial exceedance was a false positive (EPA, 2009). For example, for a 1-of-4 retesting scheme, if the initial analytical result exceeds the UPL, then up to 3 resamples shall be collected in order to verify that the initial exceedance was a false positive. Another type of retesting plan is the Modified California retesting plan. For the Modified California retesting plan, unlike the 1-of-m retesting plans, if the initial analytical

result exceeds the UPL, a majority (2 of 3) resamples need to be below the UPL in order to verify that the initial exceedance was a false positive.

Based on the Unified Guidance for Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Unified Guidance; EPA, 2009), any retesting scheme must allow sufficient time to elapse between resamples so that the resamples can be assumed to be statistically independent. The Unified Guidance also states that several authors, including Gibbons (1994) and ASTM (2004) have recommended that sampling, or in this case resampling, be conducted at not less than a quarterly interval in order to avoid temporal dependence.

9.2.2 ASSESSMENT MONITORING AND CORRECTIVE ACTIONS

An assessment monitoring program is required if the retesting plan confirms the Upper Prediction Limit (UPL) exceedance in the detection monitoring program. This section describes the assessment monitoring program and the process for follow-up corrective actions. A flow chart is presented in Figure 14 showing the monitoring and reporting requirements. In assessment monitoring, compliance is evaluated by comparison with groundwater protection standards (WAC 173-200).

As per WAC 173-351-440, assessment monitoring is required whenever a statistically significant increase over background has been detected for any of the Appendix I parameters. In the case of Vashon Island Closed Landfill, this would occur following the initial exceedance of an intrawell UPL for wells within Cc3 and an interwell UPL for wells within Cc2 (Section 9.3.6) and completion of the subsequent retesting program (Section 15.4.3.6). If the initial exceedance of the intrawell or interwell UPL has not been demonstrated to be a false positive by the retesting program, then a statistically significant increase over background conditions has occurred and assessment monitoring is required. The SKCPH must be notified of the exceedance within 14 days of completion of the retesting program. The first step following the retesting program is to investigate if a source other than the facility has caused the condition. This demonstration must be made within 90 days. If the demonstration cannot be made, then an assessment monitoring program must be initiated.

Assessment monitoring must be initiated within 90 days of a confirmed statistically significant increase over background conditions (WAC 173-351-440). Under the terms of the current MSW Handling Permit, approval for the assessment monitoring program must be obtained from SKCPH and Ecology. Assessment monitoring will consist of the initial sampling of the exceedance well and monitoring wells downgradient of the exceedance well for the WAC 173-351 Appendix III analytical parameters. A subset of wells may be agreed upon (WAC 173-351-450(1)(c)). KCSWD will provide a demonstration to the agencies per WAC 173-351-450(3) to remove Appendix III parameters. The appropriate suite of analytical parameters will be reviewed and ultimately approved by the agencies and KCSWD. . For any Appendix III analytical parameter detected, a minimum of 4 additional samples will be collected within 180 days, at not less than a 1-month interval, for the wells downgradient and upgradient (background) of the exceedance well in order to establish background conditions (intrawell/interwell UPLs) for the respective Appendix III analytical parameters.

Following establishment of the background conditions, groundwater protection standards will be established per WAC 173-200, and any detected Appendix III parameters will be added to the quarterly groundwater monitoring program (assessment monitoring program) for both the respective downgradient and upgradient monitoring wells. The SKCDPH must be notified of any Appendix III analytes detected in the background monitoring within 14 days and a notice placed in the operating record. If during the quarterly groundwater assessment monitoring program, the

Appendix III analytical parameters are shown to be at or below background conditions (intrawell/interwell UPLs) for 2 consecutive sampling events, the SKCDPH will be notified and approval obtained for returning to the quarterly groundwater detection monitoring program.

If during the quarterly groundwater assessment monitoring program, the Appendix III analytical parameters are above background conditions (intrawell/interwell UPLs), but below the established groundwater protection standards, the quarterly groundwater assessment monitoring program must be continued. If during the quarterly groundwater assessment monitoring program the Appendix III analytical parameters are above background conditions (intrawell/interwell UPLs), and above the established groundwater protection standards, the SKCDPH must be notified within 14 days.

At this point, if a demonstration can be made that the contamination was caused by an off-site source or that the statistically significant increase resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality, then SKCPH would be notified and approval obtained to return to detection monitoring. If the demonstration cannot be made, the following must be completed:

- Install additional monitoring wells in order to characterize the chemical composition of the release, the contaminant fate and transport characteristics, and the rate and extent of groundwater contamination in all respective
- groundwater flow paths;
- Install at least one additional monitoring well at the facility boundary in the direction of contaminant migration to be included in the quarterly groundwater assessment monitoring program;
- Notify land owners if their land directly overlies any part of the contaminant plume; and
- Initiate assessment, selection, and implementation of corrective measures per WAC 173-340, the Model Toxics Control Act (MTCA). s.

9.2.3 INDICATOR AND INORGANIC PARAMETERS

pH

pH is a measure of hydrogen ion activity. Ground water is typically slightly acidic. Leachate may be acidic, neutral, or slightly alkaline as a function of refuse age, the functional history of the landfill, and physical structure of leachate collection and conveyance. Leachate at Vashon Landfill has similar range and median as groundwater, typically neutral to slightly acidic. Leachate at equilibrium with LFG and the soil and waste matrix within the landfill becomes a well buffered solution, and therefore resistant to large changes in pH. The value of pH as an indicator of leachate influence is marginal at best and much less valuable than other indicators discussed later.

9.2.3.1 SPECIFIC CONDUCTANCE

Specific conductance is a measure of the ability of water to carry an electrical current. This property is related to ion concentration, charge, ion mobility, and water temperature. Solutions of acids, bases, and salts have higher conductivity than solutions of organic compounds. The greater the concentration of dissolved ions, the greater the specific conductance. Groundwaters in the Northwest, depending upon location and depth, generally have conductivities in the range of 100 to 500 μmhos/cm. Groundwater in the vicinity of Vashon Landfill that is believed to be representative of conditions unimpacted by landfilling activity has conductivities in the range of 80 to 250 μmhos/cm. Landfills can contribute dissolved species to groundwater by multiple

mechanisms: by direct mixing with leachate, by dissolution of minerals and carbon dioxide (CO_2) via landfill gas, or by mobilization driven by depressed redox conditions. Leachate has higher conductivity, at Vashon Landfill typically ranging from 200 to 3,000 μmhos/cm. As a result, specific conductance measurements can provide indications of landfill impact to groundwater by either leachate or landfill gas pathways. Specific conductance is easily measured in the field and complements analytical results of individual ionic species and total dissolved solids.

9.2.3.2 CHLORIDE

Chloride is a conservative anion; that is, processes of adsorption, ion exchange, or biological uptake do not generally retard transport of chloride in ground water. It typically occurs at levels less than 20 mg/L in ground water, depending upon local geologic conditions, and at concentrations of up to 500 mg/L in Vashon leachate. Chloride is the best indicator for differentiating impacts between leachate and landfill gas origin. Because of its high solubility, low tendency for retardation, and insensitivity to redox environments, chloride is most effectively tied to leachate as a source and aqueous flow as a transport mechanism. Changes in concentration of other parameters in the absence of changing chloride concentration are indicative of a landfill gas mechanism.

9.2.3.3 ALKALINITY

Alkalinity is the measure of the capacity of water to neutralize acids, or its buffer capacity. It is a dissolved parameter found in all groundwater. The alkalinity of natural waters is controlled primarily by the equlibria of the carbonate system. It is produced by dissolved CO_2 acting on alkaline materials in the soil to produce bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}). Hydroxide (OH^-), although minor in the systems discussed here, contributes to alkalinity as well. The analytical method used determines total alkalinity, not distinguishing between carbonate, bicarbonate, and hydroxide alkalinity. At the typical pH levels of local ground water, less than 8.3, alkalinity is dominated by the bicarbonate ion. For most practical purposes, the alkalinity due to other solute species is insignificant and can be ignored.

Alkalinity is useful as an indicator of leachate or landfill gas impact because the chemical reactions that produce landfill gases produce anomalously high concentrations of alkalinity. Carbon dioxide, produced by microbial decay of the landfill organic material, combines with water and minerals in the soil waste matrix to produce alkalinity in the leachate or the CO_2 can migrate as LFG and react with native soils and ground water to form bicarbonate.

9.2.3.4 INORGANIC NITROGEN SPECIES

Inorganic nitrogen is measured as ammonia, nitrate, and nitrite. Due to the reducing conditions typically present within a landfill, inorganic nitrogen exists primarily as ammonium ion (NH4+) in leachate, and as ammonia gas (NH3) in landfill gas. It may exist in groundwater as nitrate (NO3-). As ammonia leaches from the landfill, it is oxidized to nitrate, with nitrite (NO2-) as a transient intermediate. Nitrate is moderately mobile through soils and, like chloride, may provide indication of leachate impact on ground water. Typical concentrations of inorganic nitrogen are 1 to 100 mg/L in Vashon leachate and less than 10 mg/L in groundwater. A leachate plume stimulates the growth of soil bacteria by providing organic carbon as food. The enhanced bacterial growth in turn consumes available nitrogen. Therefore, inorganic nitrogen is not a conservative parameter as it may be transformed or removed by metabolic processes.

Inorganic nitrogen may reach groundwater from a variety of other sources. Most important in the context of groundwater evaluation at solid waste disposal sites are agricultural activities and effluent from onsite wastewater treatment (septic systems).

Trends of increase or decrease in inorganic nitrogen may offer support to other evidence of landfill impact to groundwater quality.

9.2.3.5 SULFATE

Sulfate is a naturally occurring constituent in groundwater and is also present in leachate. Sulfate levels are routinely less than 25 mg/L in groundwater and from less than 5 to 600 mg/L in Vashon leachate. It is not as mobile as chloride due to its adsorption into the soil. In biologically mediated redox reactions, sulfate may act as the electron acceptor under anaerobic conditions, or be produced by the oxidation of sulfide under aerobic conditions. As with inorganic nitrogen species, sulfate is not a conservative parameter and trends may provide supporting evidence of landfill impact to groundwater quality.

9.2.3.6 IRON

Iron is a naturally occurring constituent in soils and groundwater and is present in waste. Speciation of iron is controlled by redox processes. If oxygen levels decline to near zero, mobilization from the soil will be enhanced. This phenomenon can happen as a result of oxygen demand within a leachate plume or by natural processes within the saturated zone. Natural levels of iron are extremely variable, and exceedances of secondary drinking water criteria routinely occur in King County (Richardson et al., 1968). Iron is best used as a leachate indicator by assessing the change in concentration over time, in the context of redox environments at a site rather than by presence and absence or by comparison to standards.

9.2.3.7 MANGANESE

Manganese is naturally occurring in soils and groundwater. Like iron, speciation is controlled by redox processes. Reducing conditions will mobilize manganese from soils used as daily cover within the landfill and from native soils outside the landfill under favorable conditions. This phenomenon can happen as a result of oxygen demand within a leachate plume or by natural processes within the saturated zone. Iron and manganese behave similarly, but iron requires a slightly greater decline in oxygen levels to be mobilized; therefore, the soluble form of iron typically appears in a monitoring well after manganese. Natural levels of manganese are extremely variable, and exceedances of secondary drinking water criteria routinely occur in King County (Richardson et al., 1968).

Manganese is best used as a leachate indicator by assessing change in concentration over time, and within the context of redox conditions, rather than by presence or absence, or by comparison to standards.

9.2.4 OTHER METAL PARAMETERS

9.2.4.1 CALCIUM AND MAGNESIUM

These metals exist in natural waters as major divalent ions in solution from dissolution of minerals and ion exchange in soils. The concentration of calcium in local groundwater is generally less than 20 mg/L and is followed in decreasing abundance by magnesium, sodium, and potassium. In Vashon leachate, calcium has reached 580 mg/L followed in abundance by sodium, magnesium, and potassium. In addition to the fact that naturally occurring levels are highly variable, attenuation processes can alter the concentration and relative abundance of these constituents. The value of these analytes in groundwater monitoring is in defining the geochemical properties of a water, in validating analytical results and, as with iron and manganese, by assessing their change in concentration over time.

9.2.4.2 POTASSIUM AND SODIUM

These metals exist in natural waters as major mono-valent ions in solution from dissolution of minerals and ion exchange in soils. The concentration of sodium is generally higher than potassium. In leachate, sodium and potassium can exceed calcium and magnesium in abundance due to the effect of the high concentrations of these constituents in the waste stream. In addition to the fact that naturally occurring levels are highly variable, attenuation processes can alter the concentration and relative abundance of these constituents. The value of these analytes in groundwater monitoring is in defining the geochemical properties of a water, in validating analytical results and by comparing relative abundance fluctuations of cations over time. As with other parameters, assessing their change in concentration over time has value.

9.2.4.3 ARSENIC

Arsenic is a naturally occurring element in the earth's crust and is released to the environment by humans in a number of ways. It is released primarily as a byproduct from ore-smelters and in discontinued formulations of insecticides and pesticides, and in wood preservatives. In an oxidizing environment with a pH above 4 (which includes most natural waters), we expect to find little arsenic mobility because dissolved arsenic species are sorbed to ferric hydroxides in this environment. Conditions that reduce and mobilize iron also increase the mobility of arsenic.

Use of arsenic as a leachate indicator is limited by the naturally occurring background levels. Arsenic fate and transport are best evaluated in conjunction with other redox-sensitive species like iron and manganese. It is not uncommon for arsenic levels found in background wells to exceed state or possibly federal standards. The State groundwater criteria for arsenic is below the detection limit for the methods of analysis commonly used. Locally, and particularly on Vashon Island, considerable public and regulatory attention has been given to arsenic deposition in surficial soils from the former Asarco Smelter in Ruston.

These metals are not considered to be good leachate indicators, except in a secondary sense. They can provide insight into possible leachate contamination when evaluated in the context of overall environmental considerations such as pH, redox potential, native soil mineral content etc.

9.2.5 VOLATILE ORGANIC COMPOUNDS

Since the majority of organic compounds are synthetic, occurrence may be an indication of an impact from landfilling activities. A large number of organic compounds are potentially present in landfill waste. Although it is difficult to typify any single compound or set of compounds as organic indicators of landfill influence, data suggest the regular occurrence of particular compounds related to landfills in King County. The following groups of volatile organic compounds (VOCs) are seen in analytical results from King County Solid Waste Division (KCSWD) leachate and groundwater monitoring programs.

9.2.5.1 BTEX

Benzene, toluene, ethylbenzene and xylenes (BTEX) are constituents of petroleum. As such, they are present in the waste stream and are frequently detected in leachate and landfill gas. Due to the nature of the physical properties (solubility, vapor pressure, Henry's constant), these petroleum hydrocarbons are mobile in both vapor and aqueous phases and can impact groundwater as a result of leachate or independently through transport by landfill gas.

9.2.5.2 SOLVENTS AND DEGRADATION PRODUCTS

This group includes VOCs found in many products that are components of MSW. Paints, wood finishing products, degreasers, household cleaners, fumigants, pesticides, aerosol propellants, fire extinguishers, and refrigerants are a few of the consumer products that may contain these compounds. The most common detected in the Vashon Landfill groundwater monitoring program include 1,1-dichloroethane, 1,2-dichloropropane, and cis- and trans- 1,2-dichloroethene. Due to the nature of their physical properties (solubility, vapor pressure, Henry's constant), these constituents are mobile in both vapor and aqueous phases and can impact groundwater as a result of both leachate and landfill gas.

While some of these detected compounds are likely components of the waste stream, others are present as degradation products of tetrachloroethene (PCE) and/or trichloroethene (TCE) by the process of reductive dechlorination. These include: TCE itself, (which can be present either as a waste stream component or as a product of biological degradation of PCE) cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride. Other biological pathways can lead to 1,1-dichloroethane and chloroethane. Like the other VOCs, their physical properties render them mobile in both vapor and aqueous phases and can impact groundwater as a result of leachate and landfill gas.

9.2.5.3 CHLOROFLUOROCARBONDS (CFC's)

Dichlorodifluoromethane (CFC-12) and trichlorofluoromethane (CFC-11) were used extensively as aerosol propellants, refrigerants, and in fire extinguishers. The properties that made them attractive for these uses--low toxicity and chemical stability--later proved to be problematic, contributing to greenhouse gas emissions and ozone depletion in the upper atmosphere. Their persistence and ubiquity are recognized in the scientific literature and have allowed development of methods of dating of groundwater recharge based on their concentrations. CFCs serve as secondary confirmation of contamination but are inconclusive by themselves.

9.2.5.4 LABORATORY AND BLANK CONTAMINANTS

Methylene chloride and acetone are common laboratory solvents. They are often detected in method blanks and frequently in laboratory prepared trip blanks, often at concentrations exceeding levels found in environmental samples. Bromomethane and carbon disulfide have been detected and identified by the contract laboratory as instances of instrument contamination. For this reason, the value of these constituents in evaluating water quality is highly questionable. Concentrations of these constituents in environmental samples less than ten times greater than concentrations seen in quality assurance samples should be ignored. Several other compounds are frequently detected in both environmental samples and blanks due to their ubiquity in the environment. Toluene, dichlorodifluoromethane, trichlorofluoromethane, and xylenes may be present in samples and blanks for this reason.

Trihalomethanes (THM) may be formed as by-products of chlorination disinfection. Chlorine reacts with natural organic matter to produce one or more of the constituents chloroform, bromoform, bromodichloromethane, or dibromochloromethane. Three of these four trihalomethanes have been detected in our monitoring program. Any detection of these compounds in groundwater samples must be evaluated in light of this knowledge. Chloromethane is occasionally detected in samples and blanks. It is believed to be an artifact of sample preservation, formed by a process similar to THMs.

Caution must be used when evaluating water quality using these parameters.

9.2.6 ATTENUATION CONSIDERATIONS

Available data suggest that attenuation processes affect the nature and sequence of chemical species that may be observed in impacted wells.

The attenuation processes that are at work include a variety of physical, chemical, and biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants. (EPA, 1999)

Conservative salts such as chloride, unaffected by most attenuation processes, move rapidly in the aqueous phase of a leachate plume, as also indicated by elevated specific conductance. Sulfate follows, with a lag that is likely a function of the sulfate adsorption capacity of the soil and microbial activity. Manganese precedes iron--the source of these metals may be leachate or, more likely, when redox is depressed, the soil itself. Organic compounds, subject to more attenuation processes, tend to follow iron.

These processes may also occur within the unsaturated zone, where movement is less constrained by hydrogeology and not driven by gravity. The attenuation of gas phase constituents may result in conditions that are counter-intuitive. It is important to consider relevance of these processes in all matrices when evaluating the environmental impacts of MSW landfills.

9.3 DATA EVALUATION METHODS

Statistical and graphical methods are used to evaluate the data. The value of quantitative statistical evaluations and the conclusions drawn from them are only as good as the data used in the calculations. Results in King County's Environmental Database include analytical results using the Method Detection Limit (MDL) as the reporting limit. This can lead to qualitative results being entered into the database with numerical concentration values. While these results provide valuable information about the presence or absence of a certain constituent in a given sample, they may have unacceptable uncertainty for use in quantitative evaluations such as trend testing or comparison to regulatory standards. This becomes very important when attempting to evaluate results reported at values close to the MDL.

9.3.1 DATA QUALITY OBJECTIVES

Data quality objectives are defined in chapter 3 of the Sampling and Analysis Plan (SAP). The data is reviewed with respect to whether it meets the data quality objectives of precision, accuracy, representativeness, comparability, and completeness. Any questions or inconsistencies are resolved with the lab or field as appropriate.

9.3.2 EVALUATION OF OUTLIERS

Prior to the field and analytical data being entered into the environmental database (see Section 9.1), a comprehensive review of the field records and lab reports will be conducted in order to identify outliers related to errors in the sampling and analytical methods. Outliers will be noted and excluded from entry into the environmental database, and are therefore not included in the subsequent detection monitoring data evaluation.

9.3.3 QA/QC REVIEW

Reliance on any single analytical result or statistical calculation may lead to erroneous conclusions. Available data should be evaluated in the proper context, which includes sample population distributions, detection frequency, data quality, and type I and type II error rates.

9.3.4 CONSISTENCY REVIEW

9.3.4.1 EXCEEDANCE TABLES

Water Quality monitoring results are compared to Federal Drinking Water Maximum Contaminant Limits (MCL), 40 CFR Parts 141 and 143 and Washington State Groundwater Quality Criteria, WAC 173-200. Federal Drinking Water Standards for certain VOCs first came into effect January 9, 1989. Washington State Groundwater Quality Standards became effective on December 1, 1990 and were revised in 2005. Standards are compared to actual analytical values, not mean or median values. Exceedances are tabulated and reported quarterly, and comply with the requirement in WAC 173-351-415(2)c to report concentrations above the MCL.

It should be noted that standards have changed during the period of record and that the State Ground Water Standards were adopted in December 1990. Thus, only those standards that were applicable at the time of sampling are used in the comparison. In addition, not all parameters that are analyzed have standards.

In addition to providing information about the water quality relative to established standards, exceedances also provide a cursory evaluation of changes relative to historical data. When an established standard is exceeded for the first time, or is an order of magnitude higher than historical results, the data is reviewed more carefully. If the exceedance is inconsistent with other results from the same sample, or the particular analyte cannot be checked for consistency with other analytes, the lab is contacted and asked to verify results. Administrative errors, such as a sample switch, are corrected promptly. In some cases, the sample will be reanalyzed and a new result provided. If no error can be identified by the lab, the monitoring location will be re-sampled. Results that are demonstrated to be incorrect are flagged as rejected in the database and data that is flagged rejected in the database is not used for statistical analysis.

9.3.4.2 ION BALANCE AND TRILINEAR DIAGRAMS

Geochemical data is presented on trilinear diagrams, as required by WAC 173-351-415(2)f. Major cations and anions are plotted on individual triangles as percentages of total milliequivalents per liter (meq/L). These diagrams illustrate differences in major ion chemistry between groundwater samples and can be used to categorize water composition into identifiable groundwater types or hydrochemical facies. These hydrochemical facies reflect distinct compositions of cation and anion concentrations. The value of the diagram lies in describing relationships that exist among individual samples. Trilinear Diagrams are prepared for monitoring wells and surface water locations and are included with ionic balance calculations in quarterly reports. The same information is included in the annual reports. At times, these tools are used for leachate analysis as well.

Ion balances also provide information about the internal consistency of sample results. If the ion ratio is greater than ten percent, this is an indication of analytical error. When this disparity occurs, the individual results are reviewed. Any results that are inconsistent with historical data for that monitoring location are verified with the lab, potentially leading to corrected result packets or reanalysis.

9.3.5 GROUNDWATER ELEVATIONS

Groundwater static water levels are reviewed each quarter. Any inconsistencies with historical data are reviewed carefully and evaluated for accuracy. Since water levels are taken prior to sampling also, this provides a second data point for quality control. The quarterly static water levels are then forwarded to a licensed hydrogeologist consultant, for preparation of potentiometric maps and groundwater velocity calculations. Potentiometric maps and groundwater velocity calculations are included in each quarterly report.

