Public Review Draft
MU1 and MU2 Engineering Design Report
Cornwall Avenue Landfill Site
Bellingham, Washington

December 7, 2017

Prepared for

Port of Bellingham
Bellingham, Washington

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The material and data in this report were prepared under the supervision and direction of the undersigned.

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LIST OF ABBREVIATIONS AND ACRONYMS

AERMOD	AMS/EPA Regulatory Model
AMS	American Meteorological Society
ARAR	applicable or relevant and appropriate requirements
ASIL	acceptable source impact levels
ASTM	ASTM International
BBP	butylbenzylphthalate
BE	Biological Evaluation
BEP	bis(2-ethylhexyl)phthalate
BGS	below ground surface
BMC	Bellingham Municipal Code
BMP	best management practices
BNSF	Burlington Northern Santa Fe
CAP	Cleanup Action Plan
cfm	cubic feet per minute
CFR	Code of Federal Regulation
CH_4	methane
CHE	Coast & Harbor Engineering
City	City of Bellingham
CL	cleanup level
CLARC	Cleanup Levels and Risk Calculation
cm/s	centimeter per second
CQA	construction quality assurance
CQC	construction quality control
CO	carbon monoxide
CO_2	carbon dioxide
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSL	cleanup screening level
CSZ	Cascadia Subduction Zone
°F	degrees Fahrenheit
DNR	Washington State Department of Natural Resources
ECB	erosion control blanket
Ecology	Washington State Department of Ecology
EDR	Engineering Design Report
EIS	Environmental Impact Statement
ENR	enhanced natural recovery
EPA	US Environmental Protection Agency
ESA	Endangered Species Act

LIST OF ABBREVIATIONS AND ACRONYMS (CONT.)

ft	feet
ft^2	square feet
g	gravity
GP	Georgia Pacific
gpm	gallons per minute
GPS	global positioning system
H:V	horizontal to vertical
H_2S	hydrogen sulfide
HASP	health and safety plan
HDPE	high density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HPA	Hydraulic Project Approval
IBC	International Building Code
IHS	indicator hazardous substance
IPA	interim placement area
ISC	industrial source complex
JARPA	Joint Aquatic Resource Permit Application
LEL	lower explosive limit
LFG	landfill gas
LIDAR	light detection and ranging
LLDPE	linear low density polyethylene
m	meter
m^2/sec	square meters per second
MCE	maximum credible earthquake
MFS	Minimum Functional Standards
MHA	maximum horizontal acceleration
MHW	mean high water
MHHW	mean higher high water
MLW	mean low water
MLLW	mean lower low water
mm	millimeter
MMOP	monitoring, maintenance, and operations plan
MNR	monitored natural recovery
MSL	mean sea level
µg/m^3	micrograms per cubic meter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MSW	municipal solid waste

LIST OF ABBREVIATIONS AND ACRONYMS (CONT.)

MTCA	Model Toxics Control Act
MTL	mean tidal level
MU	management unit
NAPL	nonaqueous phase liquid
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O_2	oxygen
OSHA	Occupational Safety and Health Act
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PE	polyethylene
PGA	peak ground acceleration
PLP	potentially liable party
Port	Port of Bellingham
ppm	parts per million
PSEP	Puget Sound Estuary Protocols
PVC	polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RI/FS	remedial investigation/feasibility study
RTK	real time kinetic
SAP	sampling and analysis plan
SCO	sediment cleanup objective
SCUM II	Sediment Cleanup User's Manual II
Site	Cornwall Avenue Landfill Site
SLR	sea level rise
SMA	Shoreline Management Act
SMS	Sediment Management Standards
SQER	small quantity emission rate
SRPE	scrim-reinforced polyethylene
SVOC	semivolatile organic compound
SWPPP	stormwater pollution prevention plan
TESC	temporary erosion and sediment control
TPH	total petroleum hydrocarbons
TRM	turf reinforcing mat
US	United States
USACE	US Army Corps of Engineers
VOC	volatile organic compound

LIST OF ABBREVIATIONS AND ACRONYMS (CONT.)

WAC	Washington Administrative Code
WDFW	Washington Department of Fish & Wildlife
WISHA	Washington Industrial Safety and Health Act
WQC	water quality certification
WSDOT	Washington State Department of Transportation
yd^3	cubic yard

1.0 INTRODUCTION

This engineering design report (EDR), prepared in accordance with Consent Decree 142025935, provides the preliminary engineering design for the final cleanup action of the Cornwall Avenue Landfill site (Site; Figures 1 and 2), including the basis of design for the primary design elements. The Site and adjoining cleanup site to the north (RG Haley Site) are to be developed in the future as a waterfront public park, and some of the design details outlined in this EDR may be modified as part of park design to be compatible with the habitat and land-use objectives identified in the Park Master plan (Anchor QEA, October 2014). Future modifications to the design will need to be submitted to and approved by Ecology before they can be implemented.

The EDR for the Site is based on the cleanup action plan (CAP) (Ecology 2014) and the Consent Decree between the Washington State Department of Ecology (Ecology) and the potentially liable parties, as follows:

Site Name:	Cornwall Avenue Landfill
Site Location:	South end of Cornwall Avenue, Bellingham, WA
Facility Site Identification No.:	2913
Consent Decree No:	14-2-02593-5
Effective Date of Consent Decree:	December 1, 2014
Parties to the Consent Decree:	Ecology, City of Bellingham (City), Port of Bellingham (Port), Washington State Department of Natural Resources (DNR)
Current Property Owner:	City of Bellingham, Washington State

The Site is being cleaned up under the authority of the Model Toxics Control Act (MTCA), Chapter 70.105D of the Revised Code of Washington (RCW), and the MTCA Cleanup Regulation, Chapter 173-340 of the Washington Administrative Code (WAC). The Site cleanup action is being conducted under a Consent Decree between Ecology, the Port, the City, and DNR. The Port, the City, and DNR have been identified as potentially liable parties (PLPs) for the Site.

The Site has been subdivided into three Management Units (MUs), which are discussed in Section 1.2. This EDR addresses the final cleanup action for MU-1 and MU-2. MU-3, the outermost MU in the aquatic portion of the Site, will be addressed at a later date under an amended CAP and CD. MU-1 addresses the upland portion of the Site. MU-2 addresses the aquatic portion of the Site to the outer limits of where Site-related refuse and wood waste have come to be located, and MU-3 addresses any impacts to marine sediment beyond the limits of MU-2. The Management Units are presented on Figure 3.

1.1 Cleanup Action Goals

The CAP describes the final cleanup action for the Site. The CAP requires that for MU-1, an upland cap with stormwater controls will be constructed with the goal to prevent direct contact with existing contaminated fill, to prevent surface water infiltration through the contaminated fill, and to properly manage landfill gas (LFG). Standard construction methods and materials will be used to create the cover system required to achieve these goals. The design basis for the upland cover elements is provided in Section 5.0 of this report with design details provided on the referenced figures. Detailed design, including construction plans and specifications, will be developed based on this EDR. The overall goal of the Site cleanup action is to achieve containment and isolation of affected soil, refuse, and wood waste in perpetuity, and to prevent discharge of groundwater containing concentrations of hazardous substances that exceed the Site groundwater cleanup levels to surface water. Ecology has determined that the cleanup action in MU-1 complies with cleanup standards through containment, consistent with WAC 173-340-740(6)(f). Because the Cornwall Avenue Landfill and RG Haley sites partially overlap, this EDR is intended to accommodate the needs of both cleanups. Specific considerations and accommodations related to the RG Haley Site are discussed in subsequent sections of this EDR.

For MU-2, the primary goal of the shoreline protection/stabilization system is to prevent direct human and benthic organism contact with contaminated fill (refuse, wood waste), and protect the existing shoreline from erosion. Oceanographic engineering, including numerical modeling, was used to develop a shoreline protection system capable of resisting waves and currents, while minimizing impacts to aquatic habitat to the degree practicable.

Also for MU-2, the primary goal of the thin layer sediment cap is enhanced natural recovery (ENR) to accelerate natural recovery processes in the predominantly biologically active zone by providing a clean substrate overlying refuse and wood waste that extend beyond the limits of the shoreline protection system, within the predominantly biologically active zone for marine sediment (the upper 12 centimeters). The general plan is to place a thin layer of clean material from the edge of the shoreline stabilization system out to the edge of refuse/wood waste fill.

Habitat benefit and improved function will result from the cleanup action itself. Specific habitat related actions will be developed in coordination with permitting agencies during the detailed design and permitting process for the cleanup action.

1.2 Site Background

1.2.1 Site Description

The Site is located south of downtown Bellingham, at the southern terminus of Cornwall Avenue, adjacent to Bellingham Bay. The Site is bordered to the east by an active rail line owned by Burlington Northern Santa Fe Railway Company (BNSF), and to the north by the RG Haley Site. The Site's location and current conditions are presented on Figures 1 and 2, respectively.

The Site extends across two separate properties, one owned by the City and the other consisting of Washington state lands administered by DNR, as shown on Figure 2 (Note: project north established as the northeastern Cornwall property line). Property-related references in the CAP use the following conventions:

- DNR property or state land: The upland and in-water area owned by the State of Washington seaward of the Inner Harbor Line.
- Cornwall property: The fee-owned upland area formerly owned jointly by the Port and the City, and now owned solely by the City landward of the Inner Harbor Line.
- BNSF railway mainline: The upland area owned by BNSF.
- The Cornwall landfill, Cornwall Avenue Landfill, or the landfill: The area containing municipal refuse.

The Site is defined as the area containing refuse, the area containing wood waste within Cornwall property boundaries, the stabilized sediment piles imported as part of the interim action, imported soil fill piles, and the adjoining areas impacted by hazardous substance releases from the refuse or wood waste (see Figure 3). The Site's boundaries are described more specifically as follows:

- West and South Site Boundary: These aquatic boundaries will be set when MU-3 is defined based on regional background concentrations in sediment, as further described in Section 4.1.
- North Site Boundary: This boundary is set at the northern limit of refuse or impacts from refuse. Where refuse is absent, this boundary is established at the northern Cornwall property line.
- East Site Boundary: This boundary is set at the eastern edge of the wood waste fill, which generally coincides with the eastern Cornwall property line (i.e., where it adjoins the BNSF railway mainline).

The portion of the Site addressed by this CAP (MU-1 and MU-2) is approximately 25.8 acres in size, including about 12.6 acres of aquatic lands (MU-2) and 13.2 acres of uplands (MU-1). The aquatic lands and approximately 8.4 acres of the uplands are owned by Washington State and managed by DNR. The remaining 4.8 acres of the uplands are owned by the City. The inner harbor line represents the boundary between City-owned land and state-owned land at the Site. Property to the north of the Site is also owned by the City, and is part of the RG Haley MTCA Cleanup Site. BNSF owns the property east of the Site for the railway mainline.

Presently, the only significant features on the Site consist of a stormwater detention basin constructed in 2005 at the south end of the Site, the interim placement areas (IPAs) located in the western portion of the Site that store stabilized sediment from the interim action conducted in 2011 and 2012, and the early action fill soil placed on the eastern portion of the Site in June 2016 (see Figure 2). The Site is largely unpaved, with the exception of a section of asphalt road and discontinuous areas of unmaintained pavement in the northeastern portion of the Site.

1.2.2 Site History

The area comprising the Site historically consisted of tide flat, with the shoreline generally corresponding with the bottom of the bluff area. Dating back from pre-history to the 19th century, the

Bellingham waterfront was traditionally occupied by ancestors of the present-day Lummi Nation and Nooksack Indian Tribe. The settlement and subsistence of communities throughout this region were similar in many ways, primarily in the seasonal cycle of congregation at winter villages. Winter villages were usually located along protected coastlines, where activities such as shellfish gathering and fishing could be pursued. European settlement took hold on Bellingham Bay during the 1850s and the Bellingham waterfront has since been primarily a shipping and industrial area. A summary of Site industrial history, including ownership and use, is provided in Table 1-1. Municipal landfill operations occurred at the Site from 1954 to 1965. The landfill was covered with a soil layer of variable thickness, and the shoreline was protected by various phases of informal slope armoring consisting of a variety of rock boulders and broken concrete. Since that time, significant shoreline erosion has occurred, resulting in exposure of landfill refuse at the shoreline surface and release and redistribution of landfill refuse onto the adjacent aquatic area. The toe of the refuse fill slope extends out into Bellingham Bay to some distance beyond the shoreline.

Table 1-1. Site History

Year	Owner	Historical Activity/Operations
1888-1946		Sawmill, log storage, wood debris disposal
1946-1965	Port of Bellingham (lease holder on state-owned portion)	See below
1954-1962	City of Bellingham (sublease on state-owned portion from Port)	Refuse disposal
1962-1965	American Fabricators (sublease on state-owned portion from Port)	Refuse disposal (leased land to the City for an extension of the landfill; landfill was closed in 1965)
1971-1985	Georgia Pacific West (leaseholder, including sublease on state-owned portion from Port)	
1985	Georgia Pacific West	Purchased portion of the Site from the Port (“fee-owned portion”)
2005	Port of Bellingham	Repurchased “fee-owned portion” from Georgia Pacific West
2005	City of Bellingham	Purchased an ownership interest in the “fee-owned portion” from the Port
2012	City of Bellingham	Acquired remaining “fee-owned portions” of the Site from the Port

1.2.3 Site Investigation Background

A number of environmental investigations were conducted at the Site prior to developing the CAP. The Site Remedial Investigation/Feasibility Study (RI/FS, Landau Associates 2013) identified the previous Site investigations. The exploration boring/test pit locations for these prior Site investigations are also provided on Figure 3. In 2015, Landau Associates conducted additional predesign investigations to support development of this EDR. The results of the pre-design investigations are provided in Section 4.0.

1.2.4 Geology and Hydrogeology

The RI/FS provided a detailed description of the geology and hydrogeology of the Site. In summary:

- Bedrock underlies the entire Site at varying depths and consists of sandstone and carbonaceous shale of the Chuckanut Formation.
- Overlying the Chuckanut Formation beneath the Site and Bellingham Bay is glacial marine drift consisting of gray, silty clay with occasional gravel and marine shells. The top of the glacial marine drift ranges from 20 feet (ft) below ground surface (BGS) near the eastern edge of the landfill refuse to about 40 ft BGS near the existing shoreline. The thickness of the glacial marine drift varies from greater than 30 ft thick near the existing shoreline until it tapers out near the eastern extent of the refuse.
- Fine-grained sediments deposited in Bellingham Bay by the Nooksack River typically overlie the glacial marine drift. Boring logs indicate that this unit generally consists of green-gray silt, or green-gray silty clay and sandy silt. The silt deposited by the Nooksack River ranges in thickness from about 8 ft near the existing shoreline to near zero at the eastern edge of the refuse. The top of the Nooksack deposit is encountered at a depth of about 20 ft BGS near the eastern edge of the refuse and at a depth of about 30 ft BGS near the existing shoreline. The Nooksack deposit generally increases in thickness toward Bellingham Bay and becomes absent toward the northern and eastern portions of the Site. The Nooksack deposit represents the uppermost native deposit underlying the Site and Bellingham Bay.
- Sawdust and wood debris overlie the Nooksack deposit and the older units within the southwestern portion of the Site, and generally bounds the eastern edge of the refuse. Wood waste was encountered as shallow as 2 to 3 ft BGS east of the refuse and about 15 ft BGS within the southwestern portion of the Site.
- Landfill refuse overlies the wood waste within the southwestern portion of the Site and the Nooksack deposits or Chuckanut Formation within the northeastern portion of the Site. The refuse thickness generally increases toward Bellingham Bay, ranging in thickness from 0 to 40 ft at the eastern Site boundary to the existing shoreline, respectively. The top of the refuse was typically encountered between 2 and 5 ft BGS in the upland portion of the Site.
- Overlying the refuse is the landfill cover soil and traffic surfaces. The cover soil consists primarily of granular material (sand and gravel), wood debris, and occasional areas of cobble ballast.

There are three principal hydrostratigraphic units can be identified beneath the Site. The three units are described below from shallow to deep.

- The uppermost unit consists of the landfill refuse, sawdust, and wood debris, and other fill materials placed at and near the Site. Groundwater is first encountered in this unit.
- The second unit consists of fine-grained silts and clays of both the glacial marine drift and Nooksack deposits, which form the uppermost aquitard throughout most of the Site.
- The third unit is the sandstone of the Chuckanut Formation. This unit could act as an aquifer within portions of the formation that exhibit limited fracturing. The potential for saltwater intrusion from Bellingham Bay likely prohibits the shallow portions of the Chuckanut Formation from being a practicable source of potable water.

The depth to groundwater observed at the Site varied between 4 to 16 ft BGS during the supplemental RI activities and is shallower during the wet season. The saturated thickness of the uppermost hydrostratigraphic unit ranges from about 2 ft at the eastern edge of the Site to almost 30 ft at some locations along the shoreline in the southern portion of the Site. The saturated thickness of the uppermost hydrostratigraphic unit is generally thinner in the northern portion of the Site and thicker in the southern portion of the Site.

In the northern portion of the Site, adjacent to the RG Haley Site, groundwater flow is toward the southwest with a relatively steep hydraulic gradient (0.006 ft/ft) compared to the gradient in the southern portion of the Site (0.003 ft/ft). The higher hydraulic gradients in the northern portion of the Site correlate to an average saturated thickness of about 8 ft, while the flatter hydraulic gradient in the southern portion of the Site correlates to an average saturated thickness of about 23 ft. Thus, the variation in hydraulic gradient for these two areas is partially related to the variation in saturated thickness rather than variations in recharge and/or hydraulic conductivity.

1.2.5 Environmental Conditions

The Site RI/FS identified the following constituents of potential concern and associated media:

- Refuse and wood waste in upland "soil" and in aquatic portions of the Site
- Metals and semivolatile organic compounds (SVOCs) in Site soil
- Metals and dioxins/furans in interim action stabilized sediment within the IPA stockpiles
- Metals, polychlorinated biphenyls (PCBs), fecal coliform, manganese, and ammonia in groundwater
- Methane and possibly volatile organic compounds (VOCs) in soil gas
- Metals, PCBs, carcinogenic polycyclic aromatic hydrocarbons (cPAHs), bis(2-ethylhexyl)phthalate (BEP), and butylbenzylphthalate (BBP) in sediment

The extent of the refuse and wood debris and the overlap area discussed previously associated with the RG Haley Site are shown on Figure 3.

These constituents of potential concern were further evaluated as part of the Site RI/FS process to eliminate those which did not exceed applicable cleanup levels or were not otherwise representative of Site conditions. Those that remained from this elimination process were identified as Indicator Hazardous Substances (IHSs) for the Site. The CAP identifies Site IHSs and their associated media as follows:

- Refuse, wood waste, existing cover soils, and interim action imported dredged sediment in the upland portion of the Site
- Refuse and wood debris in the aquatic portion of the Site
- Manganese and ammonia in Site groundwater
- Methane and possibly VOCs in soil gas

- Metals (cadmium, lead, copper, silver, zinc), PCBs, cPAHs, and BEP in marine sediment

Petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), and SVOCs in the overlap area resulting from releases from the RG Haley Site are not specifically addressed in the CAP. However, the cleanup action for the Site considered coordination of the cleanup activities for the two sites to ensure the selected Site cleanup action will not preclude future cleanup activities related to the RG Haley Site releases (see Section 5.1.12).

2.0 MEDIA TO BE ADDRESSED AND CLEANUP STANDARDS

This section discusses the affected media at the Site including soil, groundwater, sediment, and air. Cleanup standards consist of: 1) cleanup levels (CLs) defined by regulatory criteria that are adequately protective of human health and the environment, and 2) the points of compliance at which the cleanup levels must be met. Cleanup levels for each media are presented in Table 2-1. The CLs presented in Table 2-1 for each media are the same as those presented in the CAP, except the CLs for air, which were developed after the CAP.

2.1 Soil

Because of its nature as a waste material and inherent heterogeneity, the refuse at the Site is considered contaminated; other solid media in the upland portion of the Site, including wood waste, the existing Site cover soil, and the interim action stabilized marine sediment brought to the Site are also considered contaminated soil for the purposes of the cleanup action. The selected cleanup action addresses the contaminated soil/refuse/wood waste/interim action sediment through containment. Containment is defined herein as preventing direct contact with contaminated soil/waste and preventing surface water from infiltrating through the soil/waste. As a result, numeric soil CLs protective of direct contact, leaching to groundwater, and/or erosion have not been established. The point of compliance for soil, based on WAC 173-340-740(6), is throughout the Site, and soil cleanup standards will be achieved through containment.

2.2 Groundwater

As discussed in the RI, Ecology has determined that Site groundwater is non-potable (Landau Associates 2013). Discharge to sediment and chemical volatilization are also not pathways of concern for this Site because the primary contaminants in groundwater have low sediment toxicity (ammonia and manganese), and volatile chemicals, if present, will be captured in a LFG collection system. Therefore, groundwater CLs protective of marine surface water are appropriate for the Site. The downgradient edge of the Site uplands, as close as technically possible to the point-of-entry of groundwater to Bellingham Bay, has been established as the point of compliance for Site groundwater.

2.3 Sediment

The sediment CLs are based on the chemical criteria and Site-specific physical criteria for refuse and wood debris coverage considered protective of benthic organisms. The physical criteria for the sediment CLs consist of the following Site-specific criteria for refuse and wood debris in the aquatic environment that Ecology considers adequately protective of benthic organisms:

- No more than a 1 ft thickness of sediment where wood debris (e.g., sawdust or wood chips) constitutes greater than 50 percent of the sediment by volume
- No detectable refuse

- No less than 1 ft of clean sediment coverage over sediment that exceeds the above criteria for wood debris and refuse.

Additional testing (bioassays) was conducted during the pre-design investigation of the selected cleanup action to confirm the protectiveness of these physical criteria. The bioassay results are summarized in Section 4.7.

2.4 Air

LFG is generated as a byproduct when buried refuse and wood waste decomposes at the Site. This gas is currently uncontrolled, and slowly migrates through the existing soil cover, ultimately ventilating to the atmosphere. Because the amount of waste at this landfill is relatively small, and due to its age, most of the decomposition has already occurred, and it is not anticipated that a large amount of LFG is being produced at this time. However, even small amounts of LFG must be provided a ventilation pathway so that it does not accumulate to concentrations that could cause safety or health risks.

LFG is primarily composed of methane and carbon dioxide, but also contains water vapor, odorous compounds, and typically trace levels of VOCs. The production of LFG decreases over time, as the source material (organic waste) is depleted through decomposition. As a result, the pre-design investigation was conducted to evaluate the quantity and quality of gas currently being produced, so an appropriate control system could be designed as part of the cleanup action.

Air quality standards for the Site include those established under the Northwest Clean Air Agency, which enforces the Clean Air Act (RCW 70.94) in this region of Washington State, in accordance with Chapter 173-460 WAC. In addition to these potential treatment and discharge regulatory criteria, generally discussed herein as air permitting considerations, cleanup standards were developed for this EDR, as discussed in the CAP.

The MTCA Method B air cleanup levels in Appendix A, Attachment A.5 (and summarized below in Table 2-1) were calculated using Ecology's standard formulas (equations 750-1 and 750-2) and default parameters presented in WAC 173-340-750, Cleanup Standards to Protect Air Quality. Toxicity data including reference doses and carcinogenic potency factors were used as specified in WAC 173-340-708 and provided by Ecology in the Cleanup Levels and Risk Calculation (CLARC) Master Spreadsheet, available through Ecology's CLARC website (Ecology website 2015). For constituents with both cancer and non-cancer risk types, the lower of the two criteria was selected for application at the Site.

Although MTCA allows adjustments to exposure parameters to match site-specific exposure expectations, the use of such adjustments would result in the calculated values being considered remediation levels instead of cleanup levels. As a result, the highly conservative default exposure parameters were used, which assume Site visitors would be present at the Site for 24 hours per day, 365 days per year, for the full time of exposure duration (6 years for non-cancer risks and 30 years for cancer risks). MTCA Method B air cleanup levels are adopted as numerical criteria, and the point of compliance is ambient air throughout the Site.

Table 2-1. Cleanup Levels

Media	Chemical Parameter	Cleanup Level	Units
Groundwater	Manganese	0.1	mg/L
	Ammonia	0.35	mg/L
Sediment	Cadmium	1	mg/kg
	Lead	21	mg/kg
	cPAHs	0.016	mg/kg
	PCBs	0.006	mg/kg
	Copper	390	mg/kg
	Silver	6.1	mg/kg
	Zinc	410	mg/kg
	bis(2-Ethylhexyl)phthalate	47[a]	mg/kg
Air	Dichlorodifluoromethane (CFC 12)	4.57E+01	μg/m^3
	Chloromethane	4.11E+01	μg/m^3
	1,3-Butadiene	8.33E-02	μg/m^3
	Bromomethane	2.29E+00	μg/m^3
	Chloroethane	4.57E+03	μg/m^3
	Acetonitrile	2.74E+01	μg/m^3
	Acrolein	9.14E-03	μg/m^3
	Acetone	1.42E+04	μg/m^3
	Trichlorofluoromethane	3.20E+02	μg/m^3
	Acrylonitrile	3.68E-02	μg/m^3
	1,1-Dichloroethene	9.14E+01	μg/m^3
	Methylene Chloride	2.50E+02	μg/m^3
	3-Chloro-1-propene (Allyl Chloride)	4.17E-01	μg/m^3
	Carbon Disulfide	3.20E+02	μg/m^3
	1,1-Dichloroethane	1.56E+00	μg/m^3
	Methyl tert-Butyl Ether	9.62E+00	μg/m^3
	Vinyl Acetate	9.14E+01	μg/m^3
	2-Butanone (MEK)	2.29E+03	μg/m^3
	Ethyl Acetate	3.20E+01	μg/m^3
	n-Hexane	3.20E+02	μg/m^3
	Chloroform	1.09E-01	μg/m^3
	1,2-Dichloroethane	9.62E-02	μg/m^3
	1,1,1-Trichloroethane	2.29E+03	μg/m^3
	Benzene	3.21E-01	μg/m^3
	Carbon Tetrachloride	4.17E-01	μg/m^3
	Cyclohexane	2.74E+03	μg/m^3
	1,2-Dichloropropane	2.50E-01	μg/m^3
	Bromodichloromethane	6.76E-02	μg/m^3
	Trichloroethene	3.70E-01	μg/m^3
	1,4-Dioxane	5.00E-01	μg/m^3
	Methyl Methacrylate	3.20E+02	μg/m^3
	cis-1,3-Dichloropropene	6.25E-01	μg/m^3
	4-Methyl-2-pentanone	1.37E+03	μg/m^3
	1,1,2-Trichloroethane	9.14E-02	μg/m^3
	Toluene	2.29E+03	μg/m^3
	Dibromochloromethane	9.26E-02	μg/m^3
	1,2-Dibromoethane	4.17E-03	μg/m^3
	Tetrachloroethene	9.62E+00	μg/m^3
	Chlorobenzene	2.29E+01	μg/m^3
	Ethylbenzene	4.57E+02	μg/m^3
	m,p-Xylenes	4.57E+01	μg/m^3
	Bromoform	2.27E+00	μg/m^3
	Styrene	4.57E+02	μg/m^3
	o-Xylene	4.57E+01	μg/m^3

Table 2-1. Cleanup Levels

Media	Chemical Parameter	Cleanup Level	Units
Air	1,1,2,2-Tetrachloroethane	4.31E-02	µg/m^3
	Cumene	1.83E+02	µg/m^3
	n-Propylbenzene	4.57E+02	µg/m^3
	1,2,4-Trimethylbenzene	3.20E+00	µg/m^3
	Benzyl Chloride	5.10E-02	µg/m^3
	1,4-Dichlorobenzene	2.27E-01	µg/m^3
	1,2-Dichlorobenzene	9.14E+01	µg/m^3
	1,2-Dibromo-3-chloropropane	4.17E-04	µg/m^3
	1,2,4-Trichlorobenzene	9.14E-01	µg/m^3
	Naphthalene	7.35E-02	µg/m^3
	Hexachlorobutadiene	1.14E-01	µg/m^3
	Vinyl Chloride	2.80E-01	µg/m^3

[a] Based on carbon-normalized SMS SCO
cPAHs = carcinogenic polycyclic aromatic hydrocarbons
µg/m^3 = micrograms per cubic meter
mg/kg = milligrams per kilogram
mg/L = milligrams per liter
PCBs = polychlorinated biphenyls
SCO = Sediment Cleanup Objective
SMS = Sediment Management Standards

Table 2-1 presents the air cleanup levels. MTCA does not provide cleanup levels for methane or landfill gas, because the reference doses and cancer potency factors necessary to calculate cleanup levels are not available. In lieu of cleanup levels, MTCA does establish an explicit upper bound, based on explosivity, for any air cleanup level that might be developed – “Standard Method B air cleanup levels shall not exceed ten percent (10%) of the lower explosive limit for any hazardous substance or mixture of hazardous substances” (WAC 173-340-750[3][b][iii]).

MTCA also invokes closure requirements under applicable landfill closure regulations, and establishes those under Chapter 173-304 WAC as the minimum. The following specific requirements from Chapter 173-304 WAC apply to the Cornwall Landfill (WAC 173-304-460[2][b][i]):

- *The concentration of explosive gases cannot exceed 25 % of the lower explosive limit (LEL) in site structures. The LEL for methane is 5% by volume;*
- *The concentration of explosive gases cannot exceed the LEL in the subsurface at or beyond the property boundary.*
- *The concentration of explosive gases cannot exceed 100 ppmv of hydrocarbons (expressed as methane) in off-site structure*

In addition to LFG and its typical constituents, some VOCs may be present in the subsurface due to releases of petroleum hydrocarbons at the adjacent RG Haley Cleanup Site. As discussed in Section 4.2.3, soil vapor characterization has been conducted, including in the area potentially impacted by RG Haley releases to evaluate the concentrations of VOCs present throughout the Site. The LFG control system will be designed to address these VOCs (if present) by providing capture, treatment if necessary, and ventilation of these gasses.

3.0 PLANNED CLEANUP ACTION

3.1 Overview of the Final Cleanup Action

The final cleanup action will consist of construction of a landfill cover system over the upland area (MU-1) and shoreline protection and a thin-layer sediment cap over the in-water area (MU-2). The design of the MU-1 and MU-2 cover systems are shown on Figures 7 through 18, and the detailed description and design is provided in Section 5.0.

The MU-1 landfill cover system will consist of:

- Low Permeability Capping System, including (from the upper surface downward):
    - Topsoil – a minimum 6-inch thickness of organic soil that will support grass growth. (The cleanup action plan [Ecology 2014], recommended at least a 1-ft-thick layer of topsoil underlain by a granular fill soil. After further review and design, it is determined that a 6-inch minimum thickness of organic topsoil over a thicker section sandy cover soil would be contribute to a better functioning cover system while providing enough thickness to support grass growth. A thinner topsoil section will be less compressible and degradable after construction, provide better protection of the underlying layers, and be less expensive to construct).
    - Cover soil – a minimum 18-inch thickness of medium- to fine-grained sand to provide a thickened cover section to protect the underlying drainage and barrier layer.
    - Drainage layer – a 200-mil (0.2 inch) nominal thickness drainage geocomposite consisting of a plastic geonet and geotubes or piping with non-woven geotextile heat bonded to both sides.
    - Geomembrane layer – A 20-mil (0.02 inch) nominal thickness scrim-reinforced polyethylene liner material to act as part of a composite infiltration barrier to infiltration of rain/snowmelt to the underlying waste.
    - Low-permeability soil layer – The fine-grained stabilized marine sediment stored at the Site as part of the 2011/2012 interim action will be placed and compacted to a minimum 2-ft thickness to form a composite infiltration barrier with the overlying geomembrane in direct contact with the upper surface.
    - LFG collection layer – a 200-mil (0.2 inch) nominal thickness drainage geocomposite consisting of a plastic geonet and geotubes or piping with non-woven geotextile heat bonded to both sides to collect and convey LFG.
    - General fill – imported soil, Site intertidal/shoreline rubble, and soil or sediment from the RG Haley Site, placed in compacted horizontal lifts then graded as needed to create adequate grades for stormwater surface drainage. Note that imported fill includes Hilton Avenue soil that was brought to the Site as approved by Ecology in 2016 as an interim action, and future clean fill soil that may be brought to the Site from offsite sources.
- Stormwater Management System, including:
    - Plugging in place the existing stormwater catch basins and piping in the northeast portion of the Site prior to grading/filling for cover construction.

  - Grading to provide adequate surface drainage and prevent stormwater ponding.
  - Constructing a lined drainage ditch around the north and east side of the landfill cover that discharges to Bellingham Bay at the current discharge point. The ditch liner system has been designed so that cover maintenance activities will not result in damage to the liner.
  - Improving drainage along the BNSF property to reduce infiltration. The drainage improvement will be contingent on groundwater monitoring showing the need to reduce upgradient recharge.
- Landfill Gas Control, including:
  - The LFG collection layer noted above as part of the cover system to collect and convey gas that rises up to the cover system, and prevent the accumulation of gasses or build-up of pressure below the low-permeability layer.
  - Four landfill gas wells installed and screened into the underlying waste to allow LFG to migrate to the LFG collection system and provide subsurface pressure relief.
  - LFG header pipes and perforated collection pipes placed in trenches to collect LFG from the wells and LFG collection layer (noted in low permeability capping system above) and direct the collected gas to the vents.
  - Two passive LFG vents fitted with wind turbines on the top of the vent pipe.
  - The vents will be fitted with flush-mount vaults to allow future installation of granular activated carbon canisters if unacceptable odor levels are detected.

The MU-2 cleanup will consist of stabilizing and protecting the intertidal and shallow subtidal zone and placing a thin layer sediment cap within the deep subtidal portion of MU-2 beyond the limits of the shoreline protection system, and will include:

- Clearing the current intertidal zone of rubble and debris and placing this rubble with imported soil as general fill in the MU-1 area.
- Constructing a shoreline protection/stabilization system along the shoreline perimeter of the Site to disperse erosive currents and/or wave action along the south and west shorelines of the Site.
- Placing a 1-ft-thick sand filter layer consisting of well-graded sand and gravel on the intertidal slope as a filtration layer beneath the shoreline stabilization system. Additionally, the groundwater compliance monitoring wells will be integrated into the sand filter treatment layer to provide representative samples of groundwater as close as practicable to the groundwater/surface water interface.
- Placing a non-woven geotextile layer atop the sand filter layer to provide separation between the sand filter and the overlying stabilization material to ensure that the filter media is not eroded through the larger stabilization media pore spaces.
- Installing shoreline stabilization material 2 to 3 ft thick and ranging in size from sandy gravel to 1.5-ft-diameter (average size) boulders to dissipate wave energy along the shoreline.

- Placing a 6-inch-thick thin layer sand cap extending from the outer boundary of the shoreline stabilization system to the outer limit of Site refuse and wood debris to enhance natural recovery.

3.2 Engineering Justification for Design

The following sections present:

- Design criteria for the various components of the cleanup action
- A description of how cleanup effectiveness will be determined and cleanup standards will be complied with
- Identification of how the release of hazardous materials will be prevented
- How worker and public safety will be protected
- How hazardous materials generated as part of the cleanup action will be managed and disposed
- A description of Site-specific features that affect the conceptual design.

3.2.1 Design Criteria

The general design criteria for this cleanup action are presented below:

- Erosion and sediment control regulations and requirements
- Allowable landfill settlement and minimum required cover system slopes
- Allowable soil slopes, including global and in-plane cover stability, under static and seismic loading
- Fill material physical and chemical characteristics appropriate for future Site use
- Required LFG controls to meet applicable air quality criteria for LFG emissions
- Finish grade and landscape stormwater controls required to meet design storm events
- Anticipated sea level rise, ocean currents, design storm wind/wave criteria used for shoreline protection design.

The development of the final cleanup action conceptual design addressing these design criteria are presented in Sections 4.0 and 5.0 in conjunction with supporting data and analyses.

3.2.2 Efficiency and Effectiveness of the Cleanup Action

The selected cleanup action complies with the provisions of WAC 173-340-360. It will be protective of human health and the environment, comply with cleanup standards and applicable state and federal laws, and provide for compliance monitoring. Refuse, wood waste, soil, and sediment with hazardous substance concentrations that exceed CLs will be contained. Institutional controls will provide notification regarding the presence of residual contaminated soils, regulate the disturbance/ management of those soils/sediment and the cleanup action components, and provide for long-term monitoring and stewardship of the cleanup action. As discussed above, the selected cleanup action is also considered to use permanent solutions to the maximum extent practicable, and to provide for a reasonable restoration time frame.

3.2.3 Compliance with Cleanup Standards

Site cleanup standards are anticipated to be achieved as long as the cleanup action is conducted in a manner that is consistent and in compliance with the CAP, accepted engineering practices, and the requirements specified in WAC 173-340-360.

3.2.4 Controls to Prevent Hazardous Material Releases

The following controls will be implemented to prevent releases of hazardous materials during implementation of the cleanup action:

- Installation and maintenance of temporary erosion and sediment control (TESC) structures and best management practices (BMPs) during construction of the cleanup action. These controls and BMPs include wetting of soil, as necessary, during excavation, grading, and compaction to control dust; silt fencing; tire washing of haul trucks; applying crushed rock over exposed soil; and stormwater drainage to infiltration areas.
- Properly covering and securing loads during hauling operations.
- Properly decontaminating all heavy equipment that comes into contact with contaminated media prior to exiting the Site.
- Deploying floating oil and debris containment booms with silt curtains around active upland shoreline and in-water work (clearing, grading, and material placement).
- Other measures as needed to prevent the release of contaminated soil, groundwater, or marine sediment beyond the limits of the Site, and to achieve surface water quality standards established for in-water construction.

Additional construction means and methods to minimize contaminant releases are provided in Section 6.0.

3.3 Permitting and Regulatory Requirements

The cleanup construction for MU-1 will involve large quantities of earthwork and, therefore, require City construction-related permits (or the substantive requirements thereof). Prior to construction (during the construction plan stage), the Port will work with the City to confirm that the project meets substantive permit requirements. The cleanup has been designed to use the existing stormwater detention system and ditches during construction prior to discharge off of the Site. The Port or construction contractor will obtain a National Pollutant Discharge Elimination System (NPDES) construction stormwater permit for the construction of the cleanup action, including development of a construction Stormwater Pollution Prevention Plan (SWPPP) that provides specific procedures for stormwater management during cleanup of contaminated soil. Additionally, the project will need to comply with the substantive provisions of a City Shoreline Substantial Development Permit.

The cleanup construction for MU-2 will require in-water construction activities that are subject to review under state and federal permitting authorities. Permitting will require coordination with the United States (US) Army Corps of Engineers (USACE) and resource services, and preparation of a Joint Aquatics Resource Permit Application (JARPA) and a Biological Evaluation (BE). Early coordination with the state and federal resource services will be conducted to discuss the various project elements and the likely impacts of the project on marine habitat. This input will be used to refine the design and address any concerns of the resource services in the design prior to submitting the JARPA. It is anticipated that the in-water work will be conducted under a Nationwide 38 permit issued by the USACE and a Hydraulic Project Approval (HPA) issued by the Washington State Department of Fish and Wildlife (WDFW). The substantive requirements of the Section 401 Water Quality Certification (WQC) will also need to be met (substantive requirements achieved through coordination with Ecology). In accordance with MTCA, all cleanup actions conducted under MTCA shall comply with applicable state and federal laws (WAC 173-340-710[1]). MTCA defines applicable state and federal laws to include legally applicable or relevant and appropriate requirements (collectively referred to as the ARARs). For this cleanup action, these ARARs include:

- Washington Water Pollution Control Act and the following implementing regulation: Water Quality Standards for Surface Waters (Chapter 173-201A WAC) and Sediment Management Standard (SMS, Chapter 173-204 WAC). These regulations establish water quality standards for surface waters of the State of Washington consistent with public health and the propagation and protection of fish, shellfish, and wildlife. These standards were used to develop the appropriate stormwater BMPs for the Site.
- Washington State Clean Air Act of 1990: Through Chapter 70.94 RCW and the Air Quality Regulations of Chapter 173-460 WAC, Washington State will regulate emissions of toxic or hazardous air pollutants from this Site. It is anticipated that the Site emissions will be below the threshold criteria of these regulations due to the low levels of air pollutants expected from discharge of LFG.
- Minimum Functional Standards for Solid Waste Handling (MFS; Chapter 173-304 WAC): These regulations contain typical closure requirements that are relevant based on the waste disposal history of the Site. The current refuse regulations, Criteria for Municipal Solid Waste Landfills (Chapter 173-351 WAC), are not an ARAR for the Site because the current solid waste regulations specifically reference the MFS as the applicable regulations for landfills that did not accept waste after October 9, 1991 (WAC 173-351-010[2][b]).
- Resource Conservation and Recovery Act (RCRA), Subtitle C regulations and Washington Hazardous Waste Management Act (Chapter 70.105 RCW) and the following implementing regulation: Dangerous Waste Regulations (Chapter 173-303 WAC), to the extent that any hazardous wastes are discovered during the cleanup action. (These regulations may be applied in the overlap area with the RG Haley Cleanup Site for any listed wastes that are present related to RG Haley operations.) These regulations establish a comprehensive statewide framework for the planning, regulation, control, and management of dangerous waste. The regulation designates those solid wastes that are dangerous or extremely hazardous to the public health and environment. The management of excavated contaminated soil from the Site will be conducted in accordance with these regulations.

- Clean Water Act, with respect to water quality criteria for surface water (Bellingham Bay) and in-water work associated with dredging or sediment capping.
- Shoreline Management Act (SMA; Chapter 90.58 RCW and WAC 173-26-201) and City of Bellingham Shoreline Substantial Development Permit (Bellingham Municipal Code [BMC] Title 22): Establishes permitting and other requirements for substantial development occurring within waters of the US or within 200 ft of a shoreline, and requires that the activities in coastal zones be consistent with local regulations. In accordance with MTCA, cleanup projects being conducted under an enforceable order or consent decree are not required to obtain the shoreline permit; however, the cleanup must be conducted in accordance with the substantive requirements of the regulation.
- Hazardous Waste Operations (Chapter 296-843 WAC): Establishes safety requirements for workers providing investigation and cleanup operations at sites containing hazardous materials. These requirements will be applicable to onsite cleanup activities and will be addressed in a Site health and safety plan prepared specifically for these activities.
- Dredge and fill requirements under Chapter 320-330 of the Code of Federal Regulations (CFR) and Hydraulic Code Rules under Chapter 220-110 WAC.
- The Endangered Species Act (ESA), due to listing of Puget Sound Chinook and the potential listing of Coastal/Puget Sound bull trout.
- City of Bellingham Stormwater Requirements BMC Chapter 15.42.
- City Critical Areas Ordinance (BMC Chapter 16.55 Critical Areas).
- Major Grading Permit; City of Bellingham Grading Ordinance, BMC Chapter 16.70.

3.4 Operation and Maintenance of the Cleanup Action

Operation and maintenance is required for perpetuity due to containment being a primary element of the cleanup action. The cleanup action will be designed to minimize long-term operation and maintenance, and due to the passive nature of the cleanup action, significant operation and maintenance activities outside of long-term compliance monitoring are not anticipated. Post-construction operation and maintenance activities for the cleanup action are described in Section 7.0.

4.0 PRE-DESIGN INVESTIGATION RESULTS

A number of pre-design characterization activities were completed to provide the necessary data and other information to design the final cleanup action for the Site. The pre-design characterization activities included:

- Land survey of the area boundaries, features, topography, and bathymetry
- LFG monitoring and modeling
- Evaluation of the physical properties of the stabilized marine sediment material placed on the Site as an interim action in 2011/2012
- Evaluation of the refuse cover thickness and refuse surface elevation
- Evaluation of the physical and chemical properties of soil to be imported to the Site for preloading and use as fill to achieve drainage grades for the landfill cover system
- Evaluation of the existing stormwater drainage conditions
- Bioassay testing to evaluate the protectiveness of accumulated marine sediment cover over refuse and wood waste in the aquatic portion of the Site
- Evaluation of eelgrass extent and shoreline habitat conditions.

The following sections describe the pre-design activities that were completed.

4.1 Surveying and Site Topography

Upland and aquatic areas of the Site were surveyed to support cleanup design activities. The upland and bathymetric surveys were combined to provide a 0.5-ft contour plan of the Site appropriate for design. The contour plan showing a 1-ft contour interval is shown on Figure 2 and used as the base plan for the remainder of the plan figures. The horizontal datum for the survey is NAD83 WA North Zone, and the vertical datum is mean lower low water (MLLW) for in-water permitting and related aquatic habitat evaluations. The City typically uses NAVD88 vertical datum, which will be used as the datum for preparation of construction documents. The relationships of the NAVD and MLLW datum to other relevant datums are provided in Table 4-1.

Table 4-1. Site Elevation of Other Datum

Datum	NAVD 88(ft)	MLLW (ft)
Highest Observed Tide	9.93	+10.42
Mean Higher High Water Level (MHHW)	8.02	+8.51
Mean High Water (MHW)	7.30	+7.79
Mean Tidal Level (MTL)	4.58	+5.07
Mean Sea Level (MSL)	4.46	+4.95
NGVD29 Datum	3.91	+4.40
Mean Low Water (MLW)	1.86	+2.35
NAVD88 Datum – Zero Elevation	0.00	+0.49
Mean Lower Low Water (MLLW) Datum	-0.49	0.00
City Datum – Zero Elevation	-1.73	-1.24
Lowest Observable Tide	-3.96	-3.47
Calculated Extremely Low Water Level	-4.99	-4.50

The bathymetric survey was completed between January 19 and January 27, 2015 during high tide conditions to provide data as high in the intertidal zone as possible and thus maximize the overlap with the upland survey limits. The bathymetric survey:

- Followed USACE Class 1 specifications
- Included approximately 125 transects, 25 ft apart to produce ½-ft contour interval bathymetry
- Used real time kinetic (RTK) global positioning system (GPS) technology to obtain bathymetric data.

The upland survey included the following elements:

- A property boundary survey
- A 25-ft survey grid to produce ½-ft contour topography of uplands
- An intertidal shoreline during low tide to fill the gap in the upper intertidal area associated with the bathymetric survey
- IPA surface elevations at the same locations as the post-construction as-builts to estimate the amount of settlement that has occurred due to compression of the underlying refuse
- Existing perimeter berms
- Top of casing elevations for groundwater monitoring wells and ground surface for temporary gas monitoring points (shown on Figure 2) to a vertical accuracy of ±0.01 ft
- Pre-design characterization boring and test pit locations and elevations
- Existing outfall locations and elevations (if accessible), catch basins, swales, drainage features, culvert invert elevations, and subsurface conveyances
- Asphalt pavement limits, gravel roads, and slabs
- Existing City monuments and benchmarks
- Existing fencing.

The surveyor used high-precision 2013 light detection and ranging (LIDAR) data available from the City to enhance the ground-measured topography in areas that have little dynamic relief or excessive ground cover. The upland survey along the shoreline was conducted during extreme low tides to extend land surveying as far into the intertidal zone as practicable because land surveying provides a higher level of accuracy than bathymetric surveying techniques, particularly in very shallow water. Delineating the intertidal/upland interface was accomplished with additional measurements using side scan imaging which included the following to a +/-0.02 ft level of accuracy:

- Collecting additional measurements for steep slopes at the shoreline to more accurately delineate the intertidal/upland interface.
- Surveying the location and top elevation of erratics (e.g., boulders, construction debris) at the intertidal/upland interface and in the upper intertidal zone that extend into upland elevations.
- Collecting additional measurements or transects at the shoreline where rapid changes in shoreline alignment occurs (i.e., localized protrusions and depressions).

The Site is relatively flat, sloping gently downward to the southwest, with a surface elevation generally ranging from about 16 to 10 ft above MLLW. The slopes of the intertidal and shallow subtidal zones (above -10 ft MLLW) range from between about 5 Horizontal to 1 Vertical (5H:1V) to 10H:1V, and are generally within 100 to 200 ft of Site uplands. The deeper subtidal zone offshore from the Site has a relatively flat slope of about 20H:1V. Site topography and bathymetry information is shown on Figure 2.

Presently, the only significant features on the Site consist of the IPAs containing stabilized sediment placed in the 2011 and 2012 interim action, with a constructed perimeter berm and stormwater ditches. The stormwater ditches are connected to the stormwater detention basin constructed in 2005 at the south end of the Site following demolition of the Georgia Pacific (GP) warehouse. The Site is largely unpaved, with the exception of an asphalt road in the northeastern portion of the Site and asphalt pavement near the northern end of the former GP warehouse building in the northeastern portion of the Site. The ground surface contains some areas with sparse vegetation consisting of a variety of grasses and weeds that are occasionally mowed by Port maintenance personnel. Additionally, habitat features near the intertidal/upland interface were carefully surveyed by the project habitat biologist using GPS instruments to ensure that the upland/aquatic interface is accurately delineated for use in evaluating the gain/loss in aquatic habitat as a result of the final cleanup action. These habitat features are also shown on Figure 2.

4.2 Landfill Gas Evaluation

A combination of field investigation and computer modeling was used to evaluate the quantity and quality of the LFG being generated at the Site. As part of this evaluation, Landau Associates developed a model of the LFG generation rate, conducted two phases of pre-design field investigation, and developed an air dispersion model using the results of the modeling and Site monitoring data. These data were then used to evaluate ambient air quality for potential impacts from the LFG being exhausted through passive vents, determine air permitting considerations, evaluate potential exposures to LFG under future Site usage, and ultimately, to develop the conceptual design elements of the LFG control system. The complete discussion of the LFG evaluation, including additional details of the modeling and monitoring effort, is provided in Appendix A.

4.2.1 Landfill Gas Generation Modeling

The production of LFG was estimated using the US Environmental Protection Agency's (EPA) LandGEM spreadsheet model – the industry standard approach for estimating LFG emissions for regulatory compliance, and a tool for LFG control system design. The estimate is based on the waste age, type, quantity of buried waste, and the subsurface environment.

LandGEM estimates the overall flow rate of LFG from a municipal solid waste landfill based on user input regarding the amount of waste buried, the year of burial, and other parameters developed by the EPA based on landfills across the US. Emissions factors used in the model are from the Compilation of Air Pollutant Emission Factors (AP-42). The model allows variation of parameters affecting the overall LFG production capacity of the waste (given infinite time), and the rate at which the LFG is released, which typically varies based on moisture content of the waste. Each of these variable parameters are constrained in the model to typically observed ranges.

Based on data collected during the RI and presented in the RI/FS report (Landau Associates 2013), approximately 94,000 cubic yards (yd^3) of wood waste was buried at the Site between 1888 to 1946 and 201,000 yd^3 of municipal solid waste was buried between 1953 to 1965. The model assumes these two types of waste were buried at constant rates during these periods of waste burial. The quantity of waste buried at the Site is relatively small in comparison to modern landfills, and additionally, because the waste is relatively old, it has likely already exhausted the majority of the original LFG producing potential. As shown graphically on Figure 4, the modeled LFG production rate estimates indicate an approximate average total LFG gas generation rate of less than 4.7 cubic feet per minute (cfm) for year 2015. Based on this low estimated rate of LFG production rate, a safety factor of greater than 2 will be applied to the production rate for design, and the capture and control system will be designed for an LFG flow rate of 10 cfm. The LFG generation modeling report is included as Appendix A, Attachment A.1.

4.2.2 Landfill Gas Monitoring

LFG monitoring was conducted by installing soil vapor monitoring probes throughout the Site, evaluating LFG quality using a portable LFG analyzer, and conducting laboratory analyses on samples of LFG collected from the Site. This section discusses the field-analyzed parameters. Section 4.2.3 discusses the results of laboratory analyses.

Thirteen temporary LFG monitoring probes were installed in the locations shown on Figure 5. Installation logs are provided in Appendix A, Attachment A.2. Landfill gas monitoring was then conducted at these 13 probes, 4 existing landfill gas vents, and 13 existing groundwater monitoring wells during two monitoring events (June 15, 2015 and August 7, 2015). LFG monitoring was conducted in accordance with the procedures presented in the Work Plan (Landau Associates 2015) during periods of declining barometric pressure. During the monitoring events, the parameters listed below were measured using field analyzers:

- Methane (CH_4)
- Oxygen (O_2)
- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Hydrogen sulfide (H_2S)
- Hydrogen Gas
- Static pressure
- Total VOCs by field measurement with photoionization detector.

Supplemental information was collected while conducting health and safety monitoring during the advancement of open borings (Section 4.3), and test pits (Section 4.4), using a lower explosive limit (LEL) meter. Monitoring results are tabulated in Appendix A, Attachment A.3.

Figure 5 presents the concentrations of methane detected during each of the monitoring events. As shown on the figure, the landfill continues to generate some quantity of LFG, evidenced by elevated levels of methane. As anticipated, the highest concentrations of methane were detected in areas where municipal solid waste (MSW) is buried, and lower concentrations were detected in areas where only wood waste is buried. Figure 5 shows a dashed green line separating the areas where these two types of waste are located. Although the concentration of LFG is low in some areas, the LFG collection system will extend throughout all areas of the Site. Based on the elevated concentrations of methane in areas with MSW, and because the degradation of MSW generates more LFG than the degradation of wood waste, additional LFG control in the form of subsurface passive extraction wells will be included in the design for this area.

4.2.3 Volatile Organic Compound and Methane Concentrations

Landfill gas samples were collected during the two sampling events from a subset of the monitoring locations, including some sample locations in the area of the Site with potential overlapping contamination from the adjacent RG Haley Site. The samples were analyzed by an accredited laboratory using EPA Method TO-15 for a list of 75 VOCs. Detectable concentrations of VOCs were found throughout most of the Site. The VOCs detected are commonly found in LFG, although they are present at this landfill at relatively low concentrations in comparison to landfills with more recent disposal. For reference, the total mass of non-methane VOCs in recently closed landfill LFG is typically about 840 parts per million (ppm), normalized to hexane (EPA 2008). This is equivalent to approximately 3,000,000 micrograms per cubic meter (µg/m^3), the unit of measurement in which the Cornwall VOC data are presented below in Table 4-2. The highest observed total VOC concentration in

Site LFG, expressed as the sum of all detected VOCs, was at LFG probe P-2, and was approximately 12,000 µg/m^3 – less than 0.5 percent of the concentration typically present in recently closed landfill LFG.

Table 4-2. Total Mass of Volatile Organic Compounds

Sample ID	Sample Date	Cumulative Sum of VOCs (µg/m^3)
CL-LFG-BACKGROUND	6/15/2015	52
CL-LFG-MW-102	6/15/2015	2,000
CL-LFG-P-2	8/7/2015	11,736
CL-LFG-P-3	6/15/2015	2,263
CL-LFG-P-3	8/7/2015	755
CL-LFG-P-6	8/7/2015	5,599
CL-LFG-P-12	6/15/2015	4,781
CL-LFG-P-12	8/7/2015	1,444
CL-LFG-VENT-3	6/15/2015	1,138
CL-LFG-VENT-4	6/15/2015	714

The concentrations of individual VOCs and methane are presented in Appendix A, Attachment A.3, Table A-3. As noted in the subsequent sections, these concentrations are applied to the total estimated LFG production rate to determine emissions for comparison to criteria for air permitting considerations. The concentrations of VOCs in ambient air are estimated through air dispersion modeling and compared to MTCA Method B air cleanup levels to evaluate human health risks through exposure to ambient air. These concentrations will be confirmed by collecting air samples at the LFG vents as part of compliance monitoring, to assess compliance with MTCA Method B air cleanup levels.

4.2.4 Permitting Considerations

In Appendix A, Attachment A.4, an evaluation is presented to compare the maximum anticipated ambient air impacts to the applicable air quality standards in Chapter 173-460 WAC, Controls for New Sources of Toxic Air Pollutants. This regulation requires an evaluation of new sources of potential toxic air pollutants (in this case, the planned LFG control system) to determine if control technology is required to reduce emissions to protect air quality, human health, or safety.