Groundwater levels in individual wells have been plotted as a function of time annually, along with precipitation. A weather station located near the borrow area pond and maintained by King County Water and Land Resources Division provides the precipitation data. Prior to 2005, precipitation data from SeaTac Airport was used. Changes in water levels before and after the 1989 closure are noted. Groundwater flow directions are defined by the potentiometric maps prepared by hydrogeologists. Upgradient and downgradient wells are determined by flow direction.

For Vashon, channel Cc1 monitoring wells are located adjacent to the channel and there is insufficient data for accuracy and therefore are not utilized in potentiometric map generation or groundwater velocity calculations. Wells in Channel Cc2 and Regional Aquifer wells are used for potentiometric maps and groundwater velocity calculations. To meet the requirement of WAC 173-351-415(2)d, e the static water levels measured at the monitoring wells are reported both with the potentiometric map report and tabulated with field data for the time period. The quarterly potentiometric reports are included in the annual report and satisfy WAC 173-351-415(1)b, c.

9.3.6 TIME-CONCENTRATION PLOTS

Time-concentration plots are prepared for the parameters of interest to provide a visual representation of changes at the site. Typically, the plots are grouped according to water bearing zone and show all wells in the water bearing zone on one graph. Other formatting may be substituted to provide a clearer representation as needed. In the plots, all non-detections (ND) are displayed on graphs as one-half the limit of detection. These values can readily be seen on the time trends because they fall below the line demarcating the detection limit. Each plot shows the concentration recorded for the period of record. Since water quality data are typically collected quarterly, the plots are useful for showing temporal changes due to seasonality, as well as long-term increasing or decreasing trends. These plots can show concentration changes over time in response to activities that have occurred during the presented timeline and will show outliers and analytic anomalies that may require further QA/QC investigation. The plots are prepared for the annual report.

9.3.7 STATISTICAL SUMMARY TABLES

The data from each well are divided into two groups for evaluation. The first group consists of all data in the period of record exclusive of the eight most recent analyses. The second group consists of the eight most recent analyses. This division is used for the statistical summary tables and the trend test tables. The more recent period is considered to have more importance, both because of the timeliness of the data and improvements in the quality of the data.

Descriptive statistics describe general measures of a sample population, the extremes (maximum, minimum,) central tendencies (mean, median), and variability (standard deviation).

They give a snapshot of sample distribution properties and are used to infer the properties of the underlying population from which the samples are drawn. By making comparisons using descriptive statistics, gross attributes of two sample populations can be compared for similarity.

Summary statistics tables include number of analyses, number of detections, maximum, minimum, mean, median, and standard deviation values.

Although both means and medians are reported in the summary tables, medians are used in the text because they tend to be a more reliable measure of central tendency in the case of non-normal distributions, particularly when there are outliers, as is the case here. Natural waters are commonly characterized by non-normal distributions.

Statistical summary tables are compiled for groundwater, surface water, and leachate.

9.3.8 PREDICTION LIMITS

The prediction interval is a statistical interval calculated, during the first quarter, annually on past background samples to estimate future values. A prediction interval can be constructed on the data from an upgradient well (interwell) or on previous samples from the same well (intrawell). If the distributions of background and foreground data are really the same, all the foreground samples should be contained below the upper prediction interval limit. The intrawell prediction limit provides information as to whether the newly obtained concentration is higher than the previous population. This limit is particularly useful when data was collected prior to the existence of the landfill. When the potential source already exists, the intrawell prediction limit provides information as to changes within the well. The interwell prediction limit provides information regarding the difference between analyte concentrations in a downgradient and an upgradient well. This is useful if no data exists to define the chemistry at the downgradient well prior to the existence of the potential source. However, spatial variation can play a role in this comparison and professional judgment should be used to evaluate the importance of the results.

The interwell prediction limit is used for evaluating the groundwater at the Vashon Landfill. No clearly defined upgradient well exists in channel Cc1, so no prediction limit is calculated. In channel Cc2, MW-20 represents the upgradient conditions for un-impacted conditions. Starting in the third quarter of 2010, intrawell prediction limits will be used to evaluate wells in the regional aquifer.

When foreground sample values lie above the upper Prediction limit, evidence that the sample from a different population distribution is indicated.

Before calculating the Prediction Limit, the data set is tested for normality by application of the Shapiro-Wilk Test for Normality. The Shapiro-Wilk test is based on the premise that if a set of data are normally distributed, the ordered values should be highly correlated with corresponding quantiles taken from a Normal distribution. The Shapiro-Wilk test gives substantial weight to evidence of non-Normality in the tails of a distribution, where the robustness of statistical tests based on the Normality assumption is most severely affected, and where validity of the statistical assumptions are most crucial.

If the data fail the test for normality, log-transformed data are tested. When normal or transformed normal data sets are determined, a parametric prediction limit is calculated and future results compared to this value. When transformation fails the test for normality, a non-parametric method is applied and future results are compared to this limit. A value greater than this limiting value is considered evidence that the result is not drawn from the same sample distribution.

The prediction limits generated for the annual report are based on a 5% false positive rate (type I error) and depend on the background distribution. For each parameter tested, an appropriate background data set is chosen.

Prediction limits are performed on Appendix I analytes to meet regulatory compliance and further tests are performed on non-appendix I analytes which are common groundwater constituents and have high detection frequencies. Prediction limits are presented on the time concentration plots, appearing on the plot as a dashed line and numerically in the associated text.

9.3.9 TREND TESTING

Trend testing was accomplished by using the Mann-Kendall test for trend. This test is well suited for environmental data (Gibbons 1994). The value of the trend test is in evaluating change over time for a given analyte. This test quantifies the visual interpretation provided by the time series plots.

The Mann-Kendall trend test involves listing the observations in temporal order, and computing all differences that may be formed between measurements and earlier measurements. The test statistic is the difference between the number of strictly positive differences and the number of strictly negative differences. If there is an underlying upward trend, then these differences will tend to be positive and a sufficiently large value of the test statistic will suggest the presence of an upward trend. The test makes no distributional assumptions (non-parametric); irregularly spaced (temporally) samples and values below detection limits are allowed in the calculation. The test yields probability (p values) that there is no temporal trend. Probability of less than 0.05 indicates a significant trend.

This test has been applied to data for the two time periods long-term (all data excluding the eight most recent sampling periods) and short-term (the last eight quarterly results). Results must be interpreted carefully in cases where frequency of detection is low or in cases where reporting limits have changed over the period of record, in order to yield meaningful results. The tabulated results presented in a table in the annual report are: number of analyses, number of detections, direction of trend, probability, and significance of trend at a 95% confidence level.

9.4 DATA QUALITY

Five analytical labs have performed laboratory services for water samples collected at the Vashon Landfill, including: Laucks from 1986 to March 1990, AmTest from March 1990 to April 1992, Analytical Resources (ARI) from April 1992 to May 1995, again Laucks from May 1995 to March 2008, PACE Analytical Services, Inc. from April 2008 to March 2009, and KCEL from April 2009 until present. The State Manchester Laboratory accredited all five laboratories for the methods used at the time the samples were analyzed.

Contamination of blanks has important ramifications for data quality. For this reason, it is mentioned in the discussions of results in the annual report whenever there is blank contamination. However, for some compounds, such as methylene chloride and acetone, the occurrences of blank contamination are too numerous to mention each separate event. Therefore, only certain instances of blank contamination are reported for these compounds. Other compounds, such as sulfate, zinc, and iron have also been detected in blanks. These detections will be noted for the individual wells in which they occur. Some data, particularly concerning solvents, must be qualified based on blank contamination events and measures of precision and accuracy.

There are several instances, particularly in the case of certain organic parameters and arsenic, where the limit of detection is above State or Federal water quality levels. Because these concentrations are not measurable, they cannot be reported. Another issue involving these limits arises when the limits of detection change. Especially noticeable for metal parameters, these

changes may be due to dilution, or due to technical or contractual specifications. These changes must be kept in mind while reviewing data evaluation and conclusions.

9.5 QUARTERLY REPORTS

Quarterly reports are a prepared list of all analysis results for the quarter. Quarterly reports present data collected during a 3-month period:

- All groundwater monitoring data for the sampling period including static water levels, field parameters, and laboratory analytical results
- Summary tables of groundwater constituents at concentrations above Maximum Contaminant Levels (MCLs), detections of volatile organic compounds, and total organic halogen concentrations (all landfills)
- Cation-anion balances (all landfills) and trilinear diagrams
- Potentiometric surface maps with flow rate and direction
- Surface water field and laboratory analysis results
- Leachate field and laboratory analysis results and hauling data
- Landfill gas probe and ambient monitoring data
- Evidence of a statistically significant increase in analyte concentration determined by comparison of analytic results to established Prediction Limits are presented. These limits are calculated annually using the sample population in the upgradient well(s). Intrawell prediction limits were used on Cc2 at the request of Sally Safioles (Ecology) because there is not a non-landfill impacted upgradient well.
- Surface Water Criteria exceedances for monitoring stations that leave the property after receiving flow from the landfill site, new surface water site SW-E, and for the seeps along the west hillside. The seeps are also compared to groundwater criteria.
- A summary evaluating quarterly monitoring activities based on the above data sources.

These reports are distributed to the Seattle King-County Department of Public Health, Washington Department of Ecology, city governments that requested regular distribution, King County Main Library, and the Vashon branch of the King County Library System.

9.6 ANNUAL REPORTS

Annual reports provide an in-depth review of changes at the site. Annual reports review the history of the site with respect to environmental conditions and landfill operations. These documents also evaluate the current conditions relative to the history and to regulatory standards.

The annual report refers to the latest description of the hydrogeologic conditions at the landfill and presents the evaluations on the groundwater quality data collected from upgradient and downgradient wells. The data are represented in compliance with Washington Department of Ecology “Criteria for Municipal Solid Waste Landfills” (WAC 173-351), and the Code of the King County Board of Health “King County Solid Waste Regulations” (Title 10, Rules and Regulations No. 8).

The reports include a summary of the water chemistry for the monitoring wells at the site, as well as for surface water and leachate. Descriptive statistics and trend test results are tabulated as

described in the previous section and information from the year's quarterly report is included, including groundwater elevations, flow rate and direction, potentiometric surface maps, ion balances, trilinear diagrams, and exceedance tables. Groundwater quality is discussed in context with site improvements, if any. Maintenance activities at the site are listed. Recommendations are presented for future site monitoring considering existing understanding.

These reports are distributed to the Seattle King-County Department of Public Health, Washington Department of Ecology, King County Main Library, and city governments and libraries located near the facility whose data are being reported.

9.7 EXCEEDANCE REPORTS

All chemicals for which there have been exceedances are reported to the Seattle King-County Department of Public Health following detection at or above one order of magnitude of their existing levels. The data review team is responsible for reporting exceedances. Exceedances are also summarized in the Quarterly and Annual Reports.

10 HEALTH AND SAFETY

Evaluate previous sampling results to determine if dangerous toxic contamination levels are present in any of the monitoring wells or sampling areas. Use proper protective equipment and clothing as required at the site.

Wear properly selected and fitted protective clothing as appropriate when sampling. Standard work clothes consist of safety shoes or boots, disposable gloves, and protective eyewear. Follow training given in the use, limitations, maintenance, cleaning, and storage of protective clothing and equipment.

Avoid unnecessary contact with hazardous materials by staying clear of puddles, vapors, mud, discolored surfaces, and site debris.

During sampling, field personnel will not eat, drink, chew gum or tobacco, smoke, take medicines, or perform any other practice that might increase hand to mouth transfer of materials from gloves, unwashed hands or equipment. After sampling and prior to any of these activities, field personnel will remove personal protective equipment and decontaminate themselves.

Some of the sample bottles provided by the laboratory contain preservatives to retard biological and/or chemical changes after collection of the sample. These preservatives may be acids (such as H2SO4) or bases (such as NaOH). Care must be taken to prevent the transferal of these preservatives from one bottle to another.

11 REFERENCES

American Society for Testing and Materials (ASTM), 2004, D7048-04, Standard Guide for Applying Statistical Methods for Assessment and Corrective Action Environmental Monitoring Programs.

Barcelona, Michael J., James P. Gibb, John A. Helfrich, and Edward E. Garske. 1985. Practical Guide For Ground-Water Sampling, Illinois State Water Survey Champaign, Illinois.

Csuros Maria.1994. Environmental Sampling and Analysis for Technicians. Lewis Publishers. Boca Raton, Florida.

Csuros Maria.1997. Environmental Sampling and Analysis Lab Manual. Lewis Publishers. Boca Raton, Florida.

Harding Lawson Associates. 1992. Evaluation of Groundwater Quality Adjacent to Duvall Landfill. Prepared for EMCON Northwest, Inc. and King County Solid Waste Division. Seattle, WA.

Kangas, M.J., T.E. Tyburski, J.A. Duchene, P.H. Friedman. 1988. Quality Assurance on the Groundwater Monitoring Task Force Facility Assessment Program. in Waste Testing and Quality Assurance, ASTM STP 999, D. Friedman, Ed. American Society for testing Materials, Philadelphia.

Karklins, Steve and Jordana Lenon, Editor. 1996.Groundwater Sampling Field Manual PUBL-DG-038 96, Wisconsin Department of Natural Resources Bureau of Drinking Water and Groundwater.

King County Solid Waste Division. 1999. King County Solid Waste Division Quality Assurance Project Plan For Environmental Monitoring For King County Solid Waste Facilities (QAPP). Seattle, Washington.

King County Solid Waste Division. 2004.Vashon Island Landfill Report Update, Prepared by Berryman & Henigar with Udaloy Environmental Services. Seattle, Washington.

Komorita, J. 1993. Memo on September 28, 1993 to David Hickok, Seattle-King County Department of Public Health, RE: Groundwater Monitoring Protocol. Seattle, Washington.

Lombard, Stewart M. and Cliff J. Kirchmer, Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies, Washington Department of Ecology, Environmental Assessment Program Publication No. 01-03-003, 2004. Washington.

Nichols, P., J.S. Jessup, D.K. Knight.1991. Reporting Environmental Data of Known Quality in Waste Testing and Quality Assurance: Third Volume, ASTM STP 1075, D. Friedman, Ed. American Society for Testing Materials. Philadelphia, Pennsylvania.

PTI, Environmental Services. 1991. A project manager's guide to requesting and Evaluating Chemical Analyses. Prepared for the U.S. Environmental Protection Agency Region 10. Puget Sound Estuary Program. Bellevue, WA.

Puls, R.W. and Barcelona, M.J., 1996, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures EPA/540/S-95/504.

RW Beck. 1996. Operation and Maintenance Manual for Enumclaw Landfill. Prepared for King County Solid Waste Division. Seattle, WA.

U.S. Environmental Protection Agency. 1992. “RCRA Ground-Water Monitoring: Draft Technical Guidance”, Office of Solid Waste.

U.S. Environmental Protection Agency. 1997. “Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) with Guidance”, Quality Assurance Program.

U.S Environmental Protection Agency, region 10. 1998. You and Quality Assurance In Region 10. Seattle, WA.

U.S. Environmental Protection Agency. 1992. SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition. Washington, DC.

U.S Environmental Protection Agency. 1994. EPA Guidance for the Data Quality Objective Process, EPA QA/G4. Washington, DC.

U.S Environmental Protection Agency. 1998. EPA Guidance for Quality Assurance Project Plans, EPA QA/G5. Washington, DC.

U.S Environmental Protection Agency. 1999. OWSER Directive 9200.4-17P. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Washington, DC.

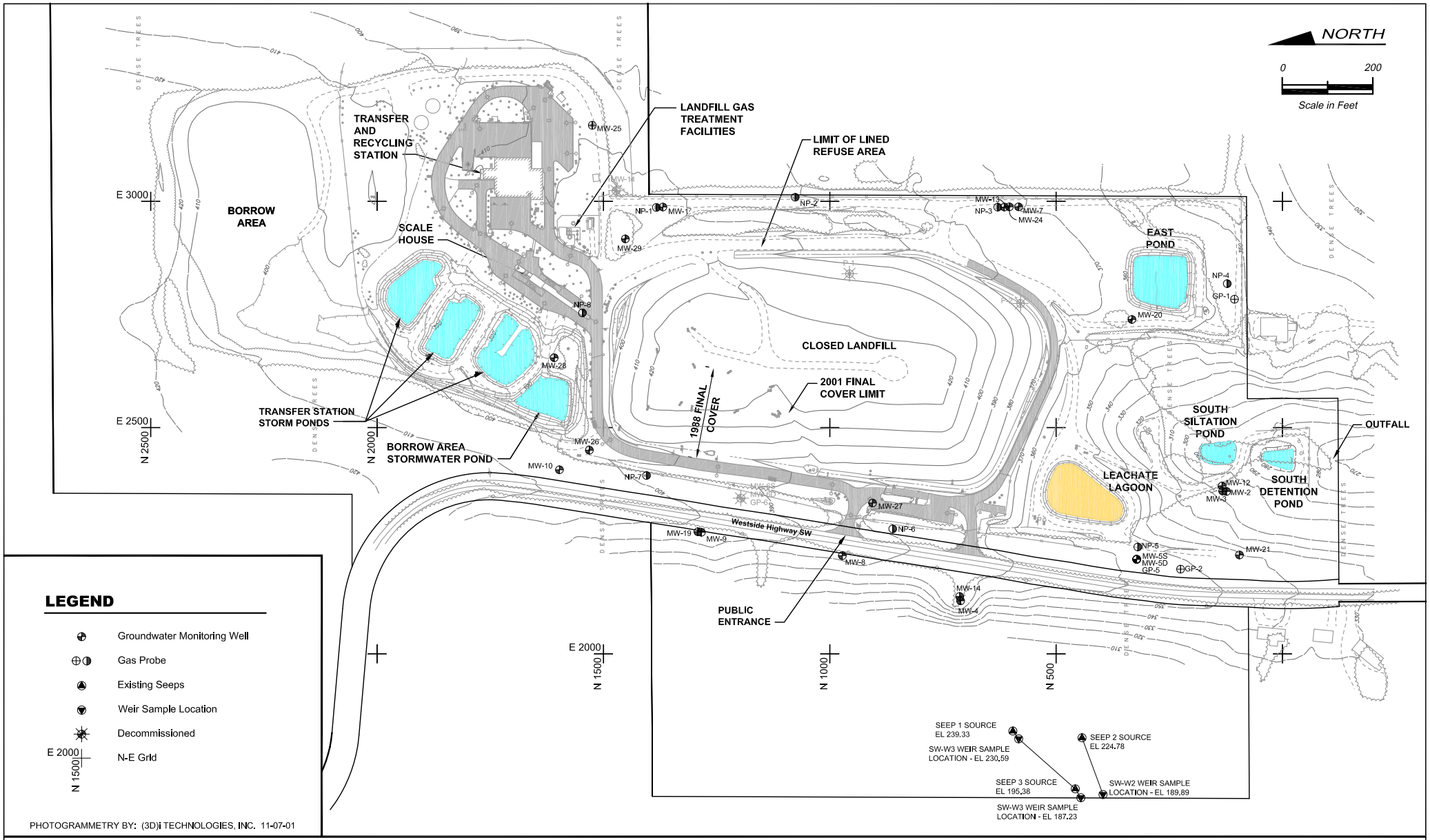
Washington State Department of Ecology. 1991. Guidelines and Specifications for Preparing Quality Assurance Project Plans. Manchester, Washington.

Woodward-Clyde. 1997. Cedar Hills Landfill, Surface Water Monitoring Evaluation Report. Prepared for King County Solid Waste Division. Seattle, Washington.

Vashon Island Closed Landfill Vicinity Map

King County
Department of
Natural Resources and Parks
Solid Waste Division

Figure 1



King County

Department of Natural Resources and Parks

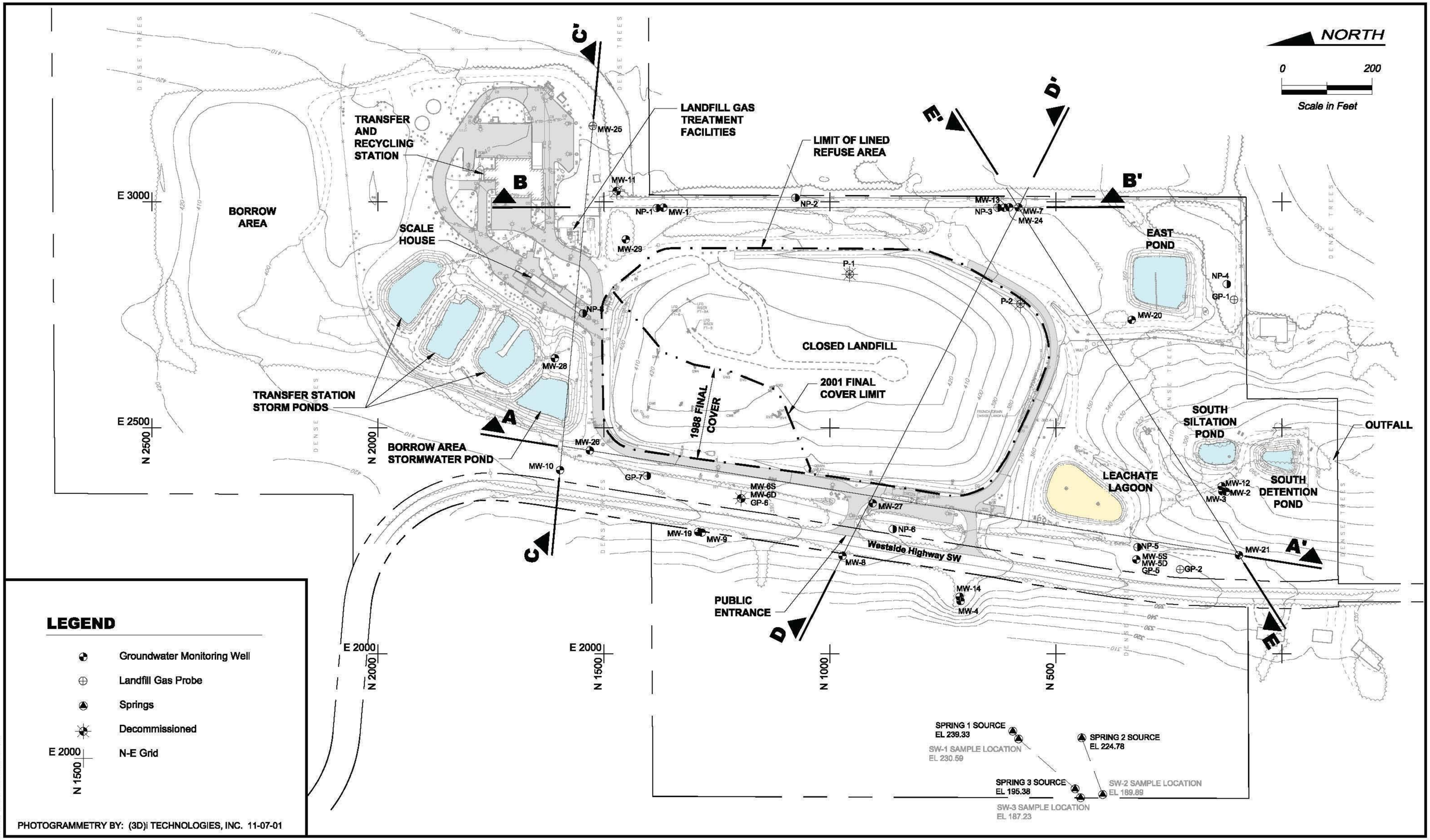
Solid Waste Division

Site Map

Source December 2004

Vashon Island Landfill Hydrogeologic Report Update

Figure **2**



PLOT DATE & TIME NOV 22 2004 09:07:08

FILE NAME (UPDATED BY) S:\CAD\KING COUNTY\4021105-011\DWG\P2105011FIG3-1.DWG (PLS)