Since new LFG vents will be constructed, it is necessary to evaluate emissions from the vents as if they are new sources of air contamination with respect to air quality. This evaluation is in addition to the assessment of MTCA cleanup standards discussed in Section 4.2.5. Chapter 173 460-080 WAC provides for a screening-level approach to demonstrating compliance with ambient air quality impact standards by comparison to several threshold criteria. These criteria are presented in WAC 173-460-150, and include *de minimis* values, small quantity emission rates (SQERs), and acceptable source impact levels (ASILs). *De minimis* values are evaluated on a the total mass of emissions per day or annum, depending on the State's preferred averaging period which varies by specific compound. If the anticipated impacts are less than the *de minimis* values, no further evaluation is required. The SQERs are also mass-based emissions criteria. If the anticipated air emissions of toxic air pollutants are greater than the SQERs, additional evaluation (i.e., air modeling) must be conducted to determine if the estimated concentrations would exceed their respective ASIL values, which are concentration-based criteria. The ASILs, SQERs, and *de minimis* values are presented in in Appendix A, Attachment A.4 for comparison to Site data. Source emissions are compared to ASILs, SQERs, and *de minimis* values to determine whether further permitting considerations or implementation of treatment technology is necessary to meet Washington's air quality standards. For this evaluation, the maximum anticipated ambient air impact is based on using the highest concentration VOC data from the pre-design investigation to estimate emissions at future LFG vents, including an assumption that non-detected compounds are present at the laboratory reporting limit.

As discussed in Appendix A, Attachment A.4, the emissions for all compounds were compared to and are well below all three criteria, including the lowest, the *de minimis* emission values. Being below the *de minimis* values indicates, according to WAC 173-460-020, "trivial levels of emissions that do not pose a threat to human health or the environment." Accordingly, the emissions are considered low enough that no air permit is required for this new source, and furthermore, air dispersion modeling would not be required for this new source to evaluate concentrations at specific receptor points; typical air permitting considerations would be concluded based on the evaluation. However, additional air dispersion modeling was conducted for this project, as discussed in the following section, to evaluate VOC concentrations at receptor locations within the Site for comparison to MTCA Method B air cleanup levels.

4.2.5 Air Dispersion Modeling and Air Cleanup Standards

The American Meteorological Society (AMS)/EPA Regulatory Model (AERMOD) was used to estimate ambient VOC concentrations at a network of approximately 650 different receptor locations spaced equally throughout the Site. Similar to the approach for air permitting considerations, the highest concentrations of individual VOCs based on the data from the pre-design investigation were used to represent the future emissions at LFG vents, and non-detected compounds were assumed to be present at the TO-15 laboratory reporting limit.

Ambient air impacts were simulated from total VOC stack emissions using the Industrial Source Complex (ISC)-AERMOD View Version 8.1 and the most recent version of AERMOD (version 15181). AERMOD incorporates data from a variety of pre-processors to incorporate meteorological parameters (actual meteorological data from 2008 to 2012 used for input), terrain heights (Site topography after implementing the cleanup), and physical stack parameters (location, height, and diameter) to predict VOC concentrations throughout ambient air at the Site. A receptor grid was established to model potential impacts to ambient air from the LFG vents. The receptor grid network consisted of a Cartesian flagpole receptor grid with 12.5-meter (m) spacing, placed at a height of 1.5 m above ground to approximate the human breathing zone.

The single receptor with the highest estimated concentration under the worst-case meteorological conditions affecting ground concentrations was used to represent ambient air conditions at the Site, and was compared to the MTCA Method B air cleanup levels in Appendix A, Attachment A.5.

Even with conservatively high assumptions regarding LFG generation, the presence and concentrations of toxic air pollutants, dispersion of LFG from the vent to the breathing zone, and cleanup levels based on highly conservative exposure parameters, the estimated concentrations of all compounds are well below cleanup levels throughout the Site, generally at least 2 orders of magnitude (100 times) below the cleanup levels. It is anticipated that the actual concentrations at the LFG vents will already be below the MTCA Method B cleanup levels before any dispersion due to the conservative assumptions used to develop the emissions estimates. Compliance monitoring will be conducted at the LFG vents to confirm the discharge already meets the cleanup levels or will be below the cleanup levels in the breathing zone.

This evaluation assumes that LFG will be ventilated through a two vent system design (discussed in Section 5.2.2.1), with vent heights a minimum of 12 ft above ground surface, and without the use of treatment prior to discharge. Based on these results, it was concluded that additional air treatment, such as carbon filtration, is not required for protection of air quality and human health. However, as discussed further in Section 5.0, the vents will be outfitted in a way that allows the addition of carbon filtration, in the event that odor control is necessary in the future. Carbon filtration can also be added if post-closure compliance monitoring demonstrates that the emissions are higher than anticipated, and treatment is needed to meet air cleanup levels prior to discharge.

4.2.6 Landfill Gas Evaluation Conclusions

Based on the results of the evaluation discussed above and presented in Appendix A, the following conclusions are carried forward for consideration during development of the LFG control system design (Section 5.2.3):

- The LFG production rate was confirmed to be low. The design will be based on a flow of 10 cfm and it is assumed for the purposes of design that LFG is being produced throughout the Site. As a result, an LFG collection layer will be included throughout the Site, beneath the low-permeability layer of the landfill cover system.
- The highest production of LFG is in the areas where MSW is buried. As a result, subsurface collection will be provided in this area, using passive extraction wells to capture LFG where it is present at the highest concentrations, and to provide subsurface pressure relief to prevent the buildup of pressure that could promote lateral migration.
- Based on worst-case assumptions regarding emissions, no air permit will be required and no treatment technology is required to meet the air quality standards for new emissions sources.

- Based on worst-case assumptions regarding emissions, and potential exposure to future Site visitors, a vent height of 12 ft will be used to protect ambient air quality and meet MTCA air cleanup standards. As previously noted, it is anticipated the actual emissions will be below cleanup levels. Compliance monitoring will be conducted to confirm cleanup levels are attained in accordance with Ecology's guidance document for establishing and evaluating air cleanup standards under MTCA (Ecology 2005).

4.3 Stabilized Sediment Testing

The CAP specifies that the stabilized sediment in the IPA stockpiles will be excavated and reworked, spread across the Site cover area, and compacted into a minimum 2-ft-thick low-permeability soil layer to function as part of the landfill low permeability cap. Landau Associates collected representative samples and conducted geotechnical testing of the stabilized sediment to:

- Confirm the suitability of the material as the low-permeability soil layer component of the landfill cap
- Determine the level of construction effort that will be required to adequately process and compact this material for its intended use.

To accomplish this task, a track mounted drilling rig, travelling on mats and/or ramps to protect the IPA cover, mobilized to the top of the IPA stockpiles and advance eight borings (approximately 120 ft apart) at the locations shown on Figure 3. Thin-walled tube samples (3-inch diameter by 30-inches long) were recovered from the IPA stockpiles at the top surface and every 3 ft of depth, and preserved for laboratory testing. All penetrations and damage to the IPA cover were repaired with glued-in-place patches of the same geomembrane material that currently covers the IPA stabilized sediment stockpiles.

Logs were prepared for each boring to document the conditions observed during drilling, including the composition and the depth of the materials encountered, and are presented in Appendix B, Attachment B.1. Representative soil samples were tested in Landau Associates' geotechnical laboratory to determine the following:

- In-place moisture and density
- Atterberg Limits
- Grain-size distribution
- Moisture/density compaction curves
- Remolded permeability.

The results of the geotechnical testing on the stabilized sediment are summarized below and detailed test results are provided in Appendix B, Attachments B.1 and B.2.

4.3.1 Moisture-Density Relationships and Hydraulic Conductivity

Per the CAP (Ecology 2014), an approximate "two-foot thick layer of low-permeability soil will be installed beneath the scrim-reinforced liner to minimize stormwater infiltration into the underlying refuse and wood debris. The fine-grained interim action sediment stored at the Site as part of the 2011/2012 interim action will be used for this purpose." The performance requirements of this low-permeability soil layer is defined in Section 9.4.1 of the RI/FS (Landau Associates 2013): "The soil would need to demonstrate permeability characteristics equivalent to a 2-ft-thick layer of soil with a hydraulic conductivity of $1x10^{-6}$ cm/s to meet the requirements for landfill closure under the MFS for solid waste handling (Chapter 173-304 WAC), which is considered an ARAR for the Site due to its historical use as a solid waste landfill."

In order to verify the hydraulic conductivity could be achieved by reworking the stabilized sediment in the IPA stockpiles, moisture density tests in conjunction with remolded permeability tests were performed to define the zone of acceptable compaction (EPA 1993a). The test results and zone of acceptable compaction are shown on Figure B-2.6 in Appendix B, Attachment B.2.

In summary, moisture density tests for both standard (ASTM International [ASTM] D698) and modified (ASTM D1557) proctor tests were first performed on stabilized sediment to determine the range of moisture content and compaction energy that would be required to rework the stabilized sediment into a stable barrier layer for the landfill cover system. Using the moisture density curves as a guide, cylindrical samples were remolded at varying moisture contents and density. These remolded samples were then tested for hydraulic conductivity using a flexible-wall permeameter (ASTM D5084). The moisture and density of the remolded samples were plotted on the moisture density curves, and those that had tested hydraulic conductivities less than $1x10^{-6}$ centimeters per second (cm/s) define the limits of the zone of acceptable compaction. It was concluded from testing that if the stabilized sediment from the IPA stockpiles was processed and compacted to be between 35 and 45 percent moisture by weight and to dry density greater than 72 pounds per cubic foot, the compacted soil would have a hydraulic conductivity less than $1x10^{-6}$ cm/s.

4.3.2 Material Conditioning Requirements for Placement

The geotechnical testing on the stabilized sediment in the IPA stockpiles revealed that the sediment in these piles is wetter and less dense than required by the zone of acceptable compaction (discussed in Section 4.3.1 above). Specifically, as provided in Appendix B, Attachment B.2, the *in situ* moisture content was found to range from 43.8 to 70.3 percent moisture by weight with an average of 17 samples at 63.8 percent moisture by weight. The dry unit weight was found to range from 54.7 to 67.6 pounds per cubic foot with an average of 17 samples at 59.1 pounds per cubic foot. In order for the stockpiled sediment to achieve the desired low hydraulic conductivity, the sediment will need to be processed to dry it to between 35 percent and 45 percent moisture. This will be achievable by spreading the soil in no more than 8-inch-thick loose lifts parallel to the subgrade (or compacted lift below it) and discing the material until it dries to the desired moisture content. By necessity, the construction would need to be conducted during summer months during sunny drier conditions.

Once the material has been dried to the desired moisture content range, it will require a higher energy-level of compaction to compact the material to over 72 pounds per cubic foot. Because the material classifies as plastic/organic silt (Figure B-2.3), the compaction equipment should be a pad-footed roller to knead and properly compact the capping material. While the material is being placed, wood fragments or other sharp-edged debris that could cause damage to the overlying geomembrane will be removed. The density, and resulting low hydraulic conductivity, is expected to be achieved when the pad-footed compactor has made several passes over the sediment, and the feet of the compactor have very little penetration into the compacted sediment (i.e. “walking out”). This process of compaction will be repeated for each lift until the 2 ft minimum thickness, low-permeability layer has been constructed. Once complete, the final surface will be smooth drum rolled or cut to finished grade just prior to placing the overlying geomembrane. Verifying compacted density, moisture content, and *in situ* hydraulic conductivity will be accomplished before covering the compacted low-permeability soil layer. Construction Quality Assurance is discussed further in Section 6.3.

4.3.3 Low-Permeability Soil Volume Available

The survey conducted on the IPA stockpiles indicates there is approximately 38,600 yd^3 of stabilized sediment available for use for the low-permeability soil layer. Considering that this volume will be dried back and compacted, it is expected that the volume available will be reduced to 35,000 to 36,000 yd^3 of in-place compacted low-permeability soil. As discussed further in Section 5.2.2.3, this is expected to exceed the volume required for the soil cap. The remainder of the material will be placed as capping material to create a low-permeability cap in excess of 2 ft, thus improving the overall performance of the cap.

4.3.4 Cover Thickness Evaluation

Test pit excavations were excavated on June 11, 2015 using a backhoe to determine landfill cover thickness and waste surface elevation in areas of the Site not adequately characterized by previous explorations. A total of 22 test pits were excavated with the logged material descriptions tabulated on Figure B-1.10 in Appendix B, Attachment B.1. The locations of the test pits are shown on Figure 3.

Exploration logs from the test pits, LFG probe logs, and previous investigation boring logs were used to evaluate the thickness of the existing cover over the landfill refuse and wood waste and develop the grading plan for the upland capping system. Including the 22 test pits and other investigations, the existing cover and top of refuse elevation was measured at 90 points across the Site.

The purpose of the cover thickness evaluation was for grading design, or more specifically, to determine where cuts could occur in the existing ground surface to minimize encountering waste. Although it is valuable to know where the top of the waste is for geotechnical purposes, the soil cover is also presumed to be contaminated, given the long use of the property for industrial purposes, the unknown source of the cover fill, and the proximity of the RG Haley Site. The cover soil must therefore be managed in the same manner for protection of human health and the environment as any exposed waste (see Section 5.1.1).

The cover ranges in thickness from 0 to 10 ft thick with an average thickness of 2.9 ft. An approximate elevation contour map of the top of waste (refuse or wood waste) is shown on Figure 3. The top of waste elevation was estimated at each of the 90 points by subtracting the cover thickness from the ground elevation at the time of the investigation and contouring this data. The top of waste generally parallels the surface contours in the northern portion of the Site with deeper pockets of cover material in the southern areas of the Site.

4.4 Imported Fill Early Action

The Site is relatively flat. Per the MFS for solid waste handling (Chapter 173-304 WAC) the landfill cover must have sufficient slope to promote drainage off the cover system. The MFS requires that a minimum 2 percent slope be established and maintained throughout post-closure operation and maintenance of the landfill. This typically requires that steeper slopes be established at the time of landfill closure in anticipation of post-closure settlement that occurs due to decomposition of the waste and settlement due to consolidation from the weight of the closure cap.

As discussed in Section 5.2.1, up to 46,000 in-place yards of fill will be needed to establish Site grades required to establish and maintain at least a minimum 2 percent slope over the upland portion of the Site. As a result, a significant volume of import fill will be required to establish Site grades beneath the capping system. Placing the additional soil on the Site months or years in advance of the MU-1 cover construction would be beneficial in preloading the Site and minimizing the long-term settlement and depressions that could form in the constructed landfill cover.

The Port identified an offsite borrow source suitable for use as general fill at the Site. The soil was located on property owned by the Port along Hilton Avenue. The subject soil was originally intertidal deposits that were dredged to create the Port's Squalicum Inner Harbor in the early 1980s, and was originally placed to create the uplands where the Hotel Bellwether and restaurants are currently located. The soil was relocated to the Hilton Avenue location when the Hotel Bellwether subgrade parking garage was constructed in the late 1990s and when the Bellwether office buildings were constructed in the early 2000s. On October 26, 2015, Landau Associates conducted a test pit investigation to collect samples for geotechnical testing. The results of the geotechnical testing for the Hilton Avenue soil are provided in Appendix F, Attachment F.1a. In summary, the soil in the stockpile ranged from gravelly sand with silt to a sandy clay with gravel. Although the material is variable in composition, it was determined to be appropriate for use as general fill to establish Site grades.

Based on its original source and the analytical results for five soil samples collected from the material in advance of placement at the Hilton Avenue property as reported by GeoEngineers in 1998 and the original sediment quality characterization conducted prior to dredging completed by the USACE in 1976 (see Appendix F, Attachment F.1c), the soil was found to be uncontaminated based on comparison to applicable MTCA soil cleanup levels for the constituents tested. To confirm that the soil quality of the Hilton Avenue material would be acceptable for use as general fill at the Site, additional characterization of soil quality was conducted at Ecology's request.

On December 10, 2015, Landau Associates collected five vertically composited samples from the material for analytical testing. Samples were collected using direct-push sampling equipment, with exploration oversight and sampling by a Landau Associates environmental professional. A single composite sample representing the full thickness of the fill material was collected from each location. All samples were analyzed for total petroleum hydrocarbons (TPH) using the NWTPH-HCID method, with follow up for any TPH ranges that were detected. Samples were also tested for heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), SVOCs, and dioxins/furans.

Highly conservative exposure and migration pathways were used to develop the screening levels used to assess whether the soil is suitable for use on the Site. The potential exposure pathways considered in screening the data included direct contact (ingestion), protection of terrestrial and aquatic species, protection of marine sediment quality, and protection of groundwater in both unsaturated and saturated soil conditions, as presented in Appendix F, Table F.1b-1. The most protective of these values was used as the screening level for evaluation of soil quality. It should be noted that these screening levels consider exposure pathways that may not be applicable for the development of soil cleanup levels, but meeting these extremely conservative screening levels clearly demonstrates that the use of this soil for general fill at the Site does not pose a threat to human health or the environment.

As shown in Appendix F, Table F.1b-2, all detected constituents were below the screening levels, with only one exception. Copper was detected in one sample at a 40.7 milligrams per kilogram (mg/kg), a concentration slightly greater than the preliminary screening level of 36 mg/kg. However, because the highest copper concentration is less than 2 times the screening level, less than 10 percent of the copper data exceed the screening level, and the 95 percent upper confidence limit on the mean for the copper data is approximately 25 mg/kg, (well below the screening level), the soil is considered to meet the copper screening level.

Based on the laboratory analyses attached and discussed above, the material was considered by Ecology on March 2, 2016 (email from Mark Adams) to be suitable for reuse as fill material at the Site to establish grades beneath the impermeable cover system. The restriction to place the imported soil under the cover system is due to Ecology’s opinion that because the material contains hazardous substances (but below MTCA cleanup levels) it is still classified a solid waste under WAC 173-350.

A contractor to the Port began transferring fill material from the stockpile on Hilton Avenue to the Site on June 1, 2016 and continued through June 28, 2016. Approximately 41,350 cubic yards of fill soil were moved from the Hilton Avenue site and placed in compacted lifts at the Site. Stockpile material was hauled to the Site with end dump truck and pups, placed in 8- to 12-inch-thick loose lifts, and compacted using a smooth drum roller. As shown on Figure 7, two distinct stockpiles were formed on the eastern portion of the Site, with a drainage ditch between them. The preloading of imported soil was accomplished by controlled placement of fill soil up to the grades shown on Figure 11 to preload the Site in excess of the proposed final grades of the landfill shown on Figure 10. Upon completion of the stockpile import, the stockpiles were bladed and graded to provide adequate drainage, per the plans. The stockpiles were then seeded, fertilized, and covered with an erosion control blanket. The imported soil was brought to the Site as an early action to be used to preload the eastern portion of the Site and to provide the majority of the fill needed to establish future grades on the Site. The construction completion report for this early action is provided as Appendix F.2.

4.5 Eelgrass and Shoreline Habitat Survey

Grette Associates was subcontracted by Landau Associates to conduct a habitat survey of the Site to assess the existing aquatic and shoreline habitat conditions. The aquatic survey was focused on surveying for the presence of eelgrass (*Zostera marina*), macroalgae, substrates, and debris. The shoreline survey focused on the existing habitat conditions (primarily vegetation, slopes, and substrates) present between the aquatic and upland portions of the site. The existing habitat conditions provide the baseline environmental conditions and were utilized to assist with the design and permitting of the cleanup action. The complete Eelgrass and Shoreline Habitat Survey is provided as Appendix E.

In summary, the eelgrass survey was conducted using 44 transects perpendicular to the shoreline between June 29 and July 1, 2015, which was within the WDFW recommended survey window. Based on sampling, eelgrass presence along the shoreline was extremely variable and limited to a narrow strip of elevations (approximately -1 ft and -9 ft MHHW). Eelgrass was observed along 29 of the 44 transects and was separated into four distinct areas based on substrates, densities, areal coverage, and habitat conditions. The delineation resulted in a total of approximately 59,850 square feet (ft^2; 1.4 acres) of eelgrass habitat within the proposed limits of the study area shown on Figure 2. Average eelgrass densities along the transects ranged from 15 to 176 turions per square meter, with an overall average density of 52 turions per square meter for the Site. In general, sea lettuce and rockweed were the dominant species present in the nearshore zone, with coverage ranging between 5 and 25 percent. In deeper waters, Turkish towel, sea lettuce, gracilaria, sargassum, and *laminaria spp.*, were common, with coverage generally less than 20 percent. A complete list of macroalgae species encountered during the Site survey is included in Appendix E.

Within the nearshore environment (0 to 100 ft from the MHHW), concrete rubble and debris were present on top of sand, gravel, and cobble. Pile stubs, wood waste, glass, metal, ceramic, and other debris were also common throughout this area. From 100 to 140 ft from the MHHW, substrates were predominated by sand and gravel with reduced amounts of rubble and debris. Beyond 140 ft from the MHHW, substrates were nearly 100 percent silt across the Site.

4.6 Coastal Processes Modeling

Coast & Harbor Engineering (CHE), a Division of Hatch Mott McDonald and a member of the Site design team, modelled the coastal processes and developed a preliminary level of design of the shoreline protection/stabilization system required for the Site cleanup action. CHE's full basis of design report is provided as Appendix C. The coastal process modeling input data, assumptions, and design criteria used in the preliminary design are provided in Appendix C, and are summarized in the following sections. The shoreline protection design, based on the coastal modeling, is presented in Section 5.2.5.

4.6.1 Design Wind Wave Storm Return Period

A 100-year return period storm event was selected for analysis and numerical modeling of stability of the shoreline erosion protection system. Typically, shoreline erosion protection projects are designed to withstand wind-wave storm events with less intensity (25- or 50-year return period). Based on previous experience with the Whatcom Waterway (Port of Bellingham) and RG Haley (City of Bellingham) projects, and due to the requirement that the cleanup action remain stable under extreme events, a 100-year storm event was selected as the design wave storm criteria for designing the Site shoreline stabilization system.

4.6.2 Sea Level Rise

Climate change predictions require that potential sea level rise (SLR) over time be considered in the design of the shoreline stabilization system. Several papers with respect to sea-level rise are recommended by the Ecology Climate Change web page (Ecology website 2016), and were considered when evaluating the potential SLR in Bellingham Bay. The SLR estimates which are most relevant to the Site are summarized in the table below.

Table 4-3. Estimated Sea Level Rise Sources

Research	Papers that Reference the Research	Notes	SLR
Strauss, B. H., Ziemlinski, R., Weiss, J. L., & Overpeck, J. T. 2012. *Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States*, .Environmental Research Letters, 7(1), 014033.	Climate Central (2016) *Sea level rise and coastal flood risk: Summary for Bellingham, WA,* July 21, 2016	Page 1, Uses *Surging Seas Risk Finder* software to predict SLR.	For Year 2050: 0.7 ft with range of 0.3 to 1.3 ft For Year 2100: 2.1 ft with range of 0.9 to 4 ft
Mote, P., Petersen, A., Reeder, S., Shipman, H., and Whitely-Binder, L. 2008. *Sea level Rise in the Coastal Waters of Washington State.* A report by the University of Washington Climate Impacts Group and the Washington Department of Oceanography (Basis for several papers, some listed to the right, and used by the Intergovernmental Panel on Climate Change [IPCC])	WSDOT, *Climate Impacts Vulnerability Assessment*, November 2011	Appendix A, page 31 for Puget Sound	For year 2050: 6 inches with range 1 to 18 inches; For Year 2100: 13 inches with range 6 to 50 inches
	National Wildlife Foundation, *Climate Change Effects in Marine and Coastal Ecosystems*, August 2011	Page 76	
	Huppert, Moore, Dyson, *Impacts of Climate Change on the Coasts of Washington State,* Chapter 8 Washington Climate Change Impacts Assessment, Climate Impactus Group	Table 2	
	Department of Ecology, *Preparing for a Changing Climate: Washington State's Integrated Climate Response Strategy*, Chapter 6 Oceans and Coastlines, April 2012	Table 1	

Research	Papers that Reference the Research	Notes	SLR
Glick, P., Clough, J., and Nunley, B. 2007. "*Sea-level Rise And Coastal Habitats In the Pacific Northwest, An Analysis For Puget Sound, Southwestern Washington, And Northwestern Oregon*". National Wildlife Federation.	Ken Reeder, *West Coast Relevant Sea Level Rise Impact Models: A review to aid local and regional planning,* White Paper to West Coast Governors Alliance on Ocean Health, October 2011	Page 10 – case study including for Puget Sound using Sea Level Affecting Marshes Model (SLAMM) prediction	For year 2025: 3 inches For Year 2100: 27 to 78 inches

A SLR of 2.4 ft over the next 100 years has been assumed for other cleanup sites in Bellingham Bay, and was the SLR value used in the Waterfront District Environmental Impact Statement (EIS) (Blumen Consulting Group, Inc. 2010). This SLR value of 2.4 ft is consistent with the above referenced literature developed for local and regional planners and engineers, and was therefore used for the Site cleanup design purposes.

It is acknowledged that SLR is a developing area of science and estimates are likely to be refined and revised over the coming years. Although a SLR value of 2.4 ft was assumed for design purposes, the design of the upland capping system in the shoreline area could easily be modified to accommodate much higher levels of SLR. The bench of the shoreline protection system could function as the base to extend the shoreline stabilization system up the adjacent 4H:1V upland slope an additional 5 ft of elevation. In other words, the design has a the flexibility to increase shoreline protection for up to 7.4 ft (or 88.8 inches) of SLR, which far exceeds all current predictions for SLR in Bellingham Bay.

4.6.3 Tidal Data and Tide Elevation Design Criteria

Two tide levels were used during modeling of wind/wave effects for engineering analysis and design of the shoreline stabilization system: Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW). MHHW tide elevation was used for design of stability of the upper part of the shoreline stabilization system assuming that the design storm were to occur during a MHHW tidal stage. MLLW tide elevation was used to design the lower part of the shoreline stabilization system assuming that the design storm occurred during a MLLW tidal stage. MHHW tide elevation was used in combination with the sea level rise increment (+2.4 ft) and storm wave height to design the upper elevation of the shoreline stabilization system.

4.6.4 Wave/Erosion Modeling

Wave conditions at the Site were the major controlling factor for the design of the coastal engineering element and the effect of tidal currents on design were found to be negligible. Therefore, detailed wave analysis and numerical modeling was performed to establish the wave conditions prior to the project (existing conditions) and upon construction of the proposed coastal elements (post-project conditions). Descriptions of the wave modeling as well as the basis of design for each coastal element are presented in Sections 2 and 3 of CHE's basis of design report in Appendix C.

4.6.5 Tsunami

Tsunamis are waves that occur in open water bodies due to earthquakes or landslides. Per the Critical Areas Report for the interim action at the Cornwall site (Landau Associates 2011), a tsunami could be generated by a large earthquake in the Pacific Ocean basin. The DNR Division of Geology and Earth Resources and the National Oceanic and Atmospheric Administration (NOAA) have published estimates of tsunami inundation in the Bellingham Bay area based on modeling of ground deformations and waves that may be generated by a major Cascadia Subduction Zone (CSZ) earthquake. The results of the DNR and NOAA modeling study (Walsh et al. 2004) entitled "Tsunami Hazard Map of the Bellingham Area, Washington: Modeled Tsunami Inundation from a Cascadia Subduction Zone Earthquake" indicate that a magnitude 9.1 Cascadia Subduction Zone earthquake may result in a tsunami wave arriving approximately 2½ hours after the earthquake at a tide stage near mean high water (MHW) which might be expected to result in a depth of inundation in the zero to 0.5 meter range (depending, of course, on the specific location/elevation along the shoreline).

The CSZ earthquake event is assumed to be a 600-year recurrence level and is based on a 1700 A.D. CSZ earthquake that had an estimated magnitude 9. Because the CSZ earthquake epicenter is on the Washington coast, the tsunami created by this event would be attenuated by the numerous islands between Bellingham Bay and the Strait of Juan de Fuca. Similarly, a large earthquake in the Seattle fault zone or deeper crustal earthquakes (e.g., 2001 Nisqually earthquake) would likely be attenuated north of Everett, Washington, with additional dissipation of the tsunami as it travels north through the islands and reaches Bellingham Bay (Walsh, T., personal communication, 2016).

Three major faults were recently found and mapped north of Bellingham located near Birch Bay, Sandy Point, and Drayton Harbor Bellingham (WDNR 2014). These faults have been estimated to being capable of earthquake magnitudes of 6 to 6.5; however, the recurrence interval is estimated to be greater than 1,000 years, and no estimate of seafloor displacement for these faults or other kinematics has yet been established for these faults. The Washington Department of Natural Resources (WDNR; Walsh, T., personal communication, 2016), indicated that they will be modeling a 2,500-year recurrence interval for the CSZ, but will not have the results of predicted tsunami inundation from this larger event until August 2017. In absence of this data (and the recent finding of new faults north of Bellingham), the WDNR recommended adding a safety factor of 20 percent to the 2004 estimated 0.5-meter maximum inundation predicted for the Site. This yields maximum design tsunami inundation of 0.6 meters or 1.8 ft for the Site.

This predicted tsunami height for the Site would be accommodated by the additional shoreline protection placed for potential sea-level rise. Minor damage from an extreme tsunami event in the distant future after some sea level rise at the Site could occur at the upland part of the shoreline (above ordinary high water elevations) due to overtopping, and/or at the lower elevation of the project (cap material) due to bottom shear stresses. However, the elevation of the upland cap will rise rapidly from the shoreline and it is concluded that if a tsunami event occurs at the Site and damage to the cap material does occur, repair of this damage would be similar to periodic maintenance repair. As a result, potential impacts from tsunami waves are not considered significant enough to require specific consideration in the design.

4.7 Sediment Quality (Bioassay) Testing

Five surface sediment samples were collected at the Site for bioassay testing. The samples were collected at the locations indicated on Figure 3. These sample locations were selected to evaluate sediment quality where at least 1 ft of sediment has been deposited by natural recovery over top of landfill refuse to evaluate whether the physical criteria established in the CAP is adequately protective of benthic organisms.

The samples were collected and processed on June 10, 2015 in accordance with the Pre-Design Investigation Work Plan (Landau Associates 2015), and submitted under chain of custody to Ramboll-Environ in Port Angeles, Washington, for evaluation. Three tests were conducted on the samples, following Puget Sound Estuary Protocols (PSEP), SMS criteria, and the Sediment Cleanup User's Manual II (SCUM II) guidance from Ecology. The three tests included a 10-day amphipod test using *E. estuaries*, a 20-day juvenile polychaete survival and growth test using *N. arenaceodentata*, and a larval development test using *M. galloprovincialis*. Sediment cleanup objectives (SCO) and cleanup screening levels (CSLs) are established by Ecology for each of the three tests. Each of the five Site samples passed all three tests at the SCO, the more conservative of the two established criteria. Additional details of the tests and results are provided in Appendix D.

4.8 Stormwater Evaluation

The existing stormwater features were mapped during the upland survey as shown on Figure 6. The existing stormwater features include the stormwater detention basin at the south end of the Site, drainage ditches, plugged stormwater catch basins at the north end of the Site, and an area that accumulates stormwater on the BNSF property near the northeast corner of the Site. There are two current or former stormwater discharge points on the Site which will be decommissioned during the construction-level design of the final cleanup action. These discharge points consist of 1) a former outfall near the northwest corner of the Site that previously discharged stormwater from the catch basins in the paved area at the north end of the Site associated with the former GP warehouse area (North Outfall), and 2) a 30-ft-wide dispersion structure discharging at the south end of the Site (South Outfall).

The condition and functionality of the North Outfall and associated stormwater system were evaluated during the RI/FS (Landau Associates 2013). The system was determined to be in poor condition with a number of plugged catch basins, and several areas of breaks and gaps in the concrete bell and spigot pipe based on a video survey of accessible portions of the system. The stormwater system was in too poor a condition to advance the video survey to the outfall. Although the outfall was not visible, observations during a heavy rainfall event indicated a significant upwelling of water (estimated to be 30 gallons per minute [gpm], or greater) at the shoreline at the estimated location of the outfall, which was interpreted to potentially be the outfall location. The predesign investigation was intended to identify the North Outfall location so the outfall can be properly abandoned, repaired, or replaced during the final cleanup action. However, the main line extending from the outfall had been plugged or crushed, making it infeasible to locate the entire outfall line without significant potholing into existing waste to find the line for abandonment. The outfall and all other elements of the northern stormwater system associated with former GP operations are therefore planned to be located and abandoned as part of the final cleanup action.

The South Outfall is associated with the existing stormwater detention basin located on the south end of the Site. This basin was constructed by GP in 2004 when the former warehouse was demolished and the upland area was re-graded for drainage. The discharge system was permitted by the City under a grading permit under standards established at that time. This system was constructed with a 30-ft-long dispersion trench and level spreader to disperse the outfall into the quarry spalls and the shoreline riprap prior to reaching Bellingham Bay.

Landau Associates' pre-design Site stormwater evaluation conducted December 11, 2015 documented the following conditions:

- Site drainage during and after heavy rain events.
- No indication of the presence of the North Outfall based on inspection of the shoreline near the previously identified outfall location for indications of concentrated stormwater flow during a rain event coinciding with low tide. Unlike the observations during the RI in 2012, there were no indications of upwelling at the outfall location.
- The five catch basins that previously discharged the North Outfall were submerged in 4 to 10 inches of water indicating they were no longer functioning. Four of the catch basins are rectangular with 16-inch by 22-inch inner dimensions. Each catch basin has an 8-inch inside-diameter pipe with the invert located approximately 1.5 ft BGS inside the vault, and have varying degrees of sedimentation in the pipes. A previously unidentified round vault, CB-5, is 18 inches in diameter with a single 8-inch pipe extending west toward CB-3. These catch basins were cleaned out and backfilled with controlled density fill in May of 2016.
- There was no major puddling or pooling due to drainage run-on to the Site from the BNSF railroad. As shown on Figure 6, a small area of saturated ground was observed with small puddles less than 1 inch deep and less than 5 ft long.
- The reconnaissance of the BNSF railroad for a preliminary evaluation of stormwater conditions in the sump area and the west side of the railroad indicated that there is drainage via a 12-inch-diameter culvert which discharges and infiltrates into an excavated depression (shown on Figure 6).
- The existing stormwater detention basin and South Outfall were observed and exhibited conditions consistent with previously obtained design drawings with some deterioration and debris on the drainage structures.

At the time of the pre-design field investigation, the lines leading to and from the catch basins were plugged with sediment, making video camera inspection of lines not possible to determine the open length.

The design of the stormwater controls for the final cleanup action is provided in Section 5.2.4.

5.0 ENGINEERING DESIGN CONSIDERATIONS

The following sections provide an overview of the Site cleanup design. As referenced herein, the engineering design of the cleanup follows generally accepted engineering practices to provide a cleanup design that is protective of human health and the environment.

5.1 Site-specific Considerations Affecting Design, Construction, or Operation of the Cleanup Action

5.1.1 Topography, Surface, and Subsurface Conditions

The Site topography, surface, and subsurface conditions are described in Sections 4.1 and 1.2.4, respectively. Topographic, surface, and subsurface conditions that were addressed in the design include:

- Shoreline erosion that has left a vertical cut bank 4 to 6 ft tall along the west side of the Site. Shoreline erosion is discussed further in Section 5.1.13.
- The upland portion of the Site is relatively flat and ponds water in places. Grading to improve drainage of stormwater from the landfill cover system will be required.
- The presence of compressible refuse and wood waste under the Site will allow the landfill cover system to settle if additional loading is applied. Potential settlement is discussed further in Section 5.1.4.
- The presence of refuse and wood waste below the Site surface generates LFG; the characterization of the LFG is discussed in Section 4.2.

Site conditions which will need to be considered during construction include:

- Staged construction to work around the IPA stockpiles and the proposed Hilton Avenue soil placement to minimize re-handling.
- Cleared trees and brush to be mixed in with the bottom 1 ft of fill soil needed to bring the final cover subgrade on the east side of the Site. Alternatively, the cleared vegetation could be mulched for offsite stockpiling and use.
- Grouting existing catch basins and abandoning the stormwater lines in place. Exposing and decommissioning the north outfall; the method of decommissioning will be determined in the field based on the configuration and condition of the outfall.
- The existing asphalt pavement will be ripped into broken pieces and left in place to be covered with the fill soil needed to bring the Site to final cover subgrade.
- Except for the Hilton Avenue fill imported to the site in 2016 (Section 4.4), all of the other existing fill at the Site, whether landfill waste, soil, wood debris, or demolition debris, and, the fill to be imported from the RG Haley Site, is and will be considered contaminated at concentrations above MTCA cleanup levels throughout. As such it must be managed as a contaminated media during construction using appropriate environmental protective measures and handling techniques.

There are no current Site topographic features that will impact the operation of the proposed Site cleanup action. The presence of LFG and the long-term functioning of the LFG venting system are addressed in the design.

5.1.2 Flooding

As shown in Appendix B.4, the Site has adequate onsite stormwater conveyances to drain to Bellingham Bay for storm events which exceed the 100-year design storm. The upland elevations are high enough to prevent the Site from being flooded by the high tide.

5.1.3 Seismic Activity

Landau Associates previously conducted a detailed seismic study of the Site for placement of the IPA stockpiles (Landau Associates 2011). The 2011 study presented seismic design parameters based on the 2009 version of the International Building Code (IBC). Appendix B, Attachment B.3 presents the evaluation of slope stability based on the updated seismic design parameters used in the 2012 IBC. As provided in Attachment B.3, the Sandy Point fault located approximately 15 km from the Site was used to determine mean horizontal acceleration and displacement. Location and distance from the Site were determined using the geologic map “Faults and Earthquakes in Washington State”, (WDNR 2014) and the USGS Seismic Hazard Mapping Tool (USGS website 2016).

In accordance with the 2012 IBC, the design earthquake event is the peak ground acceleration (PGA) with a 2 percent probability of exceedance in 50 years (a 2,475-year return period event). The general 2014 USGS earthquake hazard maps for the area show a value of 0.4 to 0.8 times the acceleration due to gravity (g) for PGA. The PGA for the Site was determined to be of 0.408g (acceleration due to gravity) using the USGS Seismic Hazard Mapping Tools, considering interactive deaggregations for the continental US (printout of the analyses is included Appendix B.3). The result was compared to the information provided on the 2014 USGS earthquake hazard map and the more detailed Figure 1613.3.1(2) from the 2012 IBC provided by the USGS Seismic Hazard Mapping Tool. Figure 1613.3.1 shows maximum PGA (or maximum credible earthquake [MCE] acceleration) values of about 0.40 near the Site.

The PGA value of 0.408g was used in the seismic slope stability analyses discussed in Section 5.1.5 below. It should be noted that an earthquake event with a 2 percent probability of exceedance in 50 years is equal to an earthquake event with a 10 percent probability of exceedance in 250 years (or 90 percent probability of non-exceedance in 250 years) as defined in RCRA Subtitle D regulations for design of landfills.

5.1.4 Settlement

The presence of compressible refuse and wood waste under the Site will allow the landfill cover system to settle if additional weight from soil fill or structures are applied. Previous Site investigations have encountered variable thickness of refuse, wood debris, and varying amounts of interbedded soil across the Site making it infeasible to map the consistency of the waste. Post-construction settlement design due to the existing subsurface conditions is discussed in Section 5.2.1.1.

5.1.5 Slope Stability

The stability of the proposed landfill geometry considering the underlying refuse materials as well as the stability of the proposed landfill cover system were analyzed as detailed in Appendix B.3. For limit equilibrium analyses, the stability of a slope is typically expressed as the factor of safety against sliding, which is the ratio of forces resisting movement divided by the forces promoting movement. A factor of safety of 1.0 indicates a slope at equilibrium, while values greater than 1.0 indicate increased slope stability. EPA (1993b) recommends factor of safety for landfill design of at least 1.5 for static conditions and at least 1.3 for seismic conditions. Displacement analysis is performed if factors of safety are less than 1.3 for seismic conditions. If displacement of the cover are predicted to be less than 1 ft, the landfill slopes are considered stable under seismic conditions (Bray et al. 1998).

Soil properties used for the slope stability analyses are summarized in the table below. The shear strength properties of each soil unit were estimated using available laboratory test results presented in the Dames & Moore (1960) and Purnell & Associates (1985) geotechnical reports; Landau Associates testing of the stabilized sediment (Appendix B, Attachment B.2); Landau Associates' testing of the fill soil to be imported to the Site (Appendix F, Attachment F.1a); empirical correlations with representative field data; and our professional engineering judgment. Reasonably conservative shear strength parameters for landfill refuse were used in the analyses, based on strength values for municipal solid waste reported in a recent study (Bray et al. 1998). Sea level and groundwater was assumed at approximately 0 and 10 ft MLLW, respectively.

Table 5-1. Soil Properties Used in Slope Stability Analyses

Soil Unit	Total Unit Weight (pounds per cubic foot)	Effective Friction Angle (ϕ, degrees)	Cohesion (c, pounds per square foot)
Stabilized Sediment (proposed landfill cover layer)	100	32	250
Silty Gravel (existing landfill cover soil)	125	36	-
Gravelly sand with silt to a sandy clay with gravel (imported fill material)	130	32	200
Wood Debris, Sawdust, Sand & Silt	75	28	-
Landfill Refuse	70	31	300
Reworked Sediments & Nooksack Deposits	80	28	150
Glaciomarine Deposits	125	32	150
Chuckanut Formation	130	45∞	1,000∞

A summary of the slope stability analysis is provided in the sections below.

5.1.5.1 Landfill Geometry Stability

The stability of the Site soil, refuse, and wood waste was evaluated under both static and seismic (pseudo-static) conditions. The stability analyses were conducted using the existing and planned profiles and limit equilibrium methods in the Rocscience computer software program SLIDE, Version 5 (Rocscience, Inc. 2005) and the results are provided in Appendix B, Attachment B.3. Based upon the conditions and assumptions noted above, the static factor of safety against slope instability is estimated to be greater than 3.0 and 3.4 for the east and west slopes, respectively.

For seismic (pseudo-static) slope stability analyses, a maximum horizontal acceleration (MHA) at the ground surface for the seismic event was calculated using Bray's seismic design procedure for solid waste landfills (Bray et al. 1998). The MHA calculation provided the lateral forces that would be experienced during a design earthquake with the PGA of 0.408g. Accordingly, a pseudo-static MHA of 0.26g determined using the Sandy Point Fault was used for the seismic slope stability analyses. Based upon the conditions and assumptions noted above, the factor of safety against seismically induced slope instability is estimated to be 1.4 and 1.1 for the proposed landfill cover profile on the east and west slopes, respectively, with predicted deformations (Makdisi and Seed 1977) less than 1 inch. Considering these factors of safety, and the yield acceleration of 0.4 g resulting in minimal displacement, the designed slope have acceptable factors of safety and allowable displacement when compared to the EPA recommendations discussed above.

5.1.5.2 Landfill Cover Stability

The stability of the cover system under saturated conditions and both static and under design seismic loading was confirmed using stability models developed by the Geosynthetic Research Institute (Soong and Koerner 1997). The cover stability analysis is provided in Appendix B, Attachment B.3. In summary, it was found that the cover system as proposed would be expected to have a factor of safety greater than 2.5 for static, saturated conditions and greater than 1.5 for design seismic conditions, which exceed the EPA minimum acceptable criteria.

5.1.6 Weather (Temperature Extremes, Rain, Wind)

The weather of Bellingham is the generally mild climate of the Pacific Northwest. Although not a specific design criteria, temperature and weather conditions may affect the health and safety of the construction workers; therefore, a Site-specific health and safety plan (HASP; discussed in Section 6.5) will be prepared by the contractor that will include provisions to address hydration and workers keeping cool within the confines of the Site if higher temperatures (i.e., above 80 degrees Fahrenheit [^{o}F]) occur during construction. Cold temperatures will also impact the safety of the workers and will also be addressed in the contractor's HASP. Cold weather can affect backfilling of excavations; therefore, the placement of backfill will not be conducted while the temperature is below 35^{o}F to avoid placing frozen soil. Accordingly, the frost depth to use in design of all buried pipe is greater than 1.5 ft (BMC Chapter 17.10.20 Section 117). The 24-hour, 25-year rain event for the design of the landfill cover system (per current solid waste regulations) is 3.5 inches. The design of the stormwater controls for the Site cleanup is detailed in Section 5.2.4.

Hourly wind data measured at the Bellingham Airport meteorological station were used for the wave and shoreline protection design. The wind data measured at the Bellingham Airport station were compiled and processed for the period from 1948 to 2014. Wind statistical analysis and determination of wind design parameters were conducted based on long-term wind data from Bellingham Airport. Wind measurements representing one-minute duration were compiled and statistically processed for a period of 41 years (from 1973 to 2014). A 100-year return period wind speed from sector 190˚-240˚ True North ranging from 49.9 to 58.1 miles per hour were selected for wave modeling and analysis (as discussed further in Section 5.2.4).

5.1.7 Existing and Future Site Use

The Site is currently vacant. Consistent with the Waterfront District Sub-Area Plan adopted by the Port and City in 2014, the City plans to use the Site for an open-space park with additional landscaping once the Site cleanup is completed. The City has completed the master plan for the planned park, currently referred to as Cornwall Beach Park (Anchor QEA 2014), although detailed park design had not commenced at the time this EDR was prepared. It is intended that the final cleanup action be designed and constructed such that it is compatible with and supports the intended final land use for the Site.

5.1.8 Future Sea Level Rise

As noted in Section 4.6.2, the design is based on a potential future SLR of 2.4 ft due to predicted long-term climate change. It is acknowledged that predicting SLR is a developing science and that estimates will likely be refined over time. To address this, a bench and shoreline slope has been included in the shoreline protection design to allow a future increase in the elevation of the shoreline protection system if long term SLR is greater than the 2.4 ft currently estimated, as discussed further in Section 5.2.5.5.

5.1.9 Local Planning and Development Considerations

The property associated with the Site is located at the southern boundary of the Waterfront District redevelopment area and the Site is included in the planning for redevelopment as a public park and open space. Development of the park could include construction of buildings where indoor air quality will need to be considered. Redevelopment may also include roadways, parking lots, and areas of vegetation whose design and construction will need to be integrated with the containment element (i.e., capping) of the selected cleanup action.

Redevelopment is still in the planning stages, as discussed in Section 5.1.7, and detailed design and construction of the Site cleanup is anticipated to be implemented in advance of Cornwall Beach Park. However, depending on the timing of the design, permitting, and construction of the final cleanup action and Cornwall Beach Park, it is possible that all or portions of the park could be constructed concurrently with the final cleanup action.

Effective implementation and compliance of the cleanup for the Site will be coordinated with ongoing and planned cleanup actions at neighboring sites and with the longer-term redevelopment strategy in the Site's vicinity. The coordination with the RG Haley Site cleanup is discussed in Section 5.1.12. The Site cleanup also has some overlap with the Whatcom Waterway site within MU-2. Because the selected remedy for the Whatcom Waterway cleanup site is monitored natural recovery (MNR) in the Site vicinity (under Consent Decree No. 07-2-02257-7), the Site cleanup action for the area of overlap (MU-2) is compatible with the Whatcom Waterway cleanup. Cleanup in MU-2 will include a shoreline stabilization system that will effectively cap the intertidal and shallow subtidal zone and a thin layer sand cap and ENR in the deep subtidal portion of MU-2, and as such, will not interfere with the Whatcom Waterway site cleanup action. In effect, the Site cleanup action will result in a shorter restoration timeframe in the area where Site and Whatcom Waterway cleanup actions overlap.

5.1.10 Permitting Requirements

Several permits or meeting the substantive requirements thereof will be required for construction of the Site cleanup. Section 3.3 identifies the permits and submittals that are expected to be required during permitting for the cleanup action.

5.1.11 Public Access

The Site cleanup has been designed to protect human health and the environment, and as such, public access might be permissible once construction of the final cleanup action is complete at the discretion of the landowners. The Site has been designed as an open space with gradual slopes to accommodate planned future land use as a public park and associated habitat enhancement, and could function in that capacity following construction in advance of the City adding the additional amenities planned as part of Cornwall Beach Park. The LFG vents will be constructed in a manner that adequately protects the public from unacceptable exposure to LFG; the LFG collection lines will be underground and the LFG well head and valves will be in lockable vaults that are flush with the landfill cover surface as shown on Figure 8. The landfill cover and shoreline protection system will be durable for pedestrian traffic and recreational use. Physical barriers will be installed to prevent unauthorized motorized vehicular traffic on the Site.

5.1.12 Coordination with RG Haley Site Cleanup

The southern end of the RG Haley Site overlaps with the northern end of the Cornwall Site. The design of the cleanup in the overlap area needs to be coordinated to assure the cleanup objectives are met for both MTCA Sites. As shown on Figure 3, the upland extent of RG Haley Site cleanup areas extend over a significant part of the northern third of the Cornwall property. In addition, Cornwall landfill waste extends beneath the southwestern portion of the Haley property. Because of this overlap, the cleanup actions implemented at the two sites will be coordinated to ensure successful remediation and long-term performance/compliance for both sites.

Although a final cleanup action has not yet been selected for the RG Haley Site, it is anticipated that each site will utilize similar remedial technologies within much of the overlap area, including low-permeability upland capping, stormwater management, sediment capping, and other engineering and institutional controls. Additionally, the sediment component of the RG Haley cleanup is anticipated to include sediment removal and consolidation of the excavated sediment within the upland low-permeability cap. Other cleanup elements expected to be included in the RG Haley final cleanup action, such as sediment capping, *in situ* solidification of soil, stormwater management, and soil gas venting (if needed) will require proactive coordination and the potential phasing of the cleanup actions for the two sites. It is anticipated that the Site and the RG Haley Site cleanup actions will be implemented as a single construction project, although certain cleanup elements for either site could be implemented separately, either prior to or following the primary construction phase. Site remedial design will identify specific cleanup components that will require coordination; however, examples of possible cleanup elements in the overlap area that will likely require coordination and/or sequencing include:

- Source control measures at the RG Haley Site such as upland soil/nonaqueous phase liquid (NAPL) solidification and stormwater controls will need to be completed before or in conjunction with construction of adjacent in-water portions of the RG Haley and Cornwall cleanup actions.
- Sediment removal included in the RG Haley cleanup action will need to be implemented using methods that minimize dispersal of contaminants and be implemented in advance of placement of the Site sand filter, shoreline stabilization system, and the thin layer sediment cap.
- Potential sediment capping (i.e., for contaminant attenuation) that may be part of the final cleanup action for the RG Haley Site will need to be implemented in advance of, or concurrent with, placement of the Site thin layer cap in MU-2.
- The RG Haley Site's groundwater remediation strategy may need to be implemented in the overlap area at the north end of the Site prior to final construction of the Site's MU-1 containment system in this area.

As discussed in Section 5.2.2 and shown on Figure 8, the northern portion of the Site cleanup is reserved for consolidation and containment of conditioned sediment and other materials removed from the in-water portion of the RG Haley Site. As such, the excavation and upland consolidation of the RG Haley sediment will need to occur in advance of completing the Site final cleanup action in this area.

5.1.13 Shoreline Erosion (Coastal Dynamics)

An evaluation of shoreline erosion was conducted for the RI/FS for the Site (Landau Associates 2013). Per section 4.1.3 of the RI/FS, shoreline erosion is estimated to have ranged from approximately 60 ft at the southwestern corner of the landfill to 10 to 30 ft at the northern edge of the landfill between 1969 and 1994. Additional evaluations in 2007 and 2012 indicated that the shoreline has continued to erode during the subsequent years, indicating that the current shoreline is inadequately armored with concrete rubble, and that debris currently serves as non-engineered erosion protection for the Site shoreline. Because of the releases of hazardous substances caused by the significant and ongoing erosion of the shoreline, shoreline stabilization is considered a primary element of the Site cleanup action. Preliminary design of the shoreline stabilization system is provided in Section 5.2.5.

5.1.14 Intertidal/Subtidal Construction

Intertidal and subtidal construction will be required to install the shoreline stabilization system and thin layer sediment cap in MU-2. In-water construction has the potential to release hazardous substances to surface water and marine sediment. The potential for these releases needs to be considered in the design of the cleanup action and in the selection of engineering controls used during construction of in-water elements of the cleanup action. The primary design consideration to limit releases during in-water construction is to limit excavation in the aquatic portion of the Site that could expose currently contained refuse and wood waste to currents and wave action during construction. The engineering controls that would be implemented during construction will include BMPs typically applied to contaminated sediment cleanup projects (e.g., floating booms, silt curtains, warning buoys), as discussed in Section 6.0.

The timing of construction relative to tidal conditions also will be considered in minimizing impacts to surface water and sediment during in-water construction. It is anticipated that most in-water construction for the shoreline stabilization system can be constructed in the dry during low tide cycles to minimize material removal and placement through the water column.

5.2 Design Details

This section provides the Site cleanup action preliminary design based on the Site-specific considerations discussed in the previous section.

5.2.1 Upland Site Grading

The Site will require cuts along the shoreline and in the intertidal zone. The material from these cuts plus imported fill will be used to establish the Site upland grades required for stormwater drainage shown on Figure 8. The materials required for the upland low-permeability capping system to cover and protect the Site will then be placed on the graded surface, as shown on Figure 10. The surface grades were established based on minimum grades allowable to facilitate drainage of the cap and the MFS requirement that a minimum 2 percent grade be maintained in the long term for landfill closure. Estimated long-term settlement due to current and historical pre-loading in the western portion of the Site uplands and loadings from fill required to establish Site grades, and in consideration of potential future filling associated with the planned Cornwall Beach Park in the eastern portion of the Site uplands, resulted in an asymmetric grading plan with steeper slopes in the eastern portion of the

Site uplands, as discussed in the following section. This relatively flat grading plan will allow maintenance equipment adequate access to the Site.

The earthwork volumes required to grade the Site to the grades shown on Figures 8 and 10 are summarized in the following table:

Table 5-2. Earthwork Volumes for Site Grading

Site Grading Element	Approximate Cut Volume (in-place yd^3)	Approximate Fill Volume (in-place yd^3)
Remove intertidal rubble to the approximate MLLW elevation	1,800	1,700
Cut shoreline edge of landfill to top of waste	5,200	4,500
Import Hilton Avenue borrow source soil to pre-load the Site and to establish minimum drainage grades		45,000
Consolidated Sediment from RG Haley Site, plus imported fill as needed	---	15,000
Totals	7,000	66,200

5.2.1.1 Estimated Settlement

Landfill refuse and wood debris are compressible and will settle due to additional weight placed on the material, biochemical decomposition, physiochemical change, and raveling of soil into voids (Sowers 1973). However, because the Cornwall Avenue Landfill refuse was deposited prior to 1965 (over 50 years ago) and LFG production is at *de minimus* quantities, it is concluded that biochemical decomposition (fermentation and decay, both anaerobic and aerobic), physiochemical change (corrosion, oxidation, combustion), and raveling of soil into voids is largely completed. Accordingly, further settlement over the refuse area will primarily occur from applying additional material weight above it. Similarly, wood waste was deposited during historical saw milling activities that pre-dated refuse placement, so the primary means of any future wood waste settlement would also be from the additional weight of the grading fill and landfill cover system.

The placement of the IPA stockpiles over the refuse in 2011/2012, and previous GP log decking operations in this area, effectively preloaded the refuse and wood waste in the western portion of the Site uplands. In summary, the settlement survey showed up to 1.5 ft of settlement under the weight of the 15 ft of soil placed in the IPA stockpiles, and indicated that the degree of settlement varied significantly, consistent with the significant variability in the consolidation and heterogeneity typical of solid waste landfills. Had the area not been previously preloaded by log decking associated with GP operations, it is anticipated that the settlement induced by the IPA stockpiles would be significantly greater. The existing IPA stockpile heights exceed the proposed height of the landfill cover over the entire refuse area. The Site will therefore be unloaded to construct the cover system in the western portion of the Site, effectively mitigating post-construction settlement, and allowing for use of the minimum MFS post-closure slopes of 2 percent in this portion of the Site uplands. Rebound is not expected in municipal solid waste refuse because the Site has been preloaded by the IPA stockpiles since 2012 and was previously preloaded by the GP log decks.

The area to the east of the IPAs is underlain by varying thickness of wood debris. The pre-design investigation determined that the wood debris thickness in this area ranges from 0.5 to 8 ft. Based on up to about 15 ft of fill being located in this portion of the Site upland in association with placement of grading fill and the final cap, and the potential for placement of a similar height of fill as part of the Cornwall Beach Park and the R.G. Haley site cleanup, some settlement is expected in the eastern portion of the Site uplands. The preliminary design grades for drainage in this portion of the Site were established at 5 percent to accommodate settlement and maintain the minimum 2 percent grades required for long-term cap performance. Post-construction settlement would need to exceed 4.5 ft to reduce the proposed 5 percent slopes over this area to less than the minimum 2 percent slopes required for drainage. As discussed below, these grades may be reduced during final design depending on the timing of placement of general fill in this area and the results of ongoing settlement monitoring.

As shown on Figure 7, additional fill soil was added to the east side of the Site from the Port's Hilton Avenue property. Compacted fill was placed to elevations which exceed the proposed final elevations of the landfill cover and placement was completed on June 21, 2016. The location of settlement monitoring monuments and the total settlement due to the additional fill loading through May 2017 is also provided on Figure 7. As of May 4, 2017, nearly a year after placement, settlement at the 13 settlement monitoring monuments ranges from zero to 0.21 ft (2.5 inches) maximum. The placement of the fill has had a similar preloading effect as the IPA stockpiles and log decking that occurred in the western portion of the Site, and the construction of the landfill cap will actually unload a majority of the Site from the current IPA and soil stockpile loading. The settlement is continuing to be monitored; however, the minimal settlement to date may allow the final grades in the eastern portion of the Site uplands to be reduced from the 5 percent grades used in the preliminary design provided herein. Final grades will be developed during final design based on settlement data collected following the placement of the Hilton Avenue fill material in the eastern portion of the Site. The settlement monitoring monument locations are shown on Figure 7, with the settlement measurements at each of these monuments through May 4, 2017 presented in Appendix F, Figure F.3. A discussion of the monitoring to measure the settlement caused by the additional fill placed on the Site is also presented in Section 6.1.1.

5.2.1.2 Site Preparation

All trees and brush will be cleared from the Site to spread evenly no more than 1-ft thick on the ground surface, and mixed with and/or filled over with the soil used to bring the Site to final cover subgrade elevations. Alternatively, the cleared vegetation could be mulched and used on site or off site if the vegetation is not intermixed with existing Site soil.

The rubble from the beach will be removed during low-tide events to the approximate MLLW elevation. The rubble will be brought to the upland portion of the Site to be incorporated in the lower level of soil needed to bring the Site to final cover subgrade. This material will be placed entirely under the landfill cover and above the groundwater table to avoid high pH runoff. The concrete rubble will be size-reduced to no larger than 2 ft on the longest dimension and mixed into the fill soil to alleviate voids. Special care will be needed in how and where the concrete rubble is placed to fill around the rubble with compacted soil, thereby reducing the potential for post-filling settlement.

5.2.1.3 Demolition

Prior to importing fill to the Site in June 2016, the existing catch basins were cleaned out and filled with CDF. Prior to filling the north end of the Site, the septic tank (see Figure 2) will also be exposed, grouted to the ground surface and the conveyance lines will be abandoned in place. Using underground utility location technology, dye testing, and test pitting, an attempt will be made to locate the conveyance like at the North Outfall. If located, it will be exposed from the surface just east of the shoreline on the upland bank, cut, and plugged with a concrete/grout plug. The existing asphalt pavement will be ripped (to remove a potential barrier for upward migration of LFG) into broken pieces no larger than 4 ft on the largest dimension and left in place to be mixed with the soil needed to bring the Site to final cover subgrade.

5.2.1.4 Waste Regrading

The grading along the shoreline will require some soil and refuse excavation, relocation, and compaction of the excavated material in the interior of the Site uplands. The excavated soil and waste will be spread in a lift no thicker than 2 ft. Depending on the composition of the excavated material, it may be mixed with fill soils and compacted with appropriate compaction equipment.

Except for the fill imported to the Site in 2016 (Section 4.4), all of the other existing fill at the Site, whether landfill waste, soil, wood debris, or demolition debris is considered contaminated at concentrations above MTCA cleanup levels throughout. As such it must be managed as a contaminated media during construction using appropriate environmental protective measures and handling techniques.

5.2.1.5 Grading and Subgrade Preparation

Once excavated waste and clearing materials have been placed and compacted, fill soil will be placed and compacted to the grades discussed in Section 5.2.2.2. The placement of the regraded waste and clearing debris at the bottom of the fill soil, with the soil placement in controlled lifts to the final fill height, will minimize the post-construction differential settlement that could otherwise cause low spots and potential ponding.

5.2.2 Landfill Capping System

The landfill capping system will be constructed on the prepared subgrade fill and will consist of a LFG collection system overlain by a composite cover system that is designed to be relatively impermeable to the release of LFG and the infiltration of precipitation.

5.2.2.1 Landfill Gas Collection Layer and Vents

The LFG collection layer will be placed above the refuse or wood waste and grading fill and below the low-permeability layer. The purpose of this layer is to collect LFG that rises up through the landfill, and route the collected LFG to passive vents for controlled release to the atmosphere. For this project, it is not anticipated that sufficient pressure could accumulate to affect the overlying cover system layers or impact slope stability. Nevertheless, a LFG collection layer will be installed to prevent accumulation of LFG or pressures that could promote cap uplift or LFG migration.

The extent of the LFG collection layer is indicated on Figure 8, and is shown in section view as a component of the cover system on Figures 14 and 15.

Calculations of the required gas transmissivity of this layer are provided in Appendix A, Attachment A.6. Several materials were evaluated for construction of this layer, including rubblized concrete sourced from the shoreline of the Site, imported sand, and geocomposite materials. As discussed in Appendix A, a geocomposite material was selected for application based on its reliable effectiveness, ease of construction, and cost. The conceptual design is based on using a geocomposite material that incorporates interwoven 1-inch diameter tubing in the rolled product that would connect the collection layer to the ventilation system using only a very a limited amount of LFG header piping. Slight positive pressures within the LFG collection layer caused by LFG generation will result in a slow flow of LFG through the layer and out the ventilation system. When these internal pressures are not present at significant levels, the transmissive connection between the collection layer and the atmosphere will allow barometric pressure changes to promote airflow through the collection layer to promote diffusion and ventilation. This LFG collection layer will be extended over the entire upland portion of the Site to the shoreline. At the shoreline, the impermeable soil cover layer extends beyond the LFG collection layer to an anchor trench, creating a barrier to LFG discharge at the shoreline. Due to the low-permeability barrier created by the cap anchor trench, the low quantities of LFG being produced, the preferential flow path to the vent pipes created by high transmissivity within the LFG collection layer, and the air mixing caused by tidal fluctuation and wave action at the shoreline, little to no LFG is expected to be emitted from shoreline terminus of the LFG collection system.

Based on extensive coverage of the LFG capture layer, the additional subsurface pressure relief provided by the extraction wells, the general layout of the Site and surroundings, and the small quantity of LFG being generated at this time, there are minimal LFG migration concerns to the north or east. However, to the north, a soil vapor collection system will be installed as part of the RG Haley cleanup site which would capture LFG migration. As shown on Figure 8 and 15 (Detail Section 4), a perimeter collection pipe and trench will be installed to capture LFG and prevent migration toward the east and the BNSF railroad right-of-way. The trench may need to be deeper than the minimum 2 ft shown to assure that it will adequately cut off gas migration eastward.

Additional elements of the LFG control system are discussed in Section 5.2.3.

5.2.2.2 Fill Soil

Fill soil is required to construct the grades across the Site necessary for drainage. As discussed in Section 4.4, fill soil formerly located at Hilton Avenue on Port property was characterized for approval by Ecology to be imported as an early phase of the final cleanup action. Early placement of the majority of fill required was advantageous to pre-load the eastern portion of the Site prior to final grading of the subgrade and construction of the upland capping system. Fill placement occurred in June 2016, with the as-built contours shown on Figure 7. The construction report for the fill placement is provided as Appendix F.2.

The fill soil was placed in loose horizontal lifts not exceeding 12 inches. The fill soil was then compacted using a pad-footed roller or similar compaction equipment to a minimum density of 90 percent of the maximum dry density and a moisture content -2 to +4 percent of optimum moisture content as defined by the Modified Proctor compaction test (ASTM D1557). This process was repeated until the contours shown on Figure 7 were achieved. Once the fill soil reached final compacted elevations, the fill was smooth-graded and covered with seed and an erosion control blanket to prevent erosion.

As shown on Figure 8, the northern approximately 2.5 acres has been reserved for fill from the RG Haley Site cleanup. It is understood that this fill will consist primarily of stabilized sediment and incidental debris from the RG Haley cleanup action. The final quantity of fill from the RG Haley Site is yet to be determined, but is estimated to range from 10,000 to 18,000 yd^3. A reasonable estimate of the volume needed within the RG Haley upland cleanup area for these materials is 15,000 in-place yd^3, which is provided for at the north end of the Site, as shown on Figure 8. As with the other fill at the Site, the RG Haley material will be placed at the base of the fill and imported soil, if needed, to bring elevations up to the finish subgrade elevation to minimize differential settlement. If additional imported fill is needed, it will be tested at the source to confirm that it is not contaminated per WSDOT 9-03.21 (1) items 2 and 3, and the records of this testing along with the quantity supplied to the Site will be included in the construction report.

The volume provided for the RG Haley material (15,000 yd^3) is based on the final capping system in this area being constructed using the cap planned for the RG Haley final cleanup action. The anticipated RG Haley cap differs from the Site cap in that it uses a single geomembrane liner low-permeability layer instead of a 2-ft-thick low-permeability soil layer in conjunction with a geomembrane. This provides 2 additional feet for placement of fill beneath the liner system, which is incorporated into the 15, 000 yd^3 total. The integration of the Site and RG Haley capping systems is described is Section 6.1.

5.2.2.3 Low-permeability Soil Layer

As described in Section 4.3, the soil from the onsite IPA material has been tested to confirm that the stabilized sediment can achieve the hydraulic conductivity requirements for use as the low-permeability soil layer in the final cover system, but will need to be dried, reworked, and compacted to meet the permeability requirements. The construction methodologies required for the low-permeability soil layer are discussed in Section 4.3.2. Approximately 30,000 in-place yd^3 are required to construct the 2-ft-thick compacted low-permeability soil layer across the landfill. This layer will not be constructed over the portion of the landfill that contains the RG Haley consolidated wastes. The transition of the low-permeability soil layer to the RG Haley Site is provided on Figure 14, Detail Section B.

5.2.2.4 Geomembrane

Once the low-permeability soil layer has been constructed, construction quality assurance testing has been completed, and the grades have been verified by survey, a geomembrane liner will be installed directly on the surface of the low-permeability soil layer. Three options for the geomembrane liner were evaluated: the 20-mil thickness scrim-reinforced polyethylene (SRPE) material specified in the CAP and used to cover the IPAs, 30-mil thickness linear low density polyethylene (LLDPE), and 30-mil thickness polyvinyl chloride (PVC). According to research (Koerner 2011), the expected geomembrane service life varies with material type and thickness but is most impacted by exposure to direct sunlight. Increased temperature testing to accelerate aging has been conducted on buried high density polyethylene (HDPE) geomembrane over the last 25 years. This study was funded by the EPA, and because of the expense, did not include testing of other geomembrane types. This testing has concluded that will require approximately 500 years at 65 °F before the HDPE geomembrane is reduced to 50 percent of its original strength and elongation properties. The time it takes to reach 50 percent of the material strength and elongation properties is referred to its halflife. In contrast, testing of exposed HDPE geomembrane over the last 12 to 13 years has yielded an HDPE halflife of approximately 70 years due to exposure to UV rays. The buried geomembrane therefore is expected to last approximately seven times longer than exposed geomembrane.

Exposed aging testing has also been performed on 40-mil LLDPE, 30-mil PVC, and other geomembranes. Aging 40-mil LLDPE was found to have an exposed halflife of approximately 49 years, with 30-mil PVC having a halflife of 21 years (Koerner 2016). It was also verified that thicker geomembranes age slower than thinner ones. Applying the factor of 7 to the exposed halflife of 40-mil LLDPE and a proportional thickness deduction, the best available research indicates the buried 30-mil LLDPE would have a life expectancy of at least 257 years. Applying the factor of 7 to the exposed halflife of 30-mil PVC indicates the buried 30-mil PVC would have a life expectancy of at least at least 147 years. The SRPE has a much thinner 8-mil low density polyethylene (PE) layer on each side of the scrim or 16-mil total. Applying the factor of 7 to the expose halflife of 40-mil LLDPE and a proportional thickness deduction, indicates the buried 20-mil SRPE would have a life expectancy of at least 137 years.

Based on the expected functional life of the buried geomembranes, all of the materials proposed are expected to last long enough for the landfill gas generation to reach *de minimus* quantities, after which the underlying 2-ft-thick low-permeability soil layer will provide the ageless barrier to infiltration of precipitation.

SRPE was selected as the preferred geomembrane for the Site cap in the CAP to protect from direct exposure to the low-permeability soil cap and will have adequate strain and seam strength properties for long-term survivability. LLDPE is considered an acceptable alternative to SRPE for this Site. PVC has somewhat poorer strain and weld strength properties than LLDPE and costs as much or more, so it was eliminated as a potential geomembrane material for the Site.

Because the uplands has already been preloaded, post construction settlement will be much less than for a typical landfill, so the strain properties and seam strength typically required for a landfill geomembrane cap are not as applicable for the Site geomembrane layer. SRPE has three-dimensional strain properties and seam strength which are considered adequate for its intended application as a component of a two-layer low-permeability system subject to the post-construction settlement anticipated for the Site cap.

The SRPE geomembrane would be brought to the Site in folded panels or rolls, carefully placed over the finished grade of the low-permeability liner such that there is direct contact with the underlying compacted soil with minimal wrinkles. Stringent QA/QC will be required to verify that the surface of the low permeability soil layer is smooth before placing the SRPE geomembrane. Once the geomembrane is placed, adjoining SRPE panels would be seamed together by glue. Glued seams can also be used for seaming to a dissimilar geomembrane that may be selected for the RG Haley cover system, with at least a 5 ft overlap of the RG Haley cover geomembrane over the SRPE as shown on Figure 14, Detail B.

Glued seams would be inspected for leaks using a vacuum box testing over the entire length of the seam. The vacuum box is common leak testing equipment for testing seams. The vacuum box consists of a long shallow box with a window as the top surface, and open base with a rubber or foam seal along the entire bottom edge of the box. The liner seam area to be tested is covered with a film of soapy water, the box would be pressed over the area, and a vacuum is applied to the inside space of the box. As a result of the applied suction, any leak in the seam will be observed by soap bubbles forming at the point of a leak in the seam. That leak point is marked for repair by re-gluing and testing again in the same way. This vacuum box testing would continue by overlapping the test areas along 100 percent of the seam.

LLDPE is the most commonly used geomembrane material for landfill liner systems. LLDPE has good three-dimensional strain properties and better long-term seam strength than SRPE because it can be welded together. In addition, if LLDPE geomembrane is used for the RG Haley AOC area cover system, it would be advantageous to use LLDPE for the Site in order to have stronger welded-seam connection with the geomembrane in that cover system. However, LLDPE may cost up to 50 percent more than SRPE depending on the fluctuating price of polyethylene resin (which is based on the price of oil). LLDPE has better performance properties, but are not considered necessary for the Site for the reasons discussed below.

If used, LLDPE panels would be deployed in rolls and seaming is accomplished using double-track fusion welding for LLDPE with extrusion welding used for patches and boots. The use of fusion and extrusion welding melt the plastic together such that the weld is stronger than the geomembrane itself. Welded seams are thus superior to glued seams in bond strength and long-term strength. Each welded seam, 100 percent of the length, would be tested for leakage using a vacuum box (as described above), air pressure, or spark testing. The double track weld allows the space between welds to be pressurized with air (up to 30 psi) after installation, and any drop in pressure over 5 minutes indicates a leak that needs to be found and repaired. Spark testing would be conducted by embedding a 24-gage copper wire in extrusion welds around areas that are not flat enough to use a vacuum box. Once the weld is complete, a low-amperage electric detector would be passed over the weld. Any spark arcing from the weld indicates a leak that needs to be repaired with additional extrusion welding. Typically every 500 ft, destructive sample across the welds are cut for strength testing, and the hole patched with additional geomembrane material. Once all panels, tests, and patches are confirmed to be complete, the geomembrane may be covered by the drainage layer.

Considering, the above discussion, either LLDPE or SRPE are anticipated to perform adequately as the geomembrane element of the upland capping system for the Site cleanup action. Because of its lower cost, SRPE remains the planned capping material, but LLDPE will be considered as an alternative capping membrane material during the construction bidding process and may be used instead of SRPE if practicable.

5.2.2.5 Drainage Layer

The drainage layer will consist of a drainage geocomposite rolled out and placed directly on the geomembrane. The preliminary design is based on a high density polyethylene (HDPE) geonet geocomposite with a geotextile heat bonded to both sides for a total thickness of approximately 0.2 inches. The geocomposite is specifically designed to transmit water while being compressed under load, with the in-plane flow capacity (transmissivity), specified for the application.

The geotextile to be heat-bonded to the geonet core will be designed to have the correct apparent opening size (ASTM 4751) to prevent intrusion of fines from the overlying cover soil layer and provide a friction layer against the underlying geomembrane. The geocomposite will also provide a protective cushion on the underlying geomembrane to help prevent post-construction damage to the geomembrane. The geomembrane will be examined for tears and holes during the construction quality assurance prior to laying the geocomposite. Good construction quality assurance (CQA) would allow discovery and repair of tears during construction. This CQA and combination of low anticipated differential settlement, and adequate strength of the geomembrane and seams, will result in preventing migration of silt upwards from the low-permeability soil layer into the drainage layer.

In order to determine the quantity of water that may percolate into the drainage layer, 30 years of Bellingham weather data was inputted in the EPA Hydrologic Evaluation of Landfill Performance (HELP) model. This model determines from the quantity of rainwater/snowmelt on the cover the quantity that runs off, the quantity that percolates downward but is evapotranspirated, and the quantity that percolates downward and is taken away by the drainage layer. The 30 year model is used to incorporate historical large storm events, and consider long-term percolation fluctuations through the cover system. The HELP Model results are provided in Appendix B, Attachment B.5.

Once the HELP model was set up for a unit area of the landfill, the slope of the cover surface was input for those slopes presented in the preliminary design (2%, 5%, and 25%) and the drainage spacing for collection pipes was increased until the head on the geomembrane was no more than 1 ft. The collection pipes will be perforated 3-inch-diameter corrugated HDPE pipe, and will be sloped to intercept seepage from the geocomposite and convey the water for discharge at the landfill perimeter. The orientation and spacing of these proposed drainage pipes is shown on Figure 10. The connection of the geocomposite layer to the drainage pipes is shown on Detail A on Figure 14.

The drainage geocomposite will be confirmed to have the minimum transmissivity in the laboratory (ASTM D4716) of 1.1 x 10^{-3} square meters per second (m^2/sec) under a gradient of 0.02 and compressive load of 2,500 pounds. This transmissivity was derived from the minimum required transmissivity required for drainage and stability of 5 x10^{-4} m^2/sec, after partial plugging by applying the reduction factors for: 1) elastic and creep intrusion of the geotextile into the geonets core space under prolonged load, 2) long-term precipitation and chemical clogging of the geonets core space, and 3) root growth or other biologic clogging (see page 18 of Appendix B-3). The factors of safety were as recommended by Koerner (2005) (Table 4-2) for surface water drains for landfill covers. The test compressive load would allow up to 18 ft of additional fill soil to be placed on the cover system for future park landscaping, while still maintaining the minimum drainage capacity required. Research (Koerner 2005) based on interpolating lab test data suggests that the life expectancy for the geocomposite drainage layer under the loading and chemical breakdown of buried conditions is over 600 years. The maximum drainage pipe spacing is tabulated in Table 5-3 below.

Table 5-3. Cover System Design Drainage Layer

Cover Type above Geomembrane	Drainage Pipe Spacing in Drain Layer (ft)		
	2% Slope	**5% Slope**	**25% Slope**
2-ft thick topsoil over geocomposite drain layer k = 10 cm/s (Cornwall Landfill Cover 2)	70	140	665

With cover system drainage capacity confirmed, the drainage system proposed was input into the slope stability analysis to demonstrate that the saturated cover would be stable under both static and the design seismic conditions. A discussion of factor of safety and acceptable slope stability criteria is provided in Section 5.1.5.2.

5.2.2.6 Topsoil and Cover Soil Layer

The drainage layer will be covered by a minimum 2-ft thickness of cover soil. The top 6-inch thickness of the cover soil will consist of topsoil that is suitable to grow a good stand of grass. The purpose of the cover soil is to protect the underlying drainage geocomposite and geomembrane from weathering, puncture by surface activities, and to provide a layer for evapotranspirating percolated water using water uptake by an established stand of grass. As demonstrated in the HELP model (Appendix B, Attachment B.5), the cover soil layer will consist of a silty sand imported to the Site with a hydraulic conductivity less than 1 $x10^{-3}$ cm/s. The topsoil will be a silty sand loam specified to comply with the requirements of Washington State Department of Transportation (WSDOT) 9-14 Type C Topsoil including fertilizer to establish grass on the cover.

Fertilizer and other landscape chemical application rates will be specified in the construction documents and in future maintenance plans to prevent the application of excess fertilizers and chemicals that could leach into the drainage layer and discharge into the bay. The topsoil will be seeded with an appropriate grass seed mixture following installation and covered with a tackifier and or erosion control blanket as necessary to prevent erosion until the grass is established. Note that NPDES or City permitting requirements for drainage systems may require modification of the plan described herein to provide for additional retention or treatment of water discharging to the bay.

5.2.2.7 Cap Penetrations (Well, Utilities, Other)

Penetrations through the cover will include the proposed groundwater monitoring wells, LFG vent pipes, associated utility boxes, and may include other utilities, piers, and/or piles associated with subsequent construction of the City’s Cornwall Beach Park. The penetrations will be cut through the cover system and once in place, the 2-ft-thick low-permeability soil layer will be restored over and around the penetration element (as applicable), compacting the low-permeability soil in 6-inch-thick lifts to within 2 inches of the penetration element. The remaining 2-inch annulus will then be filled with powdered bentonite to seal the low-permeability soil to the penetrating element. Next, the geomembrane will be restored by placing a 6-inch-minimum width strip of the same geomembrane material centered over the cut (cap strip) and seaming it in place. Utility trenches and other liner features that need to be cut through the cover system must be reviewed and approved by an engineer to verify if a continuous geocomposite LFG collection layer and /or drainage layer also is required to be restored across the cut. Liner penetrations will have a fabricated "boot" consisting of the same type of geomembrane wrapped around the element a minimum 6 inches vertically and the skirt of the geomembrane extending out over the cover geomembrane a minimum of 6 inches from the penetration element. The top of the boot will be connected to the element using double hose clamps for pipe penetrations or bolted batten strips for larger structures. The top edge of the boot will be silicon sealed to the element and the skirt will be welded or heat bonded to the existing geomembrane. A typical liner penetration detail is shown on Figure 12.

5.2.3 Landfill Gas Control

Landfill gas control will be accomplished by collecting LFG in the cover system or in LFG passive collection wells, and routing the collected gasses to a passive ventilation system. The layout of the LFG control system is provided on Figure 8, and conceptual design details are presented on Figures 12 and 13.

As discussed in Section 5.2.2.1, an LFG collection layer will be included in the cover system. This layer will extend throughout the entire upland Site to capture any rising gasses and provide a ventilation route for the gas to exit the subsurface in a controlled manner, preventing exposures. The preliminary design is based on using a transmissive collection system that combines geocomposite materials with integrated conveyance tubing to route LFG collected within the geocomposite to the header system. Quick-connect fittings are used to attach the integral tubing to pre-drilled holes in the header piping.

The LFG collection layer could also be effectively constructed using gravel and perforated PVC piping in trenches. However, the geocomposite system is anticipated to provide similar or improved transmissivity while also providing more effective conveyance with tighter pipe spacing, and more uniform coverage than would be achieved with a typical gravel and perforated piping approach. The use of the geocomposite system also reduces the trenching required to just main header trenches, limiting the potential to encounter buried waste during construction.

The LFG collection layer evaluated for this application is Draintube ™ by AFITEX-Texel, which incorporates flexible perforated piping into the geotextile layer. The piping will provide the primary means of conveyance of captured LFG to the header system and ultimately, the vents. The gas collection products are made from polypropylene, polyethylene, or high-density polyethylene, which are very stable compounds. Longevity is typically understood to be on the order of decades or centuries. Some theoretical and product-specific testing estimates the useful lifetime of the Draintube™ product to be 150 years (AFITEX-Texel 2017, CTT Group 2009, GEOROUTE Ingénierie 2014, SAGEOS 2008) based on tests of chemical fouling and oxidation. As a result, we anticipate the LFG collection and conveyance layer will provide ventilation for many years after any measurable quantity of LFG is present.

A series of four passive collection wells will be installed in the areas of the Site containing refuse, to provide subsurface pressure relief. Although lateral migration has not been a concern in the past at this landfill, the additional overburden weight of fill soils and the cover system will restrict existing ventilation pathways, and increase subsurface pressures. To prevent this change in conditions from causing subsurface lateral gas migration, the passive collection wells will be installed into the refuse, where the greatest concentration of LFG was detected. The wells will extend to a depth just above the groundwater table and provide ventilation for gasses generated in this area. Well installation details, temporary completion details, and wellhead completion details are presented on Figures 12 and 13. The wellheads will be flush-mounted at the surface and will include an isolation valve and sampling port to support long-term operations and maintenance, and compliance monitoring.

Gasses collected in both the cover system and the passive collection wells will be routed through subsurface 2-inch-diameter HDPE SDR-11 LFG header piping to one of two passive vents located in the northeastern and southeastern portions of the Site. The landfill gas generation rate is very low and thus not anticipated to generate a significant quantity of condensation within the control system. Minor droplets that form in the piping are not expected to travel significantly due to the pipe perforations and pipe sloping which prevents sagging. The vents will be constructed of stainless 4-inch-diameter pipe with a round concrete base, and an effluent point 12 ft above ground surface, so that the release of LFG is at a controlled location where exposures are not anticipated and ambient air will not be affected. The vent pipe will be metal to provide a long service life, and stainless steel will be used to provide corrosion protection from external elements and the moisture condensing from the LFG. The vents will be outfitted with a wind-turbine at the head, which will rotate in blowing conditions to provide enhancement of advection and diffusion.

Each vent will also include a subsurface vault which can be used in the future, if needed, to add carbon filtration prior to ventilation. Carbon filtration is not required to meet MTCA cleanup standards based on current data, but including the vaults would allow it to be added in the future with minimal effort if nuisance odors become a concern, or if different LFG quality conditions are determined during compliance monitoring. Sampling ports will be installed in the piping within the vaults to facilitate compliance monitoring, including chemical composition and pressure measurements. The subsurface vaults will also contain a flame arrestor, a safety device that prevents a flame from traveling through the LFG control system. This will be included based on the potential for methane to occasionally be present in the LFG control system within the explosive limit, and the possibility of lightening striking the LFG vents.

5.2.4 Stormwater and Erosion Management

5.2.4.1 Onsite Drainage

As shown on Figure 10, the majority of the upland landfill cover is designed for stormwater to sheet flow and discharge into the rock/aggregate shoreline protection systems along Bellingham Bay. Water that percolates into the cover will be intercepted by a geocomposite drainage layer that is collected by underdrain lines. As shown on Figure 10, and detailed on Figures 14 and 15, the cover drainage layer underdrain pipes will also discharge to the shoreline protection and perimeter ditch systems. The slopes on the north and east sides of the landfill will sheet flow to a collection ditch which is sloped at 0.6 percent to discharge to Bellingham Bay at the southeast corner of the landfill at the existing South Outfall location which will remain. The ditch along the north and east sides of the Site is trapezoidal in shape, with a 4-ft bottom width. A subsurface underdrain pipe is located below the drainage ditch and will also discharge at the South Outfall location. This ditch underdrain will decrease the standing water and saturated conditions in the ditch within the soil cover required to protect the underlying geomembrane. This underdrain pipe is part of the cover system design and is discussed in section 5.2.2.5. The stormwater design and ditch sizing calculations are provided in Appendix B, Attachment B.4.

5.2.4.2 Accommodation of Adjacent Properties

The ditch system will effectively prevent runoff to or run on from the BNSF property to the east and the RG Haley Site to the north. During post closure park development, landscaping may eventually require regrading and filling of the ditch system. If this occurs, cleanout structures for the subsurface underdrain pipes associated with the cover system would need to be preserved and extended to remain above grade. Alternative drainage systems including subsurface pipes, culverts, or other diversion structures may also need to be added depending on the final design of the park.

5.2.4.3 Stormwater Discharge

The MFS for design of landfills (WAC 173-304-460[3][iii]) requires that stormwater management be designed to accommodate a 24-hour, 25-year storm event, which represents an ARAR for the Site cleanup action. As detailed in Appendix B, Attachment B.4, this storm event (NOAA 1973) equates to a peak flow rate of 992 gpm and an average flow rate (over approximately 15 hours of storm runoff associated with the 24-hour, 25-year storm event) of approximately 85 gpm of stormwater into Bellingham Bay at the southeast discharge point. The peak velocity of the design storm in the channel was found to be 1.9 ft per second. It should be noted that the design flow depth is only 5.4 inches. The total depth of the collection ditch is 2 ft. As provided in the above referenced calculations, the ditch has the capacity to manage discharges greater than the 100-year storm. As shown on Figure 15, a turf reinforcing mat (TRM) will be placed in the ditch to prevent erosion during storm events. The TRM specified will be included in the construction-level design, considering the velocity expected for a 100-year storm event (Appendix B, Attachment B.4) calculations that indicate the 100-year storm will produce a ditch flow rate of 2.1 ft per second for a duration of 2 hours. As noted in Section 5.1.5.2 (Landfill Cover Stability), the sheet flow over the landfill cover system directly to the bay (areas that do not drain to the ditch) has also been designed to withstand storm events that exceed the 24-hour, 100-year storm event.

5.2.4.4 Erosion Control

Long-term, self-sustaining erosion control will be accomplished by establishing a good stand of grass on the landfill cover, placing rip rap at the stormwater ditch outlet, and shoreline protection rock/aggregate at the underdrain pipe outlet to Bellingham Bay. Temporary erosion and sediment controls (TESC) will be necessary during and after construction of the upland cover system until the grass is established. Best Management Practices (BMPs) to the TESC elements will be established during the detailed design phase, but will likely include the use of a biodegradable erosion control blanket (ECB) place on the seeded topsoil and a turf reinforcing mat (TRM) in the ditch bottom, as shown on Figure 15.

5.2.5 Shoreline Stabilization System

Shoreline protection using rock and aggregates will be required for the aquatic cover system to provide long-term protection against further erosion of the Site shoreline. CHE developed two shoreline protection alternatives. The first alternative (Baseline Alternative) uses a conventional heavy rock armor apron along the shoreline consistent with the conceptual shoreline stabilization system as presented in the Site CAP. The second alternative (Groin Alternative) includes the construction of a rock groin extending waterward from the shoreline near the southwest corner of the Site to reduce wave action and allow the use of smaller diameter materials to provide shoreline protection. The lateral boundaries of both protection alternatives are largely set, except near and extending southward from the pocket beach at the south end of the Site. The southern extent of the shoreline protection will be defined in the final design, and will provide a stable transition of the shoreline protection system into the existing rock protection and sediment in this area. Additional sediment quality characterization will be performed outside of the installed shoreline protection area as part of the evaluation of sediment quality for sediment management unit MU-3, which is not part of this cleanup action, following construction of the final cleanup action for sediment management unit MU-2.

Because the Groin Alternative allows the use of smaller size shoreline protection material, its construction would not cost more, and would likely cost less, than the Baseline Alternative. Because the smaller material sizing for the Groin Alternative provides better strata for aquatic habitat, it is the alternative chosen for the final cleanup action. However, both alternatives are presented below to illustrate the differences between the alternatives and the basis for identifying the Groin Alternative as the preferred shoreline stabilization system for the Site cleanup action.

The preliminary design for the shoreline stabilization system is presented below. Details regarding the modeling and design conducted to develop the preliminary design are provided in Appendix C.

5.2.5.1 Size (Average Diameter) and Gradation of Required Shoreline Protection Materials

Each of the shoreline protection areas (e.g. South revetment, sandy gravel revetment, gravel cobble revetment, north revetment and groin) were selected and designed to provide adequate project performance functions and meet the design criteria (including the ability to resist digging during beach play). Detailed sections of these shoreline protection elements with the average grain-size for the rock/aggregate within these areas are provided on Figure 9 for the Baseline Alternative and Figure 10 and Figures 16 through 18 for the Groin Alternative. For the Baseline Alternative, the heavy rock will have an average size of 1.9-ft diameter, 3- to 4-ft thick, extending 140 to 220 ft horizontally out into the bay. This heavy rock beach would be expensive and have poor habitat and aesthetic value. In comparison, the Groin Alternative will only require the heavy rock to build the groin and upper elevation portions of the south and very northern most shoreline. The groin will contain materials to the south of the groin and dissipate wave action to the north of the groin, allowing the majority of the shoreline protection rock size to be reduced to rounded cobbles and sandy gravel. This variable size shoreline protection would use less expensive materials and would visually blend in to the natural coastline better than the Baseline Alternative. The full gradation of the materials will require construction level design, and will be included on the construction plans and specifications.

5.2.5.2 Elevation Range of Required Shoreline Protection Material

As shown on Figure 9, the Baseline Alternative would require a heavy rock apron extending along the entire Site shoreline, extending out into the bay to elevation -5 ft MLLW from a top elevation of 13 ft MLLW and coarse gravel from -5 ft MLLW to -12 ft MLLW. The Groin Alternative shoreline stabilization system will have a top height of Elevation 12 ft MLLW along the entire shoreline. The shoreline protection extends downward to Elevation -12 ft MLLW on the north end and south beach area. As shown on Figure 10, north of the groin the shoreline protection is not required to extend as far out into the bay, the bottom elevation of the shoreline protection varying from approximately -1 ft to -6 ft MLLW. As noted in Section 5.2.5.5, the upland cover system has been designed such that additional shoreline protection elevation can be added up to Elevation 17 ft MLLW if needed in the future for potential SLR in excess of the 2.4 ft assumed for this design.

5.2.5.3 Impacts to Eelgrass and Aquatic Habitat

The Baseline Alternative stabilization of the shoreline will require rock to be placed out over the entire limits of the existing eelgrass beds in the aquatic portion of the Site, covering approximately 59,850 ft^2 (1.4 acres) of eelgrass. The Groin Alternative will cover slightly less (59,000 ft^2) of the eelgrass.

The preliminary design of the shoreline protection system will expand out into the bay causing a loss of aquatic habitat based on the change in location of the shoreline due to the placement of the shoreline protection system materials. Based on the MHHW elevation (8.51 ft MLLW), approximately

43,710 ft^2 (1.0 acre) of aquatic habitat will be lost. Based on the OHW elevation (9.5 ft MLLW) approximately 35,830 ft^2 (0.82 acre) of aquatic habitat will be lost.

The construction-level design may allow the reduction in the loss of aquatic habitat by refining the thickness of the shoreline stabilization system in the intertidal area. However, the loss of aquatic habitat cannot be entirely avoided. Specific habitat related actions to address the loss of aquatic habitat and the impact to existing eelgrass beds will be developed in coordination with the permitting agencies during detailed design and permitting for the cleanup action. Additionally, the shoreline protection system is designed to be compatible for post-cleanup habitat enhancements planned as part of the City park and identified in the Park Master Plan (Anchor QEA, October 2014, Section 4.4.1), the City of Bellingham Marine Nearshore Connectivity Study and WRIA 1 Nearshore and Estuarine Assessment and Restoration Prioritization Project Addendum 1.

Although the groin will generally improve aquatic habitat by allowing the use of smaller sized shoreline protection materials on the adjacent shoreline, it may create an impediment to juvenile salmon migration. Refinements to the groin design will be evaluated during detailed design and permitting of the cleanup action to minimize its potential impact to the migration of salmon and other potentially affected species. Potential refinements that will be considered include, but are not limited to, improving habitat function and establishing upland planting areas at the shoreline to support vegetation that will overhang the water.

5.2.5.4 Shoreline Grading

As shown on Figure 8, the existing rubble and debris on the shoreline surface will be removed prior to constructing the shoreline protection system. The removal of this material will be conducted in a manner that disturbs the underlying “beach” surface as little as possible to minimize the release of the underlying finer grained waste materials. This rubble and debris will be brought to the upland portion of the Site for use as fill under the grading fill and landfill cap. Once the debris is moved from the intertidal zone, the surface will be lightly smooth graded to form the subgrade for the shoreline protection system. The construction will likely be phased to clear and cover progressive sections of the shoreline to minimize the unprotected surface areas exposed to wave action.

5.2.5.5 Integration with Upland Cap

As shown on Figure 14, the geomembrane layer of the upland cap will be placed under the upper 2 ft of the shoreline protection system (10 ft MLLW to 12 ft MLLW) to secure the geomembrane cover to the shoreline and protect the toe of the upland slope. As shown in the details on Figure 9 for the Baseline Alternative and Figures 16 through 18 for the Groin Alternative, the top of the shoreline protection forms a bench that will be covered by a minimum 6-inch-thick layer of quarry spalls sloping toward the bay at 2 percent. This bench could be used in the future as a pedestrian pathway along the shoreline, or, with additional cover soil, could be used for riparian landscape/habitat plantings.

The bench could function as the base to extend the shoreline stabilization system up the adjacent 4H:1V upland slope at some point in the distant future if SLR were to exceed the predicted 2.4 ft used for the current design. The shoreline stabilization system could be extended up to Elevation 17 ft MLLW, an additional 5 ft of elevation, to protect against SLR and associated wind/wave impacts.

5.2.5.6 Shoreline Sand Filter and Integrated Groundwater Monitoring System

Once the shoreline has been graded, a 1-ft-thick sand filter layer will be placed on the prepared shoreline subgrade as shown on Figures 11 and 12. The gradation of the filter material will be selected during detailed design but is anticipated to be a well graded sand and gravel to provide adequate function as a filtration layer and minimize the erosion potential of the material.

Five groundwater monitoring wells will be installed within this layer at the locations shown on Figure 8. The groundwater monitoring wells will consist of Schedule 80 polyvinyl chloride (PVC) pipe, and have prepacked silica sand screens extending from elevation 0 ft MLLW to +5 ft MLLW and will be completed in a lockable utility box in the Site uplands, as illustrated on Figure 12, Detail 3.

5.2.5.7 Geotextile Separation Layer

A geotextile separation layer will be placed between the shoreline sand filter and the shoreline protection rock to inhibit scouring and washing away the sand filter through either bottom upwelling forces or surficial erosion through voids in the overlying cover material. The geotextile will be designed for the grain sizes selected during the construction plan and specification development, but will be selected for durability in a high-energy marine environment.

5.2.6 Thin Layer Sediment Cap

As shown on Figure 10 and detailed on Figures 16 through 18, a thin (minimum 6 inch thick) layer of sediment will be placed from the toe of the shoreline stabilization system to the limits of the extent of Site refuse and wood waste. The thin layer sediment cap will consist of a fine-grained sand material placed on the existing sediment to enhance natural recovery of the sea bottom over the seaward extent of the landfill. A fine grained sand (average grainsize 0.6 millimeters [mm]) was selected based on the ability to enhance the growth of natural biota in this area. The sand could be obtained from either an upland commercial source or sediment from a maintenance dredging project.

6.0 CONSTRUCTION REQUIREMENTS

The following section outlines the general construction requirements that will be considered when developing the construction plans, specifications, and construction quality assurance (CQA) plan for the Site cleanup.

6.1 Construction Sequencing/Coordination with RG Haley Site Cleanup

Construction sequencing must be considered during development of the construction plans and specifications. The existing IPAs and the planned early action grading soil that will be present on the Site at the time of construction will limit the areas available for staging materials. In addition, the existing rubble from the shoreline will be brought to the upland areas and size reduced to create part of the fill for construction of the upland landfill cap. The Site cleanup for the RG Haley Site will include sediment removal and capping as well as upland *in situ* solidification in areas where the RG Haley Site overlaps the Cornwall Site. Sediment removal associated with the RG Haley Site will produce sediment and incidental waste that will be consolidated under the northern portion of the Site. The volume of sediment to be removed and consolidated is uncertain, but is estimated to range from approximately 10,000 yd^3 to a maximum of 18,000 yd^3. The grading plan shown on Figure 8, provides for approximately 15,000 yd^{3}of the RG Haley material. Once the volume is determined, the size of the area set aside for containment of the RG Haley material will be increased or decreased as needed to accommodate the actual volume.

All of these conditions and constraints will require that construction be carefully sequenced to ensure that materials are placed effectively and efficiently. Construction sequencing required to achieve the needs of both the RG Haley Site and the Site cleanup will be specified in the construction documents. Additionally, the contractor will be required to submit a detailed construction plan for review and approval that addresses sequencing for all major construction elements.

6.1.1 Upland

The cleanup includes constructing a cover system over the upland portion of the Site which requires import soil fill to the Site to create sufficient drainage grades for the Site cover system. As described in Section 4.4, the Port identified a suitable source of fill and imported it the site in June 2016. This early action of placing fill soil on the eastern portion of the Site months or years in advance of the landfill cover construction will provide beneficial preloading, which will minimize the long-term settlement potential and aid in minimizing depressions that could form over time in the cover system.

The low-permeability soil in the IPA area has preloaded the solid waste portion on the Site uplands since 2012, and should provide 5,000 to 6,000 yd^3 of soil beyond that required to construct the 2 ft thick low-permeability cap. This material will likely be used to thicken the cap beyond the required 2 ft, but could be used as subgrade fill if needed to achieve the required subgrade surface.

The settlement due to preloading has been monitored by:

1. Installing seven settlement monuments in advance of the fill placement adjacent to the fill areas, with one location between the two preload areas to approximate settlement within the preload areas.
2. Surveying the elevation of the survey monuments adjacent to the fill areas prior to fill placement, and on a monthly basis during filling until the filling is complete.
3. Installing an additional six survey monuments within the completed preload area fill within one week of completing the fill.
4. Surveying the elevation of the settlement monuments in the fill upon completion and surveying the fill monuments and monuments adjacent to the fill at two weeks after fill completion and at one month intervals for a year after that.
5. Plotting the settlement vs. time data for each monument location, and settlement profiles (provided in Appendix F, Figure F.3).

Settlement data collected in the preload area will be used to determine the preload requirements, if any, for the area to the north that will be filled with RG Haley sediment and possibly other fill sources to achieve the desired final Site grade.

The movement of large quantities of soil around the Site will require sequencing to construct the cap on the western side in order to move the IPA soil. As the IPA soil is moved out, the imported fill and cut from the Site can be controlled placed where the IPA stockpiles were removed.

6.1.2 Shoreline and In-water Work

Work for construction of shoreline protection will be conducted during a time window allowed by the permit(s) for in-water work. The shoreline protection work will commence with construction of the sand filter layer, followed by the geotextile separation layer, armor stone (where applicable), and finer (sand/gravel to cobble) erosion protection layer. Because of the potential erodibility of the sand filter layer, the shoreline protection system will likely need to be constructed in discrete sections, progressing sequentially along the shoreline.

Placement of the thin layer sediment cap will occur after construction of all other aquatic elements of the project.

6.2 Construction Drawings and Specifications

Construction plans and specifications will be prepared under separate cover to detail the cleanup actions to be performed. The construction plans and specifications will be prepared in conformance with currently accepted engineering practice and WAC 173-340-400 (4)(b), and provide:

- A general description of the project that details the cleanup action, including work to be done, a summary of Site environmental conditions, a summary of design criteria, an existing facility map, adequate Site surveying, and a copy of permits and approvals.

- Detailed plans and specifications necessary for construction, construction materials storage, construction waste storage and management, utility locations within cleanup areas, surface drainage, materials, backfill, and change in grades.
- A description of construction impact controls (including dust, stormwater, traffic, and noise).
- Construction documentation including specific quality control tests such as soil density/in place compaction, moisture content, material gradation, subgrade strength, depth measurements, frequency of tests, and acceptable results.

Design modifications often occur during project permitting for in-water work. As a result, the design will only be developed to about a 30 percent level of design (sufficient to support JARPA preparation) in advance of progressing through a significant portion of the permitting process for in-water work, including coordination with the USACE, and consultation with federal and state resource agencies. Once permitting has progressed to the point where major design modifications are not anticipated, the preparation of construction drawings and specifications will commence.

6.3 Construction Quality Control/Quality Assurance

Day-to-day construction quality control (CQC) will be performed by the contractor, consistent with the requirements of the construction contract specifications for the cleanup action. There will be a CQA representative on site during construction to confirm that the work is being performed in accordance with the intent of the plans and specifications. Construction quality control will include the necessary elements to ensure that the provisions of the contaminated materials handling plan are being followed. In accordance with WAC 173 340 400(7)(b), all aspects of construction will be performed under the supervision of a professional engineer registered in the State of Washington or a qualified technician under the direct supervision of the project engineer.

A CQA plan will be prepared in conjunction with the construction plans and specifications. The plan includes the following monitoring parameters:

- Adequacy of construction submittals
- General construction methods and equipment
- Field engineering and survey methods
- Fill gradation, quality, and consistency
- Fill placement and compaction
- Geosynthetics testing including conformance testing, construction testing (non-destructive and destructive) and interface friction testing between the composite cover layers
- Suitability, quality, and installation of structural elements
- Stormwater runoff and erosion control measures
- Decontamination procedures
- Traffic control plan
- Contractor quality control methods and documentation

- As-built dimensions of completed work.

Specific quantitative measures and performance requirements will be established for each of the above CQC/CQA parameters and will be incorporated into the construction specifications and the CQA plan for the cleanup action.

6.3.1 Upland

Construction quality assurance for upland work will be provided under the supervision of an experienced geotechnical engineer with grade verification by a licensed professional land surveyor in the State of Washington. CQA testing will include compaction verification of fills and cover materials as soil is being placed, verification that geomembrane seams are 100 percent leak tested and representative destructive tests of the seams are taken to verify seam strength, verification that exposed grades and trenches are properly backfilled, and verifying TESCs are in place to control erosion.

6.3.2 Shoreline/In-water

Construction quality assurance for shoreline and in-water work will be provided under the supervision of an experienced coastal engineer and will include regular conditional and progress bathymetric and topographic surveys. The quality control will ensure compliance of construction materials to that specified by the design, verification of excavation grades (where appropriate), elevations of the bedding layers, and grades of constructed shoreline protection materials. Monitoring of the constructed grades and adjacent shoreline will be conducted with regard to the construction plans and specifications, the permit requirements, and as required by the project engineer or Port.

6.3.3 Model Toxics Control Act Performance Monitoring

Performance monitoring to achieve MTCA cleanup standards for soil and sediment will be achieved through CQA activities during construction of the cleanup action to contain contaminated soil, solid and wood waste, and marine sediment. Some sediment monitoring may also be necessary outside the thin layer cap to evaluate whether cap placement has impacted adjoining sediment quality. Performance monitoring for groundwater will be achieved through post-construction groundwater quality monitoring at the shoreline wells installed during construction of the shoreline protection system. Compliance monitoring, including performance monitoring, is discussed in greater detail in Section 7.0.

6.4 Control of Hazardous Materials, Accidental Discharges, and Construction Stormwater

Procedures to control and, as appropriate, respond to spills will be incorporated into the construction plans and specifications. The materials most likely to be spilled during the Site cleanup action include equipment fuel and oil, or contaminated soil. Additionally, stormwater runoff has the potential to convey contaminated water and soil off the Site, and in-water construction has the potential to release hazardous substances and elevated turbidity to surface water. The contractor will prepare construction, equipment decontamination, and stormwater management plans in accordance with requirements set forth in the plans and specifications that adequately address environmental protection measures. Additionally, project permits and/or substantive requirements will specify requirements for the monitoring and compliance of applicable water quality standards. The contractor will be required to perform work involving handling of the above materials in accordance with these plans and permit requirements. These plans will be subject to review and comment by the Port's CQA representative prior to initiating the work.

The contractor's project construction plan will describe the overall sequence and construction methods that will be used to complete the cleanup action. The plan will include detailed procedures for controlling, collecting, handling, and disposing of residual contaminated soil and debris, and any liquids generated during disposal operations. The equipment decontamination plan will provide design details for the contractor's equipment decontamination pad, including the pad dimensions; construction materials; and water collection, conveyance, and treatment systems. The contractor's stormwater management plan will provide construction details and operation procedures for collection, conveyance, and treatment and disposal of stormwater runoff, and for erosion and sediment control measures, as required to ensure that materials are properly managed and maintained within the Site boundary. The stormwater management plan will also address procedures for handling and storage of hazardous materials used for construction purposes (e.g., fuel, oil, etc.), and for prevention and, as appropriate, response to hazardous material spills or accidental discharges.

The shoreline protection system construction will be conducted with regard to BMPs and compliance with all permit requirements and water quality standards. The boundaries of the in-water construction zone will be defined by warning buoys or markers to preclude any risk to mariners. Information on the construction zone boundaries and warning to mariners may also be posted by the Coast Guard. If needed, gander booms or silt curtains will be installed prior to or during construction to minimize escape of debris, turbid water, and plume from the construction sites.

6.5 Health and Safety

Health and safety procedures that will be followed during the cleanup action are provided in this section.

6.5.1 Health and Safety during Construction

The following design features will be implemented as part of the cleanup action to ensure the safety of Site workers and the public:

- Safety Fences – Temporary security fencing will be installed around the Site to allow unrestricted access to Site cleanup personnel while maintaining a secure perimeter around the Site. A detailed temporary fencing diagram will be provided on the construction plans. Additionally, safety fencing will be installed, as necessary, around open excavations to prevent unauthorized entry.

- Excavation Safety – Any areas of an excavation that exceed 4 ft in depth will be sloped or benched to reduce the potential for sidewall collapse. Areas of an excavation that require worker entry (e.g., to perform confirmation sampling) will be accessed by appropriately sloped access ramps.

A project-specific HASP will be prepared by the Port's Engineer for use by the Port and its representatives. A HASP will also be prepared by the contractor for use by their workers before beginning work on the Site. The contractor's HASP will be at least as stringent as the Port's HASP. Each HASP will be required to satisfy the requirements of Ecology (per WAC 173-340 810); the Occupational Safety and Health Act (OSHA) of 1970 (29 U.S.C. Sec. 651 et seq.); and the Washington Industrial Safety and Health Act (WISHA) (Chapters 296-24, 296-62, and 296 155 WAC). All workers on the Site will be required to read and sign the applicable project HASP. A health and safety meeting will be conducted with the contractor, subcontractors, construction testing personnel, and appropriate Port employees before starting work at the Site and periodically during construction of the cleanup action.

6.5.2 Long-term Health and Safety

Contaminated material will be contained at the Site and securely capped with the cover system that will allow public access on the Site for use as an open space park. Post-construction intrusive activities will be subject to a restrictive covenant that specifies how such activities need to be implemented to not compromise the integrity of the cleanup action and adequately protect worker health and safety.

6.6 Construction Completion Report

Upon completion of cleanup action construction, a construction completion report will be prepared in accordance with WAC 173-400 (6)(b). The construction completion report will include:

1. A statement that the construction has been performed under the oversight of a professional engineer in the State of Washington or by qualified technicians under their direct supervision.
2. A narrative describing the aspects of the work performed including construction techniques and materials used, items installed, and tests and measurements performed. The narrative will be supplemented with daily reports and photographs in the Appendices.
3. Results of the compliance monitoring (per section 7.0) with testing results and locations shown in the Appendices.
4. As-built drawings documenting the extent of excavation and grading performed at the Site, including the following details:
    a. Existing site grades and locations and elevations of fills and cover system
    b. Panel layout drawings for geomembranes and geocomposites
    c. Location of LFG components and piping
    d. Location of underdrain piping
    e. Excavation elevations
    f. Backfill material types and grades

   g. Location of existing utilities and location and elevation of all utility repairs and replacements

   h. Field changes of dimensions and details.

5. A Statement from the engineer, based on testing results and inspections, as to whether the cleanup action has been constructed in substantial compliance with the plans and specifications and related documents.

7.0 MONITORING, MAINTENANCE, AND OPERATIONS

MTCA requires confirmation monitoring for all cleanup actions, as described in WAC 173-340-410, and periodic reviews under WAC 173-340-420 to ensure the long-term integrity of the cleanup action. Long-term care and maintenance will also be necessary to insure the integrity of the Site cleanup after construction is complete. Both the monitoring and maintenance functions will be prescribed in a Monitoring, Maintenance, and Operations Plan (MMOP). A draft of this plan will be prepared concurrent with the construction-level documents, and will be finalized after construction is complete. This will allow some MMOP elements to be built as part of the main construction work, and also allow for modifying/finalizing the requirements in the MMOP based on as-built conditions. The MMOP will address the following topics, at a minimum:

- Confirmation Monitoring, as outlined in Section 7.1.
- Facility Inspections, as outlined in Section 7.2.
- Institutional Controls, as outlined in Section 7.3.
- Contingency Response Planning, as outlined in Section 7.4.
- Equipment Specifications and O&M, as outlined in Section 7.5
- Status Reports and Record Keeping, outlined in Section 7.6

Because the MMOP provisions are likely to be changed or reduced in the future in response to the monitoring data or other factors, the MMOP will be a living document. Typically a revision of the MMOP would occur during 5-year periodic reviews, but updates at other times are also possible.

7.1 Confirmation Monitoring

Confirmation monitoring is one of the three types of compliance monitoring required under MTCA – Protection, Performance, and Confirmation. Protection monitoring is concerned with human and environmental safety during construction, and was previously discussed in Sections 6.4 and 6.5. Performance monitoring is concerned with demonstrating that the constructed remedy meets cleanup standards, and was discussed in Section 6.3.3.

Confirmation monitoring is concerned with checking the long-term effectiveness of the remedy in meeting cleanup standards. Specific procedures, analytical parameters, and sampling locations and frequency for the confirmation monitoring will be presented in the MMOP. Similarly, the scope and timing of the inspection program, the institutional control provisions, and other aspects of long-term operations and maintenance monitoring will be established in the MMOP.

7.1.1 Sediment Monitoring

Sediment monitoring will include physical monitoring to confirm the thickness and lateral extent of the thin layer cap, and sediment quality monitoring to evaluate the efficacy of the thin layer cap and possibly sediment quality beyond the limits of the thin layer cap (MU-3). The specific scope of the sediment confirmational monitoring will be established in the MMOP, and the methods and procedures for sediment quality monitoring will be established in a SAP developed as an appendix to the MMOP.

7.1.2 Groundwater Monitoring

The existing monitoring wells will be decommissioned in place in accordance with Ecology requirements. New groundwater monitoring wells shown on Figure 8 and Figure 12, Detail 3 will be installed along the shoreline within the sand filter layer under the shoreline protection system. New groundwater monitoring wells may also be installed in upland areas of the Site. While five well locations are shown on Figure 8, the actual number and location of shoreline and upland wells will be established during the detailed design. The monitoring wells will therefore be installed during construction of the shoreline protection system. The SAP will provide monitoring details including monitoring parameters, and the field and laboratory methodology used to ensure the quality of monitoring data is appropriate for assessing compliance.

7.1.3 Landfill Gas Monitoring

It is anticipated that LFG monitoring will be conducted at the vents and extraction wells just after construction, and on a set schedule thereafter for a period of time to be established in the MMOP. It is expected that the monitoring will confirm that the system effectively mitigates LFG, preventing accumulation of and unacceptable exposure to LFG. Details of the LFG monitoring program including procedures, schedule, and reporting will be developed in the MMOP and associated SAP.