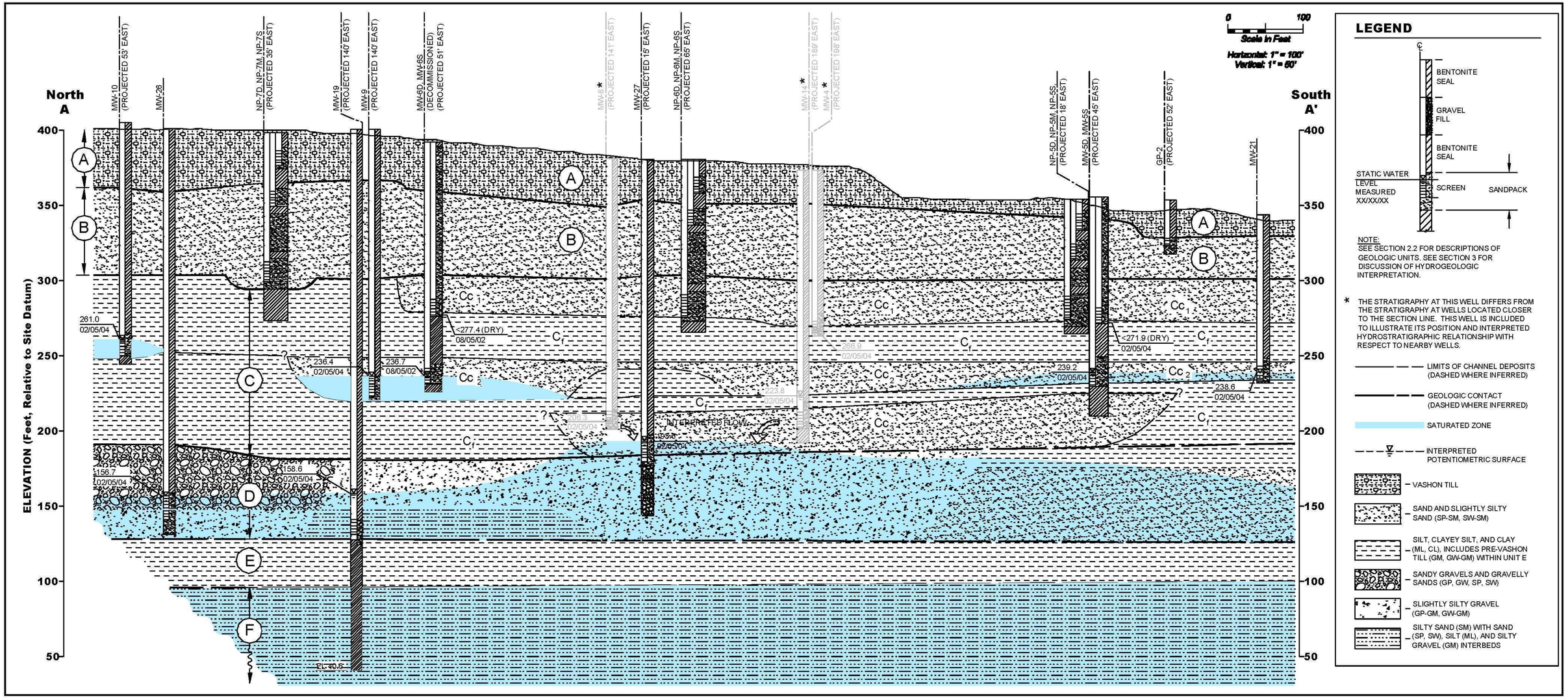
XREFS: X21104BM1, X21104GEO, X21104Lmts, X21104UT

King County
Department of Natural Resources and Parks
Solid Waste Division

Hydrogeologic Cross Section Location Map

Source December 2004,
Vashon Island Landfill Hydrogeologic Report Update
Prepared by Berryman & Henigar with UES

Figure 3



FILE NAME (UPDATED BY) S:\CAD\KING COUNTY\422TH5-DT\DWG\2710DT\SECTIONS_FLD.DWG (PES)
PLOT DATE & TIME NOV 23 2004 12:06:35
XREFS: NONE

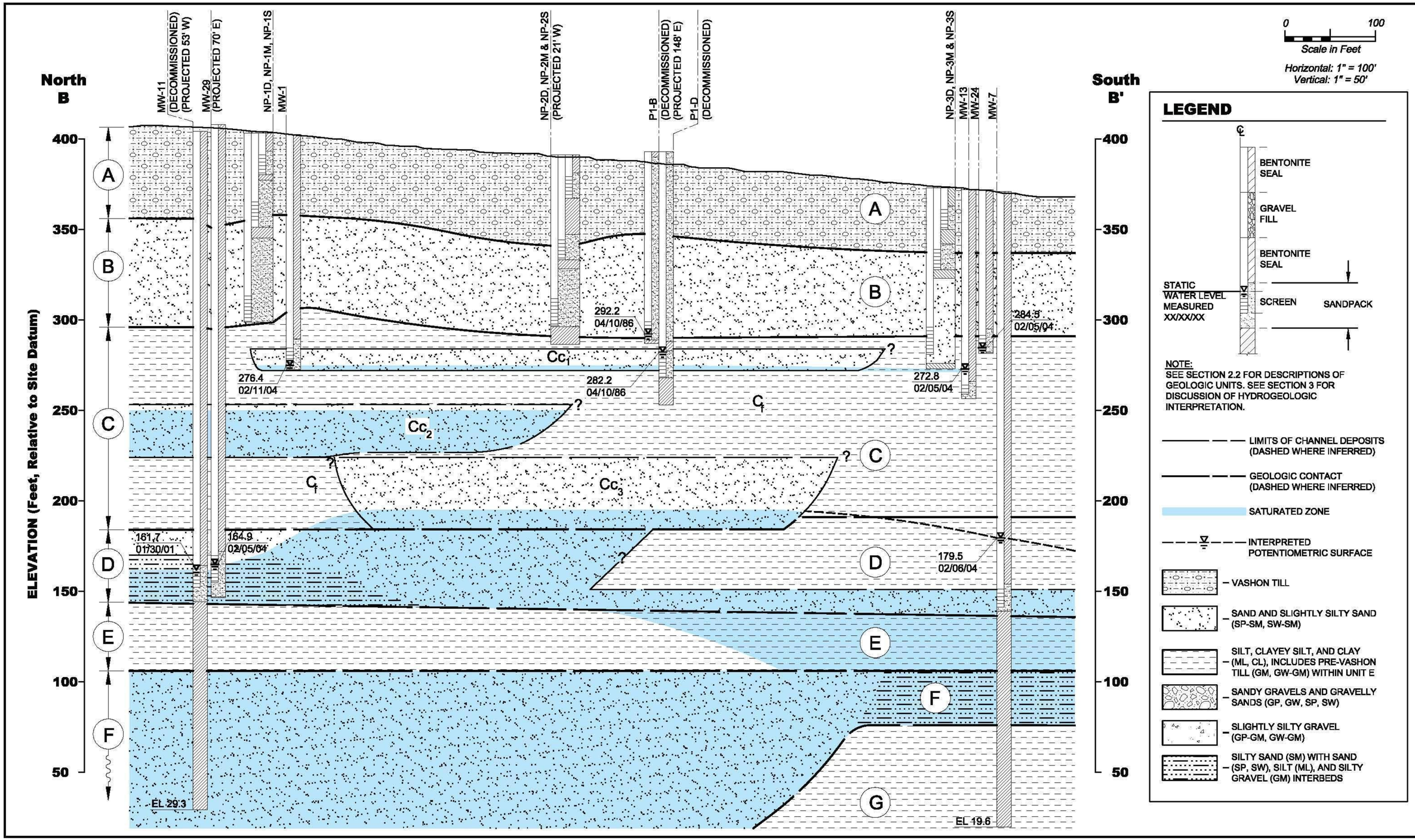
King County
Department of Natural Resources and Parks
Solid Waste Division

Hydrogeologic Cross Section A-A'

Source December 2004,
Vashon Island Landfill Hydrogeologic Report Update

Prepared by Berryman & Henigar with UES

Figure 4



King County
Department of Natural Resources and Parks
Solid Waste Division

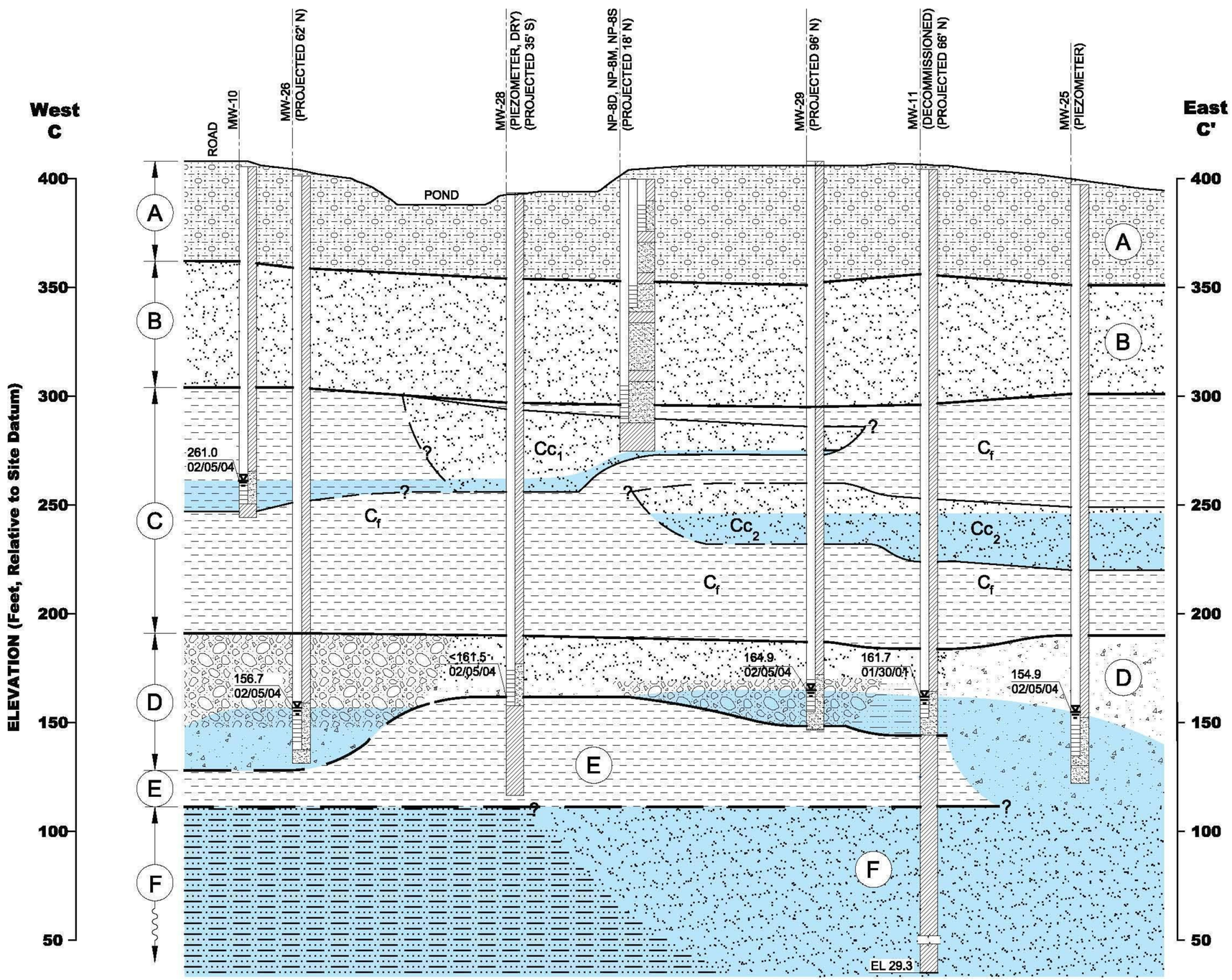
Hydrogeologic Cross Section B-B' *Figure*

Source December 2004,
Vashon Island Landfill Hydrogeologic Report Update

5

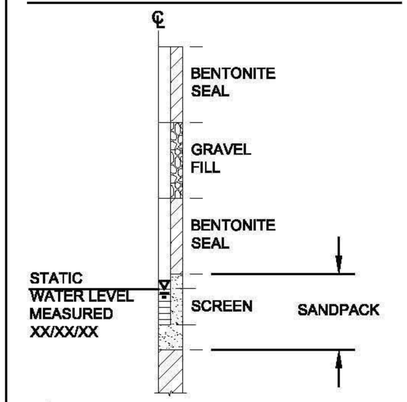
Prepared by Berryman & Henigar with UES

PLOT DATE & TIME NOV 23 2004 15:00:56
FILE NAME (UPDATED BY) S:\CAD\KING COUNTY\4021105-011\DWG\P2110501SECTIONS_F3.DWG (PLS)
XREFS: NONE



0 100
Scale in Feet
Horizontal: 1" = 100'
Vertical: 1" = 50'

LEGEND



NOTE:
SEE SECTION 2.2 FOR DESCRIPTIONS OF GEOLOGIC UNITS. SEE SECTION 3 FOR DISCUSSION OF HYDROGEOLOGIC INTERPRETATION.

- LIMITS OF CHANNEL DEPOSITS (DASHED WHERE INFERRED)
- GEOLOGIC CONTACT (DASHED WHERE INFERRED)
- SATURATED ZONE
- INTERPRETED POTENTIOMETRIC SURFACE
- VASHON TILL
- SAND AND SLIGHTLY SILTY SAND (SP-SM, SW-SM)
- SILT, CLAYEY SILT, AND CLAY (ML, CL), INCLUDES PRE-VASHON TILL (GM, GW-GM) WITHIN UNIT E
- SANDY GRAVELS AND GRAVELLY SANDS (GP, GW, SP, SW)
- SLIGHTLY SILTY GRAVEL (GP-GM, GW-GM)
- SILTY SAND (SM) WITH SAND (SP, SW), SILT (ML), AND SILTY GRAVEL (GM) INTERBEDS

King County
Department of Natural Resources and Parks
Solid Waste Division

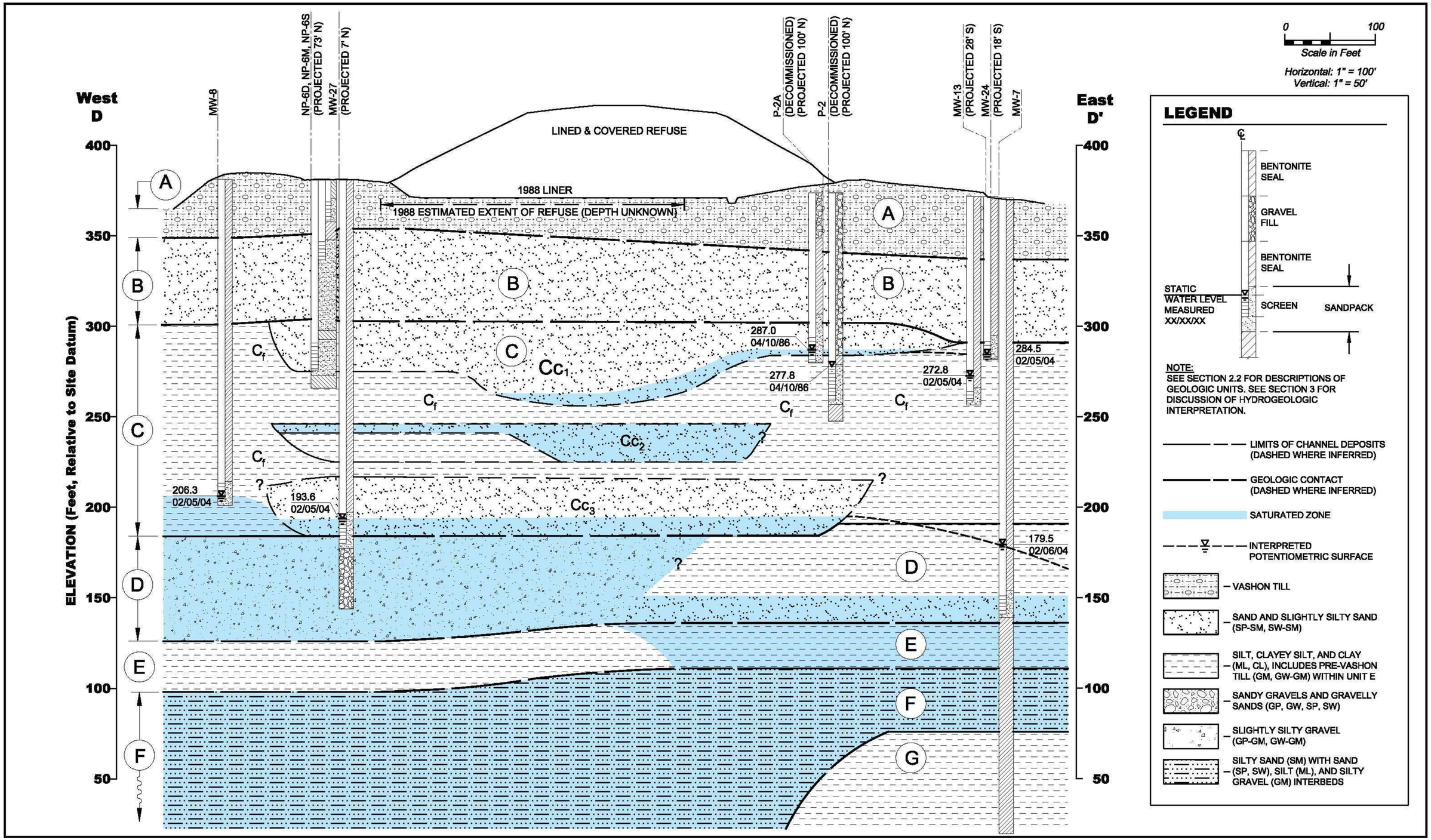
Hydrogeologic Cross Section C-C'

Source December 2004,
Vashon Island Landfill Hydrogeologic Report Update

Prepared by Berryman & Henigar with UES

Figure 6

FILE NAME (UPDATED BY)
S:\CAD\KING COUNTY\4021105-011\DWG\P2110501TSECTIONS_F3.DWG (PLS)
PLOT DATE & TIME
NOV 23 2004 15:00:56
XREFS: NONE



King County
Department of Natural Resources and Parks
Solid Waste Division

Hydrogeologic Cross Section D-D'

Source December 2004,
Vashon Island Landfill Hydrogeologic Report Update

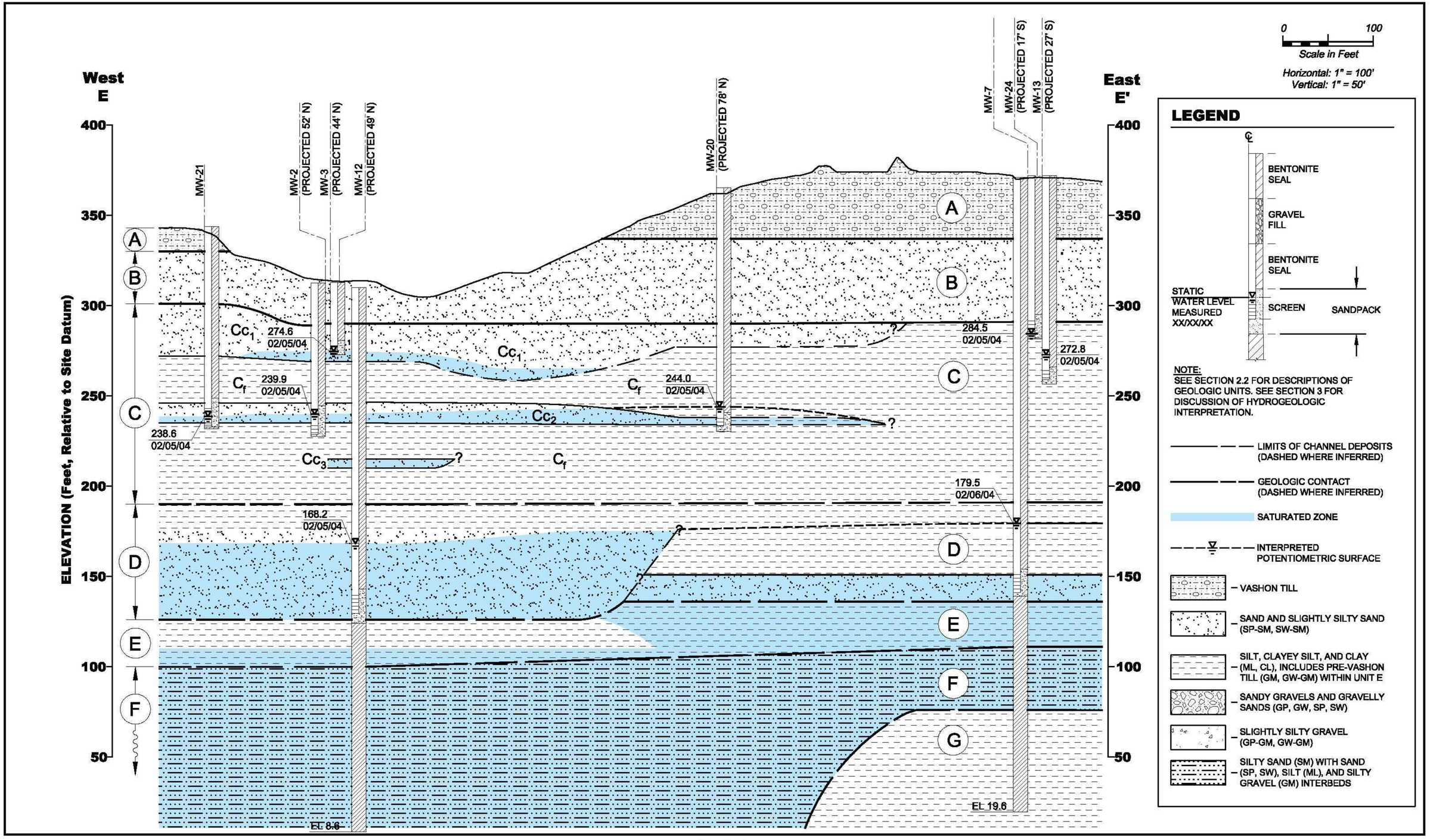
Prepared by Berryman & Henigar with UES

Figure 7

PLOT DATE & TIME
NOV 23 2004 15:00:56

FILE NAME (UPDATED BY)
S:\CAD\KING COUNTY\4021105-011\DWG\P2110501SECTIONS_F3.DWG (PLS)

XREFS: NONE



King County
Department of Natural Resources and Parks
Solid Waste Division

Hydrogeologic Cross Section E-E'

Source December 2004,
Vashon Island Landfill Hydrogeologic Report Update

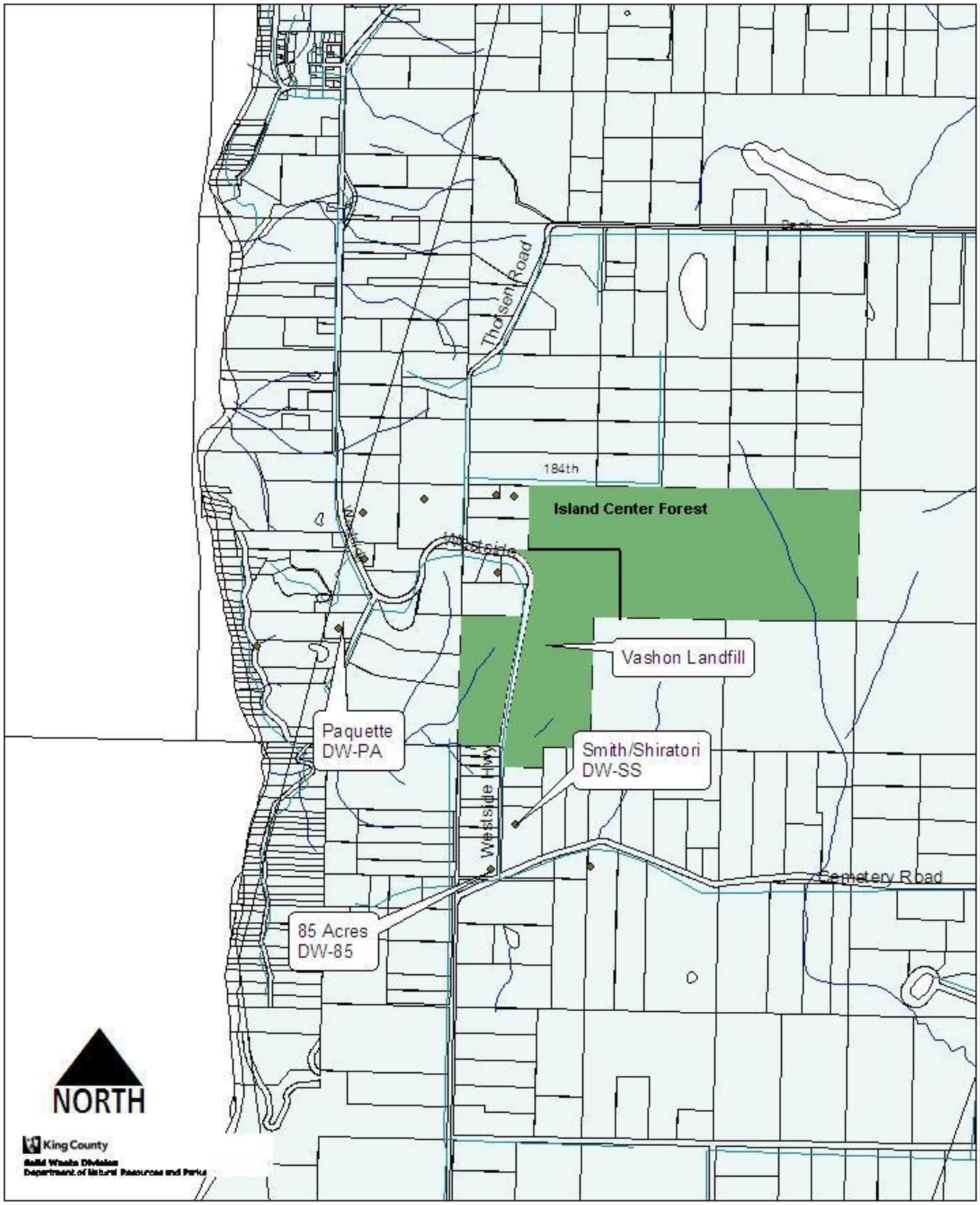
Prepared by Berryman & Henigar with UES

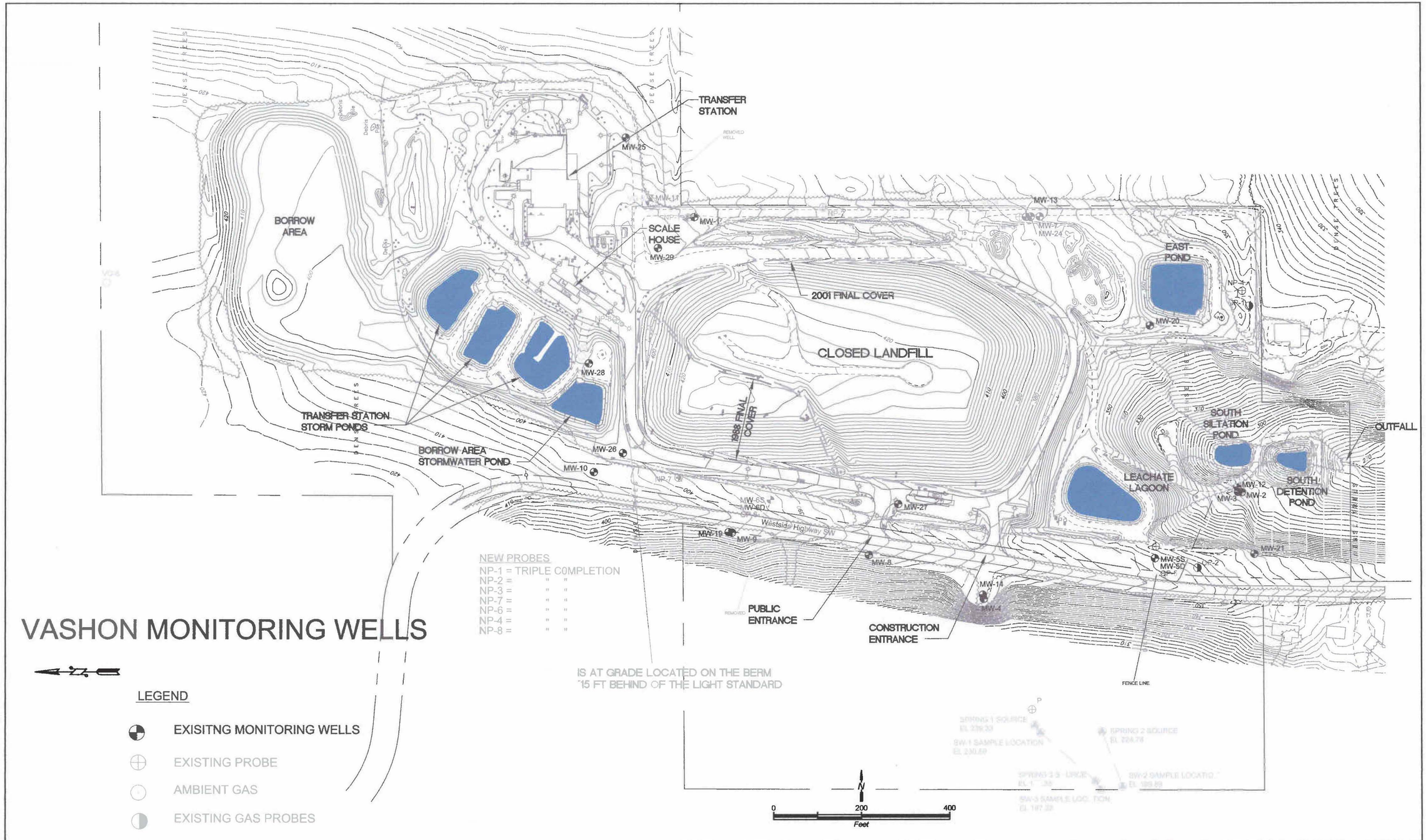
Figure 8

FILE NAME (UPDATED BY)
S:\CAD\KING COUNTY\4021105-011\DWG\P2110501SECTIONS_F3.DWG (PLS)
PLOT DATE & TIME
NOV 23 2004 15:00:56
XREFS: NONE

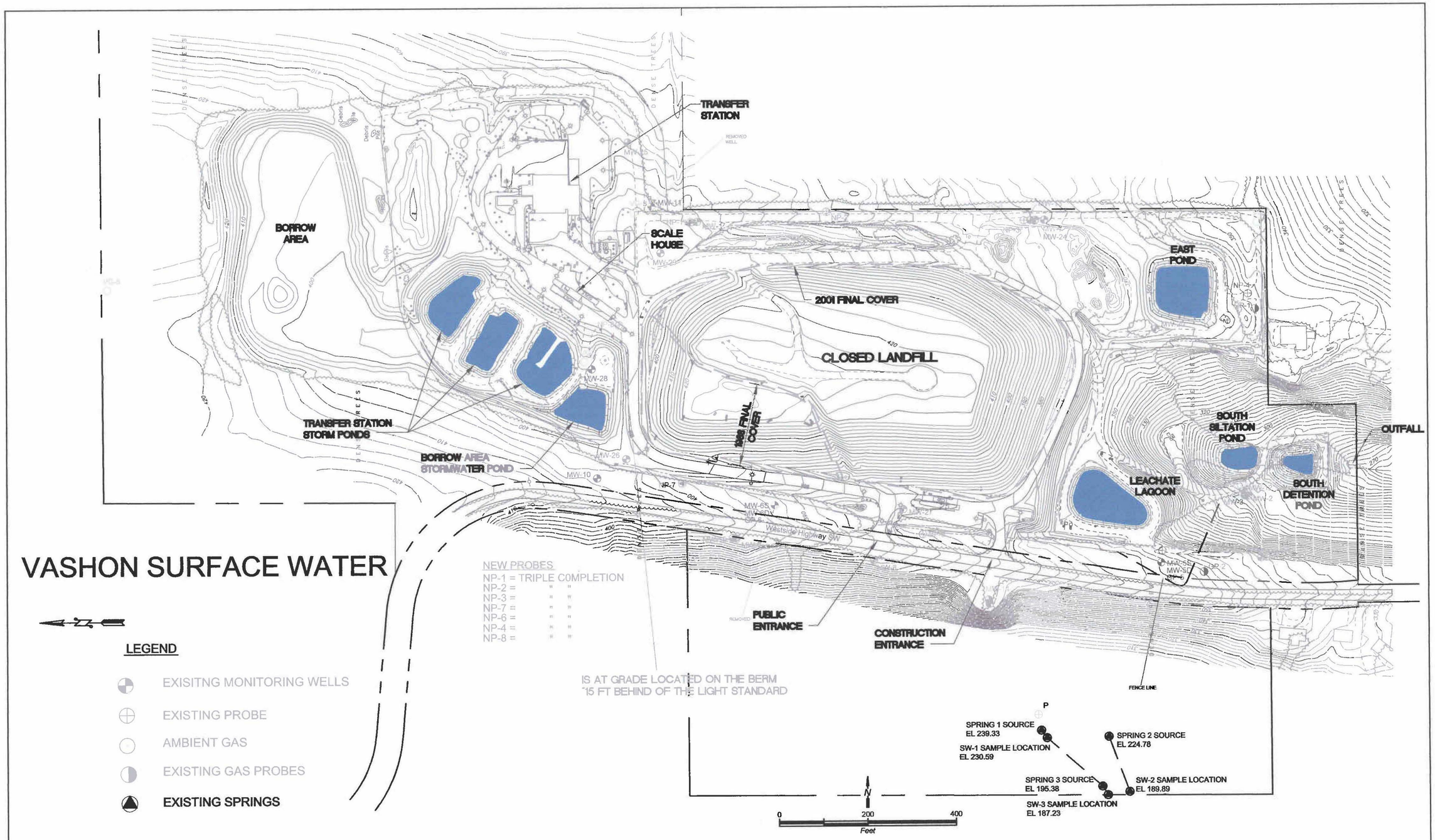
Vashon Offsite Private Wells

Figure 9

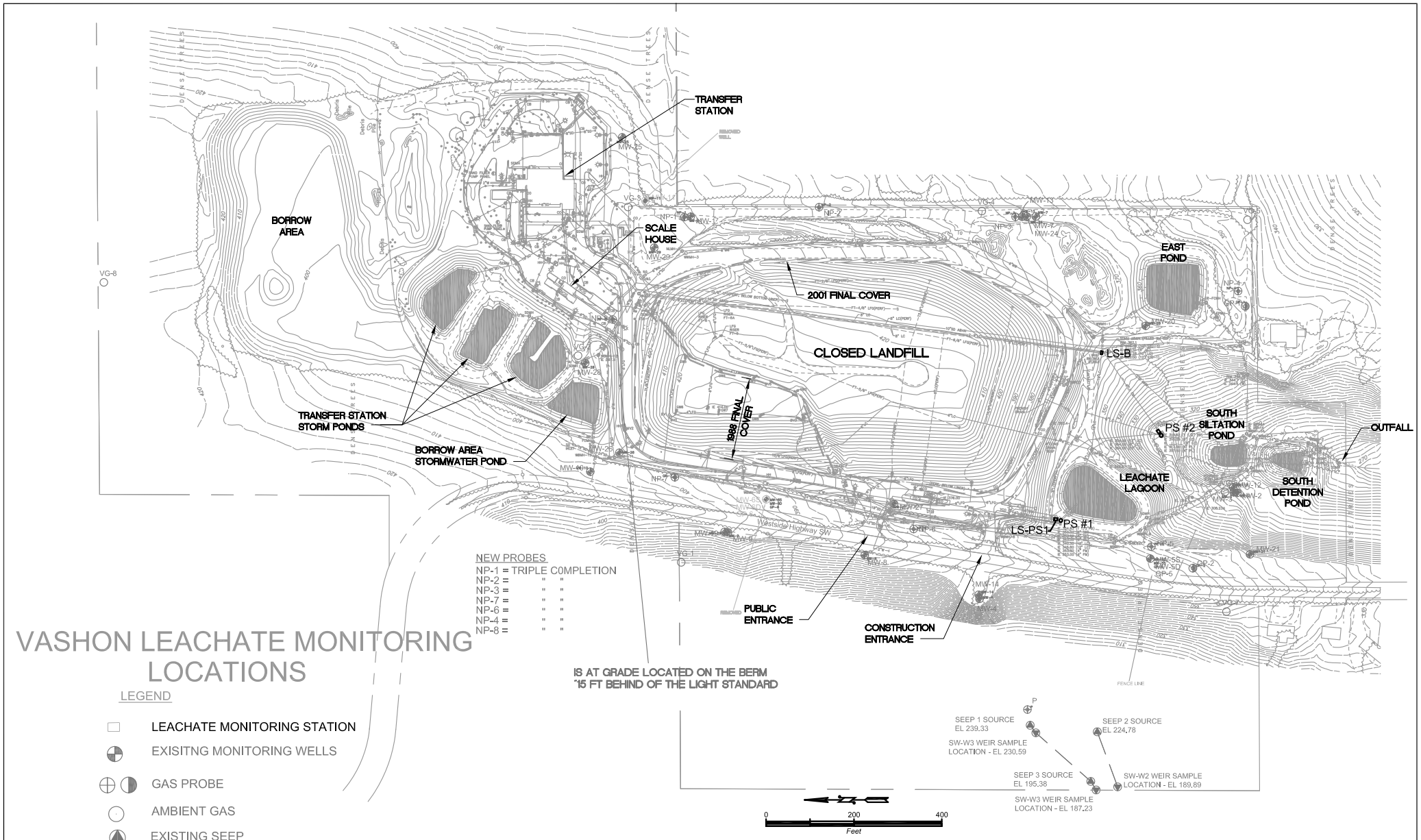




KING COUNTY Dept. of Natural Resources & Parks Solid Waste Division Vashon Landfill		**Vashon Monitoring Wells** Vashon Landfill King County, Washington	October 2004	PROJECT NO.
				FIGURE NO. 10



KING COUNTY Dept. of Natural Resources & Parks Solid Waste Division Vashon Landfill		**Vashon Surface Water** Vashon Landfill King County, Washington	October 2004	PROJECT NO.
				FIGURE NO. 11

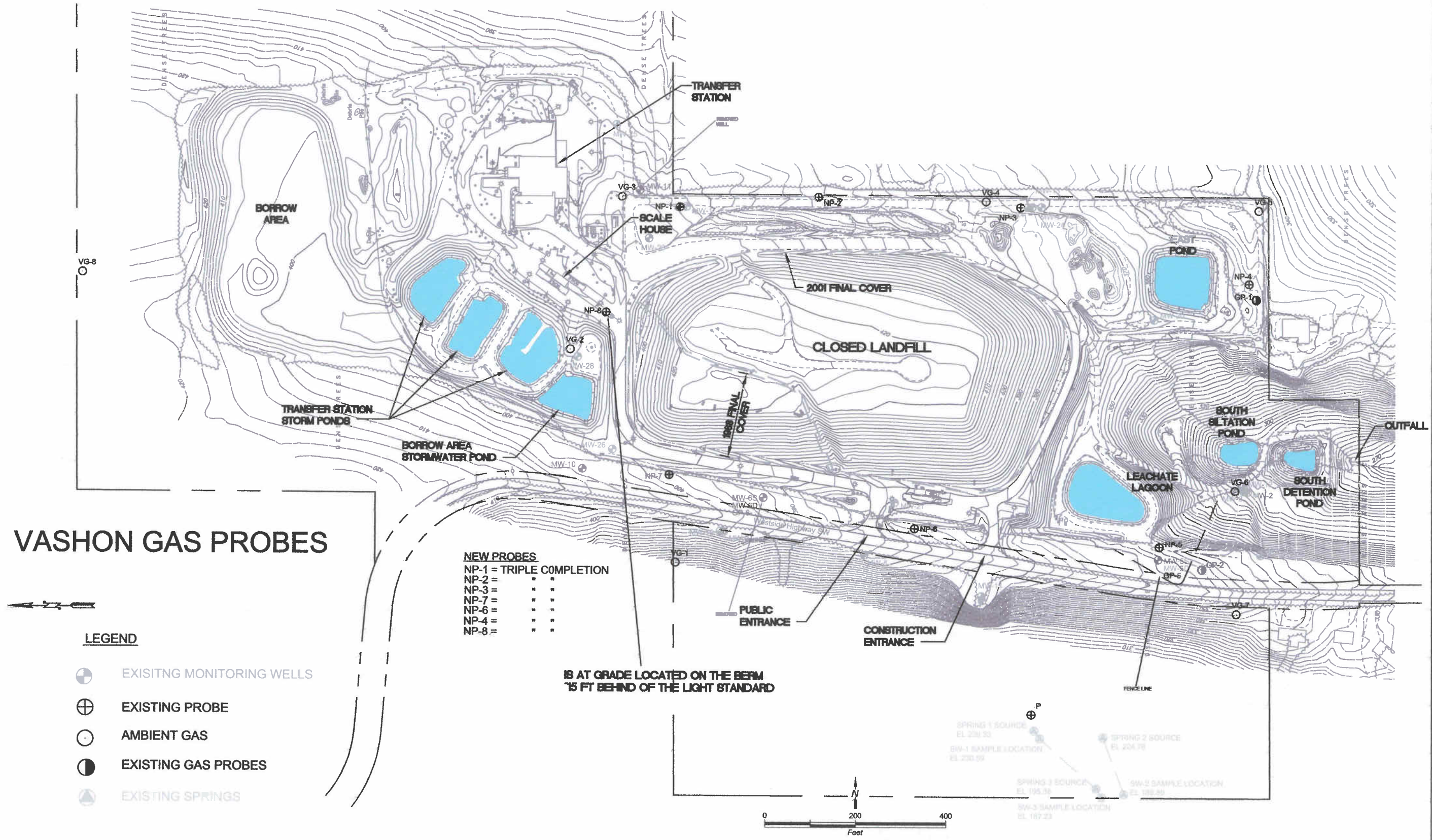


VASHON LEACHATE MONITORING LOCATIONS

LEGEND

- LEACHATE MONITORING STATION
- EXISITNG MONITORING WELLS
- GAS PROBE
- AMBIENT GAS
- EXISTING SEEP
- WEIR SAMPLE LOCATION

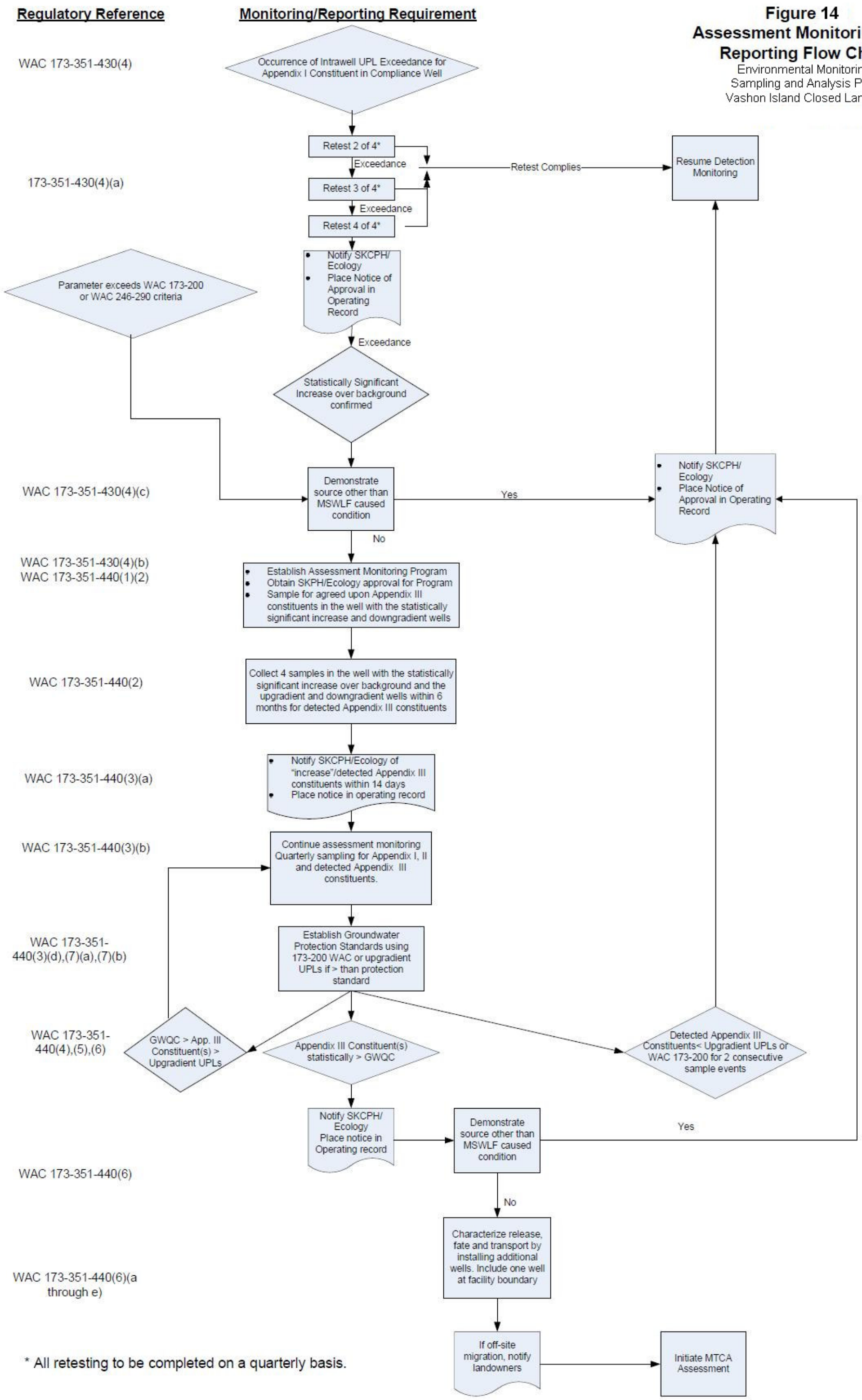
KING COUNTY Dept. of Natural Resources & Parks Solid Waste Division Vashon Landfill		**Vashon Leachate Monitoring Locations** Vashon Landfill King County, Washington	October 2004 PROJECT NO. FIGURE NO. 12



KING COUNTY Dept. of Natural Resources & Parks Solid Waste Division Vashon Landfill		**Vashon Gas Probes** Vashon Landfill King County, Washington	October 2004 PROJECT NO. FIGURE NO. 13

Figure 14
Assessment Monitoring and Reporting Flow Chart

Environmental Monitoring
Sampling and Analysis Plan
Vashon Island Closed Landfill



* All retesting to be completed on a quarterly basis.