7.1.4 Settlement Monitoring and Landfill Stability

Surface elevations at the Site uplands will be surveyed by a professional land surveyor to evaluate whether landfill settlement is occurring at a rate that could interfere with the function of the landfill cover or stormwater management system. These interferences could be caused by differential settlement that changes the slope of the landfill surface or causes surface fissures. Although uniform settlement is unlikely to cause these interferences, it will be evaluated as a parameter to assess landfill stability in terms of settlement potential. Settlement surveys will be conducted on a set schedule in a manner and for a period of time to be established in the MMOPP. Periodic analyses of landfill stability may also be necessary if changes in surface elevation suggest the need for such an analysis.

7.2 Site Inspection Requirements

7.2.1 Final Cover and Stormwater Management System Inspections

The final cover configuration is described in Section 5.0 of this document. After construction completion, the final cover and stormwater system will be inspected on a set schedule in a manner and for a period of time to be established in the MMOP. One possible scenario would include inspections monthly for the first year and after rainfall that exceeds two inches in a 24 hour period (24-hr, 2-year storm). The inspection could then be reduced to semiannually and after a rainfall that exceeds two inches in a 24-hour period thereafter for evidence of erosion, for cracking caused by desiccation during the dry summer months, and for localized depressions such as those caused by differential settlement. Significant settlement is not anticipated based on preloading of the Site uplands. The cover will also be thoroughly inspected and repaired, as necessary, if significant erosion occurs at any time following construction of the cleanup action.

7.2.2 Shoreline Protection Monitoring

The shoreline protection system will be inspected on a set schedule in a manner and for a period of time to be established in the MMOP. One possible scenarios would include annual inspections during the first 5 years after closure and following any major storm events with sustained high winds. The frequency of inspections could then be reviewed after the 5 years and, if warranted, reduced to a lesser frequency. Inspection will include, as a minimum, review of the conditions of the rocked surfaces, noting and repairing wash outs and conducting surveys to monitor settlement of the top of the shoreline protection, and adding more rock as necessary. Surveys will also need to be conducted during low tides at daylight hours, although the timing of low tides during winter months will limit the ability to observe the lower intertidal area.

7.3 Institutional Controls

Institutional controls will apply to MU-1 and MU-2. These controls will be documented in the MMOP, and will also be documented in an environmental covenant for City-owned property and a separate legal mechanism for state-owned property (managed by DNR). The covenant will be filed with Whatcom County, will be binding on the property owner, and owner’s successors and assignees, and will impose limits on property conveyance.

Institutional controls and environmental covenant provisions applicable to MU-1 will prevent activities that could compromise the integrity of the cleanup action (i.e., containment system) or otherwise result in unacceptable risks to human health or the environment. They will also prevent the use of groundwater for potable purposes and will place restrictions and management requirements on intrusive activities that could result in releases of hazardous substances or exposure of construction workers to contaminated media.

Institutional controls and environmental covenant provisions applicable to MU-2 will prevent damage to the shoreline stabilization system and the thin layer cap. Institutional controls will include prohibitions on activities that could damage or breach the shoreline stabilization system, such as shellfish collection, beach play (digging), or vessel anchoring.

7.4 Contingency Response Planning

The MMOP will include a description of processes for responding to emergencies, such as if the landfill cap or shoreline protection system is breached, exposing contaminated materials, or if the landfill gas collection system is compromised. The MMOP will describe the process for development and review of the emergency action plan, coordination with relevant regulatory agencies, and implementation of the emergency action, including permitting and contracting.

7.5 Equipment and Material Specifications

The MMOP will also include a repository of information on the materials and equipment used in the cleanup action. This information will help with ongoing maintenance and with future repairs.

7.6 Status Reports and Record Keeping

Once the Site cleanup action construction is completed, reports summarizing the confirmational monitoring results, inspections, and repairs made will be submitted to Ecology for review on a frequency commensurate with the frequency of post-cleanup activities. It is anticipated that status reports may be submitted quarterly for the first year following construction, annually for an additional 4 years, and at a frequency determined in consultation with Ecology following the first 5 years. The actual reporting frequency and contents will be established in the MMOP.

The MMOP will also specify record-keeping requirements for Site inspections, modifications and upgrades to the constructed system, any repairs that are needed, and other aspects of maintaining the integrity of the contaminated fill containment and gas control systems.

8.0 PROJECT SCHEDULE

The proposed schedule for the Site cleanup action has been developed to meet the requirements of the Consent Decree. The schedule is provided in Appendix G. However, the timing and rate of remedial design and construction following finalization of the EDR may be revised in consultation with Ecology due to the current status of remedial action grant funding, coordination with the schedule for the RG Haley Site cleanup, and other factors. As a result, the schedule in Appendix G should be considered tentative and likely to be revised in the future.

9.0 USE OF THIS REPORT

Landau Associates warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.

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Data Source: Esri 2012

G:\Projects\001\037\040\041\EDR\F01 VicinityMap.mxd 2/17/2016 NAD 1983 StatePlane Washington North FIPS 4601 Feet

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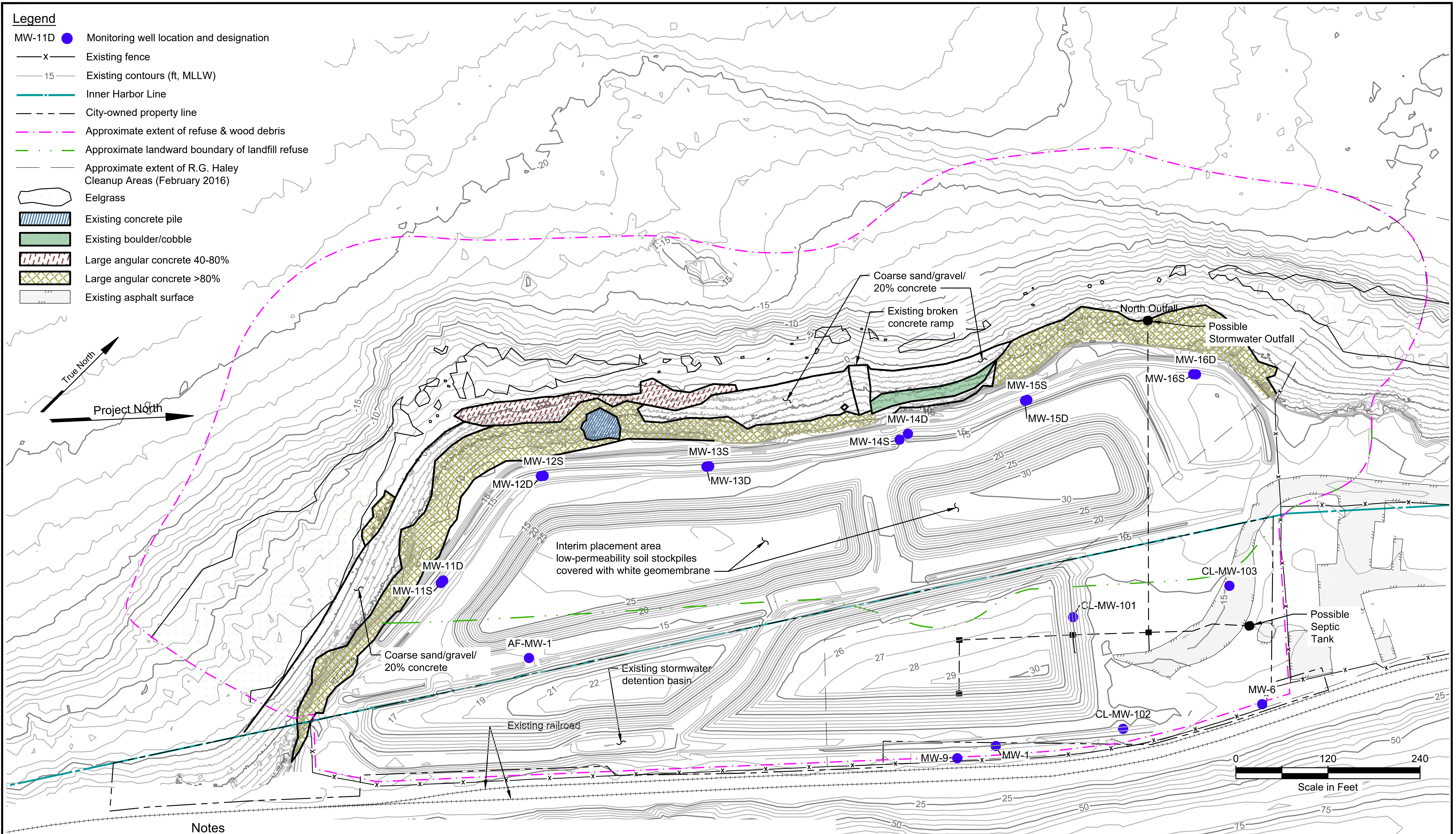
Engineering Design Report Cornwall Avenue Landfill Bellingham, Washington	**Vicinity Map**	Figure 1



LANDAU ASSOCIATES, INC. | G:\Projects\001037\040\041\EDR\F02 CurrentSiteConditions.dwg (A) "Figure 2" 6/27/2017

Notes

1. Surface contours provided by Wilson Engineering from bathymetry survey conducted February 2015 and topographic survey conducted March 2015. Eastern upland fill area contours provided by Pacific Surveying and Engineering, Inc. from survey conducted on October 15, 2016.
2. Horizontal datum: Washington State Plan North, NAD83, US ft
3. Vertical datum: MLLW, ft
4. Mapping of eel grass and shoreline features provided by Grette Associates 2015.
5. Existing Groundwater Monitoring Wells Typ. - *Decommission each well in accordance with WAC 173-160-261.*

Basemap sources: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering 2015, and Pacific Surveying and Engineering 2016

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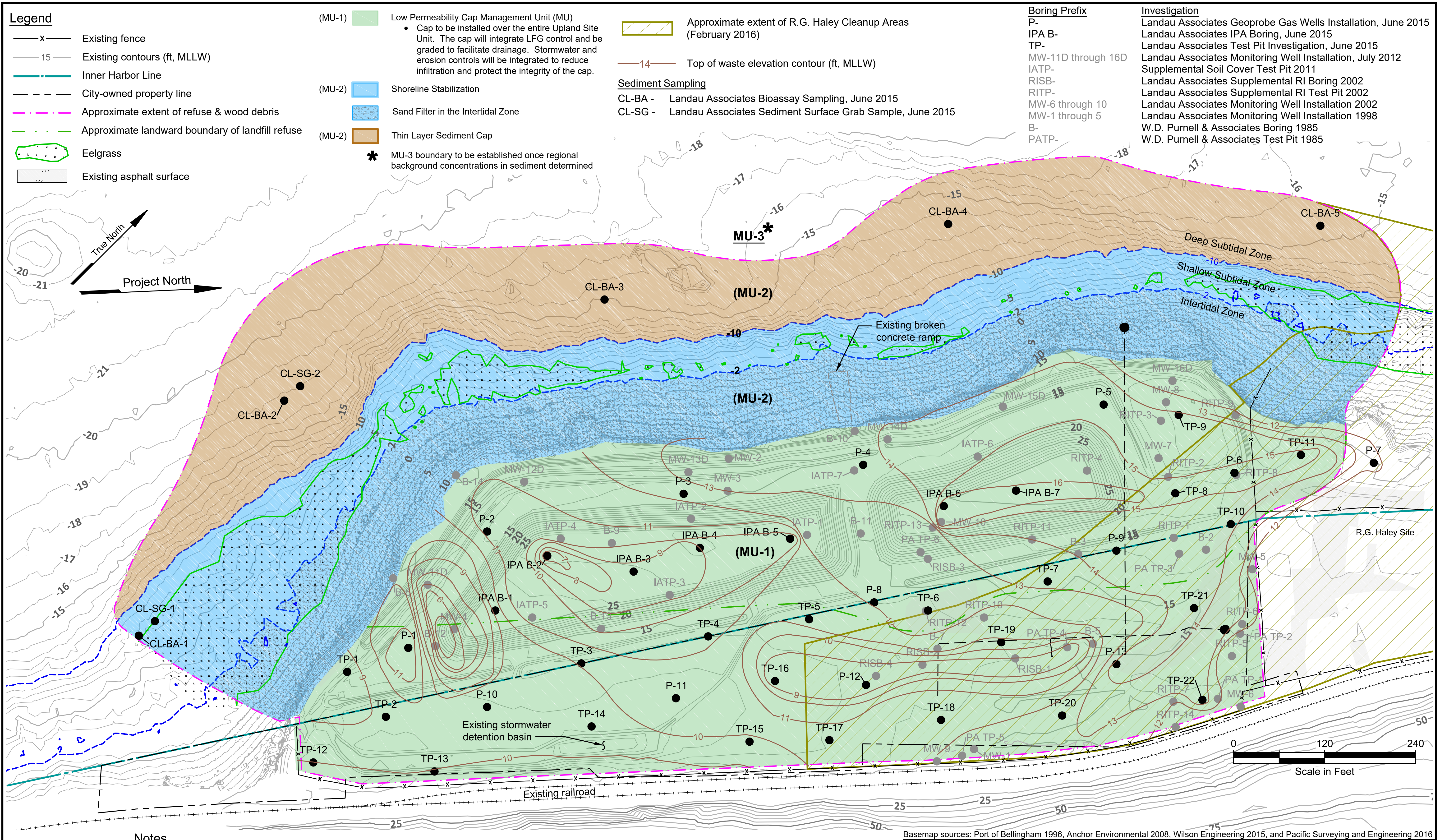
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Current Site Conditions

Figure
2

LANDAU ASSOCIATES, INC. | G:\Projects\001\037\040\041\EDR\F03 CleanupActionAreas.dwg (A) "Figure 3" 3/3/2017



Legend

- Existing fence
- Existing contours (ft, MLLW)
- Inner Harbor Line
- City-owned property line
- Approximate extent of refuse & wood debris
- Approximate landward boundary of landfill refuse
- Eelgrass
- Existing asphalt surface

(MU-1) 🟩 Low Permeability Cap Management Unit (MU)

- Cap to be installed over the entire Upland Site Unit. The cap will integrate LFG control and be graded to facilitate drainage. Stormwater and erosion controls will be integrated to reduce infiltration and protect the integrity of the cap.

(MU-2) 🟦 Shoreline Stabilization

▨ Sand Filter in the Intertidal Zone

(MU-2) 🟫 Thin Layer Sediment Cap

* MU-3 boundary to be established once regional background concentrations in sediment determined

▨ Approximate extent of R.G. Haley Cleanup Areas (February 2016)

—14— Top of waste elevation contour (ft, MLLW)

Sediment Sampling

CL-BA - Landau Associates Bioassay Sampling, June 2015

CL-SG - Landau Associates Sediment Surface Grab Sample, June 2015

Boring Prefix	Investigation
P-	Landau Associates Geoprobe Gas Wells Installation, June 2015
IPA B-	Landau Associates IPA Boring, June 2015
TP-	Landau Associates Test Pit Investigation, June 2015
MW-11D through 16D	Landau Associates Monitoring Well Installation, July 2012
IATP-	Supplemental Soil Cover Test Pit 2011
RISB-	Landau Associates Supplemental RI Boring 2002
RITP-	Landau Associates Supplemental RI Test Pit 2002
MW-6 through 10	Landau Associates Monitoring Well Installation 2002
MW-1 through 5	Landau Associates Monitoring Well Installation 1998
B-	W.D. Purnell & Associates Boring 1985
PATP-	W.D. Purnell & Associates Test Pit 1985

Basemap sources: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering 2015, and Pacific Surveying and Engineering 2016

Notes

1. Contour lines from surface provided by Wilson Engineering. Bathymetry survey conducted February 2015 and topographic survey conducted March 2015.
2. Borings and test pits were completed on the topographic surface shown here, prior to the placement of fill on the eastern portion of the site in June 2016.
3. Horizontal datum: Washington State Plane North, NAD83, US ft
4. Vertical datum: MLLW, ft

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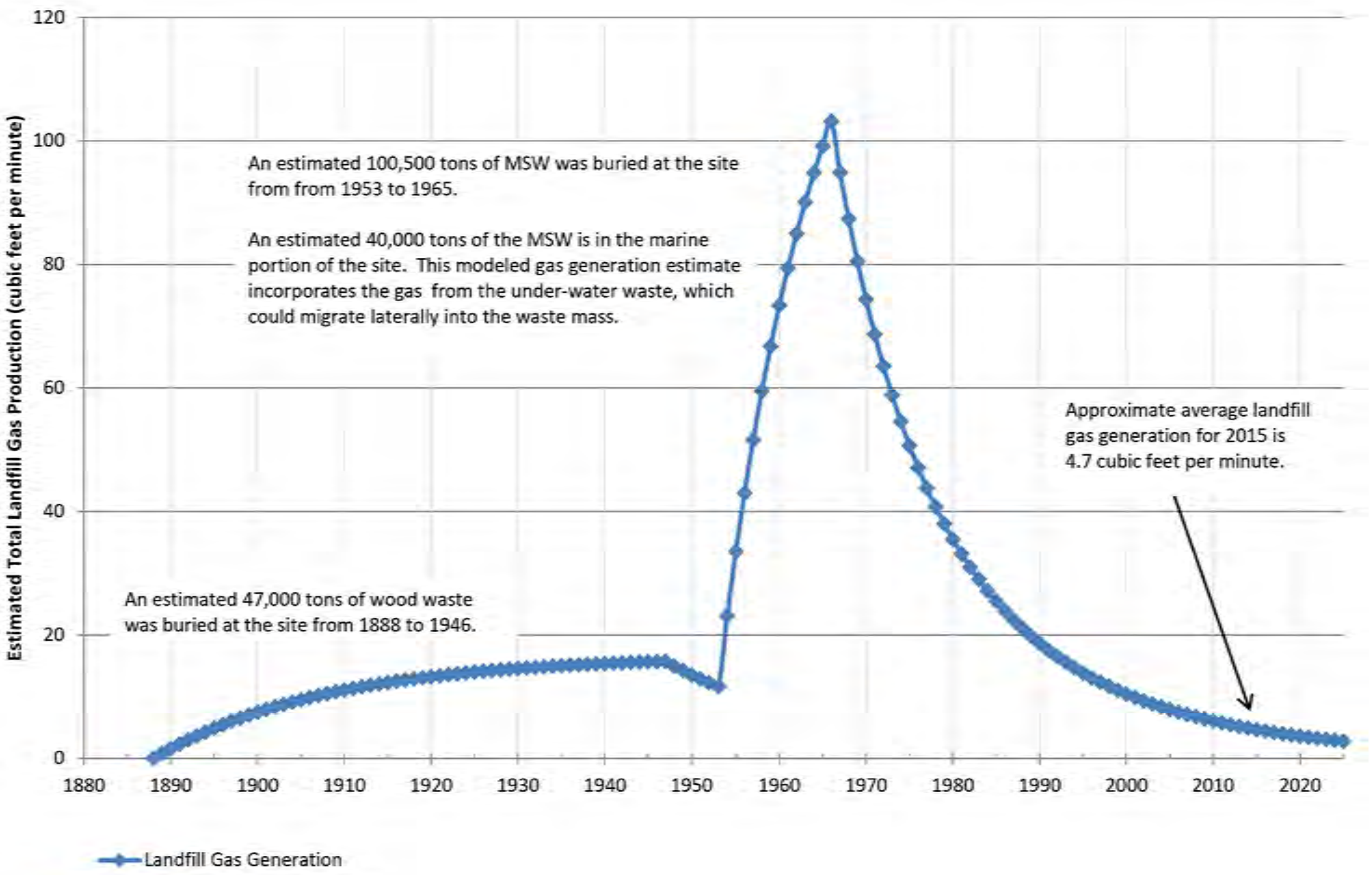
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Cleanup Action Areas

Figure
3



An estimated 100,500 tons of MSW was buried at the site from from 1953 to 1965.

An estimated 40,000 tons of the MSW is in the marine portion of the site. This modeled gas generation estimate incorporates the gas from the under-water waste, which could migrate laterally into the waste mass.

An estimated 47,000 tons of wood waste was buried at the site from 1888 to 1946.

Approximate average landfill gas generation for 2015 is 4.7 cubic feet per minute.

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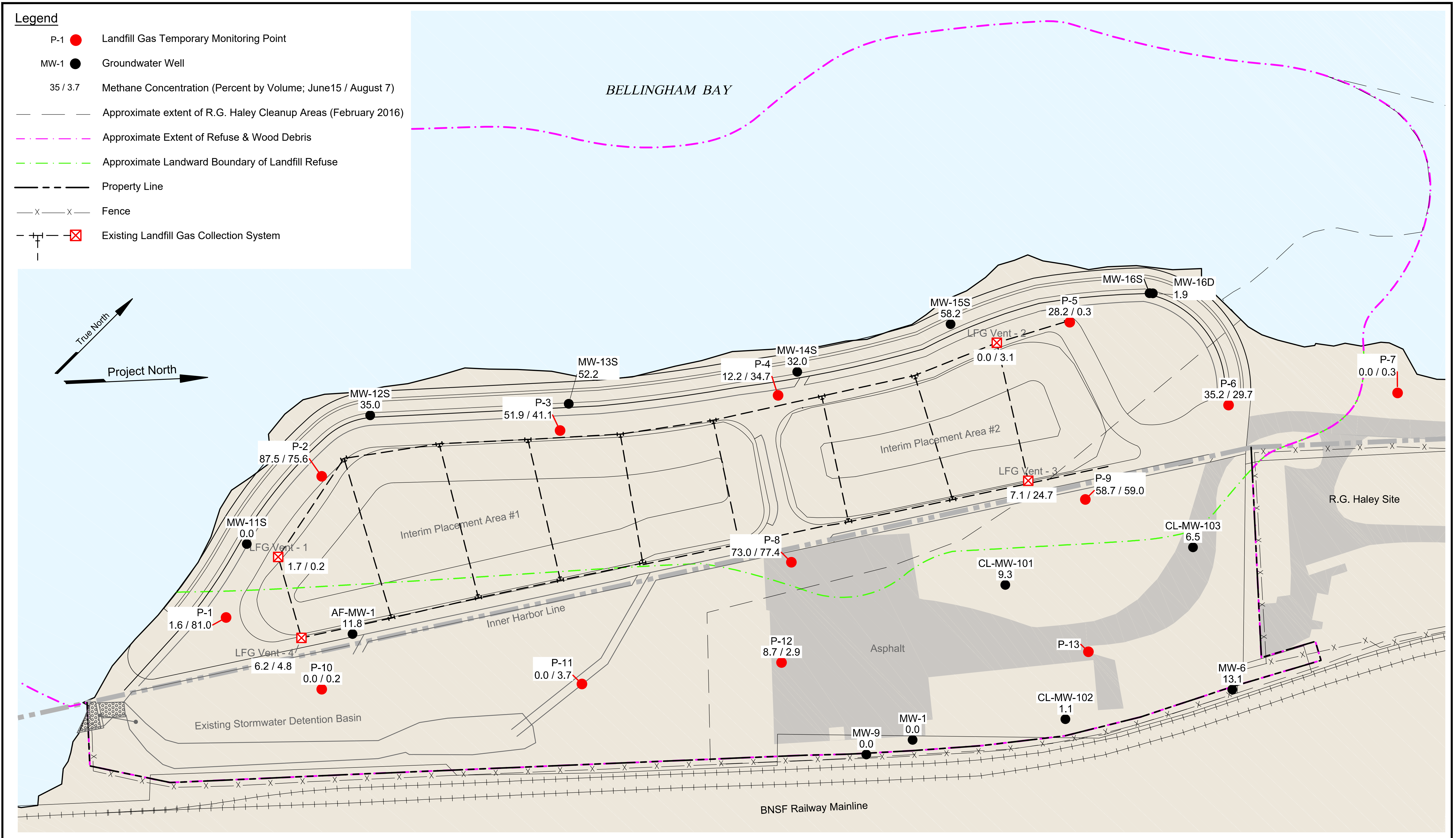
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Landfill Gas Generation Estimate
Cornwall Avenue Landfill

Figure
4



Basemap sources: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering 2015, and Pacific Surveying and Engineering 2016

Landau Associates, Inc. | G:\Projects\001\037\040\041\EDR\F05 LFGasMonitoringResults.dwg (A) "Figure 5" 6/27/2017

Note

1. Gas probes were completed on the ground surface shown here, prior to the placement of fill on the eastern portion of the site in June 2016. Gas probes under the additional fill were decommissioned by a professional engineer prior to placement of the fill.

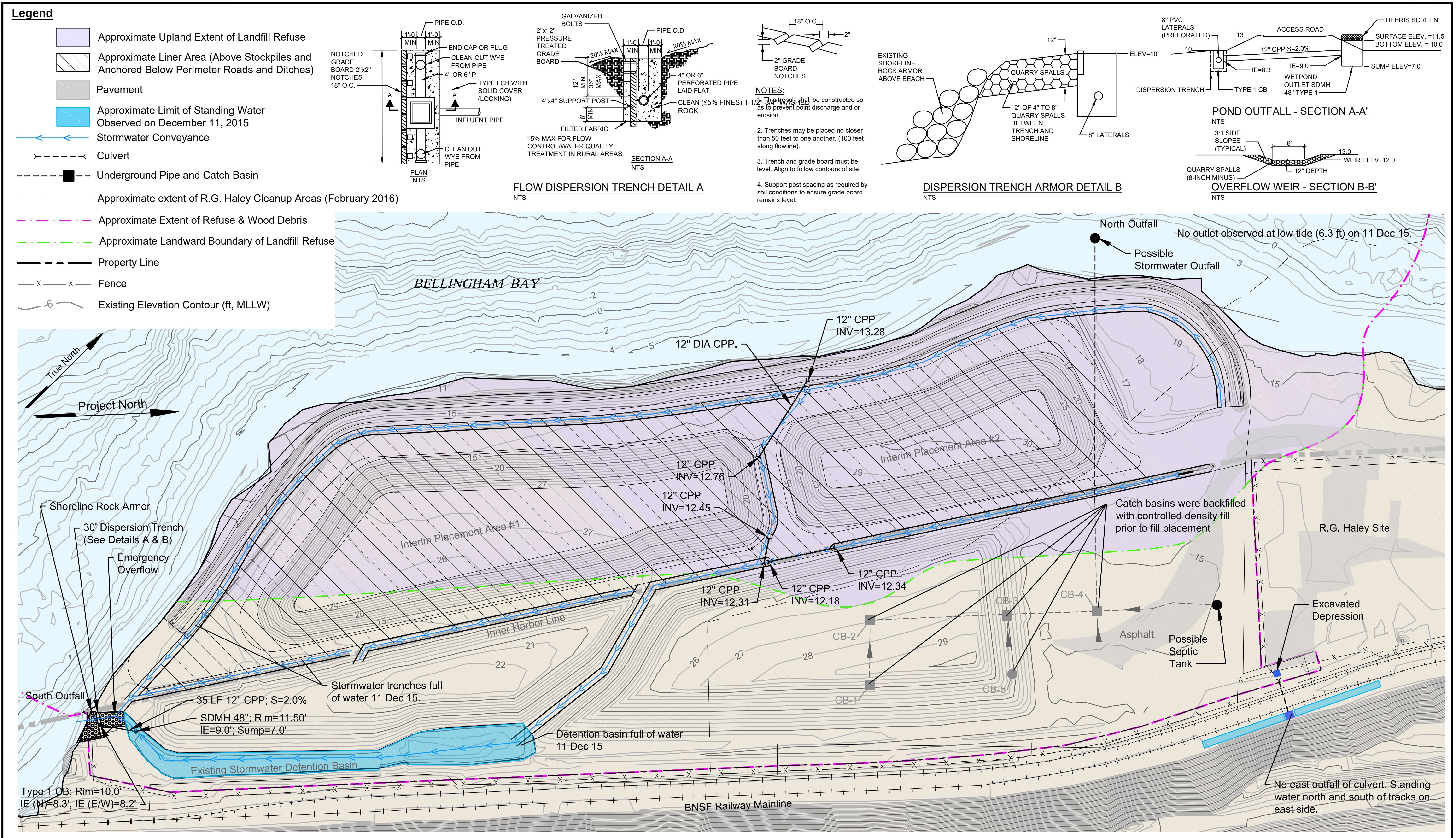
0 100 200
Scale in Feet

LANDAU ASSOCIATES

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Landfill Gas Monitoring Results
Methane Concentration

Figure
5



NOTES:

1. This trench shall be constructed so as to prevent point discharge and or erosion.

2. Trenches may be placed no closer than 50 feet to one another. (100 feet along flowline).

3. Trench and grade board must be level. Align to follow contours of site.

4. Support post spacing as required by soil conditions to ensure grade board remains level.

Basemap sources: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering 2015, and Pacific Surveying and Engineering 2016

0 100 200
Scale in Feet

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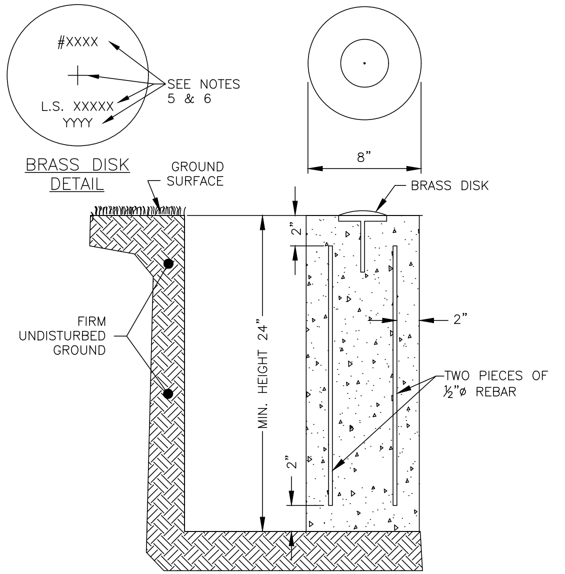
Pre-Design Work Plan
Cornwall Avenue Landfill
Bellingham, Washington

Existing Stormwater Features

Figure
6

Landau Associates, Inc. | G:\Projects\001\037\040\041\EDR\F06 StormwaterEvaluation.dwg (A) "Figure 6" 6/27/2017



NOTES:

1. BRASS DISK WAS EQUAL TO OR BETTER THAN SURV–KAP MODEL M/M–B2 (2" DIAMETER WITH ¾" DIAMETER x 2" SHANK).
2. EXCAVATION WAS FILLED WITH CLASS 4,000 CONCRETE PER APWA SECTION 03 30 04.
3. ALL LOOSE MATERIALS WERE REMOVED FROM THE BOTTOM OF THE HOLE SO THAT THE CONCRETE IS PLACED ON FIRM, UNDISTURBED EARTH.
4. THE TOP OF THE CONCRETE WAS TROWELED SMOOTH AND THE BRASS DISK SET IN THE CENTER FLUSH AND LEVEL SO THAT PUNCH MARK FALLS NO CLOSER THAN ¼" FROM THE EDGE OF DISK.
5. EXACT LOCATION OF CONTROL POINT WAS PUNCHED AFTER CONCRETE HAS BEEN SECURED IN POSITION.
6. DISK WAS STAMPED WITH CITY ASSIGNED MONUMENT NUMBER, SURVEYOR'S LICENSE NUMBER, AND THE YEAR THE MONUMENT IS PUNCHED (YYYY)

① SETTLEMENT MONITORING SURVEY MONUMENT (TYP. OF 13)

N.T.S.

Source: Pacific Surveying & Engineering, Inc. 2016

Legend

—15—	Existing contours
—20—	Compacted fill placed in June 2016 (approximately 41,355 c.y.)
—x—	Existing fence line
— —	Approximate extent of R.G. Haley Cleanup Areas (February 2016)
SSM-1 △	Settlement monitoring monument installed prior to filling on May 16, 2016 except SMM-5 destroyed by construction equipment and reinstalled June 16, 2016.
SSM-8 △	Settlement monitoring monument installed on completed fill on July 5, 2016 (Fill installation completed on June 21, 2016)
-0.01'	Total settlement (feet) as of May 4, 2017 at monument as surveyed by Wilson Engineering, LLC

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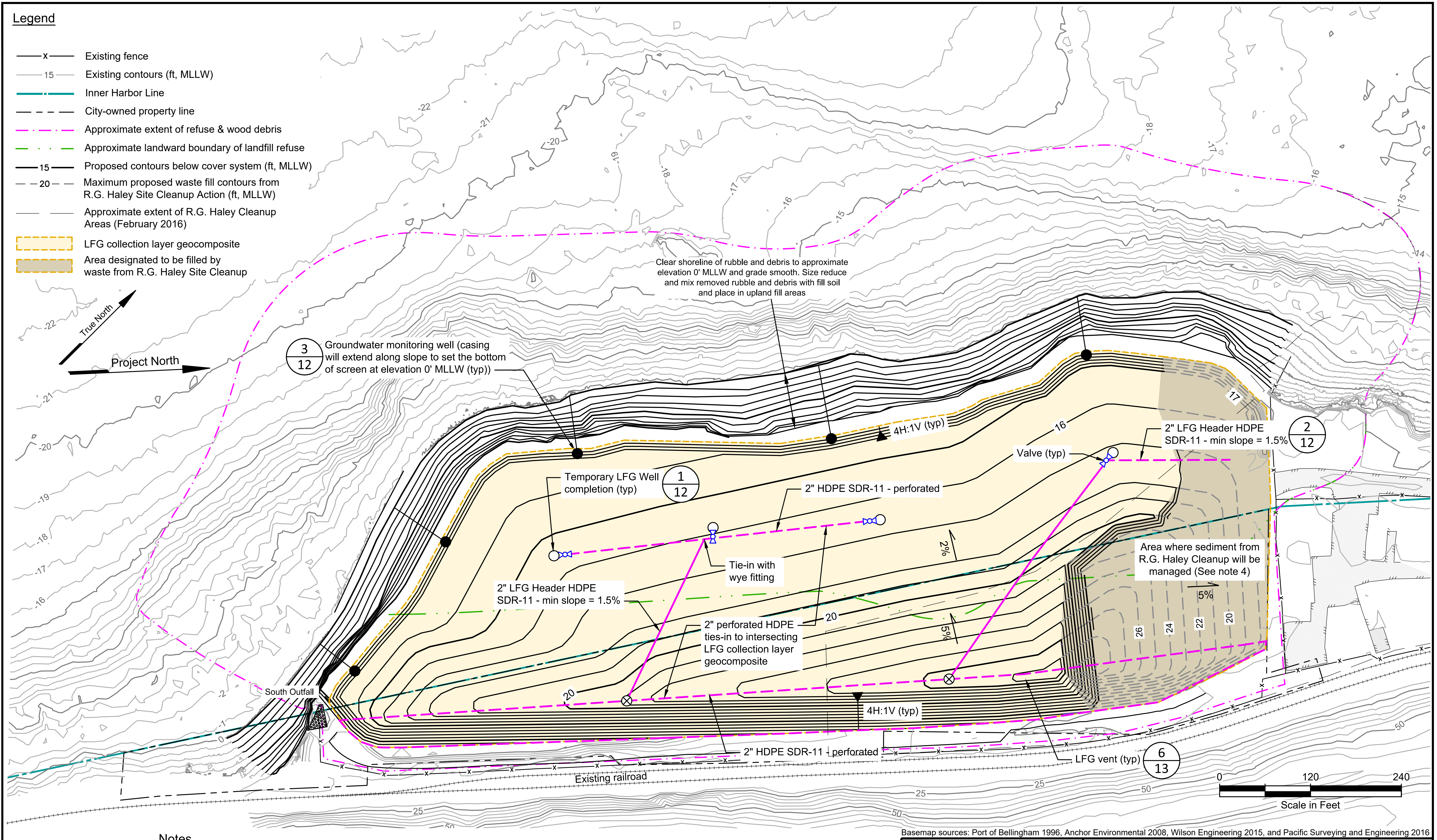
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Settlement Monitoring
(As of May 4, 2017)

Figure
7

LANDAU ASSOCIATES, INC. | G:\Projects\001\037\040\041\EDR\F07 Settlement Monitoring.dwg (A) "Figure 7" 6/27/2017



Basemap sources: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering 2015, and Pacific Surveying and Engineering 2016

LANDAU ASSOCIATES, INC. | G:\Projects\001\037\040\041\EDR\F08 SiteGradingBelowCover.dwg (A) "Figure 8" 6/27/2017

Notes

1. Contour lines from surface provided by Wilson Engineering. Bathymetry survey conducted February 2015 and topographic survey conducted March 2015.
2. Horizontal datum: Washington State Plan North, NAD83, US ft
3. Vertical datum: MLLW, ft
4. Once the volume is determined, the size of the area set aside for containment of the R.G. Haley material will be increased or decreased as needed to accommodate the actual volume.

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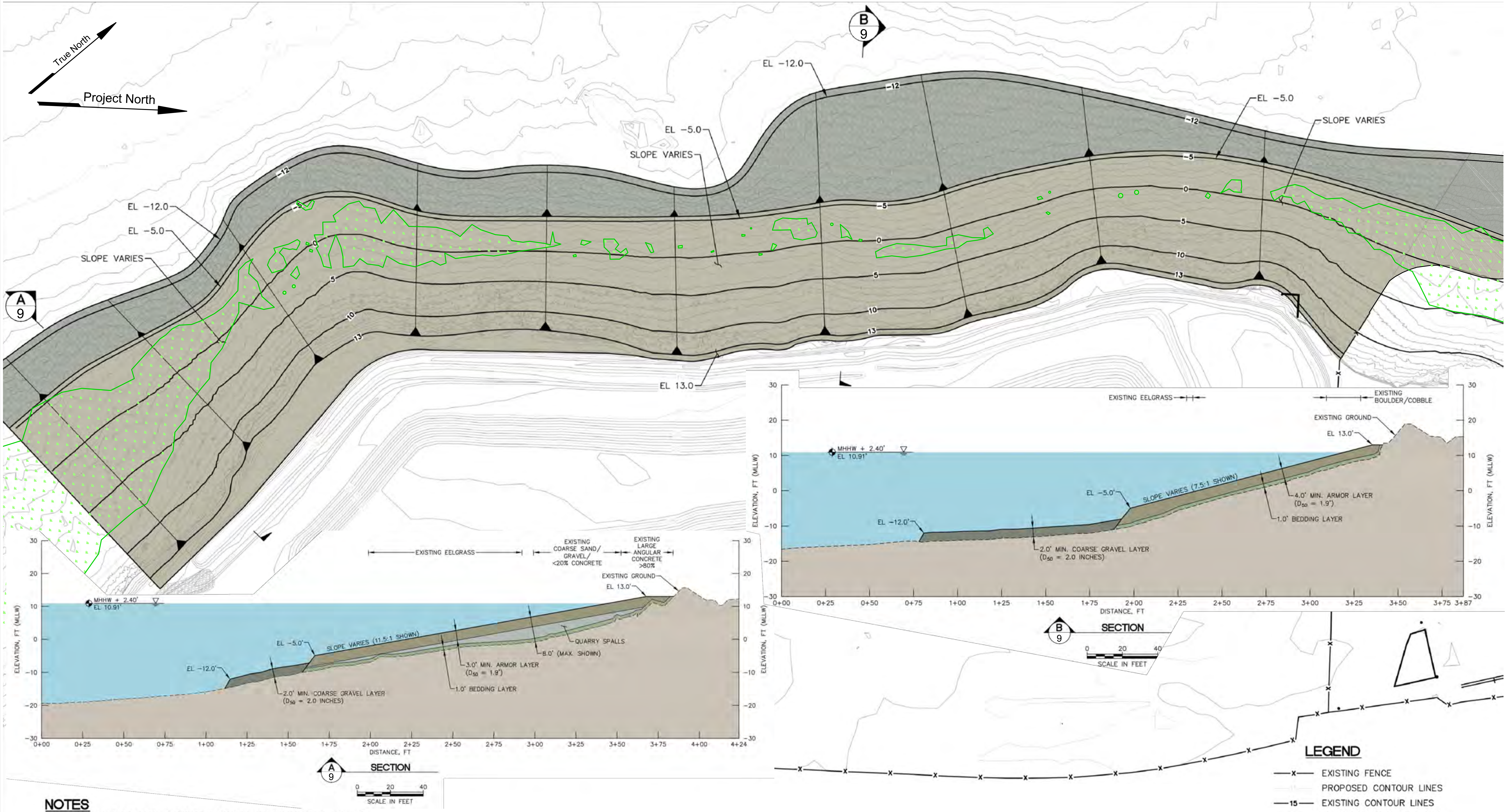
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Site Grading Plan
Below Cover

Figure
8



LEGEND

—x— EXISTING FENCE
PROPOSED CONTOUR LINES
—15— EXISTING CONTOUR LINES
—MHHW— MEAN HIGHER HIGH WATER
▨ ARMOR
▨ COARSE GRAVEL
🟩 EXISTING EEL GRASS FOOTPRINT

NOTES

1. CONTOUR LINES FROM SURFACE PROVIDED BY WILSON ENGINEERING. BATHYMETRY SURVEY CONDUCTED ON FEBRUARY 2015 AND TOPOGRAPHIC SURVEY CONDUCTED ON MARCH 2015.
2. HORIZONTAL DATUM: WASHINGTON STATE PLAN NORTH, NAD83, U.S. FT
3. VERTICAL DATUM: MLLW, FT
4. MAPPING OF SHORELINE FEATURES PROVIDED BY GRETTE ASSOCIATES.

Basemap source: Coast & Harbor Engineering 2015

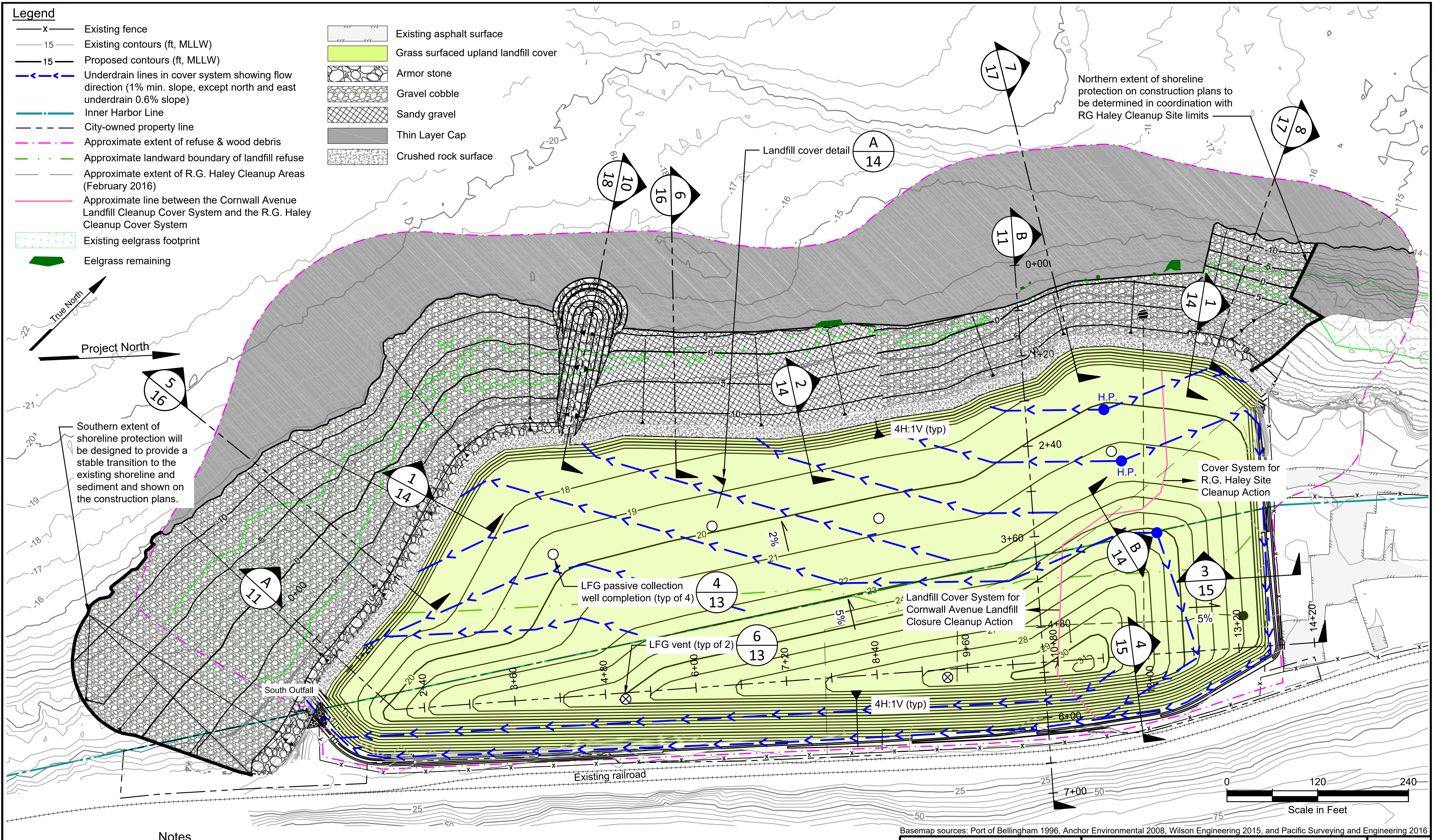
0 100 200
Scale in Feet

Landau Associates

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Baseline Shoreline Protection Plan

Figure
9



Notes

1. Contour lines from surface provided by Wilson Engineering. Bathymetry survey conducted February 2015 and topographic survey conducted March 2015.
2. Horizontal datum: Washington State Plan North, NAD83, US ft
3. Vertical datum: MLLW, ft

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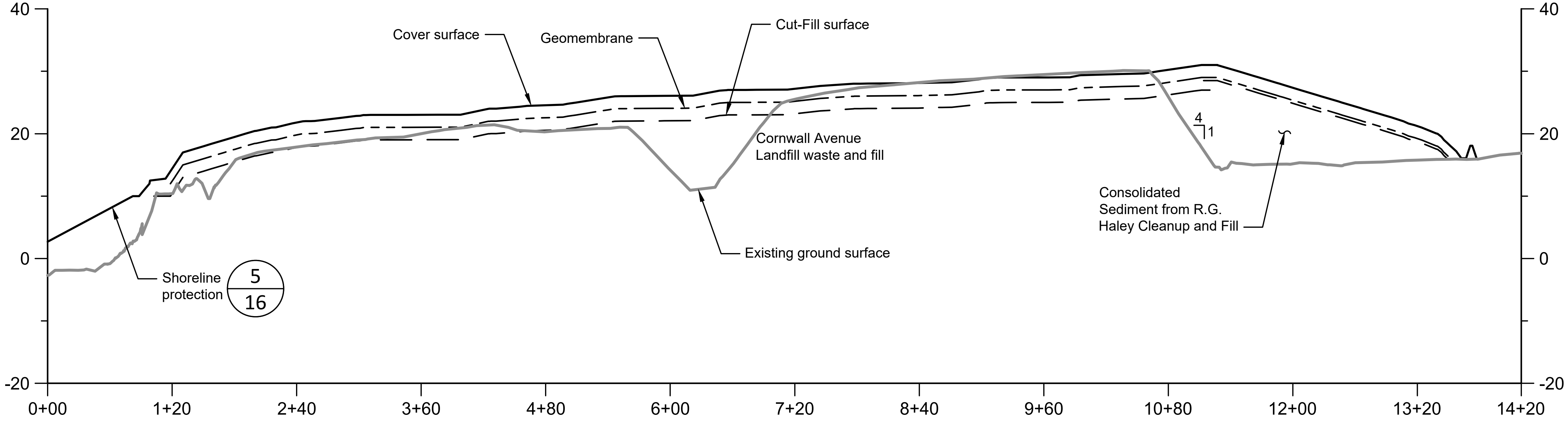
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

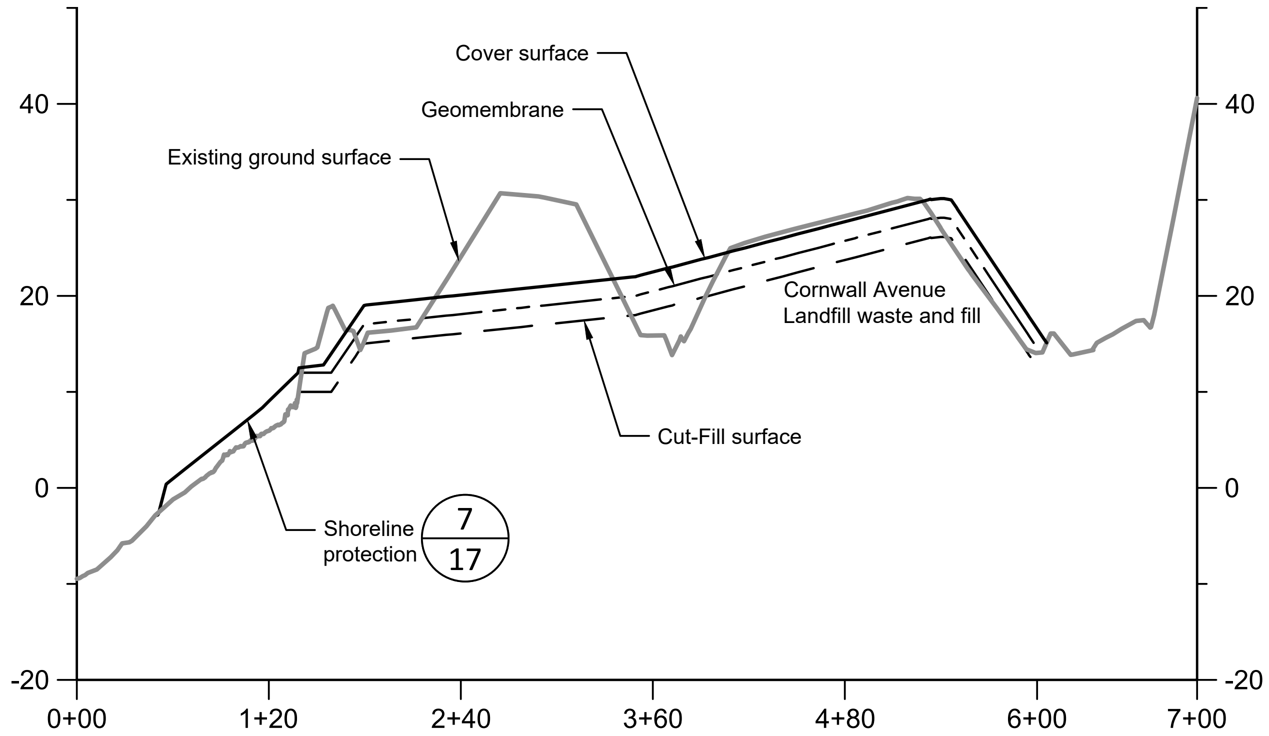
Alternative Shoreline Protection and Cover Plan

Figure
10



A
10
Section A-A'

HORIZ. 0 120 240
VERT. 0 20 40
SCALE IN FEET



B
10
Section B-B'

HORIZ. 0 120 240
VERT. 0 20 40
SCALE IN FEET

LANDAU ASSOCIATES, INC. | G:\Projects\001\037\040\041\EDR\F11 Sections.dwg (A) "Figure 11" 6/27/2017

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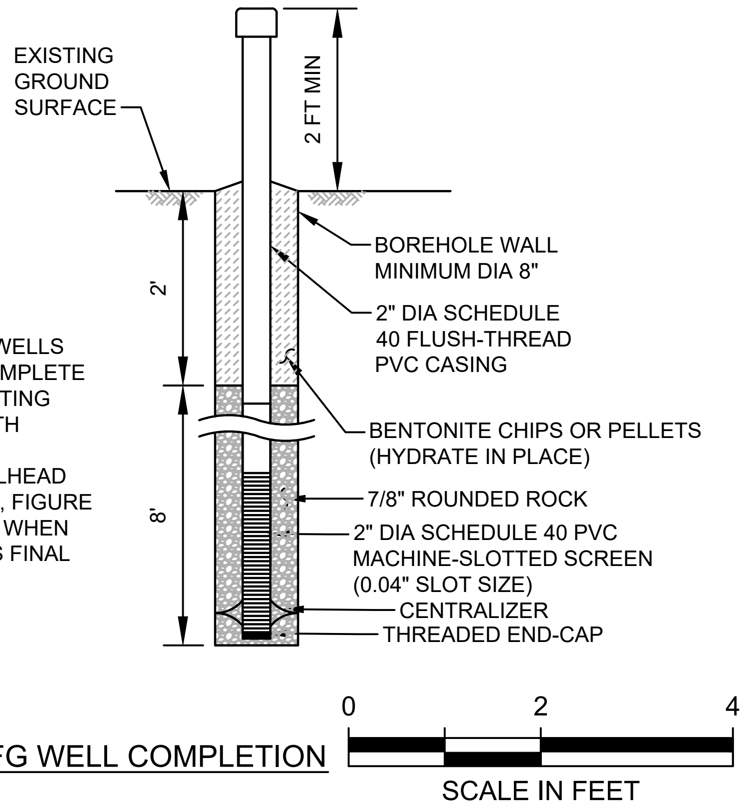
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Landfill Sections

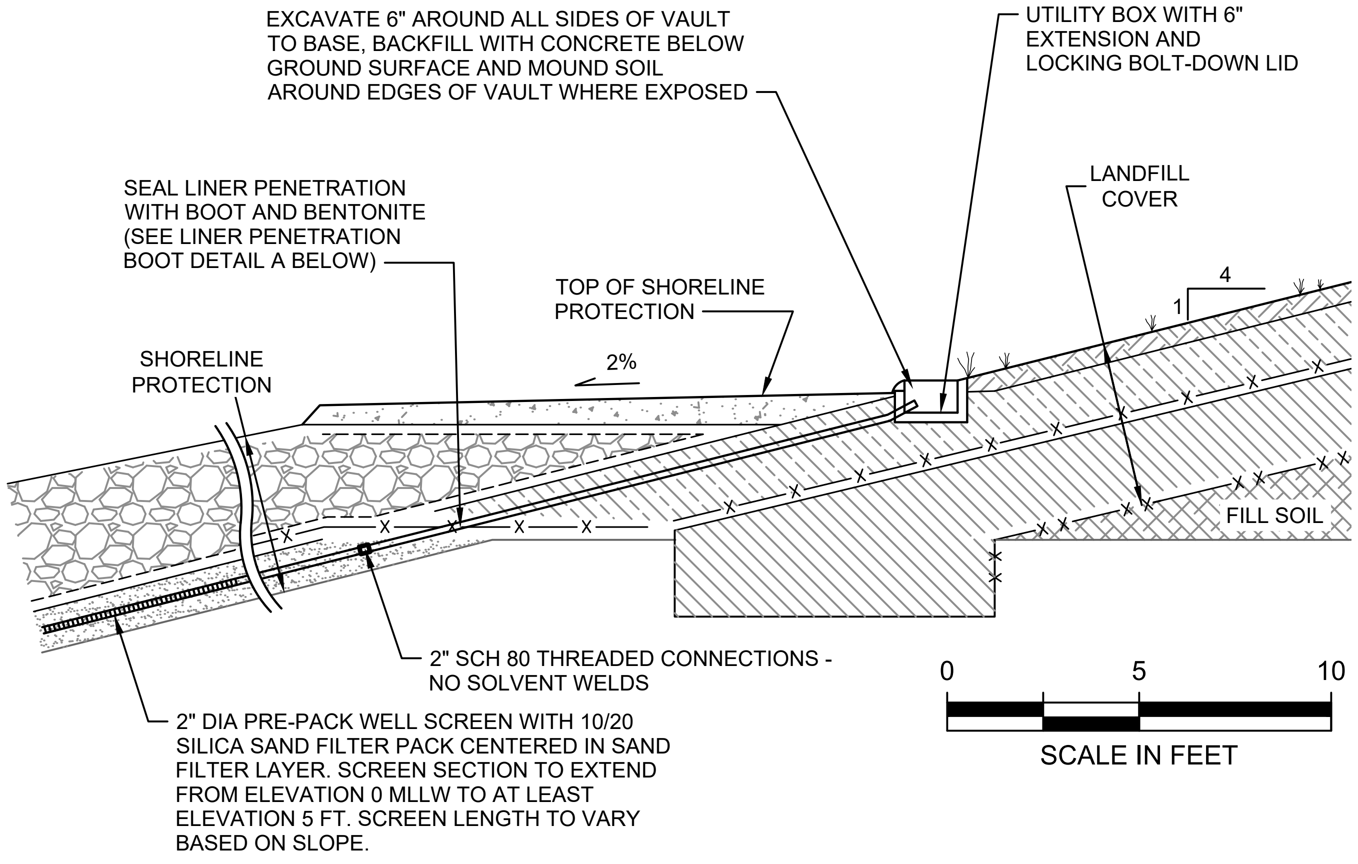
Figure
11



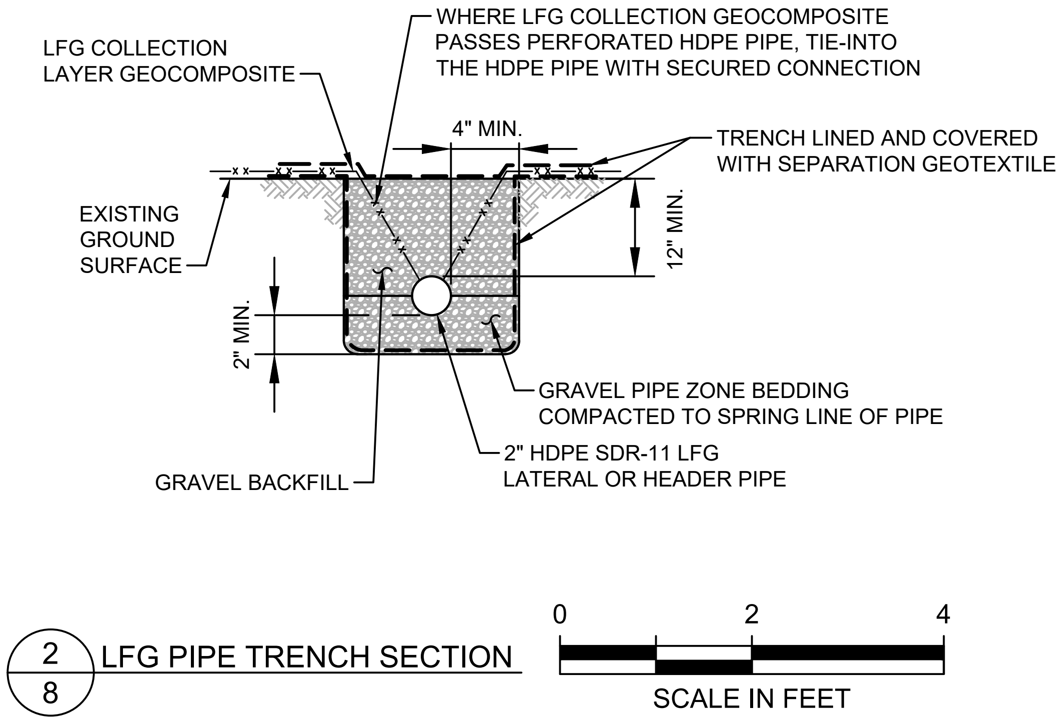
NOTE

1. INSTALL EXTRACTION WELLS AND TEMPORARILY COMPLETE WELL 2 FT ABOVE EXISTING GROUND SURFACE WITH THREADED PVC CAP. INSTALLATION OF WELLHEAD AS SHOWN IN DETAIL 4, FIGURE 8 WILL BE COMPLETED WHEN EARTHWORK REACHES FINAL GRADING ELEVATION.