King County
Department of Natural Resources and Parks
Solid Waste Division

Table 5-2
Groundwater Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Ground Water Quality Criteria Criterion*	Units	Appendix Listing
EPA 120.1	Conductance	N/A	1	--	µmhos/cm	II
EPA 150.1	pH	N/A	N/A	6.5-8.5	units	II
EPA 160.1	Total Dissolved Solids	N/A	5	500	mg/L	II
EPA 160.2	Total Suspended Solids	N/A	1	--	mg/L	--
EPA 160.3	Total Solids	N/A	5	--	mg/L	--
EPA 300.0	Chloride	16887-00-6	0.1	250	mg/L	II
EPA 300.0	Nitrate	14797-55-8	0.01	10	mg-N/L	I & III
EPA 300.0	Sulfate	14808-79-8	0.1	250	mg/L	II
EPA 310.1	Alkalinity	N/A	1	--	mg/L as CaCO3	II
EPA 350.1	Ammonia	7664-41-7	0.01	--	mg-N/L	II
EPA 315.1	Total Organic Carbon	N/A	1	--	mg/L	II
SW-846 6020	Antimony	7440-36-0	0.001	0.006	mg/L	I & III
SW-846 6020	Arsenic	7440-38-2	0.001	0.00005	mg/L	I & III
SW-846 6020	Barium	7440-39-3	0.001	1	mg/L	I & III
SW-846 6020	Beryllium	7440-41-7	0.001	0.004	mg/L	I & III
SW-846 6020	Cadmium	7440-43-9	0.002	0.005	mg/L	I & III
SW-846 6020	Calcium	7440-70-2	0.01	--	mg/L	II
SW-846 6020	Chromium	7440-47-3	0.005	0.05	mg/L	I & III
SW-846 6020	Cobalt	7440-48-4	0.003	--	mg/L	I & III
SW-846 6020	Copper	7440-50-8	0.002	1	mg/L	I & III
SW-846 6020	Iron	7439-89-6	0.01	0.3	mg/L	II

Table 5-2
Groundwater Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Ground Water Quality Criteria Criterion*	Units	Appendix Listing
SW-846 6020	Lead	7439-92-1	0.001	0.015	mg/L	I & III
SW-846 6020	Magnesium	7439-95-4	0.015	--	mg/L	II
SW-846 6020	Manganese	7439-96-5	0.001	0.05	mg/L	II
SW-846 6020	Nickel	7440-02-0	0.01	0.1	mg/L	I & III
SW-846 6020	Potassium	09/07/7440	0.3	--	mg/L	II
SW-846 6020	Selenium	7782-49-2	0.001	0.01	mg/L	I & III
SW-846 6020	Silver	7440-22-4	0.003	0.05	mg/L	I & III
SW-846 6020	Sodium	7440-23-5	0.05	20***	mg/L	II
SW-846 6020	Thallium	7440-28-0	0.001	0.002	mg/L	I & III
SW-846 6020	Vanadium	7440-62-2	0.002	--	mg/L	I & III
SW-846 6020	Zinc	7440-66-6	0.004	5	mg/L	I & III
SW-846 7470	Mercury	7439-97-6	0.0001	0.002	mg/L	III
SW-846 8260	Acetone	67-64-1	4	--	µg/L	I & III
SW-846 8260	Acrylonitrile	107-13-1	0.07	0.07	µg/L	I & III
SW-846 8260	Benzene	71-43-2	0.2	1	µg/L	I & III
SW-846 8260	2-Butanone	78-93-3	4	--	µg/L	I & III
SW-846 8260	Bromochloromethane	74-97-5	0.2	--	µg/L	I & III
SW-846 8260	Bromodichloromethane	75-27-4	0.2	0.3	µg/L	I & III
SW-846 8260	Bromoform	75-25-2	0.2	5	µg/L	I & III
SW-846 8260	Bromomethane	74-83-9	0.2	--	µg/L	I & III
SW-846 8260	Carbon Disulfide	75-15-0	0.2	--	µg/L	I & III
SW-846 8260	Carbon tetrachloride	56-23-5	0.2	0.3	µg/L	I & III

Table 5-2
Groundwater Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Ground Water Quality Criteria Criterion*	Units	Appendix Listing
SW-846 8260	Chlorobenzene	108-90-7	0.2	100	µg/L	I & III
SW-846 8260	Chloroethane	75-00-3	0.2	--	µg/L	I & III
SW-846 8260	Chloroform	67-66-3	0.2	7	µg/L	I & III
SW-846 8260	Chloromethane	74-87-3	0.2	--	µg/L	I & III
SW-846 8260	Dibromochloromethane	124-48-1	0.2	--	µg/L	I & III
SW-846 8260	Dibromomethane	74-95-3	0.2	--	µg/L	I & III
SW-846 8260	1,2-Dibromo-3-chloropropane	96-12-8	0.2	0.2	µg/L	I & III
SW-846 8260	1,2-Dibromoethane	106-93-4	0.2	0.001	µg/L	I & III
SW-846 8260	1,2-Dichlorobenzene	95-50-1	0.2	600	µg/L	I & III
SW-846 8260	1,4-Dichlorobenzene	106-46-7	0.2	4	µg/L	I & III
SW-846 8260	trans-1,4-Dichloro-2-butene	110-57-6	0.2	--	µg/L	I & III
SW-846 8260	1,1-Dichloroethane	75-34-3	0.2	1	µg/L	I & III
SW-846 8260	1,2-Dichloroethane	107-06-2	0.2	0.5	µg/L	I & III
SW-846 8260	1,1-Dichloroethene	75-35-4	0.2	7	µg/L	I & III
SW-846 8260	cis-1,2-Dichloroethene	156-59-2	0.2	70	µg/L	I & III
SW-846 8260	trans-1,2-Dichloroethene	156-60-5	0.2	100	µg/L	I & III
SW-846 8260	1,2-Dichloropropane	78-87-5	0.2	0.6	µg/L	I & III
SW-846 8260	cis-1,3-Dichloropropene	10061-01-5	0.2	--	µg/L	I & III
SW-846 8260	trans-1,3-Dichloropropene	10061-02-6	0.2	--	µg/L	I & III
SW-846 8260	Ethylbenzene	100-41-4	0.2	700	µg/L	I & III
SW-846 8260	2-Hexanone	591-78-6	4	--	µg/L	I & III

Table 5-2
Groundwater Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Ground Water Quality Criteria Criterion*	Units	Appendix Listing
SW-846 8260	Methylene Chloride	75-09-2	0.2	40	µg/L	I & III
SW-846 8260	Methyl iodide	74-88-4	0.2	--	µg/L	I & III
SW-846 8260	4-Methyl-2-Pentanone	108-10-1	4	--	µg/L	I & III
SW-846 8260	Styrene	100-42-5	0.2	100	µg/L	I & III
SW-846 8260	1,1,1,2-Tetrachloroethane	630-20-6	0.2	--	µg/L	I & III
SW-846 8260	1,1,2,2-Tetrachloroethane	79-34-5	0.2	--	µg/L	I & III
SW-846 8260	Tetrachloroethene	127-18-4	0.2	0.8	µg/L	I & III
SW-846 8260	Toluene	108-88-3	0.2	1000	µg/L	I & III
SW-846 8260	1,1,1-Trichloroethane	71-55-6	0.2	200	µg/L	I & III
SW-846 8260	1,1,2-Trichloroethane	79-00-5	0.2	5	µg/L	I & III
SW-846 8260	Trichloroethene	79-01-6	0.2	--	µg/L	I & III
SW-846 8260	Trichlorofluoromethane	75-69-4	0.2	--	µg/L	I & III
SW-846 8260	1,2,3-Trichloropropane	96-18-4	0.2	--	µg/L	I & III
SW-846 8260	Vinyl acetate	108-05-4	0.2	--	µg/L	I & III
SW-846 8260 SIM	Vinyl Chloride	75-01-4	0.02	0.02	µg/L	I & III
SW-846 8260	Xylenes, m & p	mpx	0.4	--	µg/L	I & III
SW-846 8260	Xylene, o	95-47-6	0.2	--	µg/L	I & III
SW-846 8260	Dichlorodifluoromethane*	75-71-8	0.2		µg/L	III

*Criteria shall be the most stringent concentration of the Federal Maximum Contaminant Level Goal, Maximum Contaminant Level; or State Maximum Contaminant Level
*** A Drinking Water Advisory, not an enforceable standard.

Table 6-2
Surface Water Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Units	Appendix Listing
EPA 120.1	Conductance	N/A	1	µmhos/cm	II
EPA 150.1	pH	N/A	N/A	N/A	II
EPA 160.1	Total Dissolved Solids	N/A	5	mg/L	II
EPA 160.2	Total Suspended Solids	N/A	1	mg/L	--
EPA 160.3	Total Solids	N/A	5	mg/L	--
EPA 300.0	Chloride	16887-00-6	0.1	mg/L	II
EPA 300.0	Nitrate	14797-55-8	0.01	mg-N/L	I & III
EPA 300.0	Sulfate	14808-79-8	0.1	mg/L	II
EPA 310.1	Alkalinity	N/A	1	mg/L as CaCO3	II
EPA 350.1	Ammonia	7664-41-7	0.01	mg-N/L	II
EPA 315.1	Total Organic Carbon	N/A	1	mg/L	II
EPA 405.1	Biological Oxygen Demand	N/A	2	mg/L	IV
SM 9222B	Total Coliforms	N/A	1	CFU/100 mL	IV
SM 9222D	Fecal Coliforms	N/A	1	CFU/100 mL	--
E180.1	Turbidity	N/A	0.2	NTU	--
EPA 130.2	Hardness	N/A	1	mg/L	--
EPA 360.2	Dissolved Oxygen	N/A	0.1	mg/L	--
SW-846 6020	Antimony	7440-36-0	0.001	mg/L	I & III
SW-846 6020	Arsenic	7440-38-2	0.001	mg/L	I & III
SW-846 6020	Barium	7440-39-3	0.001	mg/L	I & III
SW-846 6020	Beryllium	7440-41-7	0.001	mg/L	I & III
SW-846 6020	Cadmium	7440-43-9	0.002	mg/L	I & III
SW-846 6020	Calcium	7440-70-2	0.01	mg/L	II
SW-846 6020	Chromium	7440-47-3	0.005	mg/L	I & III
SW-846 6020	Cobalt	7440-48-4	0.003	mg/L	I & III
SW-846 6020	Copper	7440-50-8	0.002	mg/L	I & III
SW-846 6020	Iron	7439-89-6	0.01	mg/L	II
SW-846 6020	Lead	7439-92-1	0.001	mg/L	I & III
SW-846 6020	Magnesium	7439-95-4	0.015	mg/L	II
SW-846 6020	Manganese	7439-96-5	0.001	mg/L	II
SW-846 6020	Nickel	7440-02-0	0.01	mg/L	I & III
SW-846 6020	Potassium	7440-09-7	0.3	mg/L	II
SW-846 6020	Selenium	7782-49-2	0.001	mg/L	I & III
SW-846 6020	Silver	7440-22-4	0.003	mg/L	I & III
SW-846 6020	Sodium	7440-23-5	0.05	mg/L	II
SW-846 6020	Thallium	7440-28-0	0.001	mg/L	I & III
SW-846 6020	Vanadium	7440-62-2	0.002	mg/L	I & III
SW-846 6020	Zinc	7440-66-6	0.004	mg/L	I & III

Table 6-2
Surface Water Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Units	Appendix Listing
SW-846 7470	Mercury	7439-97-6	0.0001	mg/L	III
SW-846 8260	Acetone	67-64-1	4	µg/L	I & III
SW-846 8260	Acrylonitrile	107-13-1	0.07	µg/L	I & III
SW-846 8260	Benzene	71-43-2	0.2	µg/L	I & III
SW-846 8260	2-Butanone	78-93-3	4	µg/L	I & III
SW-846 8260	Bromochloromethane	74-97-5	0.2	µg/L	I & III
SW-846 8260	Bromodichloromethane	75-27-4	0.2	µg/L	I & III
SW-846 8260	Bromoform	75-25-2	0.2	µg/L	I & III
SW-846 8260	Bromomethane	74-83-9	0.2	µg/L	I & III
SW-846 8260	Carbon Disulfide	75-15-0	0.2	µg/L	I & III
SW-846 8260	Carbon tetrachloride	56-23-5	0.2	µg/L	I & III
SW-846 8260	Chlorobenzene	108-90-7	0.2	µg/L	I & III
SW-846 8260	Chloroethane	75-00-3	0.2	µg/L	I & III
SW-846 8260	Chloroform	67-66-3	0.2	µg/L	I & III
SW-846 8260	Chloromethane	74-87-3	0.2	µg/L	I & III
SW-846 8260	Dibromochloromethane	124-48-1	0.2	µg/L	I & III
SW-846 8260	Dibromomethane	74-95-3	0.2	µg/L	I & III
SW-846 8260	1,2-Dibromo-3-chloropropane	96-12-8	0.2	µg/L	I & III
SW-846 8260	1,2-Dibromoethane	106-93-4	0.2	µg/L	I & III
SW-846 8260	1,2-Dichlorobenzene	95-50-1	0.2	µg/L	I & III
SW-846 8260	1,4-Dichlorobenzene	106-46-7	0.2	µg/L	I & III
SW-846 8260	trans-1,4-Dichloro-2-butene	110-57-6	0.2	µg/L	I & III
SW-846 8260	1,1-Dichloroethane	75-34-3	0.2	µg/L	I & III
SW-846 8260	1,2-Dichloroethane	107-06-2	0.2	µg/L	I & III
SW-846 8260	1,1-Dichloroethene	75-35-4	0.2	µg/L	I & III
SW-846 8260	cis-1,2-Dichloroethene	156-59-2	0.2	µg/L	I & III
SW-846 8260	trans-1,2-Dichloroethene	156-60-5	0.2	µg/L	I & III
SW-846 8260	1,2-Dichloropropane	78-87-5	0.2	µg/L	I & III
SW-846 8260	cis-1,3-Dichloropropene	10061-01-5	0.2	µg/L	I & III
SW-846 8260	trans-1,3-Dichloropropene	10061-02-6	0.2	µg/L	I & III
SW-846 8260	Ethylbenzene	100-41-4	0.2	µg/L	I & III
SW-846 8260	2-Hexanone	591-78-6	4	µg/L	I & III
SW-846 8260	Methylene Chloride	75-09-2	0.2	µg/L	I & III
SW-846 8260	Methyl iodide	74-88-4	0.2	µg/L	I & III
SW-846 8260	4-Methyl-2-Pentanone	108-10-1	4	µg/L	I & III
SW-846 8260	Styrene	100-42-5	0.2	µg/L	I & III
SW-846 8260	1,1,1,2-Tetrachloroethane	630-20-6	0.2	µg/L	I & III
SW-846 8260	1,1,2,2-Tetrachloroethane	79-34-5	0.2	µg/L	I & III
SW-846 8260	Tetrachloroethene	127-18-4	0.2	µg/L	I & III

Table 6-2
Surface Water Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Units	Appendix Listing
SW-846 8260	Toluene	108-88-3	0.2	µg/L	I & III
SW-846 8260	1,1,1-Trichloroethane	71-55-6	0.2	µg/L	I & III
SW-846 8260	1,1,2-Trichloroethane	79-00-5	0.2	µg/L	I & III
SW-846 8260	Trichloroethene	79-01-6	0.2	µg/L	I & III
SW-846 8260	Trichlorofluoromethane	75-69-4	0.2	µg/L	I & III
SW-846 8260	1,2,3-Trichloropropane	96-18-4	0.2	µg/L	I & III
SW-846 8260	Vinyl acetate	108-05-4	0.2	µg/L	I & III
SW-846 8260 SIM	Vinyl Chloride	75-01-4	0.02	µg/L	I & III
SW-846 8260	Xylenes, m & p	mpx	0.4	µg/L	I & III
SW-846 8260	Xylenes, o	95-47-6	0.2	µg/L	I & III
SW-846 8260	Dichlorodifluoromethane	75-71-8	0.2	µg/L	III

Table 6-5
Freshwater Toxics Substances Criteria*

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Substance	Acute	Chronic	Units
Aldrin/Dieldrin [e]	2.5[a]	0.0019[b]	µg/L
Ammonia (un-ionized NH3) [hh]	[f,c]	[g,d]	mg/L
Arsenic [dd]	360.0[c]	190.0[d]	µg/L
Cadmium [dd]	[i,c]	[j,d]	µg/L
Chlordane	2.4[a]	0.0043[b]	µg/L
Chloride (Dissolved) [k]	860.0[h,c]	230.0[h,d]	mg/L
Chlorine (Total Residual)	19.0[c]	11.0[d]	µg/L
Chlorpyrifos	0.083[c]	0.041[d]	µg/L
Chromium (Hex) [dd]	15.0[c,l,ii]	10.0[d,jj]	µg/L
Chromium (Tri) [gg]	[m,c]	[n,d]	µg/L
Copper [dd]	[o,c]	[p,d]	µg/L
Cyanide [ee]	22.0[c]	5.2[d]	µg/L
DDT (and metabolites)	1.1[a]	0.001[b]	µg/L
Dieldrin/Aldrin [e]	2.5[a]	0.0019[b]	µg/L
Endosulfan	0.22[a]	0.056[b]	µg/L
Endrin	0.18[a]	0.0023[b]	µg/L
Heptachlor	0.52[a]	0.0038[b]	µg/L
Hexachlorocyclohexane (Lindane)	2.0[a]	0.08[b]	µg/L
Lead [dd]	q,c	[r,d]	µg/L
Mercury [s]	2.1[c,kk,dd]	0.012[d,ff]	µg/L
Nickel [dd]	[t,c]	[u,d]	µg/L
Parathion	0.065[c]	0.013[d]	µg/L
Pentachlorophenol (PCP)	[w,c]	[v,d]	µg/L
Polychlorinated Biphenyls (PCBs)	2.0[b]	0.014[b]	µg/L
Selenium	20.0[c,ff]	5.0[d,ff]	µg/L
Silver [dd]	[y,a]	-	µg/L
Toxaphene	0.73[c,z]	0.0002[d]	µg/L
Zinc [dd]	[aa,c]	[bb,d]	µg/L

Notes:

* Hardness values will be determined from stormwater sample SW-E

[a.] An instantaneous concentration not to be exceeded at any time.

[b.] A 24-hour average not to be exceeded.

[c.] A 1-hour average concentration not to be exceeded more than once every three years on the average.

[d.] A 4-day average concentration not to be exceeded more than once every three years on the average.

[e.] Aldrin is metabolically converted to Dieldrin. Therefore, the sum of the Aldrin and Dieldrin concentrations are compared with the Dieldrin criteria.

[f.] Shall not exceed the numerical value in total ammonia nitrogen (mg N/L) given by:

For salmonids present: $$\frac{0.275}{1 + 10^{7.204-pH}} + \frac{39.0}{1 + 10^{pH-7.204}}$$

For salmonids absent: $$\frac{0.411}{} + \frac{58.4}{}$$

$1 + 10^{7.204-pH}$ $\qquad$ $1 + 10^{pH-7.204}$

g. Shall not exceed the numerical concentration calculated as follows:
Unionized ammonia concentration for waters where salmonid habitat is an existing or designated use:

$0.80 \div (FT)(FPH)(RATIO)$

where: $RATIO = 13.5;\ 7.7 \leq pH \leq 9$

$RATIO = (20.25 \times 10^{(7.7-pH)}) \div (1 + 10^{(7.4-pH)});\ 6.5 \leq pH \leq 7.7$

$FT = 1.4;\ 15 \leq T \leq 30$

$FT = 10^{[0.03(20-T)]};\ 0 \leq T \leq 15$

$FPH = 1;\ 8 \leq pH \leq 9$

$FPH = (1 + 10^{(7.4-pH)}) \div 1.25;\ 6.5 \leq pH \leq 8.0$

Total ammonia concentrations for waters where salmonid habitat is not an existing or designated use and other fish early life stages are absent:

$$Chronic\ Criterion = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) \times \left(1.45 \times 10^{0.028(25-A)}\right)$$

where: A = *the greater of either T (temperature in degrees Celsius) or 7.*

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

Total ammonia concentration for waters where salmonid habitat is not an existing or designated use and other fish early life stages are present:

$$Chronic\ Criterion = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) \times B$$

where: B = *the lower of either 2.85, or* $1.45 \times 10^{0.028 \times (25-T)}$.

T = *temperature in degrees Celsius.*

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on the average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

i. ≤ (0.944)(e(1.128[ln(hardness)]-3.828)) at hardness = 100. Conversion factor (CF) of 0.944 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.136672 - [(ln hardness)(0.041838)].

j. ≤ (0.909)(e(0.7852[ln(hardness)]-3.490)) at hardness = 100. Conversions factor (CF) of 0.909 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.101672 - [(ln hardness)(0.041838)].

k. Criterion based on dissolved chloride in association with sodium. This criterion probably will not be adequately protective when the chloride is associated with potassium, calcium, or magnesium, rather than sodium.

l. Salinity dependent effects. At low salinity the 1-hour average may not be sufficiently protective.

m. ≤ (0.316)(e(0.8190[ln(hardness)] + 3.688))

n. ≤ (0.860)(e(0.8190[ln(hardness)] + 1.561))

o. ≤ (0.960)(e(0.9422[ln(hardness)] - 1.464))

p. ≤ (0.960)(e(0.8545[ln(hardness)] - 1.465))

[q.] ≤ (0.791)(e(1.273[ln(hardness)] - 1.460)) at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

[r.] ≤ (0.791)(e(1.273[ln(hardness)] - 4.705)) at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].

[s.] If the four-day average chronic concentration is exceeded more than once in a three-year period, the edible portion of the consumed species should be analyzed. Said edible tissue concentrations shall not be allowed to exceed 1.0 mg/kg of methylmercury.