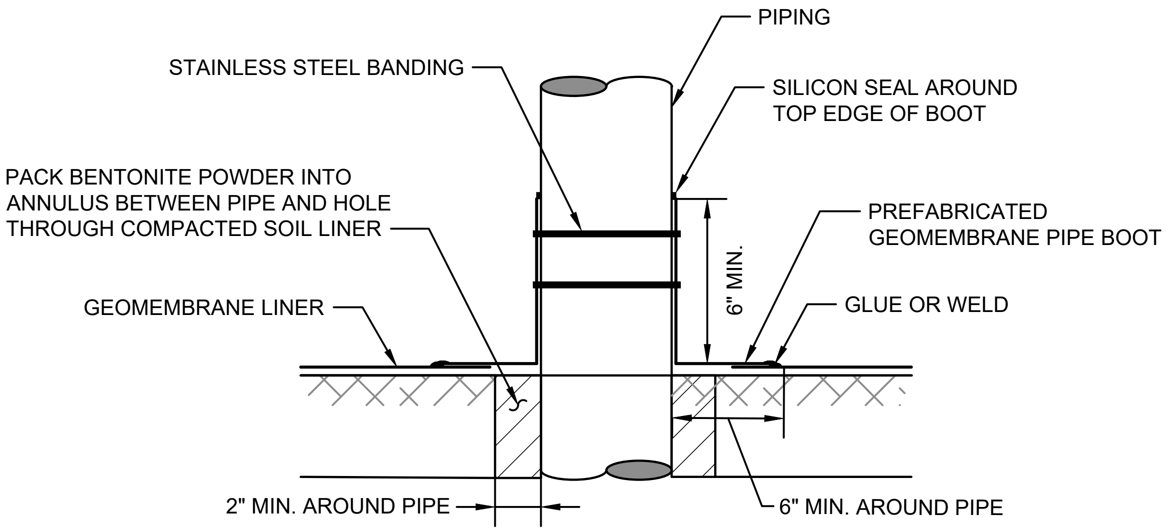
1/8 TEMPORARY LFG WELL COMPLETION



3/8 GROUNDWATER MONITORING WELL



2/8 LFG PIPE TRENCH SECTION



A/12 LINER PENETRATION BOOT DETAIL
(TYP.FOR GAS WELLS, MONITORING WELLS AND OTHER LINER PENETRATIONS)

LANDAU ASSOCIATES, INC. | G:\Projects\0011037\040\041\EDR\F12 F13 LFG Details.dwg (A) "Figure 12" 3/3/2017

LANDAU ASSOCIATES

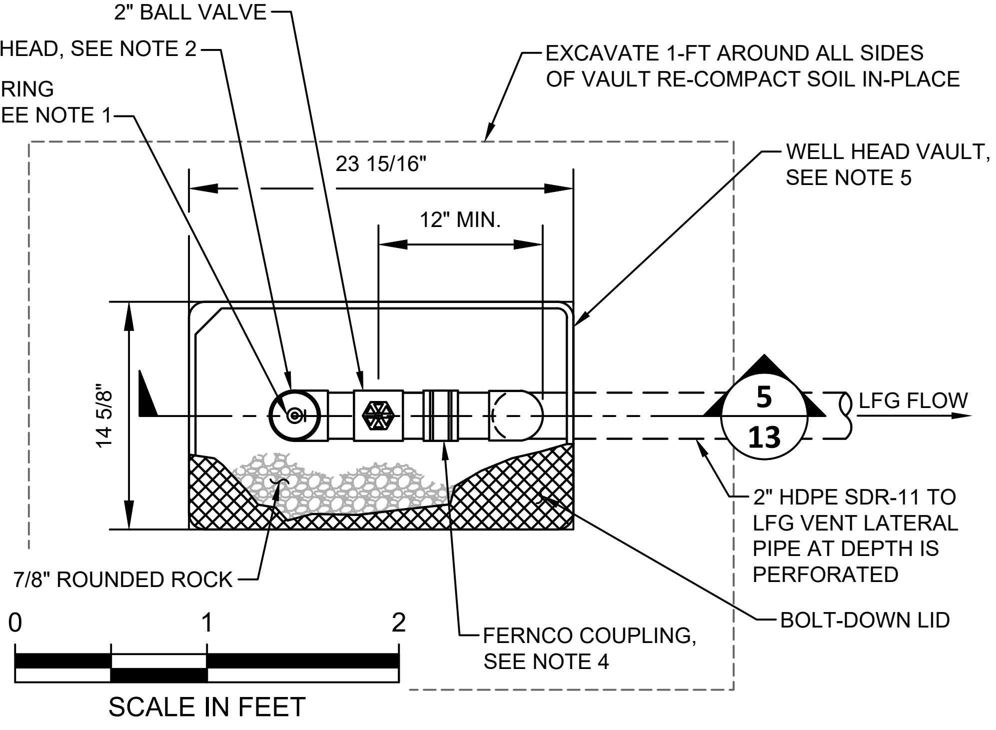
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

LFG Control System and Groundwater Monitoring Well Installation Details

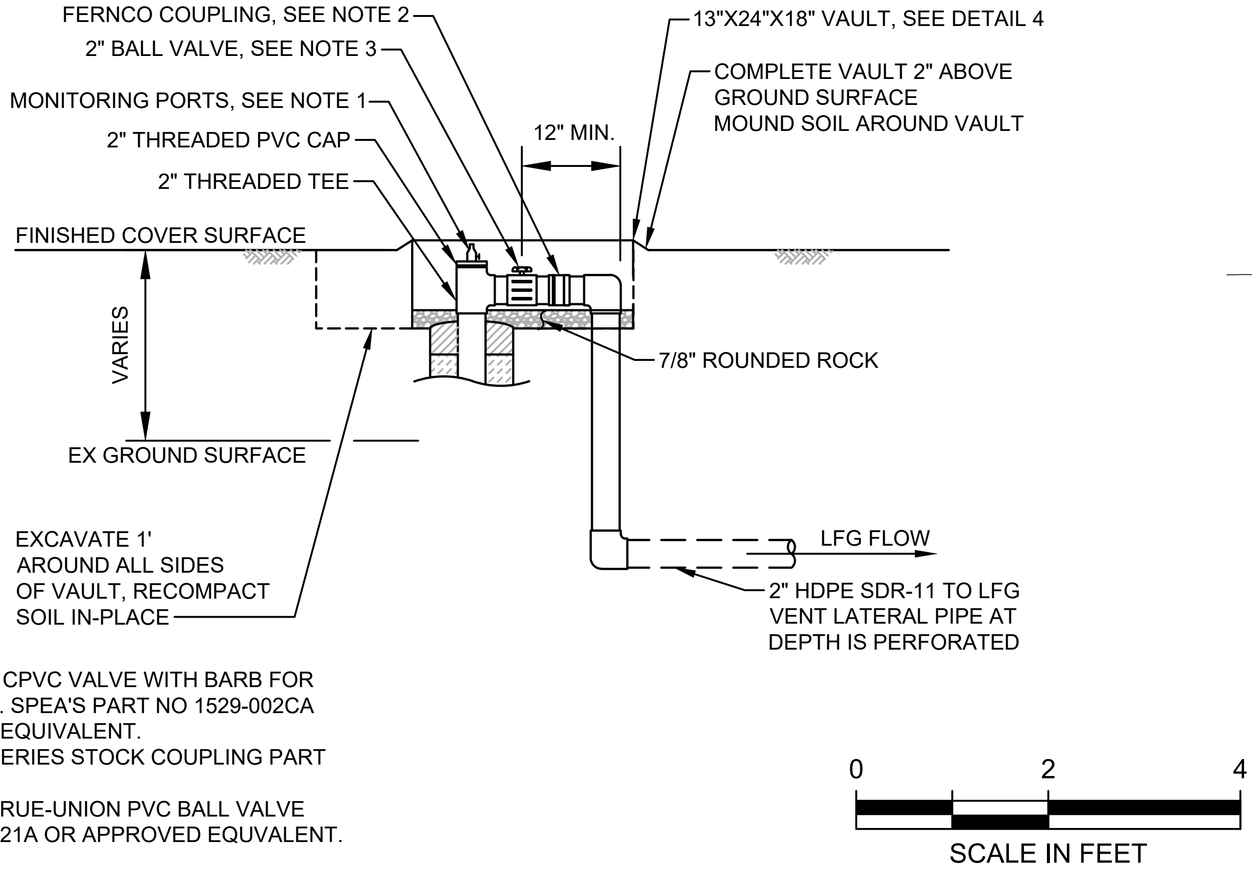
Figure
12

NOTES

1. 1/4" THREADED CPVC BALL VALVE WITH HOSE BARB FOR AIR SAMPLING SPEARS PART NO. 1529-002CA OR APPROVED EQUIVALENT MINIMUM CLARENCE BETWEEN HOSE BARB AND VAULT LID IS 6 INCHES.
2. LFG EXTRACTION WELL HEAD MINIMUM CLEARANCE TO VAULT INNER WALL IS 3 INCHES. TOP IS THREADED PVC CAP DRILLED AND TAPPED TO ACCEPT MONITORING PORT, SEE NOTE 1.
3. FERNCO 1059 SERIES STOCK COUPLING PART NO. 1059-150 OR APPROVED EQUIVALENT.
4. WELL HEAD VAULT FIBRELYTE UTILITY BOX WITH 6" EXTENSION AND LOCKING BOLT-DOWN LID BY OLD CASTLE PRECAST INC. PAR NOS: FL30T BOX 24, FL30X6, FL30T. LID TO BE ETCHED BY OLD CASTLE PRECAST WITH THE WELL NAME. CONTRACTOR TO CONFIRM LOCKING MECHANISM IS PROVIDED.



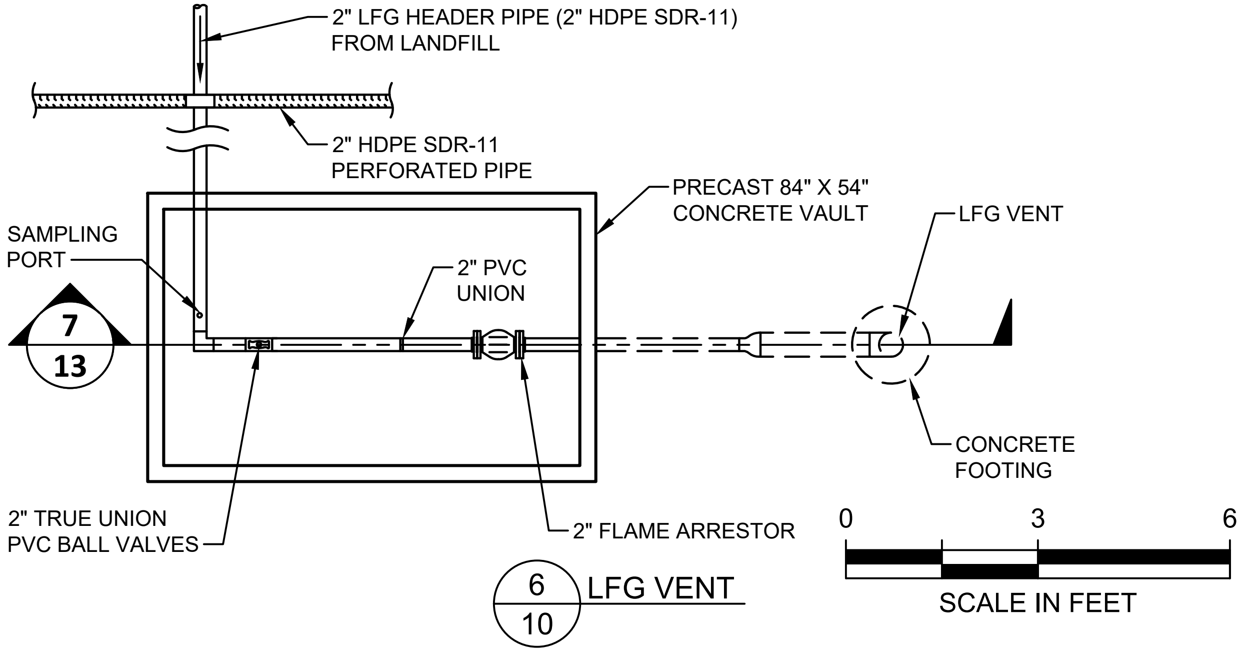
4/10 LFG PASSIVE COLLECTION WELL COMPLETION



NOTES

1. 1/4" THREADED CPVC VALVE WITH BARB FOR GAS SAMPLING. SPEA'S PART NO 1529-002CA OR APPROVED EQUIVALENT.
2. FERNCO 1059 SERIES STOCK COUPLING PART NO. 1059-150.
3. 2" THREADED TRUE-UNION PVC BALL VALVE ASAHI TYPE 21/21A OR APPROVED EQUVALENT.

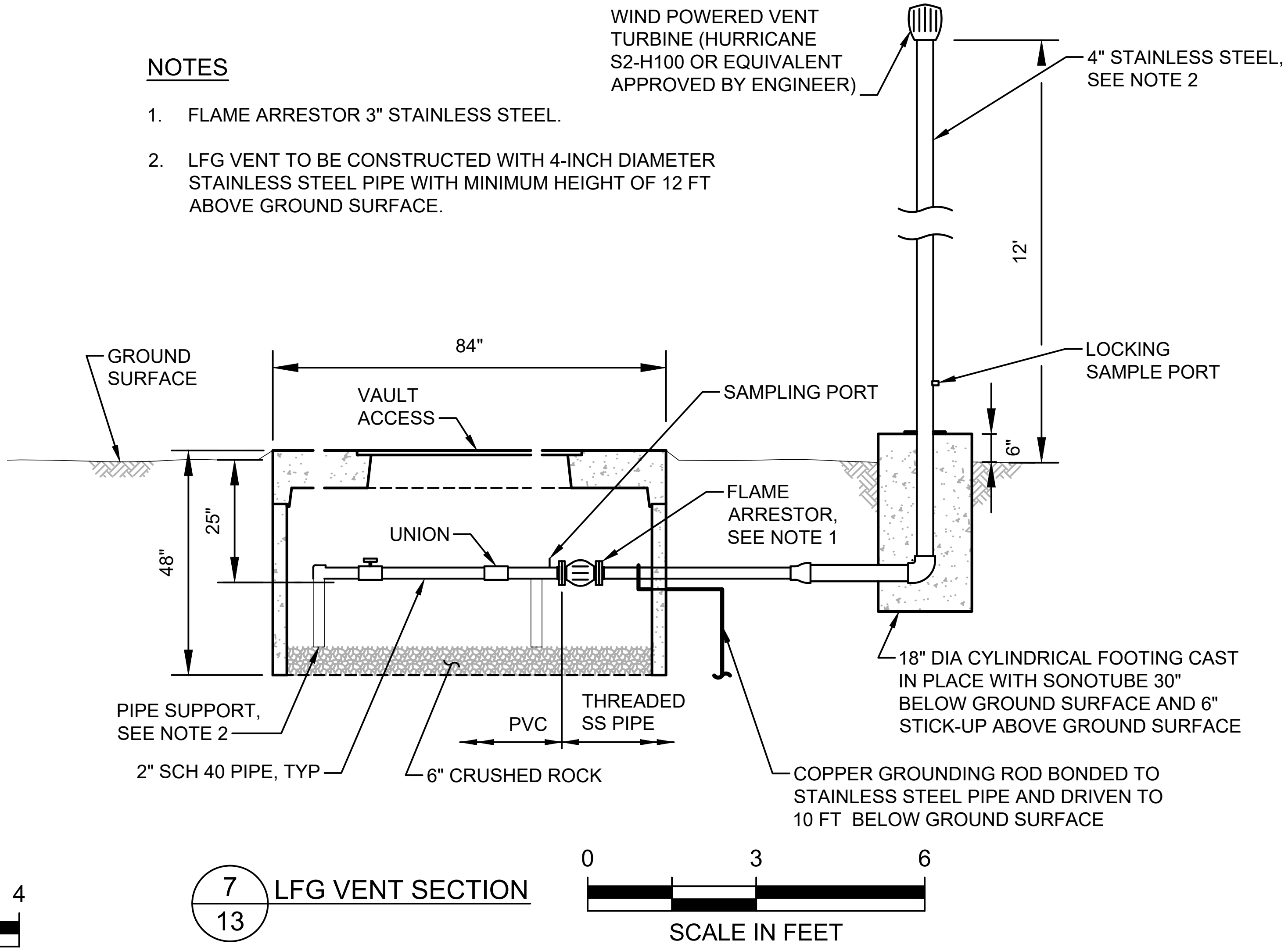
5/13 LFG PASSIVE COLLECTION WELL COMPLETION SECTION



6/10 LFG VENT

NOTES

1. FLAME ARRESTOR 3" STAINLESS STEEL.
2. LFG VENT TO BE CONSTRUCTED WITH 4-INCH DIAMETER STAINLESS STEEL PIPE WITH MINIMUM HEIGHT OF 12 FT ABOVE GROUND SURFACE.



7/13 LFG VENT SECTION

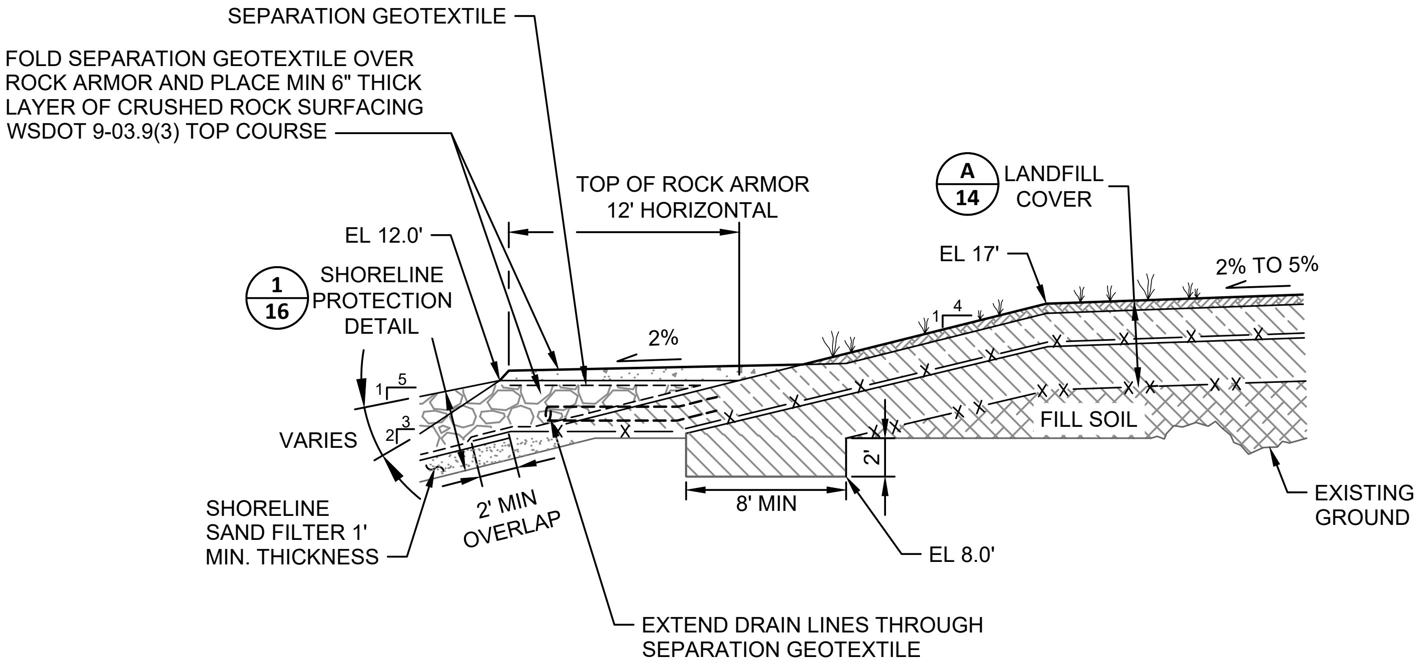
LANDAU ASSOCIATES, INC. | G:\Projects\001037\040\041\EDR\F12 F13 LFG Details.dwg (A) "Figure 13" 3/3/2017

LANDAU ASSOCIATES

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

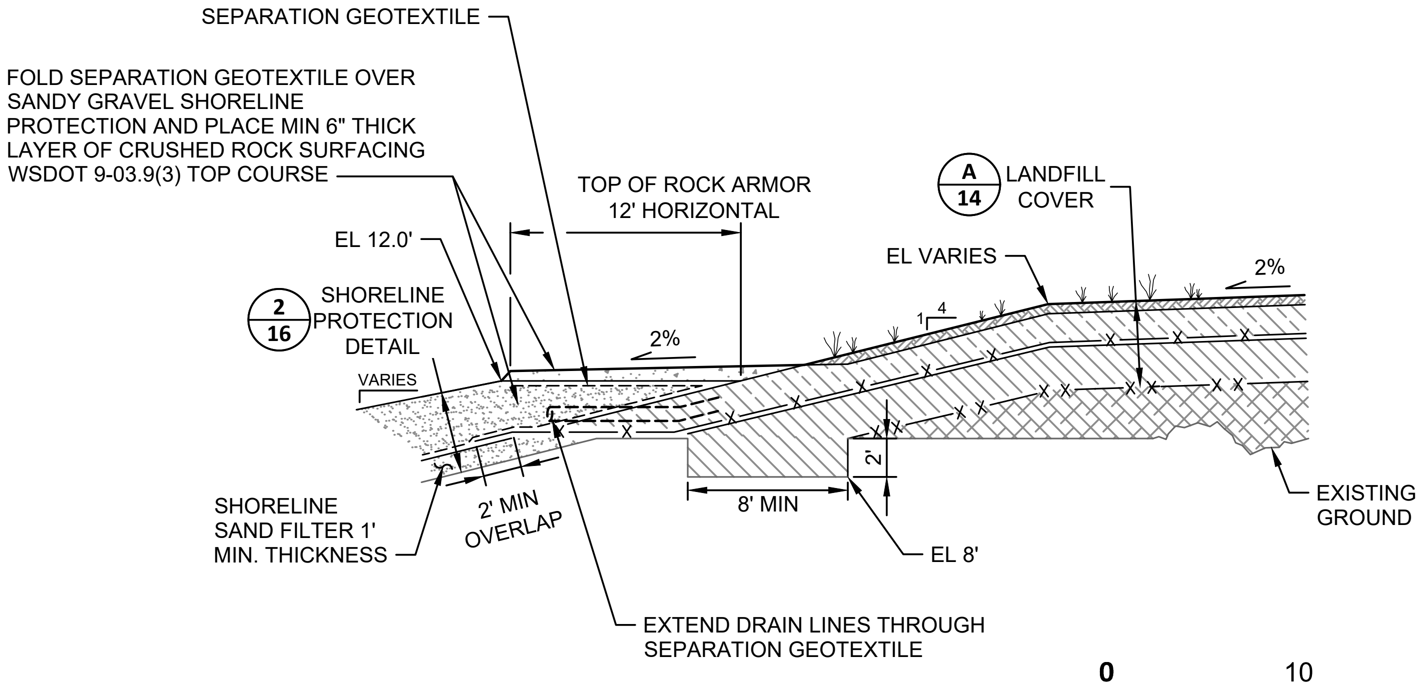
Landfill Gas Completion Details

Figure
13



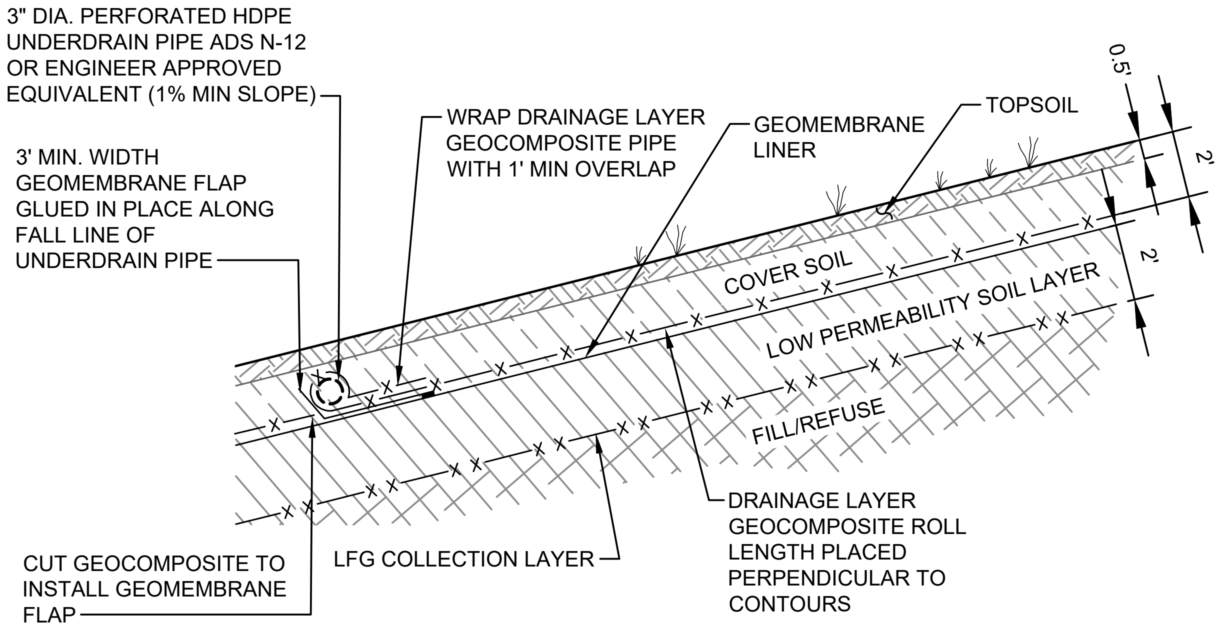
1
10
COVER TO SHORELINE TIE-IN DETAIL (TYP)

0 10 20
SCALE IN FEET



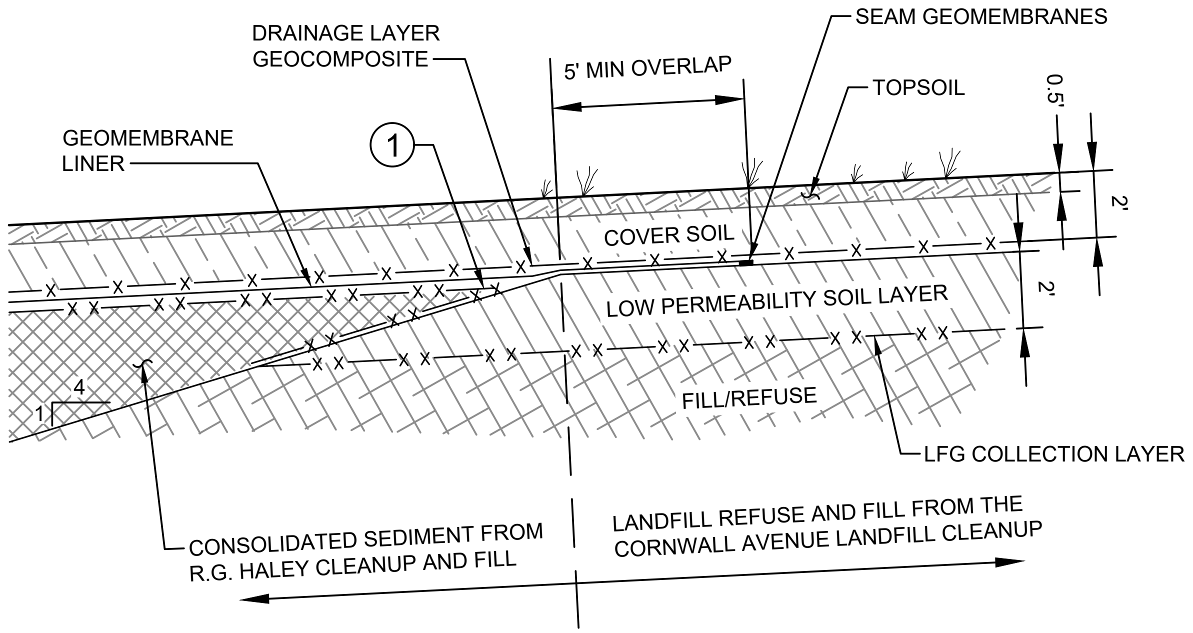
2
10
COVER TO SHORELINE TIE-IN DETAIL (TYP)

0 10 20
SCALE IN FEET



A
-
LANDFILL COVER DETAIL

0 5 10
SCALE IN FEET



①. FOLD LEADING EDGE OF LFG UP OVER LOW-PERMEABILITY SOIL LAYER, ZIP-TIE GEONET COMPONENT OF R.G. HALEY CONSOLIDATED SEDIMENT LFG COLLECTION LAYER TO EXISTING GEONET ON 5' MAX INTERVALS, OVERLAP GEOTEXTILE COMPONENT AND CONTINUOUSLY HEAT BOND ALONG SEAM.

B
10
COVER TRANSITION DETAIL

0 5 10
SCALE IN FEET

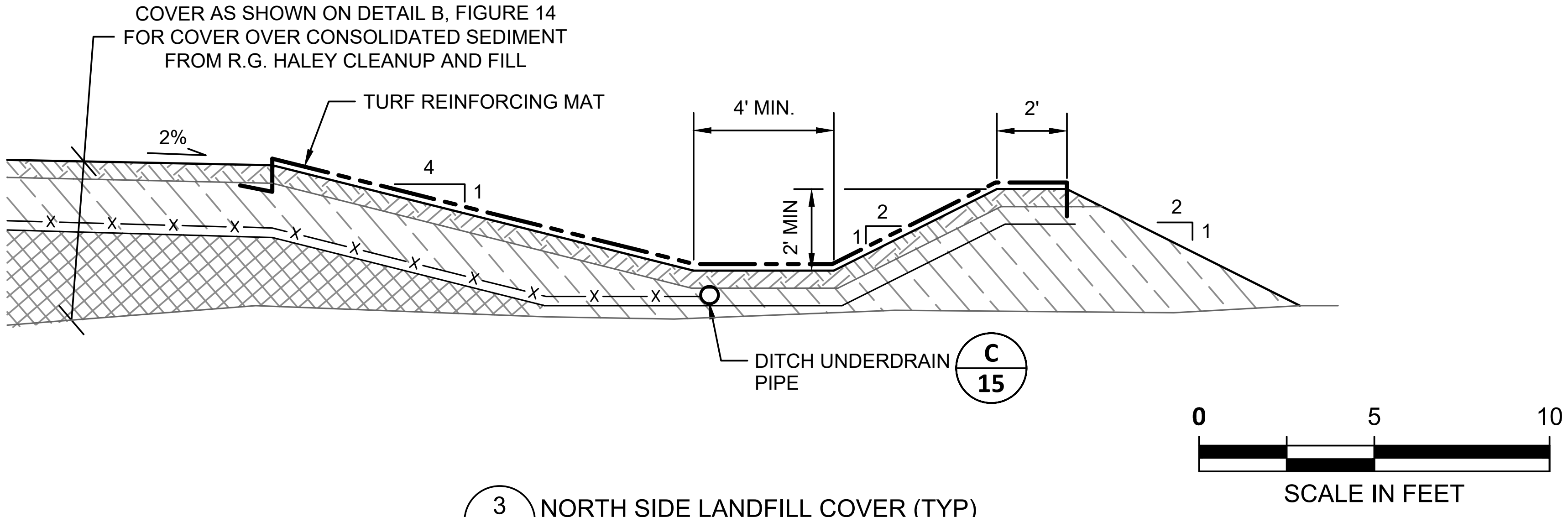
LANDAU ASSOCIATES, INC. | G:\Projects\001\037\040\041\EDR\F14 F15 Cover Details.dwg (A) "Figure 14" 6/27/2017

LANDAU
ASSOCIATES

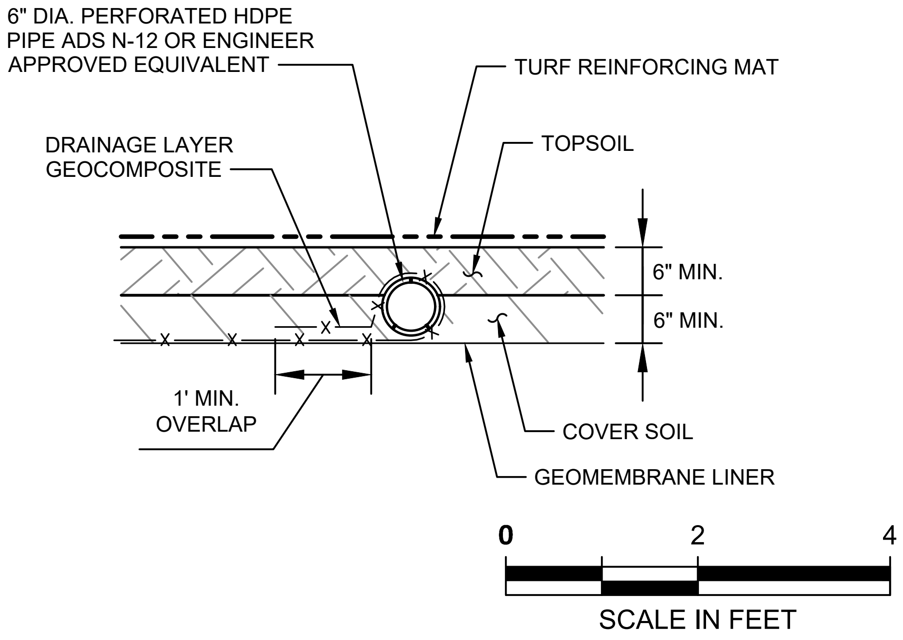
Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Cover Details

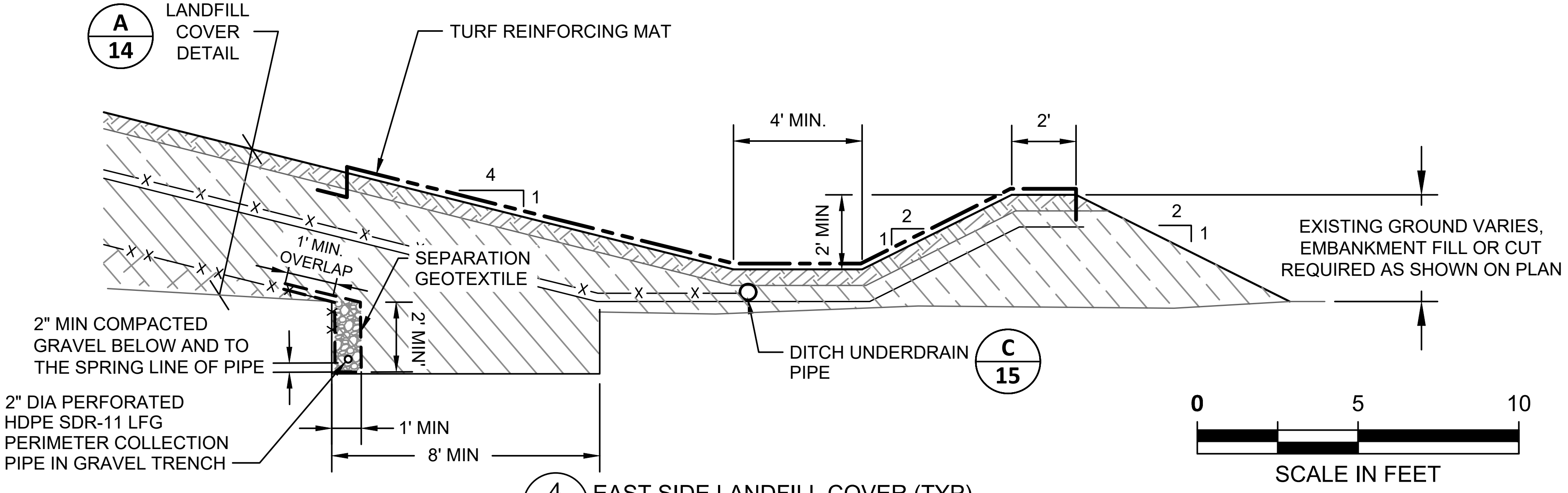
Figure
14



3
10
NORTH SIDE LANDFILL COVER (TYP)



C
-
DITCH UNDERDRAIN PIPE DETAIL



4
10
EAST SIDE LANDFILL COVER (TYP)

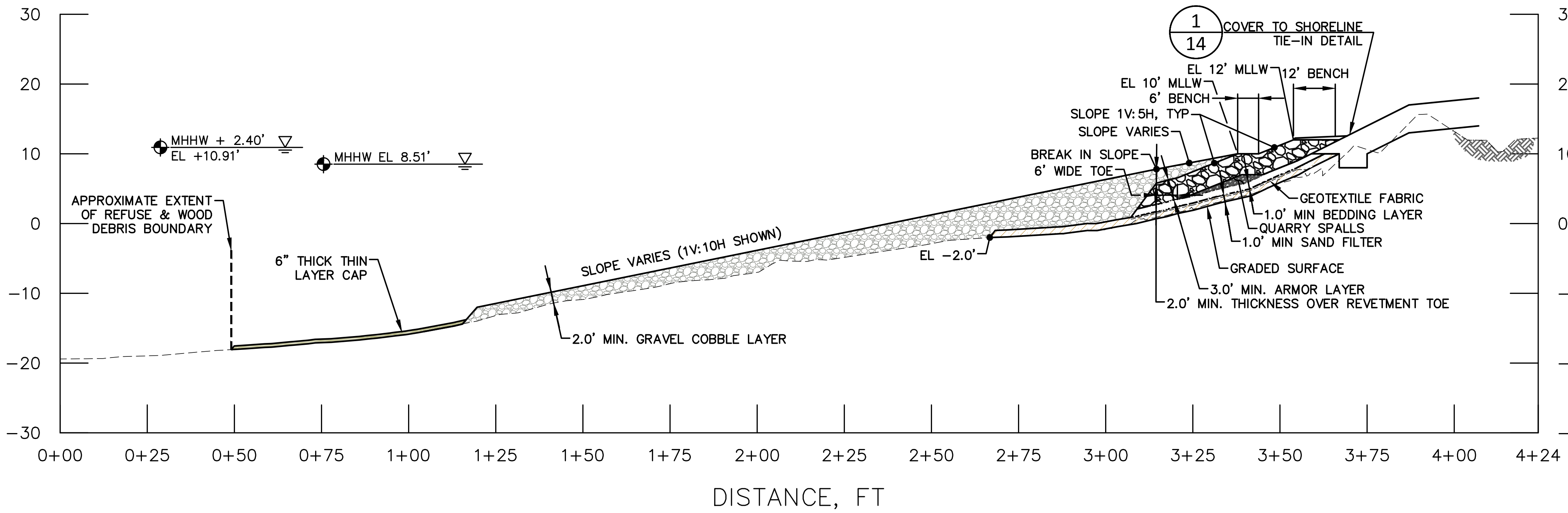
LANDAU ASSOCIATES, INC. | G:\Projects\001\037\040\041\EDR\F14 F15 Cover Details.dwg (A) "Figure 15" 6/27/2017

LANDAU
ASSOCIATES

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

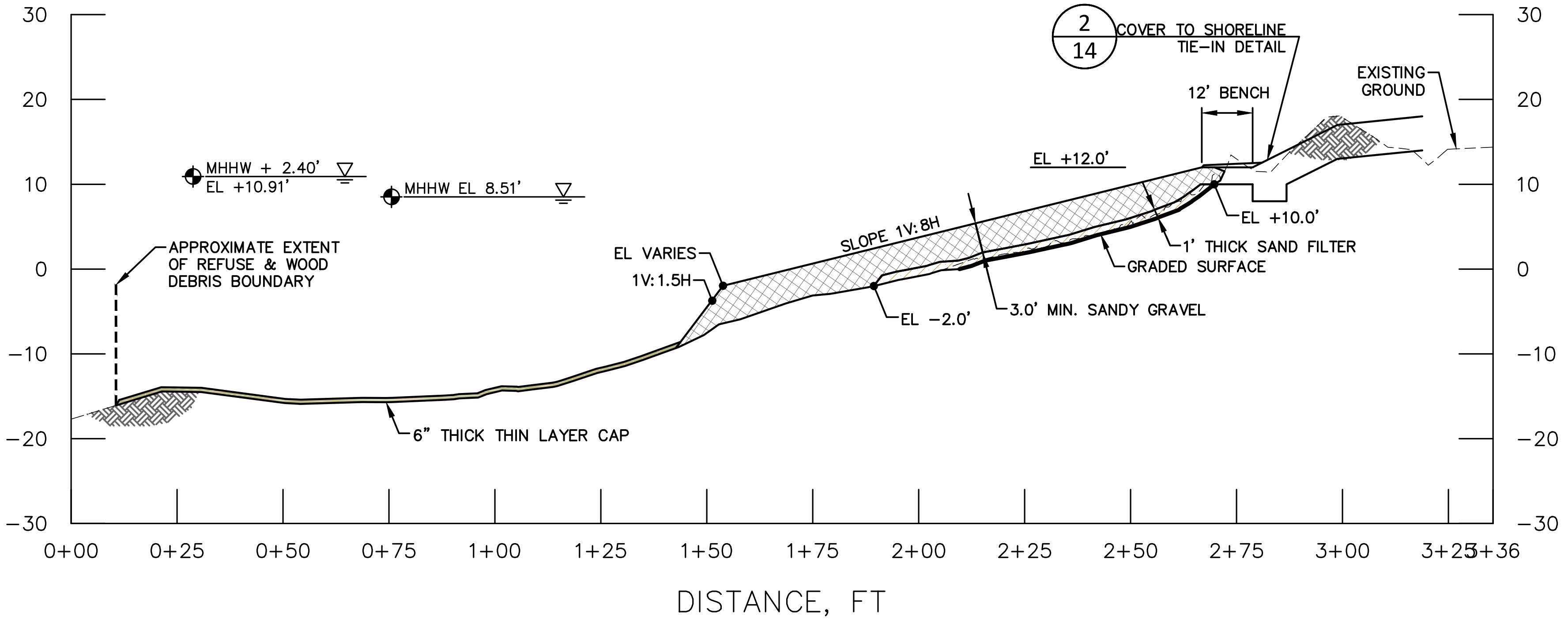
Cover Details

Figure
15



5
10
ARMOR STONE SOUTH REVETMENT

HORIZ. 0 40 80
VERT. 0 20 40
SCALE IN FEET



6
10
SANDY GRAVEL REVETMENT

HORIZ. 0 40 80
VERT. 0 20 40
SCALE IN FEET

LEGEND

PATTERN	MATERIAL	AVERAGE (D50) GRAIN SIZE
▨	ARMOR STONE	1.5 FEET
▨	QUARRY SPALLS	4 INCH
▨	GRAVEL COBBLE	2-1/2 INCH
▨	BEDDING	5/8 INCH
▨	SANDY GRAVEL	#10 U.S. SIEVE
▨	SAND FILTER	#20 U.S. SIEVE
▨	THIN LAYER CAP	#30 U.S. SIEVE

Source: Coast and Harbor Engineering 2015

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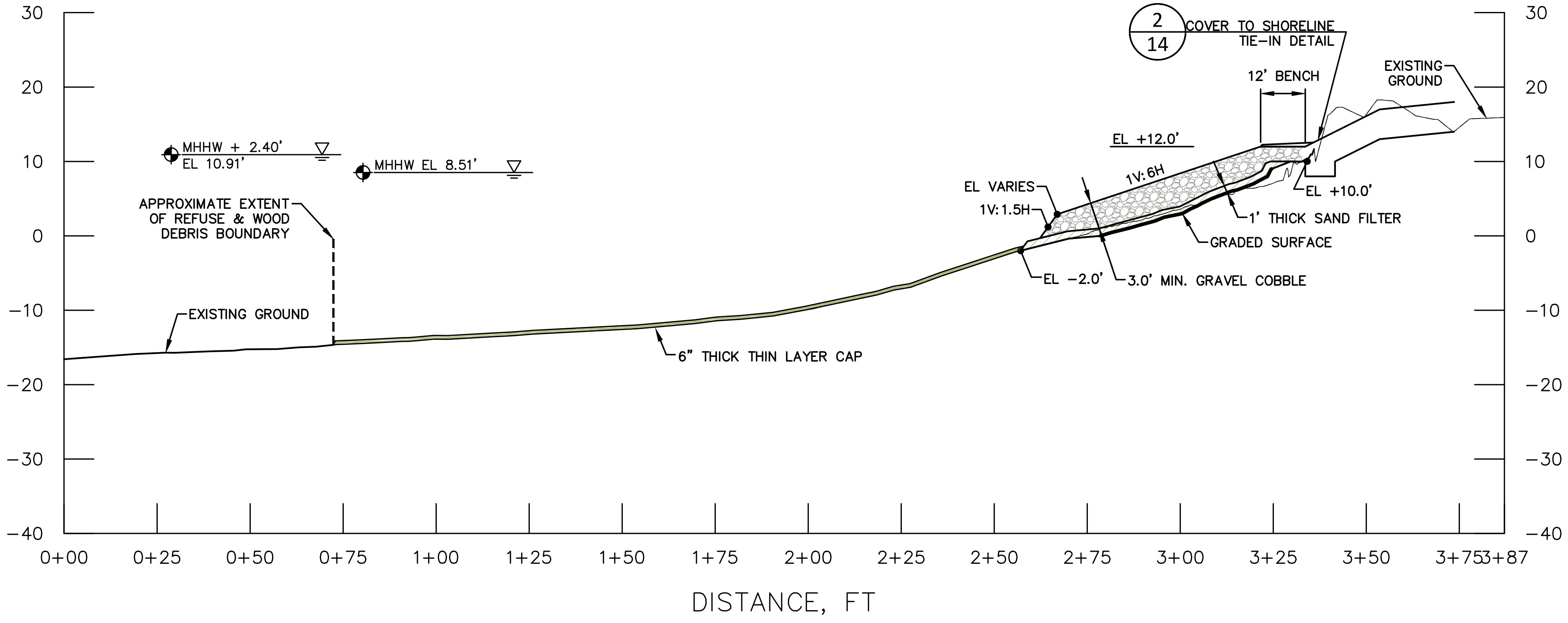
LANDAU ASSOCIATES

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

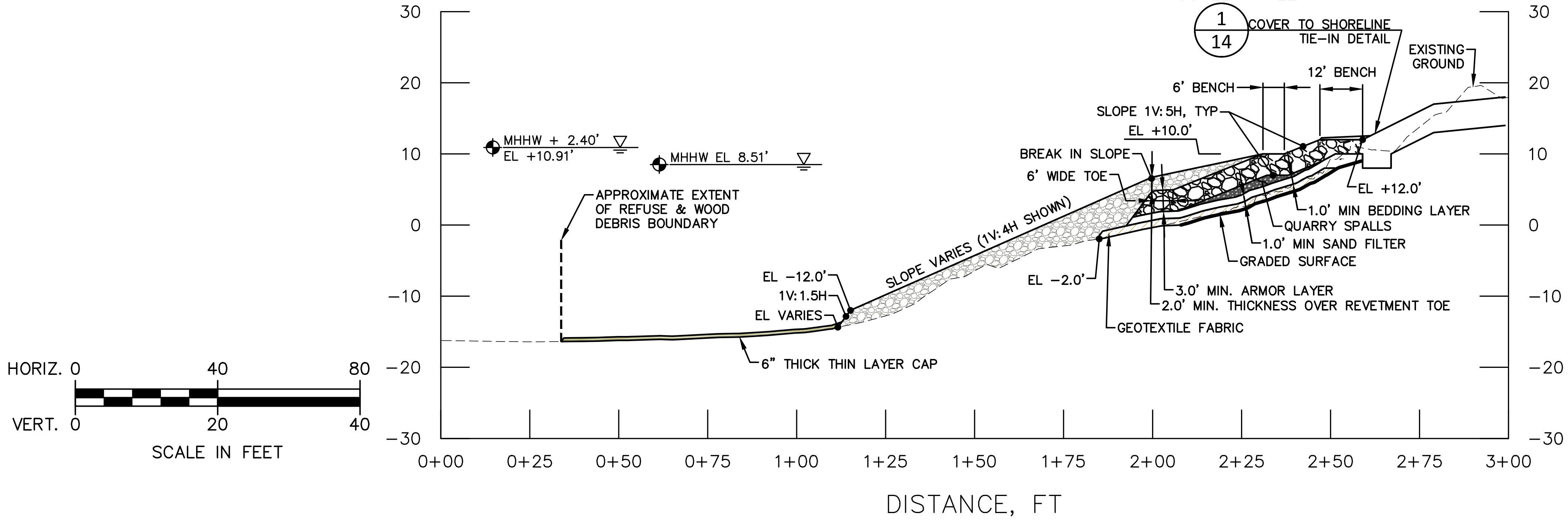
Shoreline Protection Details

Figure
16



7
10
GRAVEL COBBLE REVETMENT

HORIZ. 0 40 80
VERT. 0 20 40
SCALE IN FEET



8
10
ARMOR STONE NORTH REVETMENT

LEGEND

PATTERN	MATERIAL	AVERAGE (D50) GRAIN SIZE
▨	ARMOR STONE	1.5 FEET
▨	QUARRY SPALLS	4 INCH
▨	GRAVEL COBBLE	2-1/2 INCH
▨	BEDDING	5/8 INCH
▨	SANDY GRAVEL	#10 U.S. SIEVE
▨	SAND FILTER	#20 U.S. SIEVE
▨	THIN LAYER CAP	#30 U.S. SIEVE

Source: Coast and Harbor Engineering 2015

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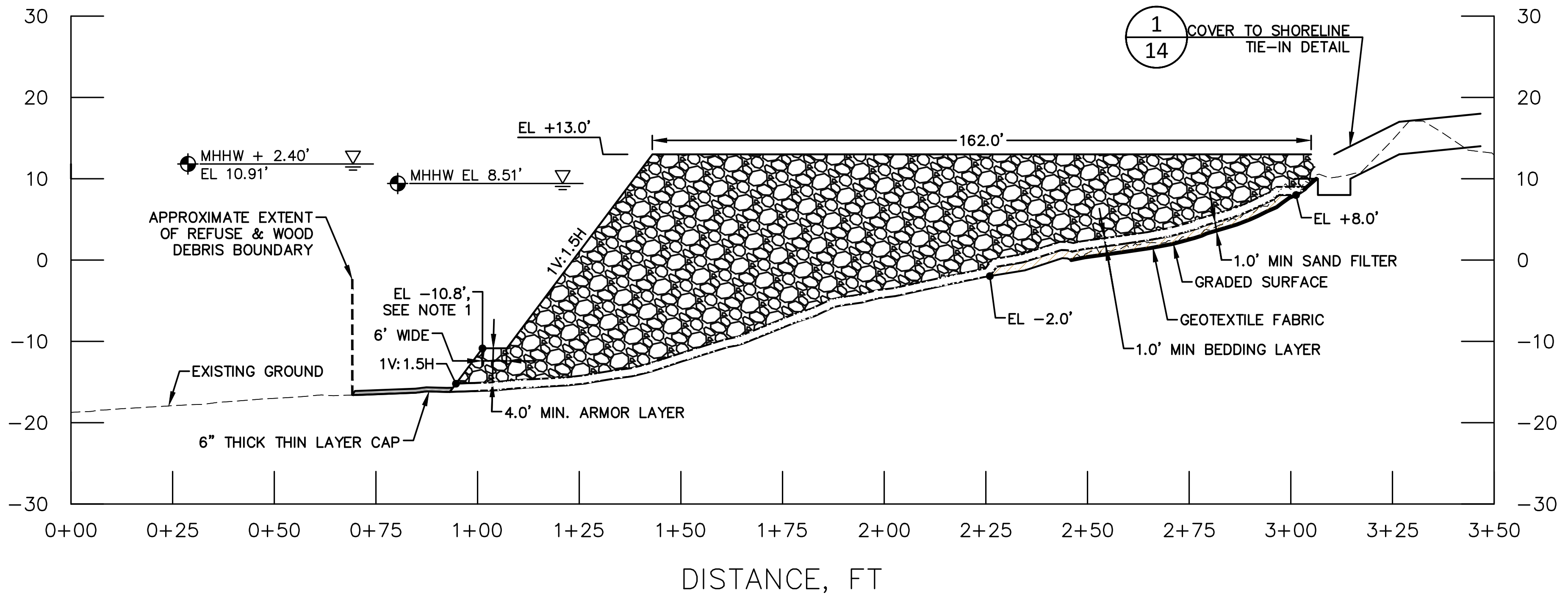
LANDAU ASSOCIATES

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Shoreline Protection Details

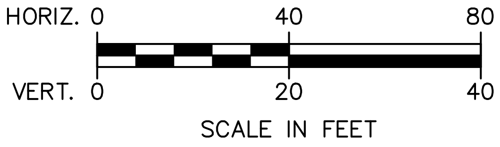
Figure
17



NOTE:

1. GROIN TOE PROTECTION DETAILS SHOWN ARE CONCEPTUAL AND SHALL BE DESIGNED IN CONSTRUCTION DRAWING PHASE.

9
10
GROIN



LEGEND

PATTERN	MATERIAL	AVERAGE (D50) GRAIN SIZE
▨	GROIN ARMOR STONE	1.9 FEET
▨	QUARRY SPALLS	4 INCH
▨	GRAVEL COBBLE	2-1/2 INCH
▨	BEDDING	5/8 INCH
▨	SAND FILTER	#20 U.S. SIEVE
▨	THIN LAYER CAP	#30 U.S. SIEVE

Source: Coast and Harbor Engineering 2015

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Shoreline Protection Details

Figure
18

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APPENDIX A

Landfill Gas Design

APPENDIX A

LANDFILL GAS CONTROL SYSTEM DESIGN

TABLE OF CONTENTS

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A.2	Landfill Gas Monitoring Probe Installation Logs
A.3	Landfill Gas Monitoring Data
A.4	Landfill Gas Emissions
A.5	Landfill Gas Cleanup Levels
A.6	Landfill Gas System Design

LANDFILL GAS CONTROL SYSTEM DESIGN

This appendix provides design-basis information for developing the landfill gas (LFG) collection and control system described in the Engineering Design Report (EDR). LFG control is a required component of this cleanup action, since the cleanup remedy includes constructing an impermeable cap over the upland portion of the Cornwall Avenue Landfill site (Site) which will affect the release of LFG from the subsurface municipal solid waste (MSW) and wood waste. In the current condition, LFG is generated as waste breaks down, and is able to slowly ventilate through the existing permeable soil cover. LFG can be explosive at higher concentrations when allowed to accumulate in confined spaces, and can pose a threat to human health if it contains volatile organic compounds (VOCs) at concentrations exceeding applicable regulatory criteria. After constructing an impermeable cap, the LFG must therefore be provided with a ventilation pathway, or it could potentially build up enough pressure during waste degradation to lift the cap or cause lateral migration. LFG must also be vented in a manner that does not pose an unacceptable risk to human health.