[t.] ≤ (0.998)(e(0.8460[ln(hardness)] + 3.3612))

[u.] ≤ (0.997)(e(0.8460[ln(hardness)] + 1.1645))

[v.] ≤ e[1.005(pH) - 5.290]

[w.] ≤ e[1.005(pH) - 4.830]

[y.] ≤ (0.85)(e(1.72[ln(hardness)] - 6.52))

[z.] Channel Catfish may be more acutely sensitive.

[aa.] ≤ (0.978)(e(0.8473[ln(hardness)] + 0.8604))

[bb.] ≤ (0.986)(e(0.8473[ln(hardness)] + 0.7614))

[dd.] These ambient criteria in the table are for the dissolved fraction. The cyanide criteria are based on the weak acid dissociable method. The metals criteria may not be used to calculate total recoverable effluent limits unless the seasonal partitioning of the dissolved to total metals in the ambient water are known. When this information is absent, these metals criteria shall be applied as total recoverable values, determined by back-calculation, using the conversion factors incorporated in the criterion equations. Metals criteria may be adjusted on a site-specific basis when data are made available to the department clearly demonstrating the effective use of the water effects ratio approach established by USEPA, as generally guided by the procedures in USEPA Water Quality Standards Handbook, December 1983, as supplemented or replaced by USEPA or ecology. Information which is used to develop effluent limits based on applying metals partitioning studies or the water effects ratio approach shall be identified in the permit fact sheet developed pursuant to WAC 173-220-060 or 173-226-110, as appropriate, and shall be made available for the public comment period required pursuant to WAC 173-220-050 or 173-226-130(3), as appropriate. Ecology has developed supplemental guidance for conducting water effect ratio studies.

[ee.] The criteria for cyanide is based on the weak acid dissociable method in the 19th Ed. Standard Methods for the Examination of Water and Wastewater, 4500-CN I, and as revised (see footnote dd, above).

[ff.] These criteria are based on the total-recoverable fraction of the metal.

[gg.] Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total-recoverable chromium.

[hh.] The listed fresh water criteria are based on un-ionized or total ammonia concentrations, while those for marine water are based on un-ionized ammonia concentrations. Tables for the conversion of total ammonia to un-ionized ammonia for freshwater can be found in the USEPA's Quality Criteria for Water, 1986. Criteria concentrations based on total ammonia for marine water can be found in USEPA Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA440/5-88-004, April 1989.

[ii.] The conversion factor used to calculate the dissolved metal concentration was 0.982.

[jj.] The conversion factor used to calculate the dissolved metal concentration was 0.962.

[kk.] The conversion factor used to calculate the dissolved metal concentration was 0.85.

Source:
WAC 173-201A-240 Toxic substances, Table 240(3), Toxics Substances Criteria

Table 6-5
Freshwater Toxics Substances Criteria*

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Substance	Acute	Chronic	Units
Aldrin/Dieldrin [e]	2.5[a]	0.0019[b]	µg/L
Ammonia (un-ionized NH3) [hh]	[f,c]	[g,d]	mg/L
Arsenic [dd]	360.0[c]	190.0[d]	µg/L
Cadmium [dd]	[i,c]	[j,d]	µg/L
Chlordane	2.4[a]	0.0043[b]	µg/L
Chloride (Dissolved) [k]	860.0[h,c]	230.0[h,d]	mg/L
Chlorine (Total Residual)	19.0[c]	11.0[d]	µg/L
Chlorpyrifos	0.083[c]	0.041[d]	µg/L
Chromium (Hex) [dd]	15.0[c,l,ii]	10.0[d,jj]	µg/L
Chromium (Tri) [gg]	[m,c]	[n,d]	µg/L
Copper [dd]	[o,c]	[p,d]	µg/L
Cyanide [ee]	22.0[c]	5.2[d]	µg/L
DDT (and metabolites)	1.1[a]	0.001[b]	µg/L
Dieldrin/Aldrin [e]	2.5[a]	0.0019[b]	µg/L
Endosulfan	0.22[a]	0.056[b]	µg/L
Endrin	0.18[a]	0.0023[b]	µg/L
Heptachlor	0.52[a]	0.0038[b]	µg/L
Hexachlorocyclohexane (Lindane)	2.0[a]	0.08[b]	µg/L
Lead [dd]	q,c	[r,d]	µg/L
Mercury [s]	2.1[c,kk,dd]	0.012[d,ff]	µg/L
Nickel [dd]	[t,c]	[u,d]	µg/L
Parathion	0.065[c]	0.013[d]	µg/L
Pentachlorophenol (PCP)	[w,c]	[v,d]	µg/L
Polychlorinated Biphenyls (PCBs)	2.0[b]	0.014[b]	µg/L
Selenium	20.0[c,ff]	5.0[d,ff]	µg/L
Silver [dd]	[y,a]	-	µg/L
Toxaphene	0.73[c,z]	0.0002[d]	µg/L
Zinc [dd]	[aa,c]	[bb,d]	µg/L

Notes:

* Hardness values will be determined from surface water sample location SW-E.

[a.] An instantaneous concentration not to be exceeded at any time.

[b.] A 24-hour average not to be exceeded.

[c.] A 1-hour average concentration not to be exceeded more than once every three years on the average.

[d.] A 4-day average concentration not to be exceeded more than once every three years on the average.

[e.] Aldrin is metabolically converted to Dieldrin. Therefore, the sum of the Aldrin and Dieldrin concentrations are compared with the Dieldrin criteria.

[f.] Shall not exceed the numerical value in total ammonia nitrogen (mg N/L) given by:

For salmonids present: $$\frac{0.275}{1 + 10^{7.204-pH}} + \frac{39.0}{1 + 10^{pH-7.204}}$$

For salmonids absent: $$\frac{0.411}{} + \frac{58.4}{}$$

$1 + 10^{7.204-pH}$ $\qquad$ $1 + 10^{pH-7.204}$

g. Shall not exceed the numerical concentration calculated as follows:
Unionized ammonia concentration for waters where salmonid habitat is an existing or designated use:

$0.80 \div (FT)(FPH)(RATIO)$

where: $RATIO = 13.5;\ 7.7 \leq pH \leq 9$

$RATIO = (20.25 \times 10^{(7.7-pH)}) \div (1 + 10^{(7.4-pH)});\ 6.5 \leq pH \leq 7.7$

$FT = 1.4;\ 15 \leq T \leq 30$

$FT = 10^{[0.03(20-T)]};\ 0 \leq T \leq 15$

$FPH = 1;\ 8 \leq pH \leq 9$

$FPH = (1 + 10^{(7.4-pH)}) \div 1.25;\ 6.5 \leq pH \leq 8.0$

Total ammonia concentrations for waters where salmonid habitat is not an existing or designated use and other fish early life stages are absent:

$$Chronic\ Criterion = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) \times \left(1.45 \times 10^{0.028(25-A)}\right)$$

where: A = the greater of either T (temperature in degrees Celsius) or 7.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

Total ammonia concentration for waters where salmonid habitat is not an existing or designated use and other fish early life stages are present:

$$Chronic\ Criterion = \left(\frac{0.0577}{1 + 10^{7.688-pH}} + \frac{2.487}{1 + 10^{pH-7.688}}\right) \times B$$

where: B = the lower of either 2.85, or $1.45 \times 10^{0.028 \times (25-T)}$.

T = temperature in degrees Celsius.

Applied as a thirty-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three years on the average. The highest four-day average within the thirty-day period should not exceed 2.5 times the chronic criterion.

i. ≤ (0.944)(e(1.128[ln(hardness)]-3.828)) at hardness = 100. Conversion factor (CF) of 0.944 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.136672 - [(ln hardness)(0.041838)].

j. ≤ (0.909)(e(0.7852[ln(hardness)]-3.490)) at hardness = 100. Conversions factor (CF) of 0.909 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.101672 - [(ln hardness)(0.041838)].

k. Criterion based on dissolved chloride in association with sodium. This criterion probably will not be adequately protective when the chloride is associated with potassium, calcium, or magnesium, rather than sodium.

l. Salinity dependent effects. At low salinity the 1-hour average may not be sufficiently protective.

m. ≤ (0.316)(e(0.8190[ln(hardness)] + 3.688))

n. ≤ (0.860)(e(0.8190[ln(hardness)] + 1.561))

o. ≤ (0.960)(e(0.9422[ln(hardness)] - 1.464))

p. ≤ (0.960)(e(0.8545[ln(hardness)] - 1.465))

Table 6-5
Freshwater Toxics Substances Criteria*

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

[q.] ≤ (0.791)(e(1.273[ln(hardness)] - 1.460)) at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].
[r.] ≤ (0.791)(e(1.273[ln(hardness)] - 4.705)) at hardness = 100. Conversion factor (CF) of 0.791 is hardness dependent. CF is calculated for other hardnesses as follows: CF = 1.46203 - [(ln hardness)(0.145712)].
[s.] If the four-day average chronic concentration is exceeded more than once in a three-year period, the edible portion of the consumed species should be analyzed. Said edible tissue concentrations shall not be allowed to exceed 1.0 mg/kg of methylmercury.
[t.] ≤ (0.998)(e(0.8460[ln(hardness)] + 3.3612))
[u.] ≤ (0.997)(e(0.8460[ln(hardness)] + 1.1645))
[v.] ≤ e[1.005(pH) - 5.290]
[w.] ≤ e[1.005(pH) - 4.830]
[y.] ≤ (0.85)(e(1.72[ln(hardness)] - 6.52))
[z.] Channel Catfish may be more acutely sensitive.
[aa.] ≤ (0.978)(e(0.8473[ln(hardness)] + 0.8604))
[bb.] ≤ (0.986)(e(0.8473[ln(hardness)] + 0.7614))
[dd.] These ambient criteria in the table are for the dissolved fraction. The cyanide criteria are based on the weak acid dissociable method. The metals criteria may not be used to calculate total recoverable effluent limits unless the seasonal partitioning of the dissolved to total metals in the ambient water are known. When this information is absent, these metals criteria shall be applied as total recoverable values, determined by back-calculation, using the conversion factors incorporated in the criterion equations. Metals criteria may be adjusted on a site-specific basis when data are made available to the department clearly demonstrating the effective use of the water effects ratio approach established by USEPA, as generally guided by the procedures in USEPA Water Quality Standards Handbook, December 1983, as supplemented or replaced by USEPA or ecology. Information which is used to develop effluent limits based on applying metals partitioning studies or the water effects ratio approach shall be identified in the permit fact sheet developed pursuant to WAC 173-220-060 or 173-226-110, as appropriate, and shall be made available for the public comment period required pursuant to WAC 173-220-050 or 173-226-130(3), as appropriate. Ecology has developed supplemental guidance for conducting water effect ratio studies.
[ee.] The criteria for cyanide is based on the weak acid dissociable method in the 19th Ed. Standard Methods for the Examination of Water and Wastewater, 4500-CN I, and as revised (see footnote dd, above).
[ff.] These criteria are based on the total-recoverable fraction of the metal.
[gg.] Where methods to measure trivalent chromium are unavailable, these criteria are to be represented by total-recoverable chromium.
[hh.] The listed fresh water criteria are based on un-ionized or total ammonia concentrations, while those for marine water are based on un-ionized ammonia concentrations. Tables for the conversion of total ammonia to un-ionized ammonia for freshwater can be found in the USEPA's Quality Criteria for Water, 1986. Criteria concentrations based on total ammonia for marine water can be found in USEPA Ambient Water Quality Criteria for Ammonia (Saltwater)-1989, EPA440/5-88-004, April 1989.
[ii.] The conversion factor used to calculate the dissolved metal concentration was 0.982.
[jj.] The conversion factor used to calculate the dissolved metal concentration was 0.962.
[kk.] The conversion factor used to calculate the dissolved metal concentration was 0.85.

Source:
WAC 173-201A-240 Toxic substances, Table 240(3), Toxics Substances Criteria

Table 7-2
Leachate Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Analysis Method	Constituent	CAS #	Method Reporting Limit	Units	Appendix Listing
EPA 120.1	Conductance	N/A	1	µmhos/cm	II
EPA 150.1	pH	N/A	N/A	N/A	II
EPA 160.1	Total Dissolved Solids	N/A	5	mg/L	II
EPA 160.2	Total Suspended Solids	N/A	1	mg/L	--
EPA 160.3	Total Solids	N/A	5	mg/L	--
EPA 300.0	Chloride	16887-00-6	0.1	mg/L	II
EPA 300.0	Nitrate	14797-55-8	0.01	mg-N/L	I & III
EPA 300.0	Sulfate	14808-79-8	0.1	mg/L	II
EPA 310.1	Alkalinity	N/A	1	mg/L as CaCO3	II
EPA 350.1	Ammonia	7664-41-7	0.01	mg-N/L	II
EPA 315.1	Total Organic Carbon	N/A	1	mg/L	II
EPA 405.1	Biological Oxygen Demand	N/A	2	mg/L	--
EPA 335.3	Cyanide	57-12-5	0.02	mg/L	III
SM 9222B	Total Coliforms	N/A	1	CFU/100mL	--
SM 9222D	Fecal Coliforms	N/A	1	CFU/100mL	--
EPA 354.1	Nitrite	14797-65-0	0.01	mg-N/L	--
SW-846 6020	Antimony	7440-36-0	0.001	mg/L	I & III
SW-846 6020	Arsenic	7440-38-2	0.001	mg/L	I & III
SW-846 6020	Barium	7440-39-3	0.001	mg/L	I & III
SW-846 6020	Beryllium	7440-41-7	0.001	mg/L	I & III
SW-846 6020	Cadmium	7440-43-9	0.002	mg/L	I & III
SW-846 6020	Calcium	7440-70-2	0.01	mg/L	II
SW-846 6020	Chromium	7440-47-3	0.005	mg/L	I & III
SW-846 6020	Cobalt	7440-48-4	0.003	mg/L	I & III
SW-846 6020	Copper	7440-50-8	0.002	mg/L	I & III
SW-846 6020	Iron	7439-89-6	0.005	mg/L	II
SW-846 6020	Lead	7439-92-1	0.001	mg/L	I & III
SW-846 6020	Magnesium	7439-95-4	0.015	mg/L	II
SW-846 6020	Manganese	7439-96-5	0.001	mg/L	II
SW-846 6020	Nickel	7440-02-0	0.01	mg/L	I & III
SW-846 6020	Potassium	9/7/7440	0.3	mg/L	II
SW-846 6020	Selenium	7782-49-2	0.001	mg/L	I & III
SW-846 6020	Silver	7440-22-4	0.003	mg/L	I & III
SW-846 6020	Sodium	7440-23-5	0.05	mg/L	II
SW-846 6020	Thallium	7440-28-0	0.001	mg/L	I & III
Analysis Method	**Constituent**	**CAS #**	**Method Reporting Limit**	**Units**	**Appendix Listing**

SW-846 6020	Vanadium	7440-62-2	0.002	mg/L	I & III
SW-846 6020	Zinc	7440-66-6	0.004	mg/L	I & III
SW-846 7470	Mercury	7439-97-6	0.0001	mg/L	III
SW-846 8260	Acetone	67-64-1	4	µg/L	I & III
SW-846 8260	Acrylonitrile	107-13-1	10	µg/L	I & III
SW-846 8260	Benzene	71-43-2	0.2	µg/L	I & III
SW-846 8260	2-Butanone	78-93-3	4	µg/L	I & III
SW-846 8260	Bromochloromethane	74-97-5	0.2	µg/L	I & III
SW-846 8260	Bromodichloromethane	75-27-4	0.2	µg/L	I & III
SW-846 8260	Bromoform	75-25-2	0.2	µg/L	I & III
SW-846 8260	Bromomethane	74-83-9	0.2	µg/L	I & III
SW-846 8260	Carbon Disulfide	75-15-0	0.2	µg/L	I & III
SW-846 8260	Carbon tetrachloride	56-23-5	0.2	µg/L	I & III
SW-846 8260	Chlorobenzene	108-90-7	0.2	µg/L	I & III
SW-846 8260	Chloroethane	75-00-3	0.2	µg/L	I & III
SW-846 8260	Chloroform	67-66-3	0.2	µg/L	I & III
SW-846 8260	Chloromethane	74-87-3	0.2	µg/L	I & III
SW-846 8260	Dibromochloromethane	124-48-1	0.2	µg/L	I & III
SW-846 8260	Dibromomethane	74-95-3	0.2	µg/L	I & III
SW-846 8260	1,2-Dibromo-3-chloropropane	96-12-8	0.2	µg/L	I & III
SW-846 8260	1,2-Dibromoethane	106-93-4	0.2	µg/L	I & III
SW-846 8260	1,2-Dichlorobenzene	95-50-1	0.2	µg/L	I & III
SW-846 8260	1,4-Dichlorobenzene	106-46-7	0.2	µg/L	I & III
SW-846 8260	trans-1,4-Dichloro-2-butene	110-57-6	100	µg/L	I & III
SW-846 8260	1,1-Dichloroethane	75-34-3	0.2	µg/L	I & III
SW-846 8260	1,2-Dichloroethane	107-06-2	0.2	µg/L	I & III
SW-846 8260	1,1-Dichloroethene	75-35-4	0.2	µg/L	I & III
SW-846 8260	cis-1,2-Dichloroethene	156-59-2	0.2	µg/L	I & III
SW-846 8260	trans-1,2-Dichloroethene	156-60-5	0.2	µg/L	I & III
SW-846 8260	1,2-Dichloropropane	78-87-5	0.2	µg/L	I & III
SW-846 8260	cis-1,3-Dichloropropene	10061-01-5	0.2	µg/L	I & III
SW-846 8260	trans-1,3-Dichloropropene	10061-02-6	0.2	µg/L	I & III
SW-846 8260	Ethylbenzene	100-41-4	0.2	µg/L	I & III
SW-846 8260	2-Hexanone	591-78-6	4	µg/L	I & III
SW-846 8260	Methylene Chloride	75-09-2	0.2	µg/L	I & III
SW-846 8260	Methyl iodide	74-88-4	0.2	µg/L	I & III
SW-846 8260	4-Methyl-2-Pentanone	108-10-1	4	µg/L	I & III
Analysis Method	**Constituent**	**CAS #**	**Method Reporting Limit**	**Units**	**Appendix Listing**

Table 7-2
Leachate Analytical Parameters

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

SW-846 8260	Styrene	100-42-5	0.2	µg/L	I & III
SW-846 8260	1,1,1,2-Tetrachloroethane	630-20-6	0.2	µg/L	I & III
SW-846 8260	1,1,2,2-Tetrachloroethane	79-34-5	0.2	µg/L	I & III
SW-846 8260	Tetrachloroethene	127-18-4	0.2	µg/L	I & III
SW-846 8260	Toluene	108-88-3	0.2	µg/L	I & III
SW-846 8260	1,1,1-Trichloroethane	71-55-6	0.2	µg/L	I & III
SW-846 8260	1,1,2-Trichloroethane	79-00-5	0.2	µg/L	I & III
SW-846 8260	Trichloroethene	79-01-6	0.2	µg/L	I & III
SW-846 8260	Trichlorofluoromethane	75-69-4	0.2	µg/L	I & III
SW-846 8260	1,2,3-Trichloropropane	96-18-4	0.2	µg/L	I & III
SW-846 8260	Vinyl acetate	108-05-4	0.2	µg/L	I & III
SW-846 8260 SIM	Vinyl Chloride	75-01-4	0.02	µg/L	I & III
SW-846 8260	Xylenes, m & p	mpx	0.4	µg/L	I & III
SW-846 8260	Xylenes, o	95-47-6	0.2	µg/L	I & III

Table 4-1
Sample Container, Preservation and Storage Conditions

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Parameter	**Sample Container**	**Storage Conditions to be used**	**Hold Time**
Conductivity	P	6° C	28 days
pH	P	6° C	15 min (Field Parameter)
Alkalinity	P	6° C	14 days
Ammonia, Nitrate/Nitrite, Phosphorous	P	6° C, H2SO4 to pH <2	1 days
Cyanide	P	6° C, NaOH to pH >12	14 days
Chloride, Fluoride, Sulfate	P	6° C	28 days
Metals, Total Recoverable	P	6° C , HNO3 to < pH 2	180 days
Metals, Dissolved (Field Filtered)	P	Field filter, 0.45-micron filter, 6° C , HNO3 to pH <2	180 days
Mercury by CVAA	P	6° C , HNO3 to pH <2	28 days
COD, TOC	P	6° C, H2SO4 to pH <2	28 days
TOC	P	6° C, H3PO4 to pH <2	28 days
TS, TSS, TDS	P	6° C	7 days
Coliform Bacteria	P	6° C	8 hours
Volatile Organic Compounds	40 mL G VOA	6° C, no headspace, pH <2	14 days
Pesticide/PCBs, Herbicides	G with teflon lid	6° C	7 days to extract 40 days to analyze

Note:
P = plastic, G = glass

Table 5-3
Groundwater Sampling Equipment

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Item	**Remarks/Response**
Keys	
Disposable gloves (powder free), first aid kit, and appropriate protective equipment	
Control box	The control box is used for well evacuation and sample collection. All sampling wells contain a dedicated sampling pump.
Regulator and hoses	
Water level indicator	
Compressed nitrogen	
Water quality sonde w/calibration standards	
Thermometer	
Coolers and ice	
Calibrated five-gallon bucket	The bucket is used to collect and measure the discharge volume when purging the well.
Calculator and watch	
Disposable cups	
0.45-micron filters	QED (or equivalent) disposable filters (0.45 micron), high capacity and standard capacity.
Appropriate sample bottles with preservatives in place	Pre-label sample bottles.
Field records, reference sheets, and chain-of-custody sheets	
Deionized or distilled water	Approximately 1000 mL per well are needed for rinsing equipment.
Tool box with wrenches, screwdrivers, pliers, tape, spare parts, Well Wizard pump repair kit, and tape measure marked in feet and hundredths-of-a foot lengths	

Table 5-3
Groundwater Sampling Equipment

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Item	**Remarks/Response**
Keys	
Disposable gloves (powder free), first aid kit, and appropriate protective equipment	
Control box	The control box is used for well evacuation and sample collection. All sampling wells contain a dedicated sampling pump.
Regulator and hoses	
Water level indicator	
Compressed nitrogen	
pH meter w/calibration standards	
Conductivity meter w/calibration standards	
Thermometer	
Coolers and ice	
Calibrated five-gallon bucket	The bucket is used to collect and measure the discharge volume when purging the well.
Calculator and watch	
Disposable cups	
0.45-micron filters	QED (or equivalent) disposable filters (0.45 micron), high capacity and standard capacity.
Appropriate sample bottles with preservatives in place	Pre-label sample bottles.
Field records, reference sheets, and chain-of-custody sheets	
Deionized or distilled water	Approximately 1000 mL per well are needed for rinsing equipment.
Tool box with wrenches, screwdrivers, pliers, tape, spare parts, Well Wizard pump repair kit, and tape measure marked in feet and hundredths-of-a foot lengths	

Table 6-3
Surface Water Sampling Equipment

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Item	Remarks/Response
Keys	
Disposable gloves (powder free), first aid kit, and appropriate protective equipment	
pH meter w/calibration standards	
Conductivity meter w/calibration standards	
Dissolved Oxygen meter	
Turbidity meter w/ calibration standards	
Thermometer	
Coolers and ice	
Disposable cups	
Appropriate sample bottles with preservatives in place	Pre-label sample bottles.
Field records, reference sheets, chain-of-custody sheets, and seals	
Backpack to carry equipment to weeps	
Peristaltic pump	
0.45-micron filters	QED (or equivalent) disposable filters (0.45 micron), high capacity and standard capacity.
Hook to remove manhole cover at Station D	
Deionized or distilled water	Approximately one gallon per sampling station is needed for rinsing equipment.
Tool box with wrenches, screwdrivers, pliers, tape, spare parts, and tape measure marked in feet and hundredths-of-a foot lengths	