The design goals of the LFG control system design are the following:

- Prevent accumulation of LFG under the landfill cap by providing an LFG capture layer beneath the impermeable cover that is connected to the atmosphere.
- Provide internal pressure relief to reduce the potential for lateral migration
- Provide controlled release of LFG through engineered vents to prevent fugitive emissions where exposure is uncontrolled, and vent LFG in a manner that is adequately protective of human health.

As part of this evaluation, Landau Associates conducted two phases of pre-design field investigation, developed a model of the LFG generation rate, and created an air dispersion model to evaluate ambient air impacts that could be caused by the LFG being exhausted through passive vents. These data were used to develop the conceptual design elements of the LFG control system included in the EDR. The design provided in the EDR is considered conservatively protective by using worst-case input parameters regarding potential hazards and weather conditions that might affect human exposure.

Many of the elements included in the design would be considered excessive based on current property usage. However, because future property usage is planned as a public park, the LFG control system design will include several considerations intended to provide adequate protection for park visitors following completion of cleanup action construction.

The following sections describe the development of Site conditions relating to LFG production, gas quality, potential exposures, and design considerations.

Landfill Gas Generation Modeling

This section summarizes the LFG production rate evaluation for the Site. The LFG production rate was estimated using the US Environmental Protection Agency's (EPA) LandGEM spreadsheet model – the industry standard approach for estimating LFG emissions for regulatory compliance, and a tool for LFG control system design. The estimate is based on the waste age, type, quantity of buried waste, and the subsurface environment.

According to the Site Remedial Investigation and Feasibility Study Report (RI/FS; Landau Associates 2013), approximately 94,000 cubic yards (yd^3) of wood waste was buried at the Site between 1888 to 1946 and 201,000 yd^3 of refuse (MSW) was buried between 1953 to 1965. This is a relatively small quantity of waste in comparison to modern landfills. Additionally, the waste is relatively old and has likely already exhausted the majority of the original LFG producing potential.

Modeling Approach

LandGEM is a spreadsheet based model prepared by EPA that estimates the overall flow rate of LFG from a MSW landfill based on user input regarding the amount of waste buried, the year of burial, and other parameters developed by EPA based on landfills across the US. Emissions factors used in the model are from the Compilation of Air Pollutant Emission Factors (AP-42; EPA 1998). The model allows variation of parameters affecting the overall LFG production capacity of the waste (given infinite time), and the rate at which the LFG is released – each constrained to typically observed ranges.

The total mass of waste is estimated based on the estimated volumes of buried MSW and wood waste, and typical waste density. Based on the reported years of operation for accepting MSW and wood waste, the total estimated buried mass of each component is separated into annual deposits. The model assumes a wood waste disposal rate of about 800 tons per year of acceptance and 4,700 tons per year of MSW; distributed in the upland portion of the landfill. Additionally, the model assumes approximately 3,100 tons per year of MSW was disposed in the marine portion of the Site.

The moisture content (saturated) of the solid waste buried under the marine portion of the Site was accounted for by adjusting the rate constant (k) to match that of a landfill with more than 40 annual inches of precipitation [$k = 0.12$ year^{-1}, as referenced in EPA's Waste Reduction Model (WARM Version 13)], maximizing this variable parameter within the allowable range. Three individual modeling runs were executed so the parameters could be varied for three unique conditions: wood waste, MSW in the marine portion of the Site, and MSW in the upland portion of the Site. It is assumed for the purposes of modeling a worst-case scenario that LFG generated by decomposition of MSW in the marine portion of the Site would migrate laterally toward the uplands and require capture and control at that location. The modeling output for each of these scenarios is provided in Attachment A.1. The results are discussed below. Note that although LandGem can be used to estimate LFG emissions, site-specific data were developed through field investigation instead. As a result, the model output provided in Attachment A.1 does not include VOCs. The site-specific VOC data derived during field testing is discussed in the following section (Landfill Gas Monitoring: Volatile Organic Compounds).

LFG Production Rate Modeling Results

The modeling results indicate an approximate total LFG gas generation rate of 4.7 cubic feet per minute (cfm) for year 2015, which includes the combined contributions of LFG generated from the degradation of all wastes at the Site (cumulative gas generation contribution from wood waste in the uplands, MSW in the uplands, and MSW in the water). Figure A-1 in Attachment A.1 presents the generation curve developed by the combining the output from the three modeling scenarios discussed above. Based on this low estimated rate of LFG production, a safety factor of greater than 2 will be applied to the production rate for design, and the capture and control system will be designed for an LFG flow rate of 10 cfm.

Landfill Gas Monitoring

Thirteen temporary LFG monitoring probes were installed throughout the Site. Installation logs are provided in Attachment A.2. LFG monitoring was conducted at these 13 probes, 4 existing landfill gas vents, and at 13 groundwater monitoring wells during 2 monitoring events as part of the pre-design investigation. The monitoring locations are shown on Figure A-2 in Attachment A.3. LFG monitoring was conducted in accordance with the procedures of the Pre-Design Investigation Work Plan (Landau Associates 2015). During the monitoring events, the following parameters were measured as presented in Tables A-1 (June 15, 2015 monitoring event) and A-2 (August 7, 2015 monitoring event) in Attachment A.3:

- Methane (CH_4)
- Oxygen (O_2)
- Carbon dioxide (CO_2)
- Carbon monoxide (CO)
- Hydrogen sulfide (H_2S)
- Hydrogen gas
- Static pressure
- Total VOCs by field-measurement with photoionization detector.

Volatile Organic Compounds

In addition to the field-analyzed parameters summarized above, LFG samples were collected during both events from a subset of the monitoring locations, and analyzed by an accredited laboratory using EPA Method TO-15 for a list of 75 VOCs. The tabulated VOC results are provided in Table A-3 along with the complete laboratory analytical reports in Attachment A.3.

Discussion of Results

The landfill continues to generate at least small quantities of LFG, as evidenced by elevated levels of methane and carbon dioxide, and depressed concentrations of oxygen. As anticipated, the highest concentrations of methane were detected in areas where MSW is buried, and lower concentrations were detected in areas where only wood waste is buried. Figure A-2 shows a dashed green line separating the areas where these two types of waste are located, and presents the concentrations of methane measured in the June and August 2015 monitoring events. The methane results indicate LFG control will be required throughout the landfill.

Other field-analyzed LFG parameters were also consistent with the general understanding of Site conditions and/or consistent with typically observed conditions at other aging landfills. Only trace levels of H_2, CO, or H_2S were observed. The most notable of these observations was a detection of 42 parts per million (ppm) H_2S at existing LFG Vent 3 in June 2015. Static pressure measurements were low across the landfill, as expected, except for an anomalously-high measurement of 8.77 inches of water at monitoring probe P-12 in June 2015. Follow-up monitoring in August did not detect H_2S in LFG Vent 3, and revealed no significant static pressure at probe P-12. Although concentrations of monitored parameters varied somewhat between the two monitoring events, the two events indicated generally similar conditions for the purposes of designing an appropriate LFG control system.

The results of VOC testing indicate there are detectable concentrations of VOCs throughout most of the Site. The VOCs detected are those typically associated with LFG, although they are present at relatively low concentrations in comparison to landfills with more recent deposits. For reference, the total mass of non-methane VOCs in LFG is typically about 840 ppm, normalized to hexane (EPA 2008). This is equivalent to approximately 3,000,000 micrograms per cubic meter (ug/m^3), the unit of measurement in which the Cornwall VOC data are presented in Table A-3. The highest observed total VOC concentration expressed as the sum of all detected VOCs was at LFG probe P-2, and was approximately 12,000 ug/m^3 – less than 0.5 percent of the concentration typically present in LFG. The low prevalence of VOCs in LFG at the Site provides further indication that LFG generation is relatively low. The results of VOC testing are used further in the evaluation below to determine if LFG emissions will require an air permit, and to determine if control technology is required for protection of human health and the environment prior to discharge.

Landfill Gas – Air Emissions Considerations

Construction of the landfill cover system will include installation of new LFG vents so that LFG can discharge from the subsurface in a controlled manner, and not be trapped beneath the low-permeability cover. Although the emissions have been occurring for decades in an uncontrolled manner, installation of the vents requires an evaluation of these emissions as a new source. In order to evaluate whether an air permit (or substantive requirements thereof) will be required, an estimate was prepared of the total annual emissions for each of the 75 VOCs included in the TO-15 analysis. The sample location with the highest detected concentration for each VOC was applied to the total estimated flow of LFG to determine the maximum potential mass-based emissions on an hourly, daily, or annual basis. The safety factor applied to the LFG generation estimate discussed in the previous section is applied for evaluating and sizing system components and is also applied in evaluating maximum reasonable exposure scenarios later in this appendix, but is not used in evaluating pollutant emissions for air permitting considerations.

The estimated emissions of VOCs are presented in Table A-4 and compared to the ambient source impact levels (ASILs), small quantity emission rates (SQERs), and *de minimis* emission values presented in Chapter 173-460 WAC (Controls for New Sources of Toxic Air Pollutants). Source emissions are compared to ASILs, SQERs, and *de minimis* values to determine whether further permitting considerations or implementing treatment technology prior to discharge is necessary. For this evaluation, the maximum anticipated ambient air impact is based on the highest concentration VOC data from the pre-design investigation being used to estimate emissions at future LFG vents, including an assumption that non-detected compounds are present at the reporting limit.

As indicated in the Table A-4, the estimated emissions for each compound are well below all regulatory criteria for air quality standards – based on both concentration and mass-based air emission rates. The emission rates were additionally below the *de minimis* quantities, which, according to WAC 173-460-020 indicates "trivial levels of emissions that do not pose a threat to human health or the environment." Accordingly, the emissions are considered low enough that no additional air dispersion modeling would be required to evaluate concentrations at receptor points and typical air permitting considerations would be concluded for a typical stationary source evaluation. However, additional air dispersion modeling was conducted for this project to evaluate the VOC concentrations at any receptor location within the Site to evaluate concentrations relative to Model Toxics Control Act (MTCA) cleanup levels for ambient air, as discussed in the following section.

Air Dispersion Modeling

The American Meteorological Society (AMS)/EPA Regulatory Model (AERMOD) was used to estimate the maximum ambient VOC concentrations associated with LFG emissions at a network of approximately 650 different receptor locations spaced throughout the Site. Similar air dispersion modeling is typically used to evaluate air quality impacts at the property line surrounding a landfill. In this instance, the model was developed to estimate VOC concentrations at a network of receptors spaced throughout the interior of the Site using the worst-case emissions and weather conditions because of the planned future use of the Site as a City park. The modeling was conducted in general accordance with EPA's Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions (40 CFR Part 51).

Ambient air impacts were simulated from total VOC stack emissions using the Industrial Source Complex (ISC)-AERMOD View Version 8.1 interface provided by Lakes Environmental. This version of the Lakes Environmental software incorporates the most recent version of AERMOD (version 15181). AERMOD incorporates the data from a variety of pre-processors (described below) to process meteorological parameters, terrain heights, and stack emission estimates with physical emission point characteristics to predict potential impacts to ambient air from the LFG vents.

Meteorological Data

Five years of surface meteorological data from Bellingham, Washington were used for this modeling analysis. Surface observation data from the National Weather Service (NWS) Bellingham International Airport Automated Surface Observing System (ASOS) station for each of the years between 2008 and 2012 were modeled to determine the worst-case case scenario (maximum modeled 1-hour impact).

Meteorological data from year 2008 was selected for the final analysis because they resulted in the highest potential impacts at any single receptor during the five year period.

The Bellingham airport meteorological tower is approximately 7 kilometers north of the Site. The 1-minute wind data from this ASOS station were processed with AERMINUTE (Version 11325) and supplemented into the surface data. This surface dataset was then processed in conjunction with concurrent twice daily upper air data collected at the NWS Quillayute, Washington observation station using the AERMET (Version 14134) preprocessor. Additionally, surface characteristics utilized in AERMET for the area surrounding the Bellingham airport meteorological tower were determined with the AERSURFACE (Version 13016) preprocessor using U.S. Geological Survey (USGS) National Land Cover Data.

Terrain Height Pre-Processing

To model complex terrain, AERMOD incorporates elevation data using the AMS/EPA Regulatory Model Terrain Pre-processor (AERMAP). The receptor grid network consisted of a Cartesian flagpole receptor grid with 12.5-meter (m) spacing, placed at a height of 1.5 m above ground to approximate the human breathing zone.

Digital topographical data for the analysis region were obtained from the Web GIS website (www.webgis.com) and processed for use in AERMOD. The Shuttle Radar Topography Mission data used for this project have a resolution of approximately 30 m (1 arc-second).

This regional data was supplemented with the Site-specific terrain data, by incorporating the proposed final surface topography after constructing the landfill cap.

Stack Emissions and Receptor Selection

For the purposes of exposure evaluation and comparison to MTCA cleanup levels, air emissions were estimated using the total estimated flow rate of 10 cfm LFG (4.6 cfm was scaled-up by a factor of safety of more than 2) and using the highest-detected concentrations of VOCs during the two pre-design investigations. The LFG flow rate and VOC concentrations were incorporated into the model as mass-based emissions rates, and the total flow was divided between the two proposed vents. The vent stacks were modeled at 4 inches in diameter and two vent heights were used with individual modeling runs: 15 ft and 12 ft above the finished grade surface.

The single receptor with the greatest potential impact was selected to represent potential exposure at the Site.

MTCA Method B Cleanup Standards

MTCA Method B criteria were calculated for both cancer and non-cancer risks for all VOCs with toxicology data available on the Washington State Department of Ecology's (Ecology's) CLARC database (Ecology website 2015). The calculated concentrations protective of both cancer and non-cancer risks are presented on Table A-5 in Attachment A.5. The lower of the two levels was selected for application at the Site. Because the VOC data generated for this Site used test method TO-15, which reports a large suite of parameters (most of which were not detected), some compounds on Table A-5 do not have associated cleanup standards.

Ecology's standard formulas and default parameters were used in the calculations, without modification. As a conservative measure, we've retained the underlying assumption in Ecology's default parameters that park visitation would be 365 days per year, and that visitors could be at the park 24 hours a day. For acute, non-cancer risks, the cleanup levels are based on a child's bodyweight, 16 kilograms (kg), and an exposure duration of 6 years. For compounds with cancer risks, the cleanup levels are based on an adult's bodyweight, 70 kg, and exposure duration of 30 years. These assumptions are extremely conservative relative to actual exposure scenarios likely to occur at the Site.

Comparison to Cleanup Levels – Results

Table A-6 in Attachment A.5 presents the maximum anticipated ambient air impacts and a comparison to the associated MTCA Method B cleanup levels. The ambient air impacts assume the worst-case emissions at two future LFG vents, the worst-case meteorological conditions affecting ground concentrations in the years between 2008 and 2012, and the single receptor out of 650 across the Site with the highest estimated exposure concentration.

As indicated on Table A-6, even with the conservatively high estimates of potential emissions and exposures, all compounds are well below cleanup levels, generally at least two orders of magnitude below, if LFG is released at the two vents indicated in the proposed design, with vent heights of 12 ft above ground surface. As a result, LFG emissions from the Site LFG system will not present an unacceptable risk to human health. It is anticipated that the actual concentrations at the LFG vents will already be below the Method B cleanup levels before any dispersion due to the conservative assumptions used to develop the emissions estimates. Compliance monitoring will be conducted at the LFG vents to confirm the discharge already meets the cleanup levels or will be below the cleanup levels in the breathing zone in accordance with Ecology's guidance document for establishing and evaluating air cleanup standards under MTCA (Ecology 2005).

Landfill Gas Control System – Design Elements

Based on the analyses presented above, typical solid-waste design practices for passive collection of LFG will be used to control and mitigate LFG, as a component of the Site cleanup. Based on the low quantity of LFG being generated, an active LFG control system using blowers to extract LFG is not required. The design will include the following elements to meet the goals stated in the introduction to this appendix. The proposed design is presented in the EDR and additional design information is provided in Attachment A.6 to this appendix.

Prevent accumulation of LFG under the landfill cap by providing an LFG capture layer beneath the impermeable cover that is connected to the atmosphere

This will be accomplished by including an LFG capture layer of geocomposite material below the impermeable layer. Several design alternatives were considered including the use of a gravel/sand layer, the use of crushed concrete (which could be manufactured from concrete debris during Site grading), or the use of a combination of geocomposite materials and conveyance piping. The use of geocomposite material provided the most economical alternative based on significant savings in installation costs during construction by eliminating most earthwork associated with alternative LFG collection systems (trenching and pipe installation).

The required transmissivity of this LFG capture layer was calculated based on equations developed by Thiel (Thiel 2005). Because LFG generation is low (assuming 10 cfm), the required transmissivity within this layer is 1.2 x 10^{-5} square meters per second (m^2/s), assuming a collection pipe spacing of 20 meters (twice the typical spacing). This specification is reported in hydraulic transmissivity (converted from gas), and includes a factor of safety of 2 to account for moisture and biofouling.

The geocomposite material evaluated for this application was Draintube™, by AFITEX-Texel, which combines standard perforated pipes and geosynthetic products into one roll-out material. The product incorporates an integrated conveyance tubing that exceeds the transmissivity requirement with a lower cost than the other alternatives considered. The integrated perforated piping has a large ventilation capacity and is the primary source of vapor transport to the headers, and ultimately, the vents. LAI has reviewed reference applications and confirmed this product has been used at over 1,000 projects world-wide including LFG capture and control at several dozen similar landfill projects; some here in the Pacific Northwest. A limited amount of additional earthwork and piping is required to connect the collection layer to the vents.

Provide internal pressure relief to reduce the potential for lateral migration

Internal pressure relief will be provided by the installation of four passive extraction wells that extend into the waste. In addition to the LFG layer discussed above, which captures LFG that has migrated upwards, these passive extraction wells will provide a ventilation pathway for LFG within the waste mass, to minimize landfill pressures that can cause lateral migration. Each of the four passive extraction wells will be focused in areas containing MSW where LFG generation is the greatest.

The passive wells will be connected through subsurface LFG lateral headers to the ventilation system and will include isolation valves and monitoring ports located in secure subsurface vaults.

Provide controlled release of LFG through engineered vents, to prevent fugitive emissions where exposure is uncontrolled

LFG collected from the passive wells and from the LFG capture layer in the cover system will be routed through subsurface LFG header piping to two passive vents. During development of the conceptual design, alternative approaches included varying the number of vents and evaluating the addition of ventilation assistance through the use of solar-powered fans and wind turbines. These additions to a passive ventilation system are useful to keep the collection system clear of LFG, but they are not powerful enough to provide active extraction of LFG from the subsurface. The inclusion of ventilation assistance was determined to be advantageous in minimizing the number of passive vents, although it should be noted that dispersion modeling and the exposure assessment was conducted without the additional convection or dispersion assistance from a solar powered blower or wind turbine. These are considered beneficial components to add to the vent stacks, but are not required elements of the design for regulatory purposes.

Based on lower capital cost and maintenance, the wind turbine was preferable to the solar assisted ventilation system evaluated. Wind turbines can provide a similar level of ventilation improvement at a small fraction of the cost and as a result, each of the 2 vents will be outfitted with a wind turbine at the head, which will rotate in the wind to enhance ventilation.

Each vent will also include a subsurface vault which can be used in the future, if needed, to add carbon filtration prior to ventilation. Carbon filtration is not required to meet MTCA cleanup standards based on current data, but including the vaults would allow it to be added in the future with minimal effort if different conditions are determined during compliance monitoring, or if nuisance odors become an issue. The subsurface vaults will also contain a flame arrestor, a safety device that prevents a flame from traveling through the LFG control system. This will be included based on the potential for methane to occasionally be present above the explosive limit, and the possibility of lightening striking the vents, since they will be elevated.

The vents will be constructed of stainless 4-inch-diameter pipe with a round concrete base, and an effluent point 12 ft above ground surface, so that the release of LFG is at a controlled location where exposures are not anticipated and ambient air will not be effected. The vent pipe will be metal to provide a long service life, and stainless steel will be used to provide corrosion protection from external elements and the moisture condensing from the LFG. The subsurface vault will be secured in concrete and will have a secure, spring-assisted metal access lid. The vent pipes could be integrated into light poles or other structures for aesthetic purposes during future Site use, if desired.

References

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ATTACHMENT A.1

Landfill Gas Generation Modeling Report

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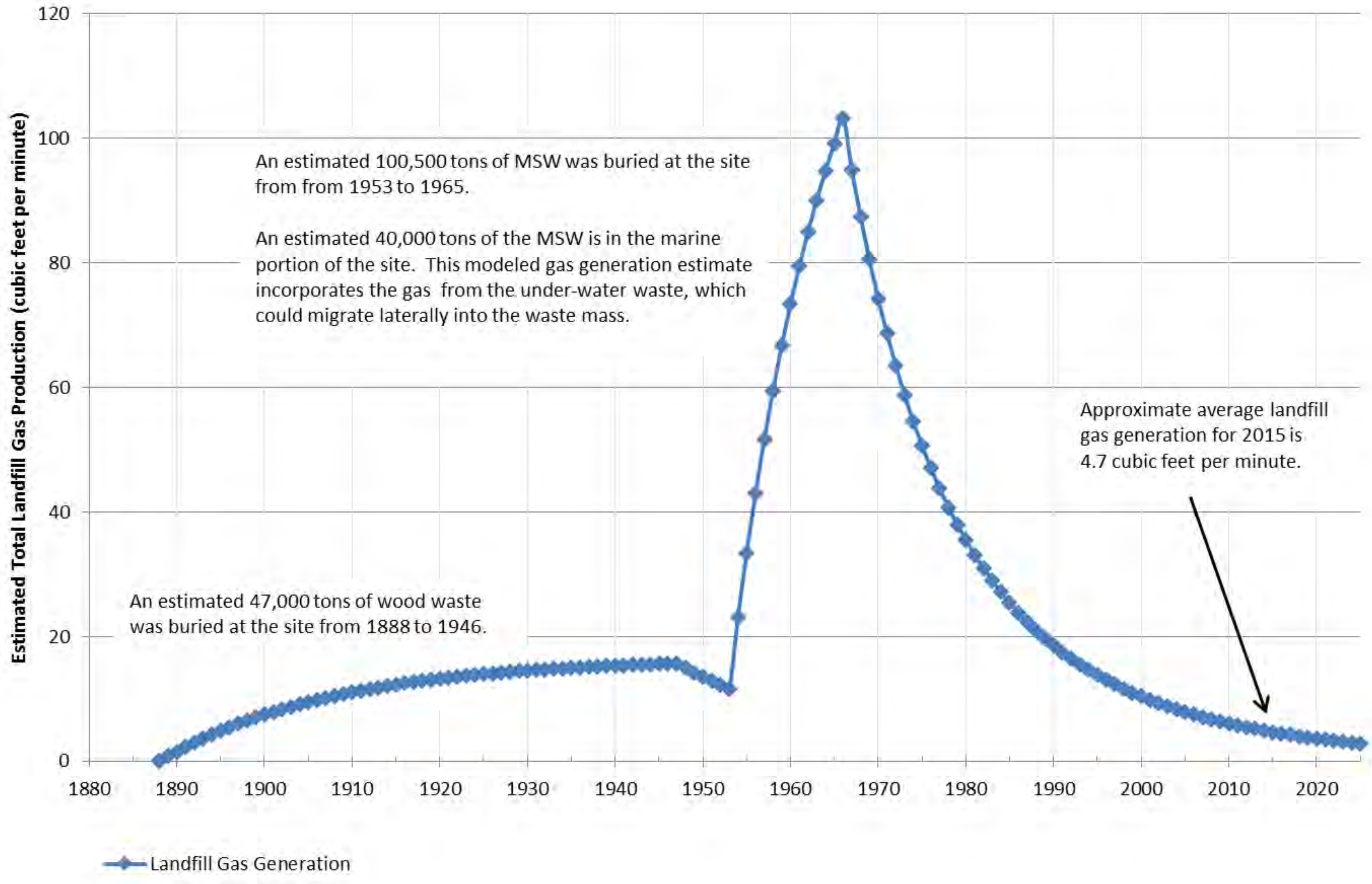


An estimated 100,500 tons of MSW was buried at the site from from 1953 to 1965.

An estimated 40,000 tons of the MSW is in the marine portion of the site. This modeled gas generation estimate incorporates the gas from the under-water waste, which could migrate laterally into the waste mass.

Approximate average landfill gas generation for 2015 is 4.7 cubic feet per minute.

An estimated 47,000 tons of wood waste was buried at the site from 1888 to 1946.

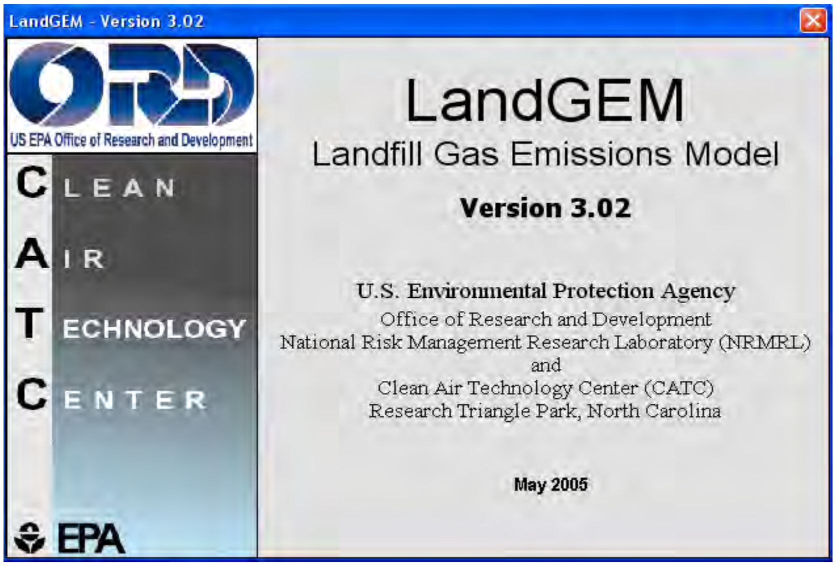
Landau Associates

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Landfill Gas Generation Estimate
Cornwall Avenue Landfill

Figure

A-1



LandGEM
Landfill Gas Emissions Model
Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Cornwall Ave - Wood Waste

Date: Friday, June 17, 2016

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o\left(\frac{M_i}{10}\right)e^{-kt_{ij}}$$

Where,
Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate *($year^{-1}$)*
L_o = potential methane generation capacity *(m^3/Mg)*
M_i = mass of waste accepted in the i^{th} year *(Mg)*
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1888**	
Landfill Closure Year (with 80-year limit)	**1946**	
Actual Closure Year (without limit)	***1946***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year $^{-1}$*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

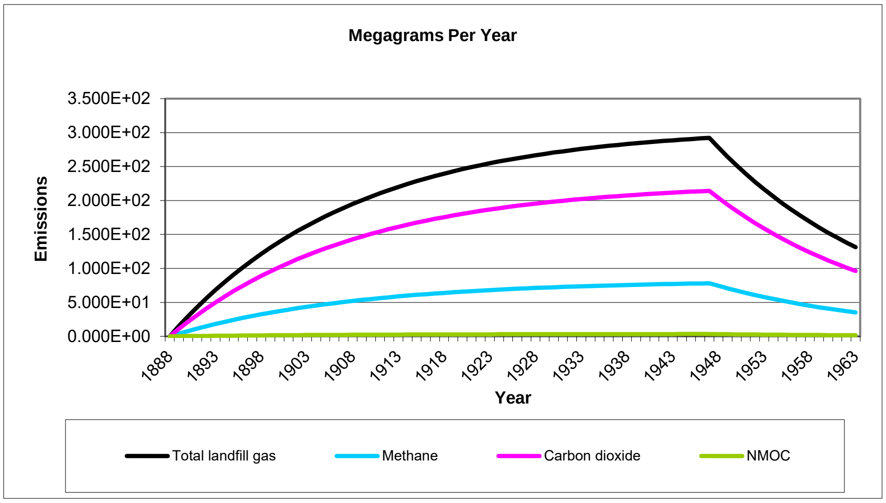
WASTE ACCEPTANCE RATES

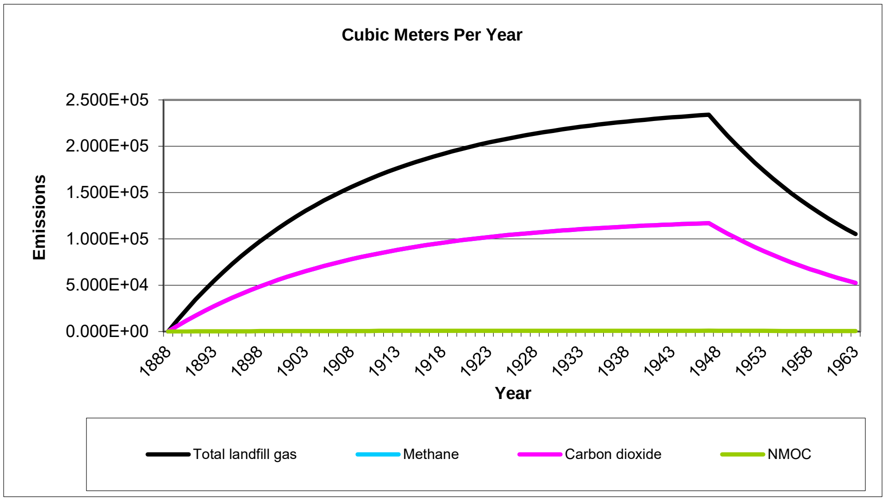
Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1888	725	797	0	0
1889	725	797	725	797
1890	725	797	1,449	1,594
1891	725	797	2,174	2,391
1892	725	797	2,898	3,188
1893	725	797	3,623	3,985
1894	725	797	4,347	4,782
1895	725	797	5,072	5,579
1896	725	797	5,796	6,376
1897	725	797	6,521	7,173
1898	725	797	7,245	7,970
1899	725	797	7,970	8,767
1900	725	797	8,695	9,564
1901	725	797	9,419	10,361
1902	725	797	10,144	11,158
1903	725	797	10,868	11,955
1904	725	797	11,593	12,752
1905	725	797	12,317	13,549
1906	725	797	13,042	14,346
1907	725	797	13,766	15,143
1908	725	797	14,491	15,940
1909	725	797	15,215	16,737
1910	725	797	15,940	17,534
1911	725	797	16,665	18,331
1912	725	797	17,389	19,128
1913	725	797	18,114	19,925
1914	725	797	18,838	20,722
1915	725	797	19,563	21,519
1916	725	797	20,287	22,316
1917	725	797	21,012	23,113
1918	725	797	21,736	23,910
1919	725	797	22,461	24,707
1920	725	797	23,185	25,504
1921	725	797	23,910	26,301
1922	725	797	24,635	27,098
1923	725	797	25,359	27,895
1924	725	797	26,084	28,692
1925	725	797	26,808	29,489
1926	725	797	27,533	30,286
1927	725	797	28,257	31,083

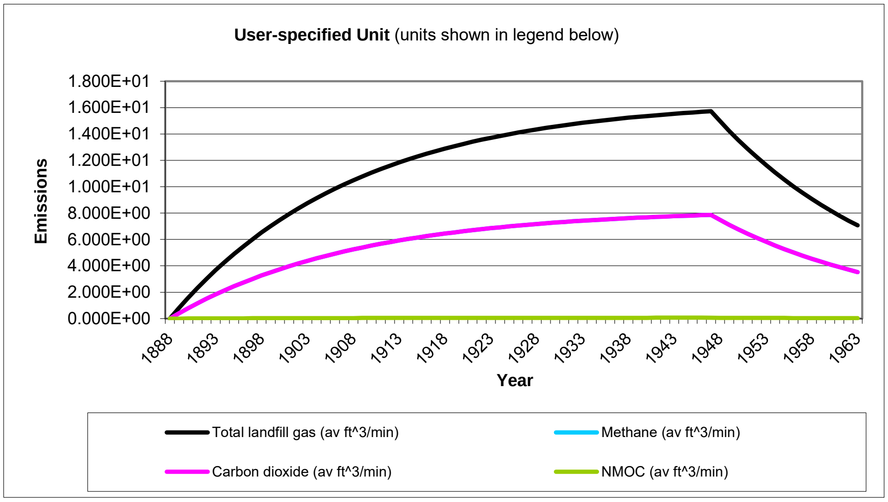
WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1928	725	797	28,982	31,880
1929	725	797	29,706	32,677
1930	725	797	30,431	33,474
1931	725	797	31,155	34,271
1932	725	797	31,880	35,068
1933	725	797	32,605	35,865
1934	725	797	33,329	36,662
1935	725	797	34,054	37,459
1936	725	797	34,778	38,256
1937	725	797	35,503	39,053
1938	725	797	36,227	39,850
1939	725	797	36,952	40,647
1940	725	797	37,676	41,444
1941	725	797	38,401	42,241
1942	725	797	39,125	43,038
1943	725	797	39,850	43,835
1944	725	797	40,575	44,632
1945	725	797	41,299	45,429
1946	725	797	42,024	46,226
1947	0	0	42,748	47,023
1948	0	0	42,748	47,023
1949	0	0	42,748	47,023
1950	0	0	42,748	47,023
1951	0	0	42,748	47,023
1952	0	0	42,748	47,023
1953	0	0	42,748	47,023
1954	0	0	42,748	47,023
1955	0	0	42,748	47,023
1956	0	0	42,748	47,023
1957	0	0	42,748	47,023
1958	0	0	42,748	47,023
1959	0	0	42,748	47,023
1960	0	0	42,748	47,023
1961	0	0	42,748	47,023
1962	0	0	42,748	47,023
1963	0	0	42,748	47,023
1964	0	0	42,748	47,023
1965	0	0	42,748	47,023
1966	0	0	42,748	47,023
1967	0	0	42,748	47,023

Graphs


Megagrams Per Year
Emissions
3.500E+02
3.000E+02
2.500E+02
2.000E+02
1.500E+02
1.000E+02
5.000E+01
0.000E+00
1888
1893
1898
1903
1908
1913
1918
1923
1928
1933
1938
1943
1948
1953
1958
1963
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
2.500E+05
2.000E+05
1.500E+05
1.000E+05
5.000E+04
0.000E+00
1888
1893
1898
1903
1908
1913
1918
1923
1928
1933
1938
1943
1948
1953
1958
1963
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
1.800E+01
1.600E+01
1.400E+01
1.200E+01
1.000E+01
8.000E+00
6.000E+00
4.000E+00
2.000E+00
0.000E+00
1888
1893
1898
1903
1908
1913
1918
1923
1928
1933
1938
1943
1948
1953
1958
1963
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1888	0	0	0	0	0	0
1889	1.504E+01	1.204E+04	8.093E-01	4.018E+00	6.022E+03	4.046E-01
1890	2.935E+01	2.350E+04	1.579E+00	7.840E+00	1.175E+04	7.895E-01
1891	4.296E+01	3.440E+04	2.311E+00	1.147E+01	1.720E+04	1.156E+00
1892	5.591E+01	4.477E+04	3.008E+00	1.493E+01	2.238E+04	1.504E+00
1893	6.822E+01	5.463E+04	3.670E+00	1.822E+01	2.731E+04	1.835E+00
1894	7.993E+01	6.401E+04	4.301E+00	2.135E+01	3.200E+04	2.150E+00
1895	9.108E+01	7.293E+04	4.900E+00	2.433E+01	3.647E+04	2.450E+00
1896	1.017E+02	8.142E+04	5.470E+00	2.716E+01	4.071E+04	2.735E+00
1897	1.118E+02	8.949E+04	6.013E+00	2.985E+01	4.475E+04	3.006E+00
1898	1.214E+02	9.717E+04	6.529E+00	3.241E+01	4.859E+04	3.264E+00
1899	1.305E+02	1.045E+05	7.020E+00	3.485E+01	5.224E+04	3.510E+00
1900	1.392E+02	1.114E+05	7.487E+00	3.717E+01	5.571E+04	3.743E+00
1901	1.474E+02	1.180E+05	7.931E+00	3.937E+01	5.902E+04	3.965E+00
1902	1.553E+02	1.243E+05	8.353E+00	4.147E+01	6.216E+04	4.177E+00
1903	1.627E+02	1.303E+05	8.755E+00	4.347E+01	6.515E+04	4.378E+00
1904	1.698E+02	1.360E+05	9.137E+00	4.536E+01	6.800E+04	4.569E+00
1905	1.766E+02	1.414E+05	9.501E+00	4.717E+01	7.070E+04	4.751E+00
1906	1.830E+02	1.466E+05	9.847E+00	4.889E+01	7.328E+04	4.923E+00
1907	1.891E+02	1.515E+05	1.018E+01	5.052E+01	7.573E+04	5.088E+00
1908	1.950E+02	1.561E+05	1.049E+01	5.207E+01	7.805E+04	5.244E+00
1909	2.005E+02	1.605E+05	1.079E+01	5.355E+01	8.027E+04	5.393E+00
1910	2.058E+02	1.648E+05	1.107E+01	5.496E+01	8.238E+04	5.535E+00
1911	2.108E+02	1.688E+05	1.134E+01	5.630E+01	8.438E+04	5.670E+00
1912	2.155E+02	1.726E+05	1.160E+01	5.757E+01	8.629E+04	5.798E+00
1913	2.201E+02	1.762E+05	1.184E+01	5.878E+01	8.810E+04	5.920E+00
1914	2.244E+02	1.797E+05	1.207E+01	5.993E+01	8.983E+04	6.036E+00
1915	2.285E+02	1.829E+05	1.229E+01	6.102E+01	9.147E+04	6.146E+00
1916	2.324E+02	1.861E+05	1.250E+01	6.207E+01	9.303E+04	6.251E+00
1917	2.361E+02	1.890E+05	1.270E+01	6.306E+01	9.452E+04	6.351E+00
1918	2.396E+02	1.919E+05	1.289E+01	6.400E+01	9.593E+04	6.445E+00
1919	2.430E+02	1.945E+05	1.307E+01	6.490E+01	9.727E+04	6.536E+00
1920	2.461E+02	1.971E+05	1.324E+01	6.575E+01	9.855E+04	6.622E+00
1921	2.492E+02	1.995E+05	1.341E+01	6.656E+01	9.977E+04	6.703E+00
1922	2.521E+02	2.018E+05	1.356E+01	6.733E+01	1.009E+05	6.781E+00
1923	2.548E+02	2.040E+05	1.371E+01	6.806E+01	1.020E+05	6.855E+00
1924	2.574E+02	2.061E+05	1.385E+01	6.876E+01	1.031E+05	6.925E+00
1925	2.599E+02	2.081E+05	1.398E+01	6.943E+01	1.041E+05	6.992E+00
1926	2.623E+02	2.100E+05	1.411E+01	7.006E+01	1.050E+05	7.056E+00
1927	2.645E+02	2.118E+05	1.423E+01	7.066E+01	1.059E+05	7.116E+00
1928	2.667E+02	2.135E+05	1.435E+01	7.123E+01	1.068E+05	7.174E+00
1929	2.687E+02	2.152E+05	1.446E+01	7.177E+01	1.076E+05	7.229E+00
1930	2.706E+02	2.167E+05	1.456E+01	7.229E+01	1.084E+05	7.281E+00
1931	2.725E+02	2.182E+05	1.466E+01	7.278E+01	1.091E+05	7.330E+00
1932	2.742E+02	2.196E+05	1.475E+01	7.325E+01	1.098E+05	7.377E+00
1933	2.759E+02	2.209E+05	1.484E+01	7.370E+01	1.105E+05	7.422E+00
1934	2.775E+02	2.222E+05	1.493E+01	7.412E+01	1.111E+05	7.465E+00
1935	2.790E+02	2.234E+05	1.501E+01	7.452E+01	1.117E+05	7.505E+00
1936	2.804E+02	2.246E+05	1.509E+01	7.491E+01	1.123E+05	7.544E+00
1937	2.818E+02	2.257E+05	1.516E+01	7.527E+01	1.128E+05	7.581E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
1938	2.831E+02	2.267E+05	1.523E+01	7.562E+01	1.133E+05	7.616E+00
1939	2.843E+02	2.277E+05	1.530E+01	7.595E+01	1.138E+05	7.649E+00
1940	2.855E+02	2.286E+05	1.536E+01	7.626E+01	1.143E+05	7.680E+00
1941	2.866E+02	2.295E+05	1.542E+01	7.656E+01	1.148E+05	7.710E+00
1942	2.877E+02	2.304E+05	1.548E+01	7.684E+01	1.152E+05	7.739E+00
1943	2.887E+02	2.312E+05	1.553E+01	7.711E+01	1.156E+05	7.766E+00
1944	2.897E+02	2.319E+05	1.558E+01	7.737E+01	1.160E+05	7.792E+00
1945	2.906E+02	2.327E+05	1.563E+01	7.761E+01	1.163E+05	7.817E+00
1946	2.914E+02	2.334E+05	1.568E+01	7.785E+01	1.167E+05	7.840E+00
1947	2.923E+02	2.340E+05	1.572E+01	7.807E+01	1.170E+05	7.862E+00
1948	2.780E+02	2.226E+05	1.496E+01	7.426E+01	1.113E+05	7.479E+00
1949	2.645E+02	2.118E+05	1.423E+01	7.064E+01	1.059E+05	7.114E+00
1950	2.516E+02	2.014E+05	1.353E+01	6.719E+01	1.007E+05	6.767E+00
1951	2.393E+02	1.916E+05	1.287E+01	6.392E+01	9.581E+04	6.437E+00
1952	2.276E+02	1.823E+05	1.225E+01	6.080E+01	9.113E+04	6.123E+00
1953	2.165E+02	1.734E+05	1.165E+01	5.783E+01	8.669E+04	5.825E+00
1954	2.060E+02	1.649E+05	1.108E+01	5.501E+01	8.246E+04	5.541E+00
1955	1.959E+02	1.569E+05	1.054E+01	5.233E+01	7.844E+04	5.270E+00
1956	1.864E+02	1.492E+05	1.003E+01	4.978E+01	7.461E+04	5.013E+00
1957	1.773E+02	1.419E+05	9.538E+00	4.735E+01	7.097E+04	4.769E+00
1958	1.686E+02	1.350E+05	9.072E+00	4.504E+01	6.751E+04	4.536E+00
1959	1.604E+02	1.284E+05	8.630E+00	4.284E+01	6.422E+04	4.315E+00
1960	1.526E+02	1.222E+05	8.209E+00	4.076E+01	6.109E+04	4.105E+00
1961	1.451E+02	1.162E+05	7.809E+00	3.877E+01	5.811E+04	3.904E+00
1962	1.381E+02	1.106E+05	7.428E+00	3.688E+01	5.528E+04	3.714E+00
1963	1.313E+02	1.052E+05	7.066E+00	3.508E+01	5.258E+04	3.533E+00
1964	1.249E+02	1.000E+05	6.721E+00	3.337E+01	5.002E+04	3.361E+00
1965	1.188E+02	9.515E+04	6.393E+00	3.174E+01	4.758E+04	3.197E+00
1966	1.130E+02	9.051E+04	6.081E+00	3.019E+01	4.526E+04	3.041E+00
1967	1.075E+02	8.610E+04	5.785E+00	2.872E+01	4.305E+04	2.892E+00
1968	1.023E+02	8.190E+04	5.503E+00	2.732E+01	4.095E+04	2.751E+00
1969	9.729E+01	7.790E+04	5.234E+00	2.599E+01	3.895E+04	2.617E+00
1970	9.254E+01	7.410E+04	4.979E+00	2.472E+01	3.705E+04	2.490E+00
1971	8.803E+01	7.049E+04	4.736E+00	2.351E+01	3.525E+04	2.368E+00
1972	8.374E+01	6.705E+04	4.505E+00	2.237E+01	3.353E+04	2.253E+00
1973	7.965E+01	6.378E+04	4.286E+00	2.128E+01	3.189E+04	2.143E+00
1974	7.577E+01	6.067E+04	4.077E+00	2.024E+01	3.034E+04	2.038E+00
1975	7.207E+01	5.771E+04	3.878E+00	1.925E+01	2.886E+04	1.939E+00
1976	6.856E+01	5.490E+04	3.689E+00	1.831E+01	2.745E+04	1.844E+00
1977	6.521E+01	5.222E+04	3.509E+00	1.742E+01	2.611E+04	1.754E+00
1978	6.203E+01	4.967E+04	3.338E+00	1.657E+01	2.484E+04	1.669E+00
1979	5.901E+01	4.725E+04	3.175E+00	1.576E+01	2.363E+04	1.587E+00
1980	5.613E+01	4.495E+04	3.020E+00	1.499E+01	2.247E+04	1.510E+00
1981	5.339E+01	4.275E+04	2.873E+00	1.426E+01	2.138E+04	1.436E+00
1982	5.079E+01	4.067E+04	2.733E+00	1.357E+01	2.033E+04	1.366E+00
1983	4.831E+01	3.869E+04	2.599E+00	1.290E+01	1.934E+04	1.300E+00
1984	4.596E+01	3.680E+04	2.473E+00	1.228E+01	1.840E+04	1.236E+00
1985	4.371E+01	3.500E+04	2.352E+00	1.168E+01	1.750E+04	1.176E+00
1986	4.158E+01	3.330E+04	2.237E+00	1.111E+01	1.665E+04	1.119E+00
1987	3.955E+01	3.167E+04	2.128E+00	1.057E+01	1.584E+04	1.064E+00
1988	3.763E+01	3.013E+04	2.024E+00	1.005E+01	1.506E+04	1.012E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1989	3.579E+01	2.866E+04	1.926E+00	9.560E+00	1.433E+04	9.628E-01
1990	3.404E+01	2.726E+04	1.832E+00	9.094E+00	1.363E+04	9.158E-01
1991	3.238E+01	2.593E+04	1.742E+00	8.650E+00	1.297E+04	8.712E-01
1992	3.080E+01	2.467E+04	1.657E+00	8.228E+00	1.233E+04	8.287E-01
1993	2.930E+01	2.346E+04	1.577E+00	7.827E+00	1.173E+04	7.883E-01
1994	2.787E+01	2.232E+04	1.500E+00	7.445E+00	1.116E+04	7.498E-01
1995	2.651E+01	2.123E+04	1.427E+00	7.082E+00	1.062E+04	7.133E-01
1996	2.522E+01	2.020E+04	1.357E+00	6.737E+00	1.010E+04	6.785E-01
1997	2.399E+01	1.921E+04	1.291E+00	6.408E+00	9.605E+03	6.454E-01
1998	2.282E+01	1.827E+04	1.228E+00	6.096E+00	9.137E+03	6.139E-01
1999	2.171E+01	1.738E+04	1.168E+00	5.798E+00	8.691E+03	5.840E-01
2000	2.065E+01	1.653E+04	1.111E+00	5.516E+00	8.267E+03	5.555E-01
2001	1.964E+01	1.573E+04	1.057E+00	5.247E+00	7.864E+03	5.284E-01
2002	1.868E+01	1.496E+04	1.005E+00	4.991E+00	7.481E+03	5.026E-01
2003	1.777E+01	1.423E+04	9.562E-01	4.747E+00	7.116E+03	4.781E-01
2004	1.691E+01	1.354E+04	9.096E-01	4.516E+00	6.769E+03	4.548E-01
2005	1.608E+01	1.288E+04	8.652E-01	4.296E+00	6.439E+03	4.326E-01
2006	1.530E+01	1.225E+04	8.230E-01	4.086E+00	6.125E+03	4.115E-01
2007	1.455E+01	1.165E+04	7.829E-01	3.887E+00	5.826E+03	3.914E-01
2008	1.384E+01	1.108E+04	7.447E-01	3.697E+00	5.542E+03	3.724E-01
2009	1.317E+01	1.054E+04	7.084E-01	3.517E+00	5.272E+03	3.542E-01
2010	1.252E+01	1.003E+04	6.738E-01	3.345E+00	5.014E+03	3.369E-01
2011	1.191E+01	9.540E+03	6.410E-01	3.182E+00	4.770E+03	3.205E-01
2012	1.133E+01	9.075E+03	6.097E-01	3.027E+00	4.537E+03	3.049E-01
2013	1.078E+01	8.632E+03	5.800E-01	2.879E+00	4.316E+03	2.900E-01
2014	1.025E+01	8.211E+03	5.517E-01	2.739E+00	4.105E+03	2.758E-01
2015	9.754E+00	7.811E+03	5.248E-01	2.605E+00	3.905E+03	2.624E-01
2016	9.278E+00	7.430E+03	4.992E-01	2.478E+00	3.715E+03	2.496E-01
2017	8.826E+00	7.067E+03	4.748E-01	2.357E+00	3.534E+03	2.374E-01
2018	8.395E+00	6.723E+03	4.517E-01	2.242E+00	3.361E+03	2.258E-01
2019	7.986E+00	6.395E+03	4.297E-01	2.133E+00	3.197E+03	2.148E-01
2020	7.596E+00	6.083E+03	4.087E-01	2.029E+00	3.041E+03	2.044E-01
2021	7.226E+00	5.786E+03	3.888E-01	1.930E+00	2.893E+03	1.944E-01
2022	6.874E+00	5.504E+03	3.698E-01	1.836E+00	2.752E+03	1.849E-01
2023	6.538E+00	5.236E+03	3.518E-01	1.746E+00	2.618E+03	1.759E-01
2024	6.219E+00	4.980E+03	3.346E-01	1.661E+00	2.490E+03	1.673E-01
2025	5.916E+00	4.737E+03	3.183E-01	1.580E+00	2.369E+03	1.592E-01
2026	5.628E+00	4.506E+03	3.028E-01	1.503E+00	2.253E+03	1.514E-01
2027	5.353E+00	4.287E+03	2.880E-01	1.430E+00	2.143E+03	1.440E-01
2028	5.092E+00	4.077E+03	2.740E-01	1.360E+00	2.039E+03	1.370E-01

Results (Continued)