Table 7-3
Leachate Sampling Equipment

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Item	**Remarks/Response**
Keys	
Disposable gloves (powder free), first aid kit, and appropriate protective equipment	
pH meter w/calibration standards	
Conductivity meter w/calibration standards	
Thermometer	
Coolers and ice	
Extension cord	
Calculator and watch	
Clean disposable "grab" sampling containers and nylon rope	
Disposable cups	
Appropriate sample bottles with preservatives in place	Pre-label sample bottles.
Field records, reference sheets, chain-of-custody sheets, and seals	
Deionized or distilled water	Approximately two gallons per sampling location are needed for rinsing equipment.
Tool box with wrenches, screwdrivers, pliers, tape, spare parts, duct tape, and tape measure marked in feet and hundredths-of-a foot lengths	

Table 8-2
Landfill Gas Monitoring Equipment

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Item	Comments
Keys	Keys are required to access the monitoring wells.
Barometer	
Temperature probe	Temperature can be measured using a thermometer or GEM 2000.
Hydrophobic filter	The filter is used to prevent water from reaching the meter. Following use, the filter should be dried for reuse.
Hydrogen sulfide meter	
Hand aspirator bulb	The aspirator bulb is used to confirm that a well is water blocked.
GEM 500 or GEM 2000 meter	The instrument should be calibrated, and the battery should be fully charged.
Watch	
Field records and reference sheets	
Tool box	

Table 5-3
Groundwater Sampling Equipment

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Item	**Remarks/Response**
Keys	
Disposable gloves (powder free), first aid kit, and appropriate protective equipment	
Control box	The control box is used for well evacuation and sample collection. All sampling wells contain a dedicated sampling pump.
Regulator and hoses	
Water level indicator	
Compressed nitrogen	
Water quality sonde w/calibration standards	
Thermometer	
Coolers and ice	
Calibrated five-gallon bucket	The bucket is used to collect and measure the discharge volume when purging the well.
Calculator and watch	
Disposable cups	
0.45-micron filters	QED (or equivalent) disposable filters (0.45 micron), high capacity and standard capacity.
Appropriate sample bottles with preservatives in place	Pre-label sample bottles.
Field records, reference sheets, and chain-of-custody sheets	
Deionized or distilled water	Approximately 1000 mL per well are needed for rinsing equipment.
Tool box with wrenches, screwdrivers, pliers, tape, spare parts, Well Wizard pump repair kit, and tape measure marked in feet and hundredths-of-a foot lengths	

KING COUNTY SOLID WASTE DIVISION
QUALIFIER INFORMATION
(Effective 4/1/2009)

QUAL	QUALIFIER DESCRIPTION
U	Undetected Analyte concentration <MDL – Less than Method detection limit
T	Estimated, Less than Reporting Detection Limit but greater than Method detection limit
J	Reported value is an estimate
B	Contamination present in Blank
C	Confluent Growth
E	Estimated, outside expected accuracy
H	Exceeds holding time
R	Data Rejected
S	Sample handling errors
X	Too numerous to count
D	Dilution
P	PASS – Qualitative result acceptable
F	FAIL – Qualitative result is not acceptable
G	Greater than
L	Less than

Table 9-1

Table 3-1
Sampling Plan Problem Response Actions

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Sampling Plan Problem	Preventative Response Actions
Broken or missing sample container bottles	Carry a spare sample container set in truck
Equipment Failure	Carry tools for onsite repairs when possible Monitor and maintain an inventory of spare parts Schedule routine maintenance
Slow producing wells	Follow slow recovery well protocol
Nitrogen tanks empty	Check tanks before leaving to the field Carry a backup tank in truck
Labeling uncertainty	Carry former field data sheet for sampling site
Illegible writing	Request clarification and make changes as indicated in Field Data Handling Section (8.1). Request improvement in future forms.
Unfamiliarity of sites	Technician should be accompanied by staff with experience of that site.
Insufficient or outdated calibration standards	Check calibration standard log before leaving to the field. Carry a backup.
Lack of supplies	Create a log and maintain it
Field technician lagging compliance with required protocol.	Create list of required training and continuous training. Keep training record for each technician.

Table 5-4
Measurement Of Depth To Water

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Put on new, clean, disposable nitrile gloves.	Protective gloves protect you and the sample.
Rinse the instrument used to measure the depth to water in the well liberally with distilled water.	This instrument is not dedicated to a single well and it must be decontaminated before use. Deionized water may also be used.
Turn the meter on, adjust the sensitivity, and push the test button to check battery power. The alarm should beep.	Adjust the sensitivity to correspond to the quality of water in the well. (Check well data to determine the water quality.)
Lower the probe through the top of the PVC well cap until the alarm sounds.	
Read the depth measurement at the top of the PVC casing.	The depth measurement is read to one one-hundredth of a foot. Check the depth measurement against historic data to ensure the reading is within an expected range.
Raise the line until the alarm goes silent. Lower the line until the alarm comes on again. Repeat this procedure.	The procedure is repeated to verify the depth measurement.
Once an identical reading has occurred three times, read and record the depth measurement.	Record the depth on the field sheet with the time, date, and meter.
Calculate the elevation of the water table by subtracting the depth measurement from the elevation of the top of the PVC casing.	The elevation of the top of the PVC casing is listed on the well's reference sheet.
Turn the meter off and rinse it with distilled water. Rinse at least the length of the line that was submersed in the well water before reeling that part of the line back onto the reel.	Store the meter away from any possible contamination.
Move to the next well and measure the depth to water there.	Measure the static water level of all wells prior to initiating sampling at the first well.

Table 5-5
Groundwater Well Evacuation

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Put on new, clean, disposable nitrile gloves.	Protective gloves protect you and the sample.
Obtain Depth to Water Measurement and record on Field Sheet.	Follow procedures in Table 5-4 of Append D
Determine pump and associated discharge volume for the well. This result is the number of gallons in one discharge volume.	Discharge volume for most wells is equal to the pore volume of the well. Pore volume is calculated by subtracting the depth to water (in feet) from the depth to bottom of screen (in feet) and multiplying the result by a conversion that converts that depth to a volume. The appropriate conversion factor is determined by the well diameter as follows: 6 inch diameter: 1.47 gallons/ft 4 inch diameter: 0.562 gallons/ft 3 inch diameter: 0.367 gallons/ft 2.5 inch diameter: 0.256 gallons/ft 2 inch diameter: 0.163 gallons/ft Wells MW-26, MW-27, MW-28 and MW-29 have a fixed discharge volume that is equal to the pump and tubing volume for that well. This value is not dependent on the water level, and is listed on the well's reference sheet. Record this number on the field sheet.
Select the appropriate controller	Use compressed nitrogen and the same controller. If the well is less than 25 feet, a peristaltic pump can be used.
Connect the regulator with hose to the nitrogen tank.	
Connect the other end of the hose to the pressure inlet on the control box.	
Connect the control box to the pump using a second hose.	This hose is attached to the pump supply connector on the control box and at the male connector located on the PVC well cap.
Connect the Teflon discharge hose to the pump discharge located on the PVC well cap.	
Position a calibrated five-gallon bucket at the end of the discharge hose to collect and measure the discharge volume(s).	Empty bucket to the storage drum, where required, and to the ground surface away from wellhead for other wells.
Adjust the control box settings and check that the pressure valve is backed off.	The discharge and refill settings are found on the well reference sheet.
Calibrate the pH and conductivity meters.	These meters must be properly calibrated at least once per day according to manufacturers' instructions before field measurements are performed. Mark on the field sheet the date and time of calibration. In addition, the calibration standards for pH should bracket the pH values expected, so 4 and 7 should be used for groundwater.

Table 5-5
Groundwater Well Evacuation

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Open the valve on the nitrogen tank, making sure that the regulator valve is backed off.	Set the pressure at the regulator to be at least 5 psi greater than the pressure required at the control box. Set the regulator on the control box to the value from the well reference sheet.
Pump one discharge volume.	Initial pumping rate will be approximately 0.5 liters per minute.
After pumping one discharge volume, collect a sample from the discharge tubing for field tests.	Use a sterile, 250-ml plastic specimen cup to collect the sample.
Test the sample's conductivity, pH, and temperature.	Record the test results and the times on the field sheet.
Pump a second discharge volume, collect a sample from the discharge tubing, and check the conductivity, pH, and temperature of the sample.	Record the test results and the times on the field sheet.
Pump a third discharge volume, collect a sample from the discharge tubing, and check the conductivity, pH, and temperature of the sample.	Record the test results and the times on the field sheet.
Compare the results of the field tests for stabilization. Conductivity, and temperature should be within ±10%, of the previous reading and pH should be within ±0.1 unit of the previous discharge volume.	If conductivity, temperature or DO vary more than ±10 %, or pH varies by more than by more than ±0.1 unit, additional volumes will have to be purged as necessary until the criteria is met.
Note on the field record the total volume of water removed from the well, the time required to remove that volume, and any other relevant information.	Record any unusual conditions, such as the color, odor, turbidity, etc., of the water.
Collect samples immediately after well evacuation is completed and stabilization is achieved.	

Table 5-6
Groundwater Sample Collection-Low Flow Procedure

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Perform calibration for ORP, pH, conductivity, turbidity and DO probes, and a temperature check for the temperature probe.	Follow procedures from the **In-Situ Troll 9500 Water Quality Sonde (Sonde) calibration** SOP. Mark on the field sheet the date and time of calibration (prior to sampling – wet lab).
Static Water Levels.	Collect site-wide static water levels prior to any sampling (prior to sampling – field).
Collect initial Depth to Water.	Record the water level on the field sheet or in the sonde/Laptop along with date and time.
Connect the nitrogen hose to the well, and connect the dedicated piece of silicon tubing from the well to the bottom of the flow-through cell.	The discharge tubing you use to connect the well to the inlet at the bottom of the flow through cell should remain at the well. The tubing from the flow through cell to the purge bucket can be stored in the truck and be used at every well.
Connect Sonde (In-Situ Troll 9500) to the laptop/tablet (or Rugged Reader).	
Turn on the laptop/tablet (or Rugged Reader) and navigate to the Flow-Sense (or Pocket-Situ) Wizard in the navigation tree.	Open Win-Situ4/Pocket-Situ. Choose Direct connection to One device. Choose Com5 or Com7(Win-Situ)/Com1(Pocket-Situ) Choose Baud Rate of 19200 Use default connection name Highlight Flow-Sense Wizard Click Start
Verify Units.	DO: mg/L ORP: mV pH: pH units Specific Conductivity: µS/cm Turbidity: NTU Temperature: degree C
Start the pump to begin purging the well, adjusting pump rate as needed to minimize drawdown.	Set the pump settings to the final flow rate from the previous sampling event at the well. The desired initial pumping rate, unless otherwise noted from the previous field event, is 200-500 mL/min. **NOTE**: RECORD TIME PURGING STARTED ON FIELDSHEET.
Enter purge volume calculation information into Flow-Sense when prompted.	Enter information from field sheet at appropriate screen prompt. (See Screens 1 – 4)
Continue to monitor the water level until ≤0.33 ft drawdown is achieved, as measured between stabilization readings.	If the water level difference between the stabilization water level measurements is greater than 0.33 feet, reduce the flow rate by decreasing the length of each pump stroke (discharge time) and increasing the time between pump strokes (refill time).
Once purging is complete, enter the Final Pumping Rate.	After "time to purge" time interval has been met, collect the final low flow pump rate (≤500 ml/min) that achieves minimal drawdown (±0.33 ft drawdown, as measured between stabilization readings).

Table 5-6
Groundwater Sample Collection-Low Flow Procedure

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Enter 180 into Measurement Interval (sec) for a 3-minute timer in between field tests (300 sec for 5-minute timer).	If lower flow rates are required to achieve minimal drawdown criteria, the interval between sampling events will need to be recalculated to ensure the volume in the flow through cell is completely replaced during the stabilization interval (typically 3-5 minutes).
Once purging is complete, enter Stabilized Drawdown.	After "time to purge" time interval has been met, collect final pumping rate and depth to water. Calculate stabilized drawdown = final depth to water – initial depth to water.
Input the Stabilization Criteria. This information only needs to be entered once into the laptop, if the correct criteria are saved, move to the next step.	**-pH units** **± 0.1 pH** **-Oxidation Redox Potential (ORP)** **± 10 mV** **-Dissolved Oxygen** **± 10%** **-Conductivity** **± 3%** **-Turbidity** **± 10%** To enter a discrete interval instead of a percentage on the Flow-Sense screen, enter a zero in the percentage column and a value in the interval column.
Click "Start" on the stabilization window of the sonde.	Begin collecting data with Flow-Sense software.
Record field parameter results to determine when stabilization of all 5 parameters is reached.	The Flow-sense software calculates percentages as follows: $\frac{(\max of\ last\ 3\ readings - \min of\ last\ 3\ readings)}{last\ reading} x\ 100\%$ It calculates the settings for discrete intervals as: $\max of\ last\ 3\ readings - \min of\ last\ 3\ readings$
Record final pump control box settings on the field sheet.	These settings will be needed the next time the well is sampled.
Record on the field sheet: • Final volume of water purged from the well. • Final field parameters values (pH, specific conductance, oxidation reduction potential, dissolved oxygen, turbidity, temperature) and time. • Depth to water • Any other relevant information in comment section.	Note unusual conditions, such as color, odor, cloudiness of water, etc. In the event a separate turbidimeter is used to measure turbidity, make sure to record the instrument ID and the time the turbidity sample was taken (preferably after stabilization but before sampling occurs).
Stop data collection from the flow-through cell and save the data file (".flo" format for In-Situ Troll 9500).	".flo" files are to be saved on the shared drive for later access by appropriate personnel.
Remove the flow through cell and collect samples from the well discharge tubing using the same low-flow pump rate. **NEVER** collect samples through flow-through cell. **DO NOT** adjust flow rate for sample collection, with the exception of filling the volatile organics sample bottles (see below).	Fill the individual bottles directly from the discharge tubing (except when the metals sample must be filtered). Do not overfill bottles containing preservatives. Care must be taken to prevent spilling of preservatives or transfer of preservatives from one bottle to another.

Table 5-6
Groundwater Sample Collection-Low Flow Procedure

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Both total and dissolved metals will be collected. The dissolved metal samples will be filtered using either the high or low capacity 0.45-micron filters. Connect the appropriate filter directly to the end of the discharge tubing. **Flush filters** with manufacturers suggested sample volume. Discard all filters after use.	Low capacity filters can be used with visibly clean water and low production wells. High capacity filters are used when there is silt or particles in the water or if the well is a high production well.
When sampling for volatile organics: Fill the bottle to the top, allowing a meniscus to form. Cap the bottle. Invert the bottle and tap it to check for bubbles. If bubbles are present, remove the cap, add a small volume of sample, re-cap, and check for bubbles again. Place VOA bottles in the foam protector. Cover the samples with ice immediately after filling.	**Reduce purge rate to approximately 0.1 L/min for filling volatiles bottles.** Since volatile organics escape rapidly into the atmosphere, care must be taken to minimize the sample's exposure to air and to avoid overfilling the bottle. Extreme caution should be used in filling and capping the VOA bottles. **Air must be prevented** from being trapped inside the bottles. **To prevent loss of preservative**, the bottles must not be overfilled.
Double check /tighten the caps of bottles after filling to prevent leaking during transportation.	
Print sample labels with the sample date and time. Also print labels for the VTRP bottles.	Put a separate label on each bottle, and also an extra label on the field sheet. Record VTRP date and bubbles on the field sheet.
Place all bottles inside the cooler and cover with ice. Place seal on the cooler.	Regardless of whether bottles are preserved chemically, sample bottles should always be chilled to < 4 ° C until the samples are delivered to the lab.
Thoroughly decon(taminate) the Sonde and flow through cell, giving extra care to the probes and seals.	Rinse the flow through cell thoroughly using DI water before leaving the sampling location. Wipe down the flow through cell, then replace dust caps and pH hydration bottle over the pH/ORP probe at the end of the day, and place the moist sponge at the bottom of the flow through cell to help prevent probes from drying out.
Close and lock the well. Clean up any debris at the sampling site.	Double check well is securely locked.
Return and secure the equipment in the truck before proceeding on.	
Deliver the samples to the laboratory within four (4) hours, following the chain-of-custody procedural guidelines pertaining to the exchange of samples.	Complete all paperwork. Record the time sampling ended. Sign and date the field record.
Perform the Post Sampling Calibration Verification Check.	Follow procedures from the **sonde calibration** SOP. Mark on the Daily Verification log, the post-sampling water quality checks. Calculate meter drift according to Daily Verification Log.

Table 6-4
Surface Water Sample Collection

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Determine the location for sample collection.	Evaluate a stable surface near the sample collection location to place field notebook, sample jars, field forms, any meters or probes, and other miscellaneous equipment
Put on new, clean, disposable nitrile disposable gloves.	Protective gloves to protect you and the sample.
Record the time on each sample bottle.	
Measure conductivity.	Record the test result and the time on the field sheet.
Measure pH and temperature.	Record the information on the field sheet.
Measure Dissolved Oxygen	Record the information on the field sheet.
Measure Turbidity	Record the information on the field sheet.
Collect surface water samples	The sampler should collect the samples without disturbing the sediments. Hold container facing upstream. Do not overfill bottles containing preservatives.
Take special precautions when sampling for Dissolved Oxygen and Volatile organics. Avoid aeration and agitation of the sample by pouring the sample slowly down the edge of the bottle. Fill the bottle to the top, allowing a meniscus to form. Then cap the bottle (using glass cap). Invert the bottle and tap it to check for bubbles. If bubbles are present, remove the cap, add a couple drops of water, recap, and check for bubbles again. Add more water to form a meniscus around the glass cap and place over a plastic cap.	
Both total and dissolved metals will be collected. For dissolved metals, filter the samples using either the high or low capacity 0.45-micron filters. Connect the appropriate filter directly to the end of the discharge tubing. Flush filters with manufacturer's suggested sample volume. Discard all filters after use.	Low capacity filters can be used with visibly clean water and low production wells. High capacity filters are used when there is silt or particles in the water or if the well is a high production well.
Fill coliform samples at least to the "EPA Fill Line." Place the sample immediately on ice.	The EPA Fill Line is a minimum; the lab prefers more volume.
Tighten the caps of bottles after filling to prevent leaking during transportation.	
Place all bottles inside the cooler and cover with ice. Place seal on the cooler.	Regardless of whether bottles are preserved chemically, sample bottles should always be chilled until the samples are delivered to the lab.
Clean and return the equipment to the truck.	
Deliver the samples to the laboratory within 4 hours following the chain-of-custody procedural guidelines pertaining to the exchange of samples.	Complete all paperwork. Record the time sampling ended. Sign and date the field record.

Table 7-4
Leachate Sample Collection

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Activity	**Remarks/Response**
Put on new, clean, disposable nitrile gloves.	Protective gloves protect you and the sample.
Calibrate pH meter and conductivity meter.	
Record the time on each sample bottle.	
Using a clean disposable container, grab a cup of sample	
Perform a conductivity analysis.	Record the test result and the time on the field sheet.
Test the sample's pH, and temperature.	Record the information on the field sheet.
Fill the metals bottles without filter.	Do not overfill bottles containing preservatives.
Take special precautions when sampling for volatile organics: Fill the bottle to the top, allowing a meniscus to form. Then cap the bottle. Invert the bottle and shake it to check for bubbles. If bubbles are present, remove the cap, add a couple drops of water, recap, and check for bubbles again. Place VOA bottles in the foam protector. Put the samples into ice immediately after filling.	Since volatile organics escape rapidly into the atmosphere, care must be taken to minimize the sample's exposure to air. Extreme caution should be used in filling and capping the VOA bottles. Air must be prevented from being trapped inside and bottles must not be overfilled to prevent loss of preservative.
Tighten the caps of bottles after filling to prevent leaking during transportation.	
Place all bottles inside the cooler and cover with ice. Place custody seals on the cooler.	Regardless of whether bottles are preserved chemically, sample bottles should always be chilled until the samples are delivered to the lab.
Clean and return the equipment to the truck.	
Deliver the samples to the laboratory within four hours following the chain-of-custody procedural guidelines pertaining to the exchange of samples.	Complete all paperwork. Record the time sampling ended. Sign and date the field record.

Table 8-3
LFG Calibration Procedures

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Step	Procedure
GEM 2000	
1	Turn the instrument on by pressing the red button. After the instrument has finished its initial process, the main screen will appear.
2	Press 1 (Menu).
3	Use the Up (2) or Down (8) keys to scroll the field calibration, and then press Enter.
4	Press 3 (Edit) to record target concentrations and manually enter the target concentrations for CH4.
5	Press Enter to move to CO2, and enter the CO2 target concentration.
6	Press Enter to move to O2, and enter the O2 target concentration.
7	Press Enter to complete.
8	Press Enter to go to the calibration menu.
9	Choose Zero Channels.
10	Choose CH4 and connect the gas bottle with 0 % CH4 (i.e., 4 % O2, balance N2).
11	Allow the gas to flow for approximately 30 seconds to ensure a compete purge of any gas in the instrument.
12	Press Enter when done.
13	Press Enter to go to the calibration menu.
14	Choose Zero Channels.
15	Choose O2 and connect the gas bottle with 0 % O2 (i.e., 50 % CH4, 35 % CO2, balance N2).
16	Allow the gas to flow for approximately 30 seconds to ensure a compete purge of any gas in the instrument.
17	Press Enter when done.
18	Press Enter to go to the calibration menu.
19	Choose Span Channels and then press Enter.
20	Choose Span CH4.
21	Verify that the CH4 calibration gas is still connected to the instrument. Wait 30 seconds for the gas to flow through the instrument.
22	Press Enter to set the CH4 span.
23	Press Enter to go to the calibration menu.
24	Choose Span Channels and then press Enter.
25	Choose Span CO2.
26	Verify that the CH4 calibration gas is still connected to the instrument. Wait 30 seconds for the gas to flow through the instrument.
27	Press Enter to set the CO2 span.
28	Press Enter to go to the calibration menu.
29	Connect the gas bottle with 4 % O2 (i.e., 0 % CH4, 0 % CO2, and 4 % O2).
30	Allow the gas to flow for approximately 30 seconds to ensure a compete purge of any gas in the instrument.
31	Choose Span Channels and then press Enter.
32	Select Span O2 and press Enter to set the O2 span.
33	Take a reading from the calibration gas bottles to verify that calibration has been done correctly.