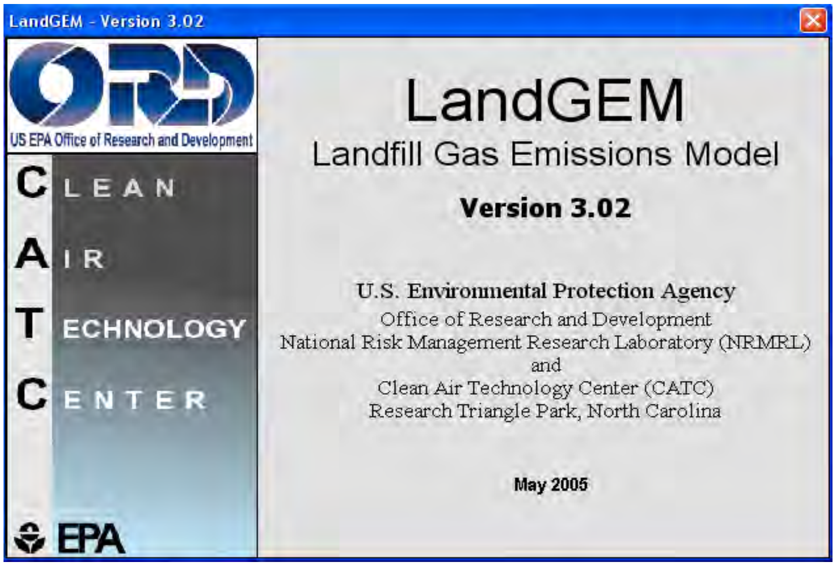
Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1888	0	0	0	0	0	0
1889	1.102E+01	6.022E+03	4.046E-01	1.727E-01	4.818E+01	3.237E-03
1890	2.151E+01	1.175E+04	7.895E-01	3.370E-01	9.401E+01	6.316E-03
1891	3.148E+01	1.720E+04	1.156E+00	4.932E-01	1.376E+02	9.245E-03
1892	4.097E+01	2.238E+04	1.504E+00	6.419E-01	1.791E+02	1.203E-02
1893	5.000E+01	2.731E+04	1.835E+00	7.832E-01	2.185E+02	1.468E-02
1894	5.858E+01	3.200E+04	2.150E+00	9.177E-01	2.560E+02	1.720E-02
1895	6.675E+01	3.647E+04	2.450E+00	1.046E+00	2.917E+02	1.960E-02
1896	7.452E+01	4.071E+04	2.735E+00	1.167E+00	3.257E+02	2.188E-02
1897	8.191E+01	4.475E+04	3.006E+00	1.283E+00	3.580E+02	2.405E-02
1898	8.894E+01	4.859E+04	3.264E+00	1.393E+00	3.887E+02	2.612E-02
1899	9.562E+01	5.224E+04	3.510E+00	1.498E+00	4.179E+02	2.808E-02
1900	1.020E+02	5.571E+04	3.743E+00	1.598E+00	4.457E+02	2.995E-02
1901	1.080E+02	5.902E+04	3.965E+00	1.692E+00	4.721E+02	3.172E-02
1902	1.138E+02	6.216E+04	4.177E+00	1.783E+00	4.973E+02	3.341E-02
1903	1.193E+02	6.515E+04	4.378E+00	1.868E+00	5.212E+02	3.502E-02
1904	1.245E+02	6.800E+04	4.569E+00	1.950E+00	5.440E+02	3.655E-02
1905	1.294E+02	7.070E+04	4.751E+00	2.027E+00	5.656E+02	3.800E-02
1906	1.341E+02	7.328E+04	4.923E+00	2.101E+00	5.862E+02	3.939E-02
1907	1.386E+02	7.573E+04	5.088E+00	2.171E+00	6.058E+02	4.070E-02
1908	1.429E+02	7.805E+04	5.244E+00	2.238E+00	6.244E+02	4.196E-02
1909	1.469E+02	8.027E+04	5.393E+00	2.302E+00	6.422E+02	4.315E-02
1910	1.508E+02	8.238E+04	5.535E+00	2.362E+00	6.590E+02	4.428E-02
1911	1.545E+02	8.438E+04	5.670E+00	2.420E+00	6.751E+02	4.536E-02
1912	1.580E+02	8.629E+04	5.798E+00	2.474E+00	6.903E+02	4.638E-02
1913	1.613E+02	8.810E+04	5.920E+00	2.526E+00	7.048E+02	4.736E-02
1914	1.644E+02	8.983E+04	6.036E+00	2.576E+00	7.186E+02	4.828E-02
1915	1.674E+02	9.147E+04	6.146E+00	2.623E+00	7.318E+02	4.917E-02
1916	1.703E+02	9.303E+04	6.251E+00	2.668E+00	7.442E+02	5.001E-02
1917	1.730E+02	9.452E+04	6.351E+00	2.710E+00	7.561E+02	5.080E-02
1918	1.756E+02	9.593E+04	6.445E+00	2.751E+00	7.674E+02	5.156E-02
1919	1.781E+02	9.727E+04	6.536E+00	2.789E+00	7.782E+02	5.229E-02
1920	1.804E+02	9.855E+04	6.622E+00	2.826E+00	7.884E+02	5.297E-02
1921	1.826E+02	9.977E+04	6.703E+00	2.861E+00	7.981E+02	5.363E-02
1922	1.847E+02	1.009E+05	6.781E+00	2.894E+00	8.074E+02	5.425E-02
1923	1.868E+02	1.020E+05	6.855E+00	2.926E+00	8.162E+02	5.484E-02
1924	1.887E+02	1.031E+05	6.925E+00	2.956E+00	8.246E+02	5.540E-02
1925	1.905E+02	1.041E+05	6.992E+00	2.984E+00	8.325E+02	5.594E-02
1926	1.922E+02	1.050E+05	7.056E+00	3.011E+00	8.401E+02	5.645E-02
1927	1.939E+02	1.059E+05	7.116E+00	3.037E+00	8.473E+02	5.693E-02
1928	1.954E+02	1.068E+05	7.174E+00	3.062E+00	8.542E+02	5.739E-02
1929	1.969E+02	1.076E+05	7.229E+00	3.085E+00	8.607E+02	5.783E-02
1930	1.984E+02	1.084E+05	7.281E+00	3.107E+00	8.669E+02	5.825E-02
1931	1.997E+02	1.091E+05	7.330E+00	3.128E+00	8.728E+02	5.864E-02
1932	2.010E+02	1.098E+05	7.377E+00	3.149E+00	8.784E+02	5.902E-02
1933	2.022E+02	1.105E+05	7.422E+00	3.168E+00	8.837E+02	5.938E-02
1934	2.034E+02	1.111E+05	7.465E+00	3.186E+00	8.888E+02	5.972E-02
1935	2.045E+02	1.117E+05	7.505E+00	3.203E+00	8.936E+02	6.004E-02
1936	2.055E+02	1.123E+05	7.544E+00	3.220E+00	8.982E+02	6.035E-02
1937	2.065E+02	1.128E+05	7.581E+00	3.235E+00	9.026E+02	6.065E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1938	2.075E+02	1.133E+05	7.616E+00	3.250E+00	9.068E+02	6.093E-02
1939	2.084E+02	1.138E+05	7.649E+00	3.264E+00	9.107E+02	6.119E-02
1940	2.092E+02	1.143E+05	7.680E+00	3.278E+00	9.145E+02	6.144E-02
1941	2.101E+02	1.148E+05	7.710E+00	3.291E+00	9.181E+02	6.168E-02
1942	2.108E+02	1.152E+05	7.739E+00	3.303E+00	9.215E+02	6.191E-02
1943	2.116E+02	1.156E+05	7.766E+00	3.315E+00	9.247E+02	6.213E-02
1944	2.123E+02	1.160E+05	7.792E+00	3.326E+00	9.278E+02	6.234E-02
1945	2.130E+02	1.163E+05	7.817E+00	3.336E+00	9.307E+02	6.253E-02
1946	2.136E+02	1.167E+05	7.840E+00	3.346E+00	9.335E+02	6.272E-02
1947	2.142E+02	1.170E+05	7.862E+00	3.356E+00	9.361E+02	6.290E-02
1948	2.038E+02	1.113E+05	7.479E+00	3.192E+00	8.905E+02	5.983E-02
1949	1.938E+02	1.059E+05	7.114E+00	3.036E+00	8.471E+02	5.691E-02
1950	1.844E+02	1.007E+05	6.767E+00	2.888E+00	8.057E+02	5.414E-02
1951	1.754E+02	9.581E+04	6.437E+00	2.747E+00	7.664E+02	5.150E-02
1952	1.668E+02	9.113E+04	6.123E+00	2.613E+00	7.291E+02	4.899E-02
1953	1.587E+02	8.669E+04	5.825E+00	2.486E+00	6.935E+02	4.660E-02
1954	1.509E+02	8.246E+04	5.541E+00	2.365E+00	6.597E+02	4.432E-02
1955	1.436E+02	7.844E+04	5.270E+00	2.249E+00	6.275E+02	4.216E-02
1956	1.366E+02	7.461E+04	5.013E+00	2.140E+00	5.969E+02	4.011E-02
1957	1.299E+02	7.097E+04	4.769E+00	2.035E+00	5.678E+02	3.815E-02
1958	1.236E+02	6.751E+04	4.536E+00	1.936E+00	5.401E+02	3.629E-02
1959	1.176E+02	6.422E+04	4.315E+00	1.842E+00	5.138E+02	3.452E-02
1960	1.118E+02	6.109E+04	4.105E+00	1.752E+00	4.887E+02	3.284E-02
1961	1.064E+02	5.811E+04	3.904E+00	1.666E+00	4.649E+02	3.123E-02
1962	1.012E+02	5.528E+04	3.714E+00	1.585E+00	4.422E+02	2.971E-02
1963	9.625E+01	5.258E+04	3.533E+00	1.508E+00	4.206E+02	2.826E-02
1964	9.155E+01	5.002E+04	3.361E+00	1.434E+00	4.001E+02	2.688E-02
1965	8.709E+01	4.758E+04	3.197E+00	1.364E+00	3.806E+02	2.557E-02
1966	8.284E+01	4.526E+04	3.041E+00	1.298E+00	3.620E+02	2.433E-02
1967	7.880E+01	4.305E+04	2.892E+00	1.234E+00	3.444E+02	2.314E-02
1968	7.496E+01	4.095E+04	2.751E+00	1.174E+00	3.276E+02	2.201E-02
1969	7.130E+01	3.895E+04	2.617E+00	1.117E+00	3.116E+02	2.094E-02
1970	6.782E+01	3.705E+04	2.490E+00	1.062E+00	2.964E+02	1.992E-02
1971	6.452E+01	3.525E+04	2.368E+00	1.011E+00	2.820E+02	1.894E-02
1972	6.137E+01	3.353E+04	2.253E+00	9.614E-01	2.682E+02	1.802E-02
1973	5.838E+01	3.189E+04	2.143E+00	9.145E-01	2.551E+02	1.714E-02
1974	5.553E+01	3.034E+04	2.038E+00	8.699E-01	2.427E+02	1.631E-02
1975	5.282E+01	2.886E+04	1.939E+00	8.275E-01	2.309E+02	1.551E-02
1976	5.025E+01	2.745E+04	1.844E+00	7.871E-01	2.196E+02	1.475E-02
1977	4.779E+01	2.611E+04	1.754E+00	7.487E-01	2.089E+02	1.403E-02
1978	4.546E+01	2.484E+04	1.669E+00	7.122E-01	1.987E+02	1.335E-02
1979	4.325E+01	2.363E+04	1.587E+00	6.775E-01	1.890E+02	1.270E-02
1980	4.114E+01	2.247E+04	1.510E+00	6.444E-01	1.798E+02	1.208E-02
1981	3.913E+01	2.138E+04	1.436E+00	6.130E-01	1.710E+02	1.149E-02
1982	3.722E+01	2.033E+04	1.366E+00	5.831E-01	1.627E+02	1.093E-02
1983	3.541E+01	1.934E+04	1.300E+00	5.547E-01	1.547E+02	1.040E-02
1984	3.368E+01	1.840E+04	1.236E+00	5.276E-01	1.472E+02	9.890E-03
1985	3.204E+01	1.750E+04	1.176E+00	5.019E-01	1.400E+02	9.408E-03
1986	3.048E+01	1.665E+04	1.119E+00	4.774E-01	1.332E+02	8.949E-03
1987	2.899E+01	1.584E+04	1.064E+00	4.541E-01	1.267E+02	8.513E-03
1988	2.758E+01	1.506E+04	1.012E+00	4.320E-01	1.205E+02	8.097E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1989	2.623E+01	1.433E+04	9.628E-01	4.109E-01	1.146E+02	7.702E-03
1990	2.495E+01	1.363E+04	9.158E-01	3.909E-01	1.090E+02	7.327E-03
1991	2.373E+01	1.297E+04	8.712E-01	3.718E-01	1.037E+02	6.969E-03
1992	2.258E+01	1.233E+04	8.287E-01	3.537E-01	9.867E+01	6.630E-03
1993	2.148E+01	1.173E+04	7.883E-01	3.364E-01	9.386E+01	6.306E-03
1994	2.043E+01	1.116E+04	7.498E-01	3.200E-01	8.928E+01	5.999E-03
1995	1.943E+01	1.062E+04	7.133E-01	3.044E-01	8.493E+01	5.706E-03
1996	1.848E+01	1.010E+04	6.785E-01	2.896E-01	8.078E+01	5.428E-03
1997	1.758E+01	9.605E+03	6.454E-01	2.754E-01	7.684E+01	5.163E-03
1998	1.673E+01	9.137E+03	6.139E-01	2.620E-01	7.310E+01	4.911E-03
1999	1.591E+01	8.691E+03	5.840E-01	2.492E-01	6.953E+01	4.672E-03
2000	1.513E+01	8.267E+03	5.555E-01	2.371E-01	6.614E+01	4.444E-03
2001	1.440E+01	7.864E+03	5.284E-01	2.255E-01	6.291E+01	4.227E-03
2002	1.369E+01	7.481E+03	5.026E-01	2.145E-01	5.985E+01	4.021E-03
2003	1.303E+01	7.116E+03	4.781E-01	2.041E-01	5.693E+01	3.825E-03
2004	1.239E+01	6.769E+03	4.548E-01	1.941E-01	5.415E+01	3.638E-03
2005	1.179E+01	6.439E+03	4.326E-01	1.846E-01	5.151E+01	3.461E-03
2006	1.121E+01	6.125E+03	4.115E-01	1.756E-01	4.900E+01	3.292E-03
2007	1.066E+01	5.826E+03	3.914E-01	1.671E-01	4.661E+01	3.132E-03
2008	1.014E+01	5.542E+03	3.724E-01	1.589E-01	4.433E+01	2.979E-03
2009	9.650E+00	5.272E+03	3.542E-01	1.512E-01	4.217E+01	2.834E-03
2010	9.179E+00	5.014E+03	3.369E-01	1.438E-01	4.012E+01	2.695E-03
2011	8.731E+00	4.770E+03	3.205E-01	1.368E-01	3.816E+01	2.564E-03
2012	8.305E+00	4.537E+03	3.049E-01	1.301E-01	3.630E+01	2.439E-03
2013	7.900E+00	4.316E+03	2.900E-01	1.238E-01	3.453E+01	2.320E-03
2014	7.515E+00	4.105E+03	2.758E-01	1.177E-01	3.284E+01	2.207E-03
2015	7.149E+00	3.905E+03	2.624E-01	1.120E-01	3.124E+01	2.099E-03
2016	6.800E+00	3.715E+03	2.496E-01	1.065E-01	2.972E+01	1.997E-03
2017	6.468E+00	3.534E+03	2.374E-01	1.013E-01	2.827E+01	1.899E-03
2018	6.153E+00	3.361E+03	2.258E-01	9.639E-02	2.689E+01	1.807E-03
2019	5.853E+00	3.197E+03	2.148E-01	9.169E-02	2.558E+01	1.719E-03
2020	5.567E+00	3.041E+03	2.044E-01	8.722E-02	2.433E+01	1.635E-03
2021	5.296E+00	2.893E+03	1.944E-01	8.296E-02	2.314E+01	1.555E-03
2022	5.038E+00	2.752E+03	1.849E-01	7.892E-02	2.202E+01	1.479E-03
2023	4.792E+00	2.618E+03	1.759E-01	7.507E-02	2.094E+01	1.407E-03
2024	4.558E+00	2.490E+03	1.673E-01	7.141E-02	1.992E+01	1.338E-03
2025	4.336E+00	2.369E+03	1.592E-01	6.792E-02	1.895E+01	1.273E-03
2026	4.124E+00	2.253E+03	1.514E-01	6.461E-02	1.803E+01	1.211E-03
2027	3.923E+00	2.143E+03	1.440E-01	6.146E-02	1.715E+01	1.152E-03
2028	3.732E+00	2.039E+03	1.370E-01	5.846E-02	1.631E+01	1.096E-03



LandGEM

Landfill Gas Emissions Model

Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Cornwall - Upland MSW

Date: Friday, June 17, 2016

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10} \right) e^{-kt_{ij}}$$

Where,

Q_{CH_4} = annual methane generation in the year of the calculation (*m^3/year*)
i = 1-year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1-year time increment
k = methane generation rate (*$year^{-1}$*)
L_o = potential methane generation capacity (*m^3/Mg*)

M_i = mass of waste accepted in the i^{th} year (*Mg*)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (*decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1953**	
Landfill Closure Year (with 80-year limit)	**1965**	
Actual Closure Year (without limit)	***1965***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.050**	*year* $^{-1}$
Potential Methane Generation Capacity, L_o	**170**	m^3/Mg
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

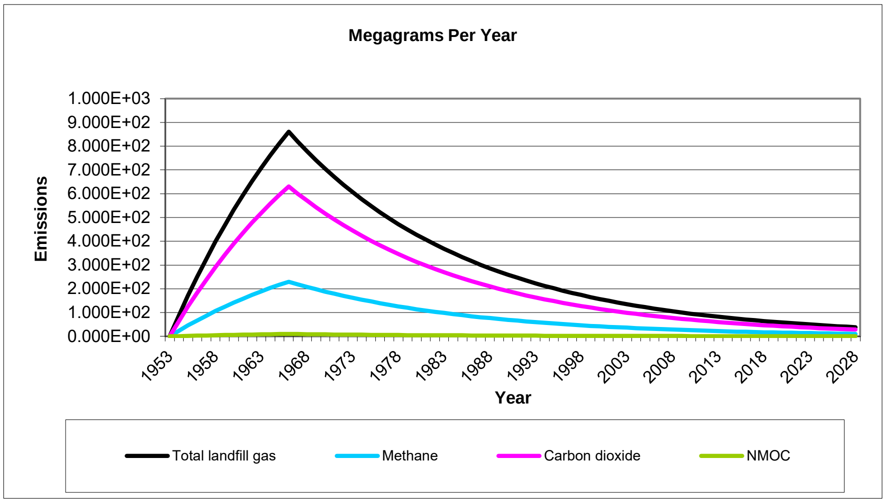
WASTE ACCEPTANCE RATES

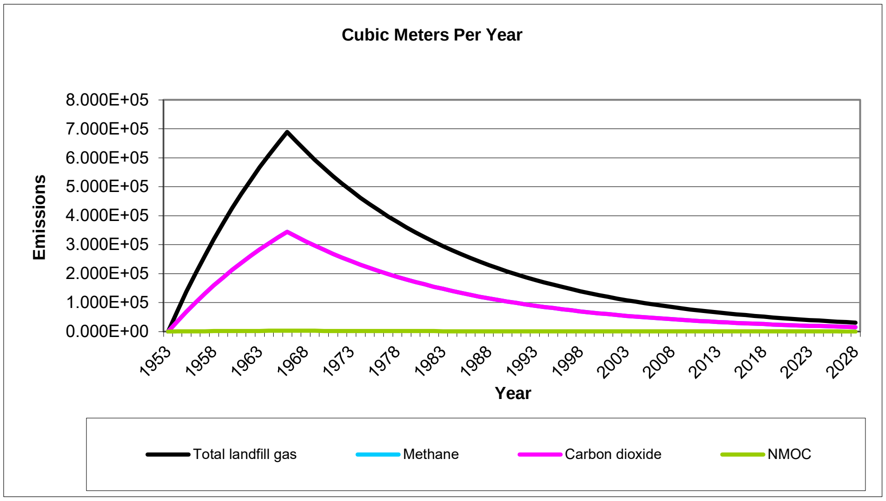
Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1953	4,231	4,654	0	0
1954	4,231	4,654	4,231	4,654
1955	4,231	4,654	8,462	9,308
1956	4,231	4,654	12,693	13,962
1957	4,231	4,654	16,924	18,616
1958	4,231	4,654	21,155	23,270
1959	4,231	4,654	25,385	27,924
1960	4,231	4,654	29,616	32,578
1961	4,231	4,654	33,847	37,232
1962	4,231	4,654	38,078	41,886
1963	4,231	4,654	42,309	46,540
1964	4,231	4,654	46,540	51,194
1965	4,231	4,654	50,771	55,848
1966	0	0	55,002	60,502
1967	0	0	55,002	60,502
1968	0	0	55,002	60,502
1969	0	0	55,002	60,502
1970	0	0	55,002	60,502
1971	0	0	55,002	60,502
1972	0	0	55,002	60,502
1973	0	0	55,002	60,502
1974	0	0	55,002	60,502
1975	0	0	55,002	60,502
1976	0	0	55,002	60,502
1977	0	0	55,002	60,502
1978	0	0	55,002	60,502
1979	0	0	55,002	60,502
1980	0	0	55,002	60,502
1981	0	0	55,002	60,502
1982	0	0	55,002	60,502
1983	0	0	55,002	60,502
1984	0	0	55,002	60,502
1985	0	0	55,002	60,502
1986	0	0	55,002	60,502
1987	0	0	55,002	60,502
1988	0	0	55,002	60,502
1989	0	0	55,002	60,502
1990	0	0	55,002	60,502
1991	0	0	55,002	60,502
1992	0	0	55,002	60,502

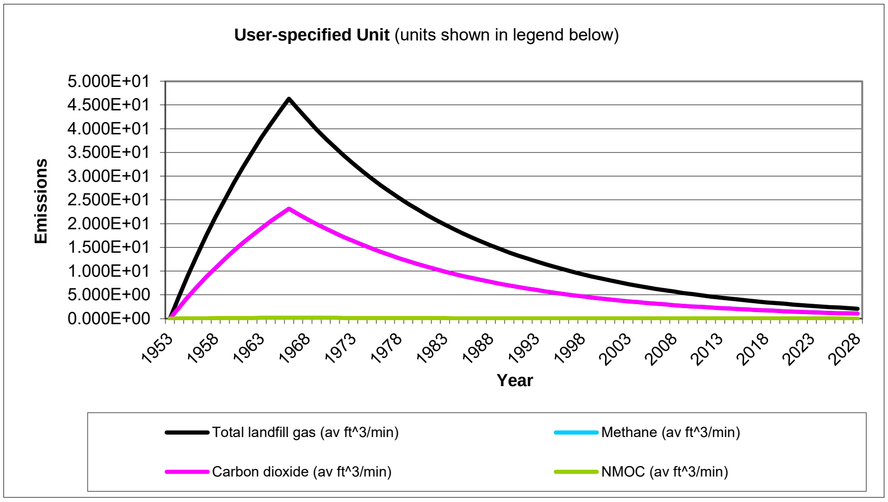
WASTE ACCEPTANCE RATES (Continued)

Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
1993	0	0	55,002	60,502
1994	0	0	55,002	60,502
1995	0	0	55,002	60,502
1996	0	0	55,002	60,502
1997	0	0	55,002	60,502
1998	0	0	55,002	60,502
1999	0	0	55,002	60,502
2000	0	0	55,002	60,502
2001	0	0	55,002	60,502
2002	0	0	55,002	60,502
2003	0	0	55,002	60,502
2004	0	0	55,002	60,502
2005	0	0	55,002	60,502
2006	0	0	55,002	60,502
2007	0	0	55,002	60,502
2008	0	0	55,002	60,502
2009	0	0	55,002	60,502
2010	0	0	55,002	60,502
2011	0	0	55,002	60,502
2012	0	0	55,002	60,502
2013	0	0	55,002	60,502
2014	0	0	55,002	60,502
2015	0	0	55,002	60,502
2016	0	0	55,002	60,502
2017	0	0	55,002	60,502
2018	0	0	55,002	60,502
2019	0	0	55,002	60,502
2020	0	0	55,002	60,502
2021	0	0	55,002	60,502
2022	0	0	55,002	60,502
2023	0	0	55,002	60,502
2024	0	0	55,002	60,502
2025	0	0	55,002	60,502
2026	0	0	55,002	60,502
2027	0	0	55,002	60,502
2028	0	0	55,002	60,502
2029	0	0	55,002	60,502
2030	0	0	55,002	60,502
2031	0	0	55,002	60,502
2032	0	0	55,002	60,502

Graphs


Megagrams Per Year
Emissions
1.000E+03
9.000E+02
8.000E+02
7.000E+02
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+02
0.000E+00
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
Emissions
8.000E+05
7.000E+05
6.000E+05
5.000E+05
4.000E+05
3.000E+05
2.000E+05
1.000E+05
0.000E+00
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
Emissions
5.000E+01
4.500E+01
4.000E+01
3.500E+01
3.000E+01
2.500E+01
2.000E+01
1.500E+01
1.000E+01
5.000E+00
0.000E+00
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1953	0	0	0	0	0	0
1954	8.783E+01	7.033E+04	4.726E+00	2.346E+01	3.517E+04	2.363E+00
1955	1.714E+02	1.372E+05	9.221E+00	4.578E+01	6.862E+04	4.610E+00
1956	2.509E+02	2.009E+05	1.350E+01	6.701E+01	1.004E+05	6.748E+00
1957	3.265E+02	2.614E+05	1.756E+01	8.720E+01	1.307E+05	8.782E+00
1958	3.984E+02	3.190E+05	2.143E+01	1.064E+02	1.595E+05	1.072E+01
1959	4.668E+02	3.738E+05	2.511E+01	1.247E+02	1.869E+05	1.256E+01
1960	5.318E+02	4.259E+05	2.861E+01	1.421E+02	2.129E+05	1.431E+01
1961	5.937E+02	4.754E+05	3.194E+01	1.586E+02	2.377E+05	1.597E+01
1962	6.526E+02	5.226E+05	3.511E+01	1.743E+02	2.613E+05	1.756E+01
1963	7.086E+02	5.674E+05	3.813E+01	1.893E+02	2.837E+05	1.906E+01
1964	7.619E+02	6.101E+05	4.099E+01	2.035E+02	3.050E+05	2.050E+01
1965	8.126E+02	6.507E+05	4.372E+01	2.170E+02	3.253E+05	2.186E+01
1966	8.608E+02	6.893E+05	4.631E+01	2.299E+02	3.446E+05	2.316E+01
1967	8.188E+02	6.556E+05	4.405E+01	2.187E+02	3.278E+05	2.203E+01
1968	7.789E+02	6.237E+05	4.190E+01	2.080E+02	3.118E+05	2.095E+01
1969	7.409E+02	5.933E+05	3.986E+01	1.979E+02	2.966E+05	1.993E+01
1970	7.047E+02	5.643E+05	3.792E+01	1.882E+02	2.822E+05	1.896E+01
1971	6.704E+02	5.368E+05	3.607E+01	1.791E+02	2.684E+05	1.803E+01
1972	6.377E+02	5.106E+05	3.431E+01	1.703E+02	2.553E+05	1.715E+01
1973	6.066E+02	4.857E+05	3.264E+01	1.620E+02	2.429E+05	1.632E+01
1974	5.770E+02	4.620E+05	3.104E+01	1.541E+02	2.310E+05	1.552E+01
1975	5.488E+02	4.395E+05	2.953E+01	1.466E+02	2.197E+05	1.476E+01
1976	5.221E+02	4.181E+05	2.809E+01	1.395E+02	2.090E+05	1.404E+01
1977	4.966E+02	3.977E+05	2.672E+01	1.327E+02	1.988E+05	1.336E+01
1978	4.724E+02	3.783E+05	2.542E+01	1.262E+02	1.891E+05	1.271E+01
1979	4.494E+02	3.598E+05	2.418E+01	1.200E+02	1.799E+05	1.209E+01
1980	4.274E+02	3.423E+05	2.300E+01	1.142E+02	1.711E+05	1.150E+01
1981	4.066E+02	3.256E+05	2.188E+01	1.086E+02	1.628E+05	1.094E+01
1982	3.868E+02	3.097E+05	2.081E+01	1.033E+02	1.549E+05	1.040E+01
1983	3.679E+02	2.946E+05	1.979E+01	9.827E+01	1.473E+05	9.897E+00
1984	3.500E+02	2.802E+05	1.883E+01	9.348E+01	1.401E+05	9.414E+00
1985	3.329E+02	2.666E+05	1.791E+01	8.892E+01	1.333E+05	8.955E+00
1986	3.167E+02	2.536E+05	1.704E+01	8.458E+01	1.268E+05	8.519E+00
1987	3.012E+02	2.412E+05	1.621E+01	8.046E+01	1.206E+05	8.103E+00
1988	2.865E+02	2.294E+05	1.542E+01	7.653E+01	1.147E+05	7.708E+00
1989	2.726E+02	2.182E+05	1.466E+01	7.280E+01	1.091E+05	7.332E+00
1990	2.593E+02	2.076E+05	1.395E+01	6.925E+01	1.038E+05	6.974E+00
1991	2.466E+02	1.975E+05	1.327E+01	6.587E+01	9.874E+04	6.634E+00
1992	2.346E+02	1.878E+05	1.262E+01	6.266E+01	9.392E+04	6.311E+00
1993	2.231E+02	1.787E+05	1.201E+01	5.960E+01	8.934E+04	6.003E+00
1994	2.123E+02	1.700E+05	1.142E+01	5.670E+01	8.498E+04	5.710E+00
1995	2.019E+02	1.617E+05	1.086E+01	5.393E+01	8.084E+04	5.432E+00
1996	1.921E+02	1.538E+05	1.033E+01	5.130E+01	7.690E+04	5.167E+00
1997	1.827E+02	1.463E+05	9.830E+00	4.880E+01	7.315E+04	4.915E+00
1998	1.738E+02	1.392E+05	9.350E+00	4.642E+01	6.958E+04	4.675E+00
1999	1.653E+02	1.324E+05	8.894E+00	4.416E+01	6.619E+04	4.447E+00
2000	1.572E+02	1.259E+05	8.460E+00	4.200E+01	6.296E+04	4.230E+00
2001	1.496E+02	1.198E+05	8.048E+00	3.995E+01	5.989E+04	4.024E+00
2002	1.423E+02	1.139E+05	7.655E+00	3.801E+01	5.697E+04	3.828E+00

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2003	1.353E+02	1.084E+05	7.282E+00	3.615E+01	5.419E+04	3.641E+00
2004	1.287E+02	1.031E+05	6.927E+00	3.439E+01	5.155E+04	3.463E+00
2005	1.225E+02	9.806E+04	6.589E+00	3.271E+01	4.903E+04	3.294E+00
2006	1.165E+02	9.328E+04	6.268E+00	3.112E+01	4.664E+04	3.134E+00
2007	1.108E+02	8.873E+04	5.962E+00	2.960E+01	4.437E+04	2.981E+00
2008	1.054E+02	8.440E+04	5.671E+00	2.816E+01	4.220E+04	2.836E+00
2009	1.003E+02	8.029E+04	5.395E+00	2.678E+01	4.014E+04	2.697E+00
2010	9.538E+01	7.637E+04	5.131E+00	2.548E+01	3.819E+04	2.566E+00
2011	9.072E+01	7.265E+04	4.881E+00	2.423E+01	3.632E+04	2.441E+00
2012	8.630E+01	6.910E+04	4.643E+00	2.305E+01	3.455E+04	2.322E+00
2013	8.209E+01	6.573E+04	4.417E+00	2.193E+01	3.287E+04	2.208E+00
2014	7.809E+01	6.253E+04	4.201E+00	2.086E+01	3.126E+04	2.101E+00
2015	7.428E+01	5.948E+04	3.996E+00	1.984E+01	2.974E+04	1.998E+00
2016	7.066E+01	5.658E+04	3.801E+00	1.887E+01	2.829E+04	1.901E+00
2017	6.721E+01	5.382E+04	3.616E+00	1.795E+01	2.691E+04	1.808E+00
2018	6.393E+01	5.119E+04	3.440E+00	1.708E+01	2.560E+04	1.720E+00
2019	6.081E+01	4.870E+04	3.272E+00	1.624E+01	2.435E+04	1.636E+00
2020	5.785E+01	4.632E+04	3.112E+00	1.545E+01	2.316E+04	1.556E+00
2021	5.503E+01	4.406E+04	2.961E+00	1.470E+01	2.203E+04	1.480E+00
2022	5.234E+01	4.191E+04	2.816E+00	1.398E+01	2.096E+04	1.408E+00
2023	4.979E+01	3.987E+04	2.679E+00	1.330E+01	1.993E+04	1.339E+00
2024	4.736E+01	3.793E+04	2.548E+00	1.265E+01	1.896E+04	1.274E+00
2025	4.505E+01	3.608E+04	2.424E+00	1.203E+01	1.804E+04	1.212E+00
2026	4.286E+01	3.432E+04	2.306E+00	1.145E+01	1.716E+04	1.153E+00
2027	4.076E+01	3.264E+04	2.193E+00	1.089E+01	1.632E+04	1.097E+00
2028	3.878E+01	3.105E+04	2.086E+00	1.036E+01	1.553E+04	1.043E+00
2029	3.689E+01	2.954E+04	1.985E+00	9.853E+00	1.477E+04	9.923E-01
2030	3.509E+01	2.810E+04	1.888E+00	9.372E+00	1.405E+04	9.439E-01
2031	3.338E+01	2.673E+04	1.796E+00	8.915E+00	1.336E+04	8.978E-01
2032	3.175E+01	2.542E+04	1.708E+00	8.480E+00	1.271E+04	8.541E-01
2033	3.020E+01	2.418E+04	1.625E+00	8.067E+00	1.209E+04	8.124E-01
2034	2.873E+01	2.300E+04	1.546E+00	7.673E+00	1.150E+04	7.728E-01
2035	2.733E+01	2.188E+04	1.470E+00	7.299E+00	1.094E+04	7.351E-01
2036	2.599E+01	2.081E+04	1.398E+00	6.943E+00	1.041E+04	6.992E-01
2037	2.473E+01	1.980E+04	1.330E+00	6.604E+00	9.899E+03	6.651E-01
2038	2.352E+01	1.883E+04	1.265E+00	6.282E+00	9.417E+03	6.327E-01
2039	2.237E+01	1.791E+04	1.204E+00	5.976E+00	8.957E+03	6.018E-01
2040	2.128E+01	1.704E+04	1.145E+00	5.684E+00	8.520E+03	5.725E-01
2041	2.024E+01	1.621E+04	1.089E+00	5.407E+00	8.105E+03	5.446E-01
2042	1.926E+01	1.542E+04	1.036E+00	5.143E+00	7.710E+03	5.180E-01
2043	1.832E+01	1.467E+04	9.855E-01	4.893E+00	7.334E+03	4.927E-01
2044	1.742E+01	1.395E+04	9.374E-01	4.654E+00	6.976E+03	4.687E-01
2045	1.657E+01	1.327E+04	8.917E-01	4.427E+00	6.636E+03	4.459E-01
2046	1.577E+01	1.262E+04	8.482E-01	4.211E+00	6.312E+03	4.241E-01
2047	1.500E+01	1.201E+04	8.069E-01	4.006E+00	6.004E+03	4.034E-01
2048	1.427E+01	1.142E+04	7.675E-01	3.810E+00	5.711E+03	3.838E-01
2049	1.357E+01	1.087E+04	7.301E-01	3.625E+00	5.433E+03	3.650E-01
2050	1.291E+01	1.034E+04	6.945E-01	3.448E+00	5.168E+03	3.472E-01
2051	1.228E+01	9.832E+03	6.606E-01	3.280E+00	4.916E+03	3.303E-01
2052	1.168E+01	9.352E+03	6.284E-01	3.120E+00	4.676E+03	3.142E-01
2053	1.111E+01	8.896E+03	5.977E-01	2.968E+00	4.448E+03	2.989E-01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2054	1.057E+01	8.462E+03	5.686E-01	2.823E+00	4.231E+03	2.843E-01
2055	1.005E+01	8.050E+03	5.409E-01	2.685E+00	4.025E+03	2.704E-01
2056	9.562E+00	7.657E+03	5.145E-01	2.554E+00	3.829E+03	2.572E-01
2057	9.096E+00	7.284E+03	4.894E-01	2.430E+00	3.642E+03	2.447E-01
2058	8.652E+00	6.928E+03	4.655E-01	2.311E+00	3.464E+03	2.328E-01
2059	8.230E+00	6.590E+03	4.428E-01	2.198E+00	3.295E+03	2.214E-01
2060	7.829E+00	6.269E+03	4.212E-01	2.091E+00	3.135E+03	2.106E-01
2061	7.447E+00	5.963E+03	4.007E-01	1.989E+00	2.982E+03	2.003E-01
2062	7.084E+00	5.672E+03	3.811E-01	1.892E+00	2.836E+03	1.906E-01
2063	6.738E+00	5.396E+03	3.625E-01	1.800E+00	2.698E+03	1.813E-01
2064	6.410E+00	5.133E+03	3.449E-01	1.712E+00	2.566E+03	1.724E-01
2065	6.097E+00	4.882E+03	3.280E-01	1.629E+00	2.441E+03	1.640E-01
2066	5.800E+00	4.644E+03	3.120E-01	1.549E+00	2.322E+03	1.560E-01
2067	5.517E+00	4.418E+03	2.968E-01	1.474E+00	2.209E+03	1.484E-01
2068	5.248E+00	4.202E+03	2.823E-01	1.402E+00	2.101E+03	1.412E-01
2069	4.992E+00	3.997E+03	2.686E-01	1.333E+00	1.999E+03	1.343E-01
2070	4.748E+00	3.802E+03	2.555E-01	1.268E+00	1.901E+03	1.277E-01
2071	4.517E+00	3.617E+03	2.430E-01	1.207E+00	1.808E+03	1.215E-01
2072	4.297E+00	3.441E+03	2.312E-01	1.148E+00	1.720E+03	1.156E-01
2073	4.087E+00	3.273E+03	2.199E-01	1.092E+00	1.636E+03	1.099E-01
2074	3.888E+00	3.113E+03	2.092E-01	1.038E+00	1.557E+03	1.046E-01
2075	3.698E+00	2.961E+03	1.990E-01	9.878E-01	1.481E+03	9.948E-02
2076	3.518E+00	2.817E+03	1.893E-01	9.396E-01	1.408E+03	9.463E-02
2077	3.346E+00	2.679E+03	1.800E-01	8.938E-01	1.340E+03	9.002E-02
2078	3.183E+00	2.549E+03	1.713E-01	8.502E-01	1.274E+03	8.563E-02
2079	3.028E+00	2.424E+03	1.629E-01	8.087E-01	1.212E+03	8.145E-02
2080	2.880E+00	2.306E+03	1.550E-01	7.693E-01	1.153E+03	7.748E-02
2081	2.740E+00	2.194E+03	1.474E-01	7.318E-01	1.097E+03	7.370E-02
2082	2.606E+00	2.087E+03	1.402E-01	6.961E-01	1.043E+03	7.011E-02
2083	2.479E+00	1.985E+03	1.334E-01	6.621E-01	9.925E+02	6.669E-02
2084	2.358E+00	1.888E+03	1.269E-01	6.299E-01	9.441E+02	6.343E-02
2085	2.243E+00	1.796E+03	1.207E-01	5.991E-01	8.981E+02	6.034E-02
2086	2.134E+00	1.709E+03	1.148E-01	5.699E-01	8.543E+02	5.740E-02
2087	2.030E+00	1.625E+03	1.092E-01	5.421E-01	8.126E+02	5.460E-02
2088	1.931E+00	1.546E+03	1.039E-01	5.157E-01	7.730E+02	5.194E-02
2089	1.836E+00	1.471E+03	9.880E-02	4.905E-01	7.353E+02	4.940E-02
2090	1.747E+00	1.399E+03	9.399E-02	4.666E-01	6.994E+02	4.699E-02
2091	1.662E+00	1.331E+03	8.940E-02	4.438E-01	6.653E+02	4.470E-02
2092	1.581E+00	1.266E+03	8.504E-02	4.222E-01	6.328E+02	4.252E-02
2093	1.504E+00	1.204E+03	8.089E-02	4.016E-01	6.020E+02	4.045E-02

Results (Continued)

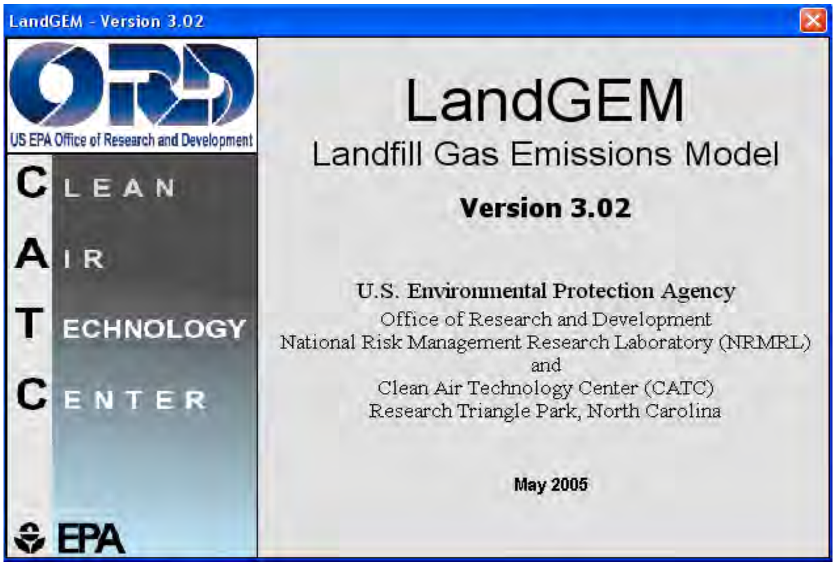
Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
1953	0	0	0	0	0	0
1954	6.437E+01	3.517E+04	2.363E+00	1.008E+00	2.813E+02	1.890E-02
1955	1.256E+02	6.862E+04	4.610E+00	1.968E+00	5.489E+02	3.688E-02
1956	1.838E+02	1.004E+05	6.748E+00	2.880E+00	8.035E+02	5.399E-02
1957	2.393E+02	1.307E+05	8.782E+00	3.748E+00	1.046E+03	7.026E-02
1958	2.920E+02	1.595E+05	1.072E+01	4.574E+00	1.276E+03	8.573E-02
1959	3.421E+02	1.869E+05	1.256E+01	5.359E+00	1.495E+03	1.005E-01
1960	3.898E+02	2.129E+05	1.431E+01	6.106E+00	1.703E+03	1.145E-01
1961	4.351E+02	2.377E+05	1.597E+01	6.817E+00	1.902E+03	1.278E-01
1962	4.783E+02	2.613E+05	1.756E+01	7.493E+00	2.090E+03	1.404E-01
1963	5.193E+02	2.837E+05	1.906E+01	8.136E+00	2.270E+03	1.525E-01
1964	5.584E+02	3.050E+05	2.050E+01	8.747E+00	2.440E+03	1.640E-01
1965	5.955E+02	3.253E+05	2.186E+01	9.329E+00	2.603E+03	1.749E-01
1966	6.308E+02	3.446E+05	2.316E+01	9.883E+00	2.757E+03	1.852E-01
1967	6.001E+02	3.278E+05	2.203E+01	9.401E+00	2.623E+03	1.762E-01
1968	5.708E+02	3.118E+05	2.095E+01	8.942E+00	2.495E+03	1.676E-01
1969	5.430E+02	2.966E+05	1.993E+01	8.506E+00	2.373E+03	1.594E-01
1970	5.165E+02	2.822E+05	1.896E+01	8.091E+00	2.257E+03	1.517E-01
1971	4.913E+02	2.684E+05	1.803E+01	7.697E+00	2.147E+03	1.443E-01
1972	4.673E+02	2.553E+05	1.715E+01	7.321E+00	2.042E+03	1.372E-01
1973	4.445E+02	2.429E+05	1.632E+01	6.964E+00	1.943E+03	1.305E-01
1974	4.229E+02	2.310E+05	1.552E+01	6.624E+00	1.848E+03	1.242E-01
1975	4.022E+02	2.197E+05	1.476E+01	6.301E+00	1.758E+03	1.181E-01
1976	3.826E+02	2.090E+05	1.404E+01	5.994E+00	1.672E+03	1.124E-01
1977	3.640E+02	1.988E+05	1.336E+01	5.702E+00	1.591E+03	1.069E-01
1978	3.462E+02	1.891E+05	1.271E+01	5.424E+00	1.513E+03	1.017E-01
1979	3.293E+02	1.799E+05	1.209E+01	5.159E+00	1.439E+03	9.671E-02
1980	3.133E+02	1.711E+05	1.150E+01	4.908E+00	1.369E+03	9.199E-02
1981	2.980E+02	1.628E+05	1.094E+01	4.668E+00	1.302E+03	8.750E-02
1982	2.835E+02	1.549E+05	1.040E+01	4.441E+00	1.239E+03	8.324E-02
1983	2.696E+02	1.473E+05	9.897E+00	4.224E+00	1.178E+03	7.918E-02
1984	2.565E+02	1.401E+05	9.414E+00	4.018E+00	1.121E+03	7.532E-02
1985	2.440E+02	1.333E+05	8.955E+00	3.822E+00	1.066E+03	7.164E-02
1986	2.321E+02	1.268E+05	8.519E+00	3.636E+00	1.014E+03	6.815E-02
1987	2.208E+02	1.206E+05	8.103E+00	3.458E+00	9.648E+02	6.482E-02
1988	2.100E+02	1.147E+05	7.708E+00	3.290E+00	9.177E+02	6.166E-02
1989	1.997E+02	1.091E+05	7.332E+00	3.129E+00	8.730E+02	5.866E-02
1990	1.900E+02	1.038E+05	6.974E+00	2.977E+00	8.304E+02	5.579E-02
1991	1.807E+02	9.874E+04	6.634E+00	2.831E+00	7.899E+02	5.307E-02
1992	1.719E+02	9.392E+04	6.311E+00	2.693E+00	7.514E+02	5.049E-02
1993	1.635E+02	8.934E+04	6.003E+00	2.562E+00	7.147E+02	4.802E-02
1994	1.556E+02	8.498E+04	5.710E+00	2.437E+00	6.799E+02	4.568E-02
1995	1.480E+02	8.084E+04	5.432E+00	2.318E+00	6.467E+02	4.345E-02
1996	1.408E+02	7.690E+04	5.167E+00	2.205E+00	6.152E+02	4.133E-02
1997	1.339E+02	7.315E+04	4.915E+00	2.098E+00	5.852E+02	3.932E-02
1998	1.274E+02	6.958E+04	4.675E+00	1.995E+00	5.566E+02	3.740E-02
1999	1.212E+02	6.619E+04	4.447E+00	1.898E+00	5.295E+02	3.558E-02
2000	1.152E+02	6.296E+04	4.230E+00	1.805E+00	5.037E+02	3.384E-02
2001	1.096E+02	5.989E+04	4.024E+00	1.717E+00	4.791E+02	3.219E-02
2002	1.043E+02	5.697E+04	3.828E+00	1.634E+00	4.557E+02	3.062E-02

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	(m^3/year)	(av ft^3/min)	(Mg/year)	(m^3/year)	(av ft^3/min)
2003	9.919E+01	5.419E+04	3.641E+00	1.554E+00	4.335E+02	2.913E-02
2004	9.435E+01	5.155E+04	3.463E+00	1.478E+00	4.124E+02	2.771E-02
2005	8.975E+01	4.903E+04	3.294E+00	1.406E+00	3.923E+02	2.636E-02
2006	8.538E+01	4.664E+04	3.134E+00	1.337E+00	3.731E+02	2.507E-02
2007	8.121E+01	4.437E+04	2.981E+00	1.272E+00	3.549E+02	2.385E-02
2008	7.725E+01	4.220E+04	2.836E+00	1.210E+00	3.376E+02	2.268E-02
2009	7.348E+01	4.014E+04	2.697E+00	1.151E+00	3.212E+02	2.158E-02
2010	6.990E+01	3.819E+04	2.566E+00	1.095E+00	3.055E+02	2.053E-02
2011	6.649E+01	3.632E+04	2.441E+00	1.042E+00	2.906E+02	1.952E-02
2012	6.325E+01	3.455E+04	2.322E+00	9.908E-01	2.764E+02	1.857E-02
2013	6.016E+01	3.287E+04	2.208E+00	9.425E-01	2.629E+02	1.767E-02
2014	5.723E+01	3.126E+04	2.101E+00	8.965E-01	2.501E+02	1.681E-02
2015	5.444E+01	2.974E+04	1.998E+00	8.528E-01	2.379E+02	1.599E-02
2016	5.178E+01	2.829E+04	1.901E+00	8.112E-01	2.263E+02	1.521E-02
2017	4.926E+01	2.691E+04	1.808E+00	7.716E-01	2.153E+02	1.446E-02
2018	4.686E+01	2.560E+04	1.720E+00	7.340E-01	2.048E+02	1.376E-02
2019	4.457E+01	2.435E+04	1.636E+00	6.982E-01	1.948E+02	1.309E-02
2020	4.240E+01	2.316E+04	1.556E+00	6.642E-01	1.853E+02	1.245E-02
2021	4.033E+01	2.203E+04	1.480E+00	6.318E-01	1.763E+02	1.184E-02
2022	3.836E+01	2.096E+04	1.408E+00	6.010E-01	1.677E+02	1.126E-02
2023	3.649E+01	1.993E+04	1.339E+00	5.716E-01	1.595E+02	1.072E-02
2024	3.471E+01	1.896E+04	1.274E+00	5.438E-01	1.517E+02	1.019E-02
2025	3.302E+01	1.804E+04	1.212E+00	5.172E-01	1.443E+02	9.696E-03
2026	3.141E+01	1.716E+04	1.153E+00	4.920E-01	1.373E+02	9.223E-03
2027	2.988E+01	1.632E+04	1.097E+00	4.680E-01	1.306E+02	8.773E-03
2028	2.842E+01	1.553E+04	1.043E+00	4.452E-01	1.242E+02	8.345E-03
2029	2.703E+01	1.477E+04	9.923E-01	4.235E-01	1.181E+02	7.938E-03
2030	2.571E+01	1.405E+04	9.439E-01	4.028E-01	1.124E+02	7.551E-03
2031	2.446E+01	1.336E+04	8.978E-01	3.832E-01	1.069E+02	7.183E-03
2032	2.327E+01	1.271E+04	8.541E-01	3.645E-01	1.017E+02	6.832E-03
2033	2.213E+01	1.209E+04	8.124E-01	3.467E-01	9.673E+01	6.499E-03
2034	2.105E+01	1.150E+04	7.728E-01	3.298E-01	9.201E+01	6.182E-03
2035	2.003E+01	1.094E+04	7.351E-01	3.137E-01	8.752E+01	5.881E-03
2036	1.905E+01	1.041E+04	6.992E-01	2.984E-01	8.326E+01	5.594E-03
2037	1.812E+01	9.899E+03	6.651E-01	2.839E-01	7.920E+01	5.321E-03
2038	1.724E+01	9.417E+03	6.327E-01	2.700E-01	7.533E+01	5.062E-03
2039	1.640E+01	8.957E+03	6.018E-01	2.569E-01	7.166E+01	4.815E-03
2040	1.560E+01	8.520E+03	5.725E-01	2.443E-01	6.816E+01	4.580E-03
2041	1.484E+01	8.105E+03	5.446E-01	2.324E-01	6.484E+01	4.357E-03
2042	1.411E+01	7.710E+03	5.180E-01	2.211E-01	6.168E+01	4.144E-03
2043	1.342E+01	7.334E+03	4.927E-01	2.103E-01	5.867E+01	3.942E-03
2044	1.277E+01	6.976E+03	4.687E-01	2.000E-01	5.581E+01	3.750E-03
2045	1.215E+01	6.636E+03	4.459E-01	1.903E-01	5.309E+01	3.567E-03
2046	1.155E+01	6.312E+03	4.241E-01	1.810E-01	5.050E+01	3.393E-03
2047	1.099E+01	6.004E+03	4.034E-01	1.722E-01	4.803E+01	3.227E-03
2048	1.045E+01	5.711E+03	3.838E-01	1.638E-01	4.569E+01	3.070E-03
2049	9.945E+00	5.433E+03	3.650E-01	1.558E-01	4.346E+01	2.920E-03
2050	9.460E+00	5.168E+03	3.472E-01	1.482E-01	4.134E+01	2.778E-03
2051	8.999E+00	4.916E+03	3.303E-01	1.410E-01	3.933E+01	2.642E-03
2052	8.560E+00	4.676E+03	3.142E-01	1.341E-01	3.741E+01	2.514E-03
2053	8.142E+00	4.448E+03	2.989E-01	1.276E-01	3.558E+01	2.391E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2054	7.745E+00	4.231E+03	2.843E-01	1.213E-01	3.385E+01	2.274E-03
2055	7.367E+00	4.025E+03	2.704E-01	1.154E-01	3.220E+01	2.163E-03
2056	7.008E+00	3.829E+03	2.572E-01	1.098E-01	3.063E+01	2.058E-03
2057	6.666E+00	3.642E+03	2.447E-01	1.044E-01	2.913E+01	1.958E-03
2058	6.341E+00	3.464E+03	2.328E-01	9.934E-02	2.771E+01	1.862E-03
2059	6.032E+00	3.295E+03	2.214E-01	9.449E-02	2.636E+01	1.771E-03
2060	5.738E+00	3.135E+03	2.106E-01	8.988E-02	2.508E+01	1.685E-03
2061	5.458E+00	2.982E+03	2.003E-01	8.550E-02	2.385E+01	1.603E-03
2062	5.192E+00	2.836E+03	1.906E-01	8.133E-02	2.269E+01	1.525E-03
2063	4.939E+00	2.698E+03	1.813E-01	7.736E-02	2.158E+01	1.450E-03
2064	4.698E+00	2.566E+03	1.724E-01	7.359E-02	2.053E+01	1.379E-03
2065	4.469E+00	2.441E+03	1.640E-01	7.000E-02	1.953E+01	1.312E-03
2066	4.251E+00	2.322E+03	1.560E-01	6.659E-02	1.858E+01	1.248E-03
2067	4.043E+00	2.209E+03	1.484E-01	6.334E-02	1.767E+01	1.187E-03
2068	3.846E+00	2.101E+03	1.412E-01	6.025E-02	1.681E+01	1.129E-03
2069	3.659E+00	1.999E+03	1.343E-01	5.731E-02	1.599E+01	1.074E-03
2070	3.480E+00	1.901E+03	1.277E-01	5.452E-02	1.521E+01	1.022E-03
2071	3.310E+00	1.808E+03	1.215E-01	5.186E-02	1.447E+01	9.721E-04
2072	3.149E+00	1.720E+03	1.156E-01	4.933E-02	1.376E+01	9.247E-04
2073	2.995E+00	1.636E+03	1.099E-01	4.692E-02	1.309E+01	8.796E-04
2074	2.849E+00	1.557E+03	1.046E-01	4.464E-02	1.245E+01	8.367E-04
2075	2.710E+00	1.481E+03	9.948E-02	4.246E-02	1.185E+01	7.959E-04
2076	2.578E+00	1.408E+03	9.463E-02	4.039E-02	1.127E+01	7.571E-04
2077	2.452E+00	1.340E+03	9.002E-02	3.842E-02	1.072E+01	7.201E-04
2078	2.333E+00	1.274E+03	8.563E-02	3.654E-02	1.020E+01	6.850E-04
2079	2.219E+00	1.212E+03	8.145E-02	3.476E-02	9.698E+00	6.516E-04
2080	2.111E+00	1.153E+03	7.748E-02	3.307E-02	9.225E+00	6.198E-04
2081	2.008E+00	1.097E+03	7.370E-02	3.145E-02	8.775E+00	5.896E-04
2082	1.910E+00	1.043E+03	7.011E-02	2.992E-02	8.347E+00	5.608E-04
2083	1.817E+00	9.925E+02	6.669E-02	2.846E-02	7.940E+00	5.335E-04
2084	1.728E+00	9.441E+02	6.343E-02	2.707E-02	7.553E+00	5.075E-04
2085	1.644E+00	8.981E+02	6.034E-02	2.575E-02	7.184E+00	4.827E-04
2086	1.564E+00	8.543E+02	5.740E-02	2.450E-02	6.834E+00	4.592E-04
2087	1.487E+00	8.126E+02	5.460E-02	2.330E-02	6.501E+00	4.368E-04
2088	1.415E+00	7.730E+02	5.194E-02	2.217E-02	6.184E+00	4.155E-04
2089	1.346E+00	7.353E+02	4.940E-02	2.108E-02	5.882E+00	3.952E-04
2090	1.280E+00	6.994E+02	4.699E-02	2.006E-02	5.595E+00	3.759E-04
2091	1.218E+00	6.653E+02	4.470E-02	1.908E-02	5.322E+00	3.576E-04
2092	1.158E+00	6.328E+02	4.252E-02	1.815E-02	5.063E+00	3.402E-04
2093	1.102E+00	6.020E+02	4.045E-02	1.726E-02	4.816E+00	3.236E-04



LandGEM

Landfill Gas Emissions Model

Version 3.02

U.S. Environmental Protection Agency
Office of Research and Development
National Risk Management Research Laboratory (NRMRL)
and
Clean Air Technology Center (CATC)
Research Triangle Park, North Carolina

May 2005

Summary Report

Landfill Name or Identifier: Marine MSW - Bioreactor

Date: Friday, June 17, 2016

Description/Comments:

About LandGEM:

First-Order Decomposition Rate Equation:

$$Q_{CH_4} = \sum_{i=1}^{n}\sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10}\right) e^{-kt_{ij}}$$

Where,

Q_{CH4} = annual methane generation in the year of the calculation *(m^3/year)*

i = 1-year time increment

n = (year of the calculation) - (initial year of waste acceptance)

j = 0.1-year time increment

k = methane generation rate *(year^{-1})*

L_o = potential methane generation capacity *(m^3/Mg)*

M_i = mass of waste accepted in the i^{th} year *(Mg)*

t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year *(decimal years*, e.g., 3.2 years)

LandGEM is based on a first-order decomposition rate equation for quantifying emissions from the decomposition of landfilled waste in municipal solid waste (MSW) landfills. The software provides a relatively simple approach to estimating landfill gas emissions. Model defaults are based on empirical data from U.S. landfills. Field test data can also be used in place of model defaults when available. Further guidance on EPA test methods, Clean Air Act (CAA) regulations, and other guidance regarding landfill gas emissions and control technology requirements can be found at http://www.epa.gov/ttnatw01/landfill/landflpg.html.

LandGEM is considered a screening tool — the better the input data, the better the estimates. Often, there are limitations with the available data regarding waste quantity and composition, variation in design and operating practices over time, and changes occurring over time that impact the emissions potential. Changes to landfill operation, such as operating under wet conditions through leachate recirculation or other liquid additions, will result in generating more gas at a faster rate. Defaults for estimating emissions for this type of operation are being developed to include in LandGEM along with defaults for convential landfills (no leachate or liquid additions) for developing emission inventories and determining CAA applicability. Refer to the Web site identified above for future updates.