Table 8-4
Gas Monitoring Procedures

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Step	Procedure	Comments
Uniform Probe Monitoring Procedures		
1	Prior to monitoring, check the GEM 2000 internal and external filters, battery status, and calibrating unit.	
2	Allow the meter infrared (IR) bench to warm up for at least 1 minute.	
3	Check the battery status.	Record the battery status for each set of readings.
4	The GEM 2000 automatically reads barometric pressure.	Record the time, date, location, probe ID, and ambient temperature. This information should be entered into meter.
5	Inspect the probe sampling connections for damage.	Record any damage using the GEM 2000 comments section.
6	Zero the pressure transducers. Read the static pressure of all completions.	Record the static pressure in inches water column. Zero the transducers before each probe completion reading. Open the valve after connecting the hose; close the valve before disconnecting the hose.
7	Connect the meter to the probe using 4 feet of clear tubing and a water trap filter.	Observe the clear tubing during sampling. Discontinue the sampling procedure if water is seen in the tubing (before reaching filter if possible). Note the presence of water in the probe and pumping duration. Use the boring log to approximate depth to water surface.
8	Read and record stabilized methane, oxygen, and carbon dioxide concentrations. Use UEL or LEL as appropriate.	Use the probe pore volume spreadsheet to determine the time needed to evacuate one pore volume. A stabilized result should be available within 30 to 45 seconds after the one pore volume. If a switch between UEL and LEL scales is required during sampling, a stabilized result should be available 30 to 45 seconds after pumping restarts.
9	Log the results making sure to include the meter's identification number.	Follow the instructions on Pages 41 to 50 of the operations manual.
10	Complete the meter purge cycle before taking the next reading.	
Uniform Ambient Air Station Monitoring Procedures		
Step	**Procedure**	**Comments**
1	Allow the meter infrared (IR) bench to warm up for at least 1 minute.	
2	Prior to monitoring, check the GEM 2000 internal and external filters, battery status, split or cracks at the inlet hose and calibrating unit.	
3	Check the battery status.	
4	The GEM 2000 automatically reads barometric pressure.	Record the time, date, location, monitoring station ID, and ambient temperature. This information should be entered into meter.

Table 8-4
Gas Monitoring Procedures

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Step	Procedure	Comments
5	Read and record stabilized methane, oxygen, and carbon dioxide concentrations. Use UEL or LEL as appropriate.	
6	Log the results making sure to include the meter's identification number.	Follow the instructions on Pages 41 to 50 of the operations manual.
7	Complete the meter purge cycle before taking the next reading.	

Table 9-2
Data Quality Objectives (DQOs)

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Indicator	**Accuracy %Recovery**	**Precision %RPD**	**Completeness**	**Detection Limit**	**Units**
pH	80-120	10%	95%	N/A	N/A
Conductance	70-130	20%	95%	1	umhos/cm
Total Dissolved Solids	70-130	20%	90%	2	mg/L
Suspended Solids	70-130	20%	90%	1	mg/L
Chemical Oxygen Demand	70-130	20%	90%	5	mg/L
Total Organic Carbon	70-130	20%	90%	1	mg/L
Total Organic Halogens	70-130	20%	90%	0.02	mg/L
Biological Oxygen Demand	70-130	20%	90%	2	mg/L
Coliforms, t CFU	NA	40%	90%	1	CFU/100ml
Coliforms, f CFU	NA	40%	90%	1	CFU/100ml
Hardness	70-130	20%	90%		mg/L CaCO3
Turbidity	70-130	20%	90%		NTU
Alkalinity, total (CaCO3)	70-130	20%	90%	1	mg/L CaCO3
Ammonia, (NH3)	70-130	20%	90%	0.01	mg-N/L
Chloride	70-130	10%	90%	1	mg/L
Cyanide	70-130	20%	90%	0.02	mg/L
Fluoride	70-130	10%	90%	1	mg/L
Nitrate, (NO3)	70-130	10%	90%	0.01	mg/L
Nitrite, (NO2)	70-130	20%	90%	0.005	mg/L
NO3 + NO2	70-130	10%	90%	0.01	mg-N/L
Phosphate, total	70-130	20%	90%	0.01	mg-P/L
Sulfate (SO4)	70-130	10%	90%	1	mg/L
Total Kjeldahl N	70-130	20%	90%	0.1	mg/L
Antimony, dissolved	80-120	10%	90%	0.001	mg/L
Antimony, total	80-120	20%	90%	0.001	mg/L
Arsenic, dissolved	80-120	10%	90%	0.001	mg/L
Arsenic, total	80-120	20%	90%	0.001	mg/L
Barium, dissolved	80-120	10%	90%	0.001	mg/L
Barium, total	80-120	20%	90%	0.001	mg/L
Beryllium, dissolved	80-120	10%	90%	0.001	mg/L
Beryllium, total	80-120	20%	90%	0.001	mg/L
Cadmium, dissolved	80-120	10%	90%	0.002	mg/L
Cadmium, total	80-120	20%	90%	0.002	mg/L
Chromium, dissolved	80-120	10%	90%	0.005	mg/L
Chromium, total	80-120	20%	90%	0.005	mg/L
Copper, dissolved	80-120	10%	90%	0.002	mg/L
Copper, total	80-120	20%	90%	0.002	mg/L
Iron, dissolved	80-120	10%	90%	0.005	mg/L
Iron, total	80-120	20%	90%	0.005	mg/L
Lead, dissolved	80-120	10%	90%	0.001	mg/L
Lead, total	80-120	20%	90%	0.001	mg/L

Table 9-2
Data Quality Objectives (DQOs)

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Indicator	Accuracy %Recovery	Precision %RPD	Completeness	Detection Limit	Units
Manganese, dissolved	80-120	10%	90%	0.001	mg/L
Manganese, total	80-120	20%	90%	0.001	mg/L
Mercury, dissolved	80-120	10%	90%	0.0001	mg/L
Nickel, dissolved	80-120	20%	90%	0.01	mg/L
Nickel, total	80-120	20%	90%	0.01	mg/L
Selenium, dissolved	80-120	10%	90%	0.001	mg/L
Selenium, total	80-120	20%	90%	0.001	mg/L
Silver, dissolved	80-120	10%	90%	0.003	mg/L
Silver, total	80-120	20%	90%	0.003	mg/L
Thallium, dissolved	80-120	10%	90%	0.001	mg/L
Thallium, total	80-120	20%	90%	0.001	mg/L
Zinc, dissolved	80-120	10%	90%	0.004	mg/L
Zinc, total	80-120	20%	90%	0.004	mg/L
Aluminum, dissolved	80-120	10%	90%	0.02	mg/L
Aluminum, total	80-120	20%	90%	0.02	mg/L
Calcium, dissolved	80-120	20%	90%	0.01	mg/L
Calcium, total	80-120	20%	90%	0.01	mg/L
Cobalt, dissolved	80-120	20%	90%	0.003	mg/L
Cobalt, total	80-120	20%	90%	0.003	mg/L
Magnesium, dissolved	80-120	20%	90%	0.015	mg/L
Magnesium, total	80-120	20%	90%	0.015	mg/L
Potassium, dissolved	80-120	20%	90%	0.3	mg/L
Potassium, total	80-120	20%	90%	0.3	mg/L
Sodium, dissolved	80-120	20%	90%	0.01	mg/L
Sodium, total	80-120	20%	90%	0.01	mg/L
Tin, dissolved	80-120	20%	90%	0.01	mg/L
Tin, total	80-120	20%	90%	0.01	mg/L
Vanadium, dissolved	80-120	20%	90%	0.002	mg/L
Vanadium, total	80-120	20%	90%	0.002	mg/L
Gross Alpha Activity	80-120	10%	90%	3	pCi/l
Gross Beta Activity	80-120	10%	90%	4	pCi/l
Radium 226	80-120	10%	90%	1	pCi/l
Radium 228	80-120	10%	90%	1	pCi/l
Radium 226+228	80-120	10%	90%	2	pCi/l
Acetone	80-120	40%	90%	4	ug/L
Benzene	80-120	10%	90%	0.2	ug/L
Bromodichloromethane	80-120	10%	90%	0.2	ug/L
Bromoform	80-120	10%	90%	0.2	ug/L
Bromomethane	70-130	20%	90%	0.2	ug/L
2-Butanone	70-130	20%	90%	4	ug/L
Carbon Disulfide	70-130	20%	90%	0.2	ug/L
Carbon Tetrachloride	80-120	10%	90%	0.2	ug/L
Chlorobenzene	80-120	10%	90%	0.2	ug/L

Table 9-2
Data Quality Objectives (DQOs)

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Indicator	Accuracy %Recovery	Precision %RPD	Completeness	Detection Limit	Units
Chloroethane	70-130	20%	90%	0.2	ug/L
Chloromethane	70-130	20%	90%	0.2	ug/L
Chloroform	80-120	10%	90%	0.2	ug/L
Dibromochloromethane	80-120	10%	90%	0.2	ug/L
Dichlorobenzene	80-120	10%	90%	0.2	ug/L
Dichlorobenzene	70-130	20%	90%	0.2	ug/L
Dichlorobenzene	80-120	10%	90%	0.2	ug/L
Dichlorobenzene	80-120	10%	90%	0.2	ug/L
Dichlorodifluoromethane	75-125	15%	90%	0.2	ug/L
Dichloroethane	80-120	10%	90%	0.2	ug/L
Dichloroethane	80-120	10%	90%	0.2	ug/L
Dichloroethene	80-120	10%	90%	0.2	ug/L
Dichloroethene	80-120	10%	90%	0.2	ug/L
trDichloroethene	80-120	10%	90%	0.2	ug/L
Dichloropropane	80-120	10%	90%	0.2	ug/L
Dichloropropene	70-130	20%	90%	0.2	ug/L
trDichloropropene	70-130	20%	90%	0.2	ug/L
Dichloropropene, total	80-120	10%	90%	0.2	ug/L
Ethylbenzene	80-120	10%	90%	0.2	ug/L
2-Hexanone	70-130	20%	90%	4	ug/L
Methylene Chloride	80-120	10%	90%	0.2	ug/L
4-Met2-Pentanone	70-130	20%	90%	4	ug/L
Styrene	80-120	10%	90%	0.2	ug/L
1,1,Tetrachloroethane	70-130	20%	90%	0.2	ug/L
Tetrachloroethylene	80-120	10%	90%	0.2	ug/L
Toluene	80-120	10%	90%	0.2	ug/L
1,Trichloroethane	80-120	10%	90%	0.2	ug/L
1,Trichloroethane	80-120	10%	90%	0.2	ug/L
Trichloroethene	80-120	10%	90%	0.2	ug/L
Trichlorofluoromethane	75-125	15%	90%	0.2	ug/L
Vinyl Acetate	70-130	20%	90%	0.2	ug/L
Vinyl Chloride	80-120	10%	90%	0.02	ug/L
Total Xylenes	80-120	10%	90%	0.4	ug/L
o-Xylene	75-125	15%	90%	0.2	ug/L
Acetonitrile	70-130	20%	90%	10	ug/L
Acrolein	70-130	20%	90%	10	ug/L
Acrylonitrile	80-120	10%	90%	100	ug/L
Allyl chloride	70-130	20%	90%	10	ug/L
Bromochloromethane	70-130	20%	90%	0.2	ug/L
Bromoethane	70-130	20%	90%	0.2	ug/L
2-Chloroethylvinylether	70-130	20%	90%	0.2	ug/L
Chloroprene	70-130	20%	90%	20	ug/L
Dibr3-Chloropropane	80-120	10%	90%	0.2	ug/L

Table 9-2
Data Quality Objectives (DQOs)

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Indicator	Accuracy %Recovery	Precision %RPD	Completeness	Detection Limit	Units
Dibromoethane	80-120	10%	90%	0.2	ug/L
Dibromomethane	70-130	20%	90%	0.2	ug/L
Dichloropropane	70-130	20%	90%	0.2	ug/L
Dichloropropane	70-130	20%	90%	0.2	ug/L
Dichloropropene	70-130	20%	90%	0.2	ug/L
Isobutyl alcohol	70-130	20%	90%	100	ug/L
Methacrylonitrile	70-130	20%	90%	5	ug/L
Methyl Iodide	70-130	20%	90%	0.2	ug/L
Methyl methacrylate	70-130	20%	90%	2	ug/L
Propionitrile	70-130	20%	90%	60	ug/L
1,1,Tetrachloroethane	70-130	20%	90%	0.2	ug/L
trDichlbutene	70-130	20%	90%	100	ug/L
1,Trichloropropane	70-130	20%	90%	0.2	ug/L
Aldrin	80-120	10%	90%	0.025	ug/L
Dieldrin	80-120	10%	90%	0.1	ug/L
Endrin	80-120	10%	90%	0.1	ug/L
Endrin Aldehyde	70-130	20%	90%	0.2	ug/L
Isodrin	70-130	20%	90%	10	ug/L
Alpha BHC	70-130	20%	90%	0.025	ug/L
Beta BHC	70-130	20%	90%	0.025	ug/L
Delta BHC	70-130	20%	90%	0.1	ug/L
Lindane	80-120	10%	90%	0.025	ug/L
alpha Chlordane	80-120	10%	90%	0.025	ug/L
DDD	80-120	10%	90%	0.1	ug/L
DDE	80-120	10%	90%	0.1	ug/L
DDT	80-120	10%	90%	0.1	ug/L
Endosulfan I	70-130	20%	90%	0.1	ug/L
Endosulfan II	70-130	20%	90%	0.1	ug/L
Endosulfan Sulfate	70-130	20%	90%	0.5	ug/L
Heptachlor	80-120	10%	90%	0.025	ug/L
Heptachlor Epoxide	80-120	10%	90%	0.025	ug/L
Methoxychlor	80-120	10%	90%	2	ug/L
Toxaphene	80-120	10%	90%	2.5	ug/L
Aroclor 1016	80-120	10%	90%	0.01	ug/L
Aroclor 1221	80-120	10%	90%	0.01	ug/L
Aroclor 1232	80-120	10%	90%	0.01	ug/L
Aroclor 1242	80-120	10%	90%	0.01	ug/L
Aroclor 1248	80-120	10%	90%	0.01	ug/L
Aroclor 1254	80-120	10%	90%	0.01	ug/L
Aroclor 1260	80-120	10%	90%	0.01	ug/L
D	80-120	10%	90%	5	ug/L
2,T	80-120	10%	90%	2	ug/L
2,TP	80-120	10%	90%	1	ug/L

Table 9-2
Data Quality Objectives (DQOs)

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Indicator	**Accuracy %Recovery**	**Precision %RPD**	**Completeness**	**Detection Limit**	**Units**
Dinoseb	70-130	20%	90%	1	ug/L

Table 5-1
Groundwater Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Well Number[e]	General Condition								Recommendations	
	Well Diameter (inches)	Top of PVC Casing Elevation (feet)[a]	Top of Screen Elevation[b]	Bottom of Screen Elevation[b]	Installation Date	Decommissioned	Sampling Pump	Groundwater Zone Monitored	Purpose[d]	Selection Rationale and Comments
MW-1	3	403.6	284.48	274.48	09/08/1983	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc1)	Background monitoring	Located in sands and gravels incised into top of silt upgradient of site.
MW-10	2	407.51	262.34	252.34	07/01/1995	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc1)	Background monitoring	Receives lateral drainage from Cc1 north of site.
MW-11	2	406.39	162.28	152.28	05/15/1995	Yes - 2003	Dedicated Bladder Pump[c]			
MW-12	2	312.39	139.62	129.62	05/26/1995	No	Dedicated Bladder Pump[c]	Regional aquifer	Water quality monitoring	Located downgradient of site.
MW-13	2	374.07	264	259	04/22/1992	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc1)	Water quality monitoring	Receives lateral drainage from Cc1 southeast of site.
MW-14	2	375.68	212.62	202.62	06/21/1995	Yes - 2015	Dedicated Bladder Pump[c]			
MW-19	2	403.83	141.1	131.1	06/12/1995	No	Dedicated Bladder Pump[c]	Regional aquifer	Water quality monitoring	Located near an area where perched groundwater discharges to the regional aquifer.
MW-2	3	314.28	233.58	228.58	09/09/1983	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc2)	Water quality monitoring	Located in impacted area; screens sand within lacustrine silt.
MW-24	2	373.93	291.5	281.5	04/27/1992	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc1)	Water level monitoring	Screen is almost entirely within lacustrine silt; water level has not risen above top of silt during period of record.

Table 5-1
Groundwater Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Well Number[e]	General Condition								Recommendations	
	Well Diameter (inches)	Top of PVC Casing Elevation (feet)[a]	Top of Screen Elevation[b]	Bottom of Screen Elevation[b]	Installation Date	Decommissioned	Sampling Pump	Groundwater Zone Monitored	Purpose[d]	Selection Rationale and Comments
MW-25	2	399.22	148.78	134.68	08/11/2003	No	Dedicated Bladder Pump[c]	Regional aquifer	Water level monitoring	Groundwater levels at this location constrain regional flow directions.
MW-26	2	403.4	155.12	141.02	08/06/2003	No	Dedicated Bladder Pump[c]	Regional aquifer	Water quality monitoring	Located downgradient of site.
MW-27	2	383.06	194.27	180.07	08/15/2003	No	Dedicated Bladder Pump[c]	Regional aquifer	Water quality monitoring	Located near an area where perched groundwater discharges to the regional aquifer.
MW-28	2	395.59	173.91	159.51	08/29/2003	No	Dedicated Bladder Pump[c]	Regional aquifer	Water level monitoring	Located downgradient of site; dry well due to localized relief of silt within regional aquifer, use for water quality monitoring will be reconsidered if regional groundwater levels rise.
MW-29	2	410.57	169.8	155	08/29/2003	No	Dedicated Bladder Pump[c]	Regional aquifer	Water quality monitoring	Located downgradient of site.
MW-4	3	374.21	273.08	263.08	09/14/1983	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc1)	Water quality monitoring	Seasonally dry; screens top of lacustrine silt; significant “sump” within silt.
MW-5D	2	357.2	240.86	229.86	03/06/1986	Yes - 2015	Dedicated Bladder Pump[c]			
MW-5S	2	356.63	281.86	271.86	03/06/1986	Yes - 2015	Dedicated Bladder Pump[c]			

Table 5-1
Groundwater Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Well Number[e]	General Condition								Recommendations	
	Well Diameter (inches)	Top of PVC Casing Elevation (feet)[a]	Top of Screen Elevation[b]	Bottom of Screen Elevation[b]	Installation Date	Decommissioned	Sampling Pump	Groundwater Zone Monitored	Purpose[d]	Selection Rationale and Comments
MW-6D	2	394.1	241.92	231.92	03/19/1986	Yes - 2003	Dedicated Bladder Pump[c]			
MW-6S	2	394.2	287.42	277.42	03/19/1986	Yes - 2003	Dedicated Bladder Pump[c]			
MW-7	2	373.25	151.09	141.09	04/28/1995	No	Dedicated Bladder Pump[c]	Regional aquifer	Water quality monitoring	Located downgradient of site.
MW-8	2	383.42	213.24	203.24	06/30/1995	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc3)	Water quality monitoring	Monitors zone beneath lacustrine silt that may discharge to regional aquifer.
MW-9	2	402.57	233.64	223.64	06/12/1995	No	Dedicated Bladder Pump[c]	Perched saturated zone (Cc2)	Water quality monitoring	Monitors zone beneath lacustrine silt that may discharge to regional aquifer.
P-1B	2	No data	299.08	289.08	03/29/1986	Yes	Dedicated Bladder Pump[c]			
P-1D	2	No data	278.5	268.5	03/12/1986	Yes	Dedicated Bladder Pump[c]			
P-1S	2	No data	304	294	03/12/1986	Yes	Dedicated Bladder Pump[c]			
P-2A	2	No data	293.6	281.6	03/24/1986	Yes	Dedicated Bladder Pump[c]			

Table 5-1
Groundwater Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Well Number[e]	General Condition								Recommendations	
	Well Diameter (inches)	Top of PVC Casing Elevation (feet)[a]	Top of Screen Elevation[b]	Bottom of Screen Elevation[b]	Installation Date	Decommissioned	Sampling Pump	Groundwater Zone Monitored	Purpose[d]	Selection Rationale and Comments
P-2[d]	2	No data	273.73	258.73	03/19/1986	Yes	Dedicated Bladder Pump[c]			
P-4	1	No data	374.9	372.9	02/29/1988	No	Dedicated Bladder Pump[c]			

Notes:
[a] All survey data in feet are relative to site datum.
[b] Well installed as a dual-completion.
[c] Well Wizard, Model QED T1200
[d] Water levels will be monitored and groundwater samples will be collected from wells proposed for background monitoring or water quality monitoring in conformance with the constraints noted in the text. No groundwater samples will be collected from wells proposed for water level monitoring.
[e] All wells sampled quarterly unless there is insufficient water.
Source:
Vashon Island Hydrogeologic Report Update, Table 4-1

Table 6-1
Surface Water Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Monitoring Station	Location	Purpose
SW-D	Discharge point from north detention pond	Monitors site run-on
SW-B	Discharge point at south end of site	Monitors site run-off
SW-E	On Robinwood Rd SW, approximately 200' south from intersection with Sunset Rd. At the upstream side of the culvert on the NE side of Robinwood Rd. SW.	Monitors the downstream discharge of the unnamed stream that drains SW-W1, SW-W2, and SW-W3
SW-W1	Seep on the west hillside	Monitors discharge from groundwater channel Cc2 to unnamed stream
SW-W2	Seep on the west hillside	Monitors discharge from groundwater channel Cc2 to unnamed stream
SW-W3	Seep on the west hillside	Monitors discharge from groundwater channel Cc3 to unnamed stream

Table 7-1
Leachate Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Monitoring Station	Location	Purpose
LS-B	Junction box	Characterization
LS-PS1	Post aeration	Evaluate pretreatment performance
LS-LVT	Tanker discharge	Permit compliance

Table 8-1
Landfill Gas Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Probes	Location	Relative Depth
GP-1	SE corner	Medium
GP-2	SW corner	Medium
MW-5	SW corner	Shallow
MW-13	SE side	
MW-24	SE side	
NP-1S	NE corner	Shallow
NP-1I	NE corner	Medium
NP-1D	NE corner	Deep
NP-2S	E side	Shallow
NP-2I	E side	Medium
Probes	Location	Relative Depth
NP-2D	E side	Deep
NP-3S	SE side	Shallow
NP-3I	SE side	Medium
NP-3D	SE side	Deep
NP-4S	SE corner	Shallow
NP-4I	SE corner	Medium
NP-4D	SE corner	Deep
NP-5S	SW corner	Shallow
NP-5I	SW corner	Medium
NP-5D	SW corner	Deep
NP-6S	W side	Shallow
NP-6I	W side	Medium
NP-6D	W side	Deep
NP-7S	NW corner	Shallow
NP-7I	NW corner	Medium
NP-7D	NW corner	Deep
NP-8S	N side	Shallow
NP-8I	N side	Medium
NP-8D	N side	Deep
Ambient Stations		
AM-1	NW corner across road	n/a
AM-2	N side	n/a
AM-3	NE corner	n/a
AM-4	E side	n/a
AM-5	SE corner	n/a

Table 8-1
Landfill Gas Monitoring Network

Environmental Monitoring Sampling and Analysis Plan
Vashon Island Closed Landfill
King County, Washington

Probes	Location	Relative Depth
AM-6	S side	n/a
AM-7	SW corner across road	n/a
AM-8	N property line	n/a
AM-CB	Transfer Station Cashier Booth	n/a