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1953**	
Landfill Closure Year (with 80-year limit)	**1965**	
Actual Closure Year (without limit)	***1965***	
Have Model Calculate Closure Year?	**No**	
Waste Design Capacity		*megagrams*

MODEL PARAMETERS

Methane Generation Rate, k	**0.120**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**170**	*m^3/Mg*
NMOC Concentration	**4,000**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

GASES / POLLUTANTS SELECTED

Gas / Pollutant #1:	**Total landfill gas**
Gas / Pollutant #2:	**Methane**
Gas / Pollutant #3:	**Carbon dioxide**
Gas / Pollutant #4:	**NMOC**

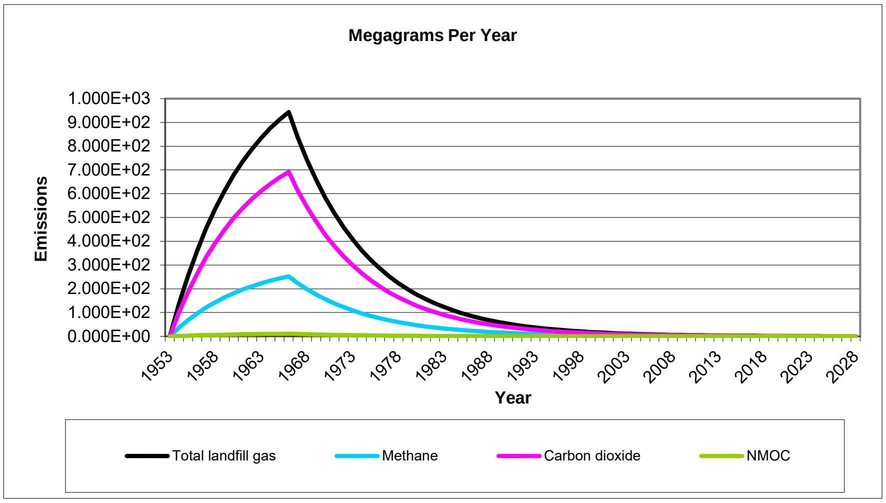
WASTE ACCEPTANCE RATES

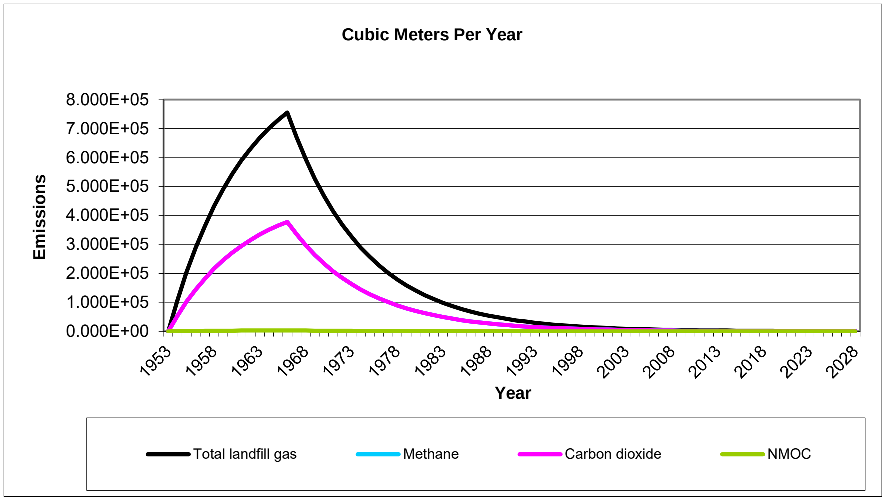
Year	**Waste Accepted**		**Waste-In-Place**	
	(Mg/year)	***(short tons/year)***	***(Mg)***	***(short tons)***
1953	2,797	3,077	0	0
1954	2,797	3,077	2,797	3,077
1955	2,797	3,077	5,595	6,154
1956	2,797	3,077	8,392	9,231
1957	2,797	3,077	11,189	12,308
1958	2,797	3,077	13,986	15,385
1959	2,797	3,077	16,784	18,462
1960	2,797	3,077	19,581	21,539
1961	2,797	3,077	22,378	24,616
1962	2,797	3,077	25,175	27,693
1963	2,797	3,077	27,973	30,770
1964	2,797	3,077	30,770	33,847
1965	2,797	3,077	33,567	36,924
1966	0	0	36,365	40,001
1967	0	0	36,365	40,001
1968	0	0	36,365	40,001
1969	0	0	36,365	40,001
1970	0	0	36,365	40,001
1971	0	0	36,365	40,001
1972	0	0	36,365	40,001
1973	0	0	36,365	40,001
1974	0	0	36,365	40,001
1975	0	0	36,365	40,001
1976	0	0	36,365	40,001
1977	0	0	36,365	40,001
1978	0	0	36,365	40,001
1979	0	0	36,365	40,001
1980	0	0	36,365	40,001
1981	0	0	36,365	40,001
1982	0	0	36,365	40,001
1983	0	0	36,365	40,001
1984	0	0	36,365	40,001
1985	0	0	36,365	40,001
1986	0	0	36,365	40,001
1987	0	0	36,365	40,001
1988	0	0	36,365	40,001
1989	0	0	36,365	40,001
1990	0	0	36,365	40,001
1991	0	0	36,365	40,001
1992	0	0	36,365	40,001

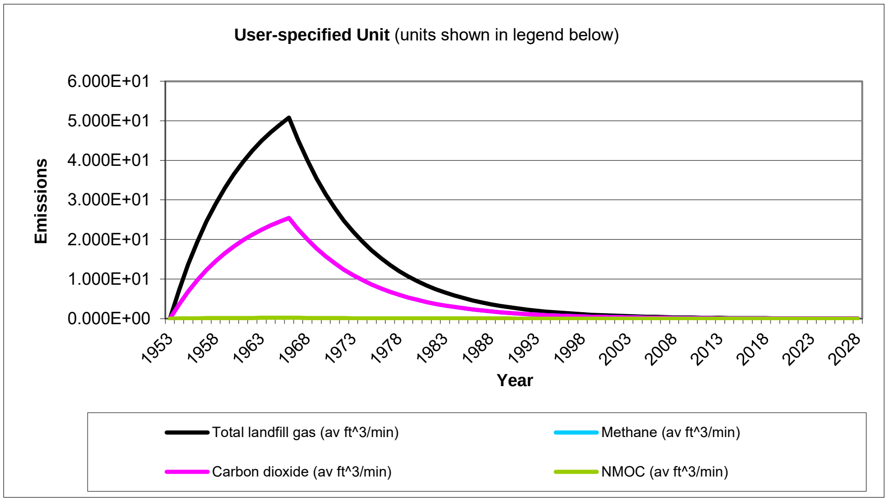
WASTE ACCEPTANCE RATES (Continued)

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1993	0	0	36,365	40,001
1994	0	0	36,365	40,001
1995	0	0	36,365	40,001
1996	0	0	36,365	40,001
1997	0	0	36,365	40,001
1998	0	0	36,365	40,001
1999	0	0	36,365	40,001
2000	0	0	36,365	40,001
2001	0	0	36,365	40,001
2002	0	0	36,365	40,001
2003	0	0	36,365	40,001
2004	0	0	36,365	40,001
2005	0	0	36,365	40,001
2006	0	0	36,365	40,001
2007	0	0	36,365	40,001
2008	0	0	36,365	40,001
2009	0	0	36,365	40,001
2010	0	0	36,365	40,001
2011	0	0	36,365	40,001
2012	0	0	36,365	40,001
2013	0	0	36,365	40,001
2014	0	0	36,365	40,001
2015	0	0	36,365	40,001
2016	0	0	36,365	40,001
2017	0	0	36,365	40,001
2018	0	0	36,365	40,001
2019	0	0	36,365	40,001
2020	0	0	36,365	40,001
2021	0	0	36,365	40,001
2022	0	0	36,365	40,001
2023	0	0	36,365	40,001
2024	0	0	36,365	40,001
2025	0	0	36,365	40,001
2026	0	0	36,365	40,001
2027	0	0	36,365	40,001
2028	0	0	36,365	40,001
2029	0	0	36,365	40,001
2030	0	0	36,365	40,001
2031	0	0	36,365	40,001
2032	0	0	36,365	40,001

Graphs


Megagrams Per Year
1.000E+03
9.000E+02
8.000E+02
7.000E+02
6.000E+02
5.000E+02
4.000E+02
3.000E+02
2.000E+02
1.000E+02
0.000E+00
Emissions
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


Cubic Meters Per Year
8.000E+05
7.000E+05
6.000E+05
5.000E+05
4.000E+05
3.000E+05
2.000E+05
1.000E+05
0.000E+00
Emissions
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
Year
Total landfill gas
Methane
Carbon dioxide
NMOC


User-specified Unit (units shown in legend below)
6.000E+01
5.000E+01
4.000E+01
3.000E+01
2.000E+01
1.000E+01
0.000E+00
Emissions
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
2023
2028
Year
Total landfill gas (av ft^3/min)
Methane (av ft^3/min)
Carbon dioxide (av ft^3/min)
NMOC (av ft^3/min)

Results

Year	Total landfill gas			Methane		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
1953	0	0	0	0	0	0
1954	1.351E+02	1.082E+05	7.270E+00	3.609E+01	5.410E+04	3.635E+00
1955	2.550E+02	2.042E+05	1.372E+01	6.810E+01	1.021E+05	6.858E+00
1956	3.612E+02	2.893E+05	1.944E+01	9.649E+01	1.446E+05	9.718E+00
1957	4.555E+02	3.647E+05	2.451E+01	1.217E+02	1.824E+05	1.225E+01
1958	5.391E+02	4.317E+05	2.901E+01	1.440E+02	2.158E+05	1.450E+01
1959	6.133E+02	4.911E+05	3.299E+01	1.638E+02	2.455E+05	1.650E+01
1960	6.790E+02	5.437E+05	3.653E+01	1.814E+02	2.719E+05	1.827E+01
1961	7.374E+02	5.904E+05	3.967E+01	1.970E+02	2.952E+05	1.984E+01
1962	7.891E+02	6.319E+05	4.246E+01	2.108E+02	3.159E+05	2.123E+01
1963	8.350E+02	6.686E+05	4.492E+01	2.230E+02	3.343E+05	2.246E+01
1964	8.757E+02	7.012E+05	4.711E+01	2.339E+02	3.506E+05	2.356E+01
1965	9.118E+02	7.301E+05	4.906E+01	2.435E+02	3.651E+05	2.453E+01
1966	9.438E+02	7.557E+05	5.078E+01	2.521E+02	3.779E+05	2.539E+01
1967	8.371E+02	6.703E+05	4.504E+01	2.236E+02	3.351E+05	2.252E+01
1968	7.424E+02	5.945E+05	3.994E+01	1.983E+02	2.972E+05	1.997E+01
1969	6.585E+02	5.273E+05	3.543E+01	1.759E+02	2.636E+05	1.771E+01
1970	5.840E+02	4.676E+05	3.142E+01	1.560E+02	2.338E+05	1.571E+01
1971	5.180E+02	4.148E+05	2.787E+01	1.384E+02	2.074E+05	1.393E+01
1972	4.594E+02	3.679E+05	2.472E+01	1.227E+02	1.839E+05	1.236E+01
1973	4.074E+02	3.263E+05	2.192E+01	1.088E+02	1.631E+05	1.096E+01
1974	3.614E+02	2.894E+05	1.944E+01	9.652E+01	1.447E+05	9.721E+00
1975	3.205E+02	2.566E+05	1.724E+01	8.561E+01	1.283E+05	8.622E+00
1976	2.843E+02	2.276E+05	1.529E+01	7.593E+01	1.138E+05	7.647E+00
1977	2.521E+02	2.019E+05	1.356E+01	6.734E+01	1.009E+05	6.782E+00
1978	2.236E+02	1.791E+05	1.203E+01	5.973E+01	8.953E+04	6.015E+00
1979	1.983E+02	1.588E+05	1.067E+01	5.297E+01	7.940E+04	5.335E+00
1980	1.759E+02	1.408E+05	9.464E+00	4.698E+01	7.042E+04	4.732E+00
1981	1.560E+02	1.249E+05	8.393E+00	4.167E+01	6.246E+04	4.197E+00
1982	1.384E+02	1.108E+05	7.444E+00	3.696E+01	5.540E+04	3.722E+00
1983	1.227E+02	9.827E+04	6.603E+00	3.278E+01	4.913E+04	3.301E+00
1984	1.088E+02	8.716E+04	5.856E+00	2.907E+01	4.358E+04	2.928E+00
1985	9.653E+01	7.730E+04	5.194E+00	2.579E+01	3.865E+04	2.597E+00
1986	8.562E+01	6.856E+04	4.606E+00	2.287E+01	3.428E+04	2.303E+00
1987	7.594E+01	6.081E+04	4.086E+00	2.028E+01	3.040E+04	2.043E+00
1988	6.735E+01	5.393E+04	3.624E+00	1.799E+01	2.697E+04	1.812E+00
1989	5.973E+01	4.783E+04	3.214E+00	1.596E+01	2.392E+04	1.607E+00
1990	5.298E+01	4.242E+04	2.850E+00	1.415E+01	2.121E+04	1.425E+00
1991	4.699E+01	3.763E+04	2.528E+00	1.255E+01	1.881E+04	1.264E+00
1992	4.167E+01	3.337E+04	2.242E+00	1.113E+01	1.669E+04	1.121E+00
1993	3.696E+01	2.960E+04	1.989E+00	9.873E+00	1.480E+04	9.943E-01
1994	3.278E+01	2.625E+04	1.764E+00	8.757E+00	1.313E+04	8.819E-01
1995	2.908E+01	2.328E+04	1.564E+00	7.766E+00	1.164E+04	7.822E-01
1996	2.579E+01	2.065E+04	1.387E+00	6.888E+00	1.032E+04	6.937E-01
1997	2.287E+01	1.831E+04	1.231E+00	6.109E+00	9.157E+03	6.153E-01
1998	2.029E+01	1.624E+04	1.091E+00	5.418E+00	8.122E+03	5.457E-01
1999	1.799E+01	1.441E+04	9.680E-01	4.806E+00	7.203E+03	4.840E-01
2000	1.596E+01	1.278E+04	8.585E-01	4.262E+00	6.389E+03	4.293E-01
2001	1.415E+01	1.133E+04	7.614E-01	3.780E+00	5.666E+03	3.807E-01
2002	1.255E+01	1.005E+04	6.753E-01	3.353E+00	5.026E+03	3.377E-01

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2003	1.113E+01	8.915E+03	5.990E-01	2.974E+00	4.457E+03	2.995E-01
2004	9.874E+00	7.907E+03	5.312E-01	2.637E+00	3.953E+03	2.656E-01
2005	8.757E+00	7.012E+03	4.712E-01	2.339E+00	3.506E+03	2.356E-01
2006	7.767E+00	6.220E+03	4.179E-01	2.075E+00	3.110E+03	2.089E-01
2007	6.889E+00	5.516E+03	3.706E-01	1.840E+00	2.758E+03	1.853E-01
2008	6.110E+00	4.892E+03	3.287E-01	1.632E+00	2.446E+03	1.644E-01
2009	5.419E+00	4.339E+03	2.916E-01	1.447E+00	2.170E+03	1.458E-01
2010	4.806E+00	3.849E+03	2.586E-01	1.284E+00	1.924E+03	1.293E-01
2011	4.263E+00	3.413E+03	2.293E-01	1.139E+00	1.707E+03	1.147E-01
2012	3.781E+00	3.027E+03	2.034E-01	1.010E+00	1.514E+03	1.017E-01
2013	3.353E+00	2.685E+03	1.804E-01	8.957E-01	1.343E+03	9.020E-02
2014	2.974E+00	2.381E+03	1.600E-01	7.944E-01	1.191E+03	8.000E-02
2015	2.638E+00	2.112E+03	1.419E-01	7.045E-01	1.056E+03	7.096E-02
2016	2.339E+00	1.873E+03	1.259E-01	6.249E-01	9.366E+02	6.293E-02
2017	2.075E+00	1.661E+03	1.116E-01	5.542E-01	8.307E+02	5.582E-02
2018	1.840E+00	1.474E+03	9.901E-02	4.915E-01	7.368E+02	4.950E-02
2019	1.632E+00	1.307E+03	8.781E-02	4.360E-01	6.535E+02	4.391E-02
2020	1.448E+00	1.159E+03	7.788E-02	3.867E-01	5.796E+02	3.894E-02
2021	1.284E+00	1.028E+03	6.908E-02	3.429E-01	5.140E+02	3.454E-02
2022	1.139E+00	9.118E+02	6.127E-02	3.042E-01	4.559E+02	3.063E-02
2023	1.010E+00	8.087E+02	5.434E-02	2.698E-01	4.044E+02	2.717E-02
2024	8.957E-01	7.173E+02	4.819E-02	2.393E-01	3.586E+02	2.410E-02
2025	7.944E-01	6.362E+02	4.274E-02	2.122E-01	3.181E+02	2.137E-02
2026	7.046E-01	5.642E+02	3.791E-02	1.882E-01	2.821E+02	1.895E-02
2027	6.249E-01	5.004E+02	3.362E-02	1.669E-01	2.502E+02	1.681E-02
2028	5.543E-01	4.438E+02	2.982E-02	1.481E-01	2.219E+02	1.491E-02
2029	4.916E-01	3.936E+02	2.645E-02	1.313E-01	1.968E+02	1.322E-02
2030	4.360E-01	3.491E+02	2.346E-02	1.165E-01	1.746E+02	1.173E-02
2031	3.867E-01	3.097E+02	2.081E-02	1.033E-01	1.548E+02	1.040E-02
2032	3.430E-01	2.746E+02	1.845E-02	9.161E-02	1.373E+02	9.226E-03
2033	3.042E-01	2.436E+02	1.637E-02	8.125E-02	1.218E+02	8.183E-03
2034	2.698E-01	2.160E+02	1.452E-02	7.206E-02	1.080E+02	7.258E-03
2035	2.393E-01	1.916E+02	1.287E-02	6.392E-02	9.580E+01	6.437E-03
2036	2.122E-01	1.699E+02	1.142E-02	5.669E-02	8.497E+01	5.709E-03
2037	1.882E-01	1.507E+02	1.013E-02	5.028E-02	7.536E+01	5.064E-03
2038	1.669E-01	1.337E+02	8.982E-03	4.459E-02	6.684E+01	4.491E-03
2039	1.481E-01	1.186E+02	7.966E-03	3.955E-02	5.928E+01	3.983E-03
2040	1.313E-01	1.052E+02	7.065E-03	3.508E-02	5.258E+01	3.533E-03
2041	1.165E-01	9.327E+01	6.266E-03	3.111E-02	4.663E+01	3.133E-03
2042	1.033E-01	8.272E+01	5.558E-03	2.759E-02	4.136E+01	2.779E-03
2043	9.162E-02	7.336E+01	4.929E-03	2.447E-02	3.668E+01	2.465E-03
2044	8.126E-02	6.507E+01	4.372E-03	2.171E-02	3.253E+01	2.186E-03
2045	7.207E-02	5.771E+01	3.878E-03	1.925E-02	2.886E+01	1.939E-03
2046	6.392E-02	5.118E+01	3.439E-03	1.707E-02	2.559E+01	1.720E-03
2047	5.669E-02	4.540E+01	3.050E-03	1.514E-02	2.270E+01	1.525E-03
2048	5.028E-02	4.026E+01	2.705E-03	1.343E-02	2.013E+01	1.353E-03
2049	4.460E-02	3.571E+01	2.399E-03	1.191E-02	1.786E+01	1.200E-03
2050	3.955E-02	3.167E+01	2.128E-03	1.057E-02	1.584E+01	1.064E-03
2051	3.508E-02	2.809E+01	1.887E-03	9.370E-03	1.405E+01	9.437E-04
2052	3.111E-02	2.491E+01	1.674E-03	8.311E-03	1.246E+01	8.370E-04
2053	2.760E-02	2.210E+01	1.485E-03	7.371E-03	1.105E+01	7.423E-04

Results (Continued)

Year	Total landfill gas			Methane		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2054	2.447E-02	1.960E+01	1.317E-03	6.538E-03	9.799E+00	6.584E-04
2055	2.171E-02	1.738E+01	1.168E-03	5.798E-03	8.691E+00	5.840E-04
2056	1.925E-02	1.542E+01	1.036E-03	5.143E-03	7.708E+00	5.179E-04
2057	1.708E-02	1.367E+01	9.187E-04	4.561E-03	6.837E+00	4.594E-04
2058	1.514E-02	1.213E+01	8.148E-04	4.045E-03	6.064E+00	4.074E-04
2059	1.343E-02	1.076E+01	7.227E-04	3.588E-03	5.378E+00	3.613E-04
2060	1.191E-02	9.540E+00	6.410E-04	3.182E-03	4.770E+00	3.205E-04
2061	1.057E-02	8.461E+00	5.685E-04	2.822E-03	4.230E+00	2.842E-04
2062	9.371E-03	7.504E+00	5.042E-04	2.503E-03	3.752E+00	2.521E-04
2063	8.312E-03	6.656E+00	4.472E-04	2.220E-03	3.328E+00	2.236E-04
2064	7.372E-03	5.903E+00	3.966E-04	1.969E-03	2.951E+00	1.983E-04
2065	6.538E-03	5.235E+00	3.518E-04	1.746E-03	2.618E+00	1.759E-04
2066	5.799E-03	4.643E+00	3.120E-04	1.549E-03	2.322E+00	1.560E-04
2067	5.143E-03	4.118E+00	2.767E-04	1.374E-03	2.059E+00	1.384E-04
2068	4.561E-03	3.653E+00	2.454E-04	1.218E-03	1.826E+00	1.227E-04
2069	4.046E-03	3.240E+00	2.177E-04	1.081E-03	1.620E+00	1.088E-04
2070	3.588E-03	2.873E+00	1.931E-04	9.584E-04	1.437E+00	9.653E-05
2071	3.182E-03	2.548E+00	1.712E-04	8.501E-04	1.274E+00	8.561E-05
2072	2.823E-03	2.260E+00	1.519E-04	7.539E-04	1.130E+00	7.593E-05
2073	2.503E-03	2.005E+00	1.347E-04	6.687E-04	1.002E+00	6.734E-05
2074	2.220E-03	1.778E+00	1.195E-04	5.931E-04	8.890E-01	5.973E-05
2075	1.969E-03	1.577E+00	1.060E-04	5.260E-04	7.884E-01	5.298E-05
2076	1.747E-03	1.399E+00	9.397E-05	4.665E-04	6.993E-01	4.698E-05
2077	1.549E-03	1.240E+00	8.334E-05	4.138E-04	6.202E-01	4.167E-05
2078	1.374E-03	1.100E+00	7.392E-05	3.670E-04	5.501E-01	3.696E-05
2079	1.219E-03	9.757E-01	6.556E-05	3.255E-04	4.879E-01	3.278E-05
2080	1.081E-03	8.654E-01	5.815E-05	2.887E-04	4.327E-01	2.907E-05
2081	9.585E-04	7.675E-01	5.157E-05	2.560E-04	3.838E-01	2.579E-05
2082	8.501E-04	6.808E-01	4.574E-05	2.271E-04	3.404E-01	2.287E-05
2083	7.540E-04	6.038E-01	4.057E-05	2.014E-04	3.019E-01	2.028E-05
2084	6.687E-04	5.355E-01	3.598E-05	1.786E-04	2.677E-01	1.799E-05
2085	5.931E-04	4.749E-01	3.191E-05	1.584E-04	2.375E-01	1.596E-05
2086	5.261E-04	4.212E-01	2.830E-05	1.405E-04	2.106E-01	1.415E-05
2087	4.666E-04	3.736E-01	2.510E-05	1.246E-04	1.868E-01	1.255E-05
2088	4.138E-04	3.314E-01	2.226E-05	1.105E-04	1.657E-01	1.113E-05
2089	3.670E-04	2.939E-01	1.975E-05	9.803E-05	1.469E-01	9.873E-06
2090	3.255E-04	2.607E-01	1.751E-05	8.695E-05	1.303E-01	8.757E-06
2091	2.887E-04	2.312E-01	1.553E-05	7.712E-05	1.156E-01	7.767E-06
2092	2.561E-04	2.050E-01	1.378E-05	6.840E-05	1.025E-01	6.888E-06
2093	2.271E-04	1.819E-01	1.222E-05	6.066E-05	9.093E-02	6.109E-06

Results (Continued)

Year	**Carbon dioxide**			**NMOC**		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***	***(Mg/year)***	***(m^3/year)***	***(av ft^3/min)***
1953	0	0	0	0	0	0
1954	9.902E+01	5.410E+04	3.635E+00	1.551E+00	4.328E+02	2.908E-02
1955	1.869E+02	1.021E+05	6.858E+00	2.927E+00	8.166E+02	5.487E-02
1956	2.647E+02	1.446E+05	9.718E+00	4.147E+00	1.157E+03	7.774E-02
1957	3.338E+02	1.824E+05	1.225E+01	5.230E+00	1.459E+03	9.803E-02
1958	3.951E+02	2.158E+05	1.450E+01	6.190E+00	1.727E+03	1.160E-01
1959	4.495E+02	2.455E+05	1.650E+01	7.041E+00	1.964E+03	1.320E-01
1960	4.977E+02	2.719E+05	1.827E+01	7.796E+00	2.175E+03	1.461E-01
1961	5.404E+02	2.952E+05	1.984E+01	8.466E+00	2.362E+03	1.587E-01
1962	5.783E+02	3.159E+05	2.123E+01	9.060E+00	2.527E+03	1.698E-01
1963	6.119E+02	3.343E+05	2.246E+01	9.586E+00	2.674E+03	1.797E-01
1964	6.418E+02	3.506E+05	2.356E+01	1.005E+01	2.805E+03	1.885E-01
1965	6.682E+02	3.651E+05	2.453E+01	1.047E+01	2.920E+03	1.962E-01
1966	6.917E+02	3.779E+05	2.539E+01	1.084E+01	3.023E+03	2.031E-01
1967	6.135E+02	3.351E+05	2.252E+01	9.610E+00	2.681E+03	1.801E-01
1968	5.441E+02	2.972E+05	1.997E+01	8.524E+00	2.378E+03	1.598E-01
1969	4.826E+02	2.636E+05	1.771E+01	7.560E+00	2.109E+03	1.417E-01
1970	4.280E+02	2.338E+05	1.571E+01	6.705E+00	1.871E+03	1.257E-01
1971	3.796E+02	2.074E+05	1.393E+01	5.947E+00	1.659E+03	1.115E-01
1972	3.367E+02	1.839E+05	1.236E+01	5.274E+00	1.471E+03	9.886E-02
1973	2.986E+02	1.631E+05	1.096E+01	4.678E+00	1.305E+03	8.769E-02
1974	2.648E+02	1.447E+05	9.721E+00	4.149E+00	1.157E+03	7.777E-02
1975	2.349E+02	1.283E+05	8.622E+00	3.680E+00	1.027E+03	6.898E-02
1976	2.083E+02	1.138E+05	7.647E+00	3.264E+00	9.105E+02	6.118E-02
1977	1.848E+02	1.009E+05	6.782E+00	2.895E+00	8.075E+02	5.426E-02
1978	1.639E+02	8.953E+04	6.015E+00	2.567E+00	7.162E+02	4.812E-02
1979	1.453E+02	7.940E+04	5.335E+00	2.277E+00	6.352E+02	4.268E-02
1980	1.289E+02	7.042E+04	4.732E+00	2.019E+00	5.634E+02	3.785E-02
1981	1.143E+02	6.246E+04	4.197E+00	1.791E+00	4.997E+02	3.357E-02
1982	1.014E+02	5.540E+04	3.722E+00	1.589E+00	4.432E+02	2.978E-02
1983	8.994E+01	4.913E+04	3.301E+00	1.409E+00	3.931E+02	2.641E-02
1984	7.977E+01	4.358E+04	2.928E+00	1.250E+00	3.486E+02	2.342E-02
1985	7.075E+01	3.865E+04	2.597E+00	1.108E+00	3.092E+02	2.078E-02
1986	6.275E+01	3.428E+04	2.303E+00	9.830E-01	2.742E+02	1.843E-02
1987	5.565E+01	3.040E+04	2.043E+00	8.718E-01	2.432E+02	1.634E-02
1988	4.936E+01	2.697E+04	1.812E+00	7.732E-01	2.157E+02	1.449E-02
1989	4.378E+01	2.392E+04	1.607E+00	6.858E-01	1.913E+02	1.286E-02
1990	3.883E+01	2.121E+04	1.425E+00	6.083E-01	1.697E+02	1.140E-02
1991	3.444E+01	1.881E+04	1.264E+00	5.395E-01	1.505E+02	1.011E-02
1992	3.054E+01	1.669E+04	1.121E+00	4.785E-01	1.335E+02	8.969E-03
1993	2.709E+01	1.480E+04	9.943E-01	4.244E-01	1.184E+02	7.955E-03
1994	2.403E+01	1.313E+04	8.819E-01	3.764E-01	1.050E+02	7.055E-03
1995	2.131E+01	1.164E+04	7.822E-01	3.338E-01	9.313E+01	6.257E-03
1996	1.890E+01	1.032E+04	6.937E-01	2.961E-01	8.260E+01	5.550E-03
1997	1.676E+01	9.157E+03	6.153E-01	2.626E-01	7.326E+01	4.922E-03
1998	1.487E+01	8.122E+03	5.457E-01	2.329E-01	6.497E+01	4.366E-03
1999	1.319E+01	7.203E+03	4.840E-01	2.066E-01	5.763E+01	3.872E-03
2000	1.169E+01	6.389E+03	4.293E-01	1.832E-01	5.111E+01	3.434E-03
2001	1.037E+01	5.666E+03	3.807E-01	1.625E-01	4.533E+01	3.046E-03
2002	9.199E+00	5.026E+03	3.377E-01	1.441E-01	4.020E+01	2.701E-03

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2003	8.159E+00	4.457E+03	2.995E-01	1.278E-01	3.566E+01	2.396E-03
2004	7.236E+00	3.953E+03	2.656E-01	1.134E-01	3.163E+01	2.125E-03
2005	6.418E+00	3.506E+03	2.356E-01	1.005E-01	2.805E+01	1.885E-03
2006	5.692E+00	3.110E+03	2.089E-01	8.917E-02	2.488E+01	1.672E-03
2007	5.049E+00	2.758E+03	1.853E-01	7.909E-02	2.206E+01	1.483E-03
2008	4.478E+00	2.446E+03	1.644E-01	7.015E-02	1.957E+01	1.315E-03
2009	3.971E+00	2.170E+03	1.458E-01	6.221E-02	1.736E+01	1.166E-03
2010	3.522E+00	1.924E+03	1.293E-01	5.518E-02	1.539E+01	1.034E-03
2011	3.124E+00	1.707E+03	1.147E-01	4.894E-02	1.365E+01	9.174E-04
2012	2.771E+00	1.514E+03	1.017E-01	4.341E-02	1.211E+01	8.136E-04
2013	2.457E+00	1.343E+03	9.020E-02	3.850E-02	1.074E+01	7.216E-04
2014	2.180E+00	1.191E+03	8.000E-02	3.414E-02	9.526E+00	6.400E-04
2015	1.933E+00	1.056E+03	7.096E-02	3.028E-02	8.448E+00	5.677E-04
2016	1.715E+00	9.366E+02	6.293E-02	2.686E-02	7.493E+00	5.035E-04
2017	1.521E+00	8.307E+02	5.582E-02	2.382E-02	6.646E+00	4.465E-04
2018	1.349E+00	7.368E+02	4.950E-02	2.113E-02	5.894E+00	3.960E-04
2019	1.196E+00	6.535E+02	4.391E-02	1.874E-02	5.228E+00	3.513E-04
2020	1.061E+00	5.796E+02	3.894E-02	1.662E-02	4.637E+00	3.115E-04
2021	9.409E-01	5.140E+02	3.454E-02	1.474E-02	4.112E+00	2.763E-04
2022	8.345E-01	4.559E+02	3.063E-02	1.307E-02	3.647E+00	2.451E-04
2023	7.402E-01	4.044E+02	2.717E-02	1.160E-02	3.235E+00	2.173E-04
2024	6.565E-01	3.586E+02	2.410E-02	1.028E-02	2.869E+00	1.928E-04
2025	5.822E-01	3.181E+02	2.137E-02	9.121E-03	2.545E+00	1.710E-04
2026	5.164E-01	2.821E+02	1.895E-02	8.090E-03	2.257E+00	1.516E-04
2027	4.580E-01	2.502E+02	1.681E-02	7.175E-03	2.002E+00	1.345E-04
2028	4.062E-01	2.219E+02	1.491E-02	6.364E-03	1.775E+00	1.193E-04
2029	3.603E-01	1.968E+02	1.322E-02	5.644E-03	1.575E+00	1.058E-04
2030	3.195E-01	1.746E+02	1.173E-02	5.006E-03	1.397E+00	9.383E-05
2031	2.834E-01	1.548E+02	1.040E-02	4.440E-03	1.239E+00	8.322E-05
2032	2.514E-01	1.373E+02	9.226E-03	3.938E-03	1.099E+00	7.381E-05
2033	2.229E-01	1.218E+02	8.183E-03	3.492E-03	9.743E-01	6.546E-05
2034	1.977E-01	1.080E+02	7.258E-03	3.097E-03	8.641E-01	5.806E-05
2035	1.754E-01	9.580E+01	6.437E-03	2.747E-03	7.664E-01	5.150E-05
2036	1.555E-01	8.497E+01	5.709E-03	2.437E-03	6.798E-01	4.567E-05
2037	1.379E-01	7.536E+01	5.064E-03	2.161E-03	6.029E-01	4.051E-05
2038	1.224E-01	6.684E+01	4.491E-03	1.917E-03	5.347E-01	3.593E-05
2039	1.085E-01	5.928E+01	3.983E-03	1.700E-03	4.743E-01	3.186E-05
2040	9.624E-02	5.258E+01	3.533E-03	1.508E-03	4.206E-01	2.826E-05
2041	8.536E-02	4.663E+01	3.133E-03	1.337E-03	3.731E-01	2.507E-05
2042	7.571E-02	4.136E+01	2.779E-03	1.186E-03	3.309E-01	2.223E-05
2043	6.715E-02	3.668E+01	2.465E-03	1.052E-03	2.935E-01	1.972E-05
2044	5.955E-02	3.253E+01	2.186E-03	9.329E-04	2.603E-01	1.749E-05
2045	5.282E-02	2.886E+01	1.939E-03	8.275E-04	2.308E-01	1.551E-05
2046	4.685E-02	2.559E+01	1.720E-03	7.339E-04	2.047E-01	1.376E-05
2047	4.155E-02	2.270E+01	1.525E-03	6.509E-04	1.816E-01	1.220E-05
2048	3.685E-02	2.013E+01	1.353E-03	5.773E-04	1.611E-01	1.082E-05
2049	3.268E-02	1.786E+01	1.200E-03	5.120E-04	1.428E-01	9.598E-06
2050	2.899E-02	1.584E+01	1.064E-03	4.541E-04	1.267E-01	8.512E-06
2051	2.571E-02	1.405E+01	9.437E-04	4.028E-04	1.124E-01	7.550E-06
2052	2.280E-02	1.246E+01	8.370E-04	3.572E-04	9.966E-02	6.696E-06
2053	2.022E-02	1.105E+01	7.423E-04	3.168E-04	8.839E-02	5.939E-06

Results (Continued)

Year	Carbon dioxide			NMOC		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*	*(Mg/year)*	*(m^3/year)*	*(av ft^3/min)*
2054	1.794E-02	9.799E+00	6.584E-04	2.810E-04	7.839E-02	5.267E-06
2055	1.591E-02	8.691E+00	5.840E-04	2.492E-04	6.953E-02	4.672E-06
2056	1.411E-02	7.708E+00	5.179E-04	2.210E-04	6.167E-02	4.143E-06
2057	1.251E-02	6.837E+00	4.594E-04	1.960E-04	5.469E-02	3.675E-06
2058	1.110E-02	6.064E+00	4.074E-04	1.739E-04	4.851E-02	3.259E-06
2059	9.844E-03	5.378E+00	3.613E-04	1.542E-04	4.302E-02	2.891E-06
2060	8.731E-03	4.770E+00	3.205E-04	1.368E-04	3.816E-02	2.564E-06
2061	7.744E-03	4.230E+00	2.842E-04	1.213E-04	3.384E-02	2.274E-06
2062	6.868E-03	3.752E+00	2.521E-04	1.076E-04	3.002E-02	2.017E-06
2063	6.091E-03	3.328E+00	2.236E-04	9.543E-05	2.662E-02	1.789E-06
2064	5.403E-03	2.951E+00	1.983E-04	8.464E-05	2.361E-02	1.586E-06
2065	4.792E-03	2.618E+00	1.759E-04	7.506E-05	2.094E-02	1.407E-06
2066	4.250E-03	2.322E+00	1.560E-04	6.658E-05	1.857E-02	1.248E-06
2067	3.769E-03	2.059E+00	1.384E-04	5.905E-05	1.647E-02	1.107E-06
2068	3.343E-03	1.826E+00	1.227E-04	5.237E-05	1.461E-02	9.817E-07
2069	2.965E-03	1.620E+00	1.088E-04	4.645E-05	1.296E-02	8.707E-07
2070	2.630E-03	1.437E+00	9.653E-05	4.120E-05	1.149E-02	7.722E-07
2071	2.332E-03	1.274E+00	8.561E-05	3.654E-05	1.019E-02	6.849E-07
2072	2.069E-03	1.130E+00	7.593E-05	3.241E-05	9.041E-03	6.074E-07
2073	1.835E-03	1.002E+00	6.734E-05	2.874E-05	8.018E-03	5.388E-07
2074	1.627E-03	8.890E-01	5.973E-05	2.549E-05	7.112E-03	4.778E-07
2075	1.443E-03	7.884E-01	5.298E-05	2.261E-05	6.308E-03	4.238E-07
2076	1.280E-03	6.993E-01	4.698E-05	2.005E-05	5.594E-03	3.759E-07
2077	1.135E-03	6.202E-01	4.167E-05	1.778E-05	4.962E-03	3.334E-07
2078	1.007E-03	5.501E-01	3.696E-05	1.577E-05	4.401E-03	2.957E-07
2079	8.930E-04	4.879E-01	3.278E-05	1.399E-05	3.903E-03	2.622E-07
2080	7.921E-04	4.327E-01	2.907E-05	1.241E-05	3.462E-03	2.326E-07
2081	7.025E-04	3.838E-01	2.579E-05	1.100E-05	3.070E-03	2.063E-07
2082	6.231E-04	3.404E-01	2.287E-05	9.761E-06	2.723E-03	1.830E-07
2083	5.526E-04	3.019E-01	2.028E-05	8.657E-06	2.415E-03	1.623E-07
2084	4.901E-04	2.677E-01	1.799E-05	7.678E-06	2.142E-03	1.439E-07
2085	4.347E-04	2.375E-01	1.596E-05	6.810E-06	1.900E-03	1.276E-07
2086	3.855E-04	2.106E-01	1.415E-05	6.040E-06	1.685E-03	1.132E-07
2087	3.419E-04	1.868E-01	1.255E-05	5.357E-06	1.494E-03	1.004E-07
2088	3.033E-04	1.657E-01	1.113E-05	4.751E-06	1.325E-03	8.906E-08
2089	2.690E-04	1.469E-01	9.873E-06	4.214E-06	1.176E-03	7.899E-08
2090	2.386E-04	1.303E-01	8.757E-06	3.737E-06	1.043E-03	7.005E-08
2091	2.116E-04	1.156E-01	7.767E-06	3.315E-06	9.247E-04	6.213E-08
2092	1.877E-04	1.025E-01	6.888E-06	2.940E-06	8.202E-04	5.511E-08
2093	1.664E-04	9.093E-02	6.109E-06	2.607E-06	7.274E-04	4.887E-08

ATTACHMENT A.2

Landfill Gas Monitoring Probe Installation Logs

P-1

SAMPLE DATA

SOIL PROFILE

Drilling Method: Geoprobe™

Ground Elevation (ft):

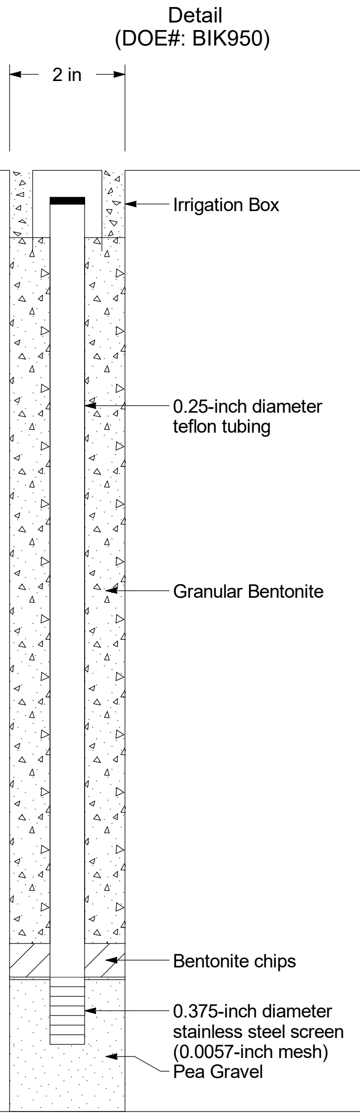
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Description
0						SM	Gray, fine to coarse SAND with gravel and silt (medium dense, damp) (no odor, no sheen) [FILL]
						SM	Brownish-black, silty, fine to coarse SAND with gravel (medium dense, damp) (no odor, no sheen)
						ML	Dark gray SILT with trace fine to medium sand (dense, damp) (no odor, no sheen)
2							No Recovery
4						ML	Dark gray SILT with trace fine to medium sand (dense, damp) (no odor, no sheen)
							-- with wood debris
6						SP	Dark gray, medium SAND with trace gravel (medium dense, wet) (no odor, no sheen)
							No Recovery

Boring Completed 06/10/15
Total Depth of Boring = 7.0 ft.

GROUNDWATER

Water Level

Groundwater not encountered.



Completed 06/10/15
Total Depth of = 7.0 ft.

8

10

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill
Bellingham, WA

Log of P-1

Figure
A-1

P-2

SAMPLE DATA	SOIL PROFILE	GROUNDWATER

Depth (ft) | Sample Number & Interval | Sampler Type | Blows/Foot | PID (ppm) | Graphic Symbol | USCS Symbol

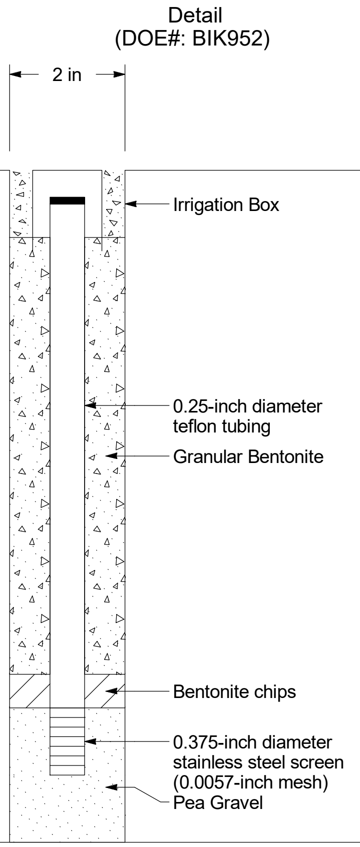
Drilling Method: Geoprobe™

Ground Elevation (ft):

USCS Symbol	
SM	Brown, silty, fine to medium SAND with gravel and cobbles (medium dense, moist) (no odor, no sheen) [FILL]
GM	Dark gray GRAVEL with trace silt (medium dense, moist) (no odor, no sheen)
SM	Dark gray, fine SAND with trace gravel (dense, moist) (no odor, no sheen)
WD	WOOD DEBRIS (no odor, no sheen) [MUNICIPAL SOLID WASTE]
SM	Brownish-black, fine to coarse SAND with trace glass, brick fragments and wood debris (medium dense, moist) (strong organic odor, no sheen)
SM	Dark gray, rust mottled, silty fine to medium SAND with trace fine gravel and glass (medium dense, moist) (no odor, no sheen)
	No Recovery

Water Level

Groundwater not encountered.



Boring Completed 06/11/15
Total Depth of Boring = 5.0 ft.

Completed 06/11/15
Total Depth of = 5.0 ft.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Cornwall Landfill
Bellingham, WA

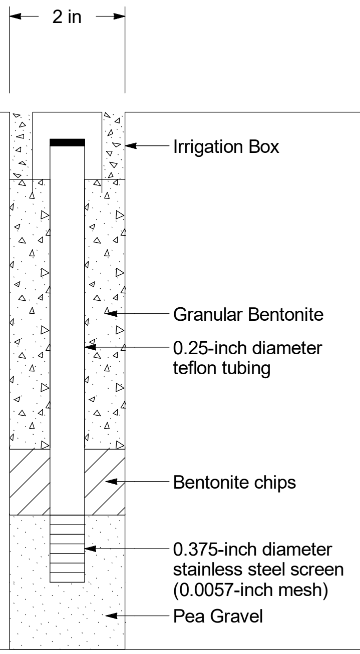
Log of P-2

Figure
A-2

P-3

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft):	Water Level
0						SM	Brown, silty fine SAND with cobbles and gravel (medium dense, moist) (no odor, no sheen) [FILL]	Groundwater not encountered.
						SM	Blackish, brown, silty fine SAND with fine gravel and trace wood chips (medium dense, damp) (no odor, no sheen)	
2						GP	White GRAVEL (no odor, no sheen)	
						WD	Black to brown WOOD DEBRIS (organic odor) [Municipal Solid Waste]	
						SM	Dark gray, silty, fine SAND with coarse sand and trace gravel (medium dense, damp) (no odor, no sheen)	
							No recovery	
4								

Detail
(DOE#: BIK953)



Boring Completed 06/11/15
Total Depth of Boring = 4.0 ft.

Completed 06/11/15
Total Depth of = 4.0 ft.

6

8

10

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

LANDAU ASSOCIATES

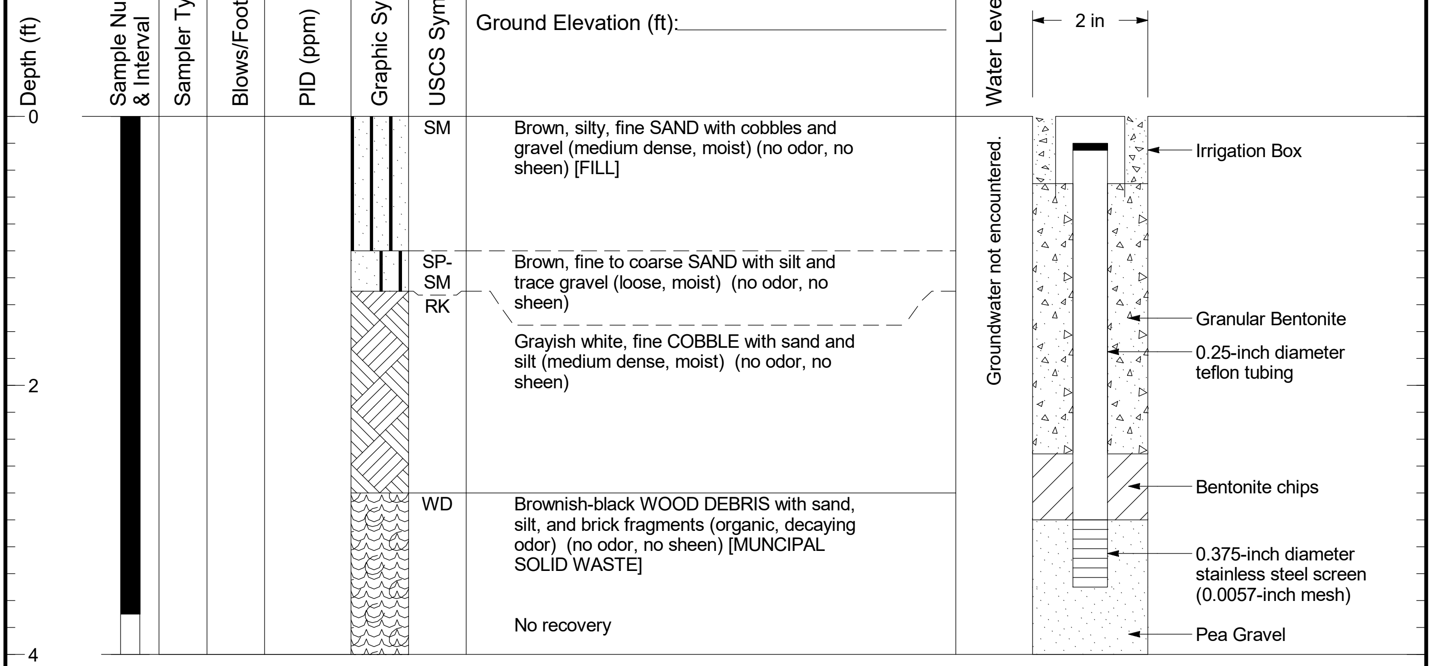
Cornwall Landfill
Bellingham, WA

Log of P-3

Figure
A-3

P-4

SAMPLE DATA	SOIL PROFILE	GROUNDWATER
Depth (ft) / Sample Number & Interval / Sampler Type / Blows/Foot / PID (ppm)	Graphic Symbol / USCS Symbol / Drilling Method: Geoprobe™ Ground Elevation (ft):	Water Level / Detail (DOE#: BIK954)



USCS Symbol	Description
SM	Brown, silty, fine SAND with cobbles and gravel (medium dense, moist) (no odor, no sheen) [FILL]
SP-SM	Brown, fine to coarse SAND with silt and trace gravel (loose, moist) (no odor, no sheen)
RK	Grayish white, fine COBBLE with sand and silt (medium dense, moist) (no odor, no sheen)
WD	Brownish-black WOOD DEBRIS with sand, silt, and brick fragments (organic, decaying odor) (no odor, no sheen) [MUNCIPAL SOLID WASTE] No recovery

Boring Completed 06/11/15
Total Depth of Boring = 4.0 ft.

Completed 06/11/15
Total Depth of = 4.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

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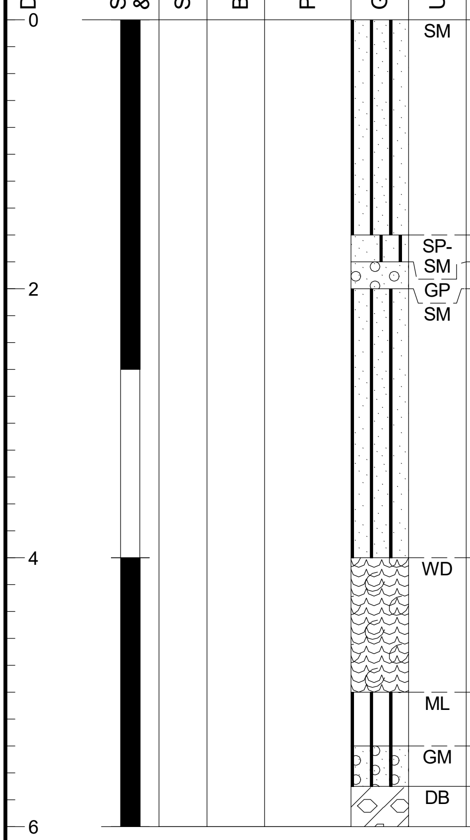
Cornwall Landfill Bellingham, WA	Log of P-4	Figure A-4

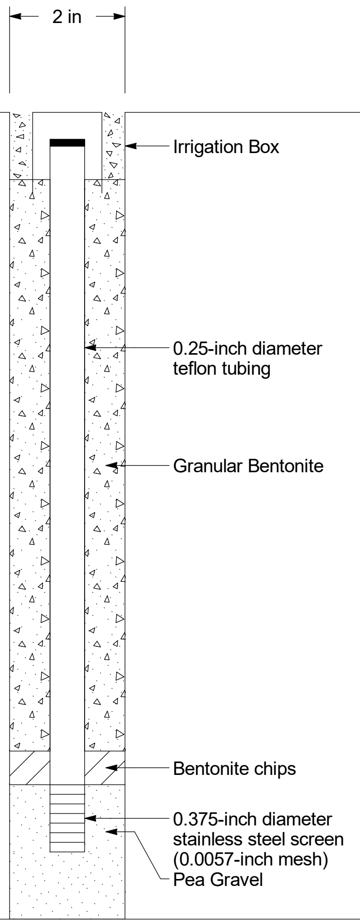
P-5

SAMPLE DATA	SOIL PROFILE	GROUNDWATER
Depth (ft) Sample Number & Interval Sampler Type Blows/Foot PID (ppm)	Graphic Symbol USCS Symbol Drilling Method: Geoprobe™ Ground Elevation (ft):	Water Level Detail (DOE#: BIK955)



SM	Brown, silty, fine SAND with cobbles and gravel (medium dense, dry) (no odor, no sheen) [FILL]
SP-SM	Brown, fine to coarse SAND with silt and trace gravel (medium dense, damp) (no odor, no sheen)
GP	Grayish-white, crushed GRAVEL (loose, dry) (no odor, no sheen)
SM	Silty, fine SAND with trace coarse gravel and wood debris (medium dense, damp) (no odor, no sheen) No Recovery
WD	Silty, WOOD DEBRIS with sand (medium dense, damp) (organic odor, no sheen)
ML	Dark gray SILT with sand and wood debris (dense, damp) (no odor, no sheen)
GM	Gray, silty GRAVEL with sand (loose, dry) (no odor, no sheen)
DB	DEBRIS (red brick fragments, silt, sand and wood debris) (petroleum-like odor, no sheen) [MUNICIPAL SOLID WASTE]

Groundwater not encountered.



Boring Completed 06/11/15
Total Depth of Boring = 6.0 ft.

Completed 06/11/15
Total Depth of = 6.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

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Cornwall Landfill
Bellingham, WA

Log of P-5

Figure
A-5

P-6

SAMPLE DATA | SOIL PROFILE | GROUNDWATER

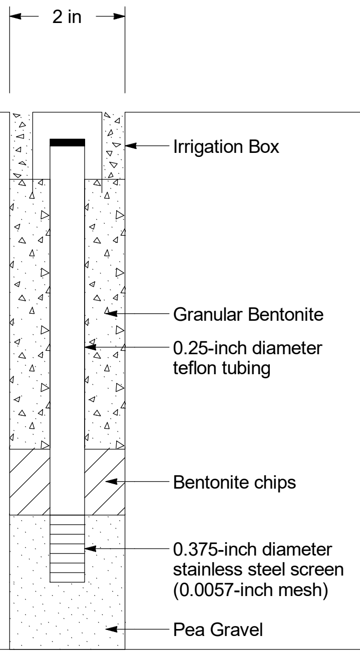
Drilling Method: Geoprobe™

Ground Elevation (ft):

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	USCS Symbol	Description
0					GP-GM	Sandy GRAVEL with silt and cobbles (medium dense, moist) (no odor, no sheen) [FILL]
					SP-SM	Brown, medium to coarse SAND with silt (medium dense, damp) (no odor, no sheen)
2					ML	Blackish brown, sandy SILT with trace wood chips and glass (dense, damp) (no odor, no sheen)
					DB	DEBRIS (Glass, wood chips, metal) (organic odor, no sheen) [MUNICIPAL SOLID WASTE] No recovery
4						

Water Level: Groundwater not encountered.

Detail
(DOE#: BIK956)



Boring Completed 06/11/15
Total Depth of Boring = 4.0 ft.

Completed 06/11/15
Total Depth of = 4.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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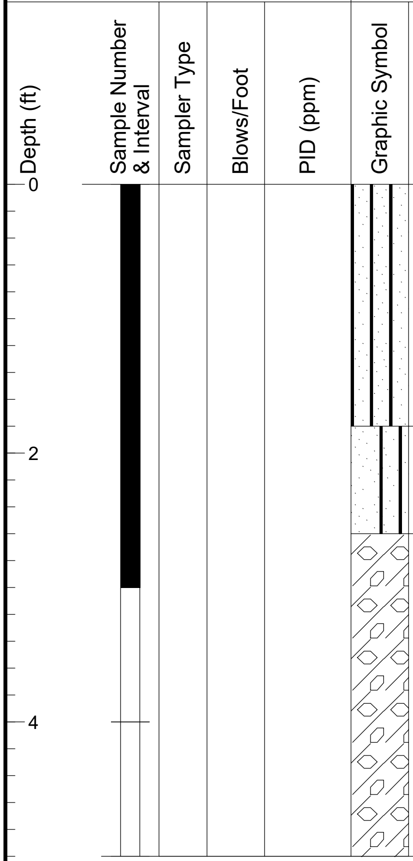
Cornwall Landfill
Bellingham, WA

Log of P-6

P-7

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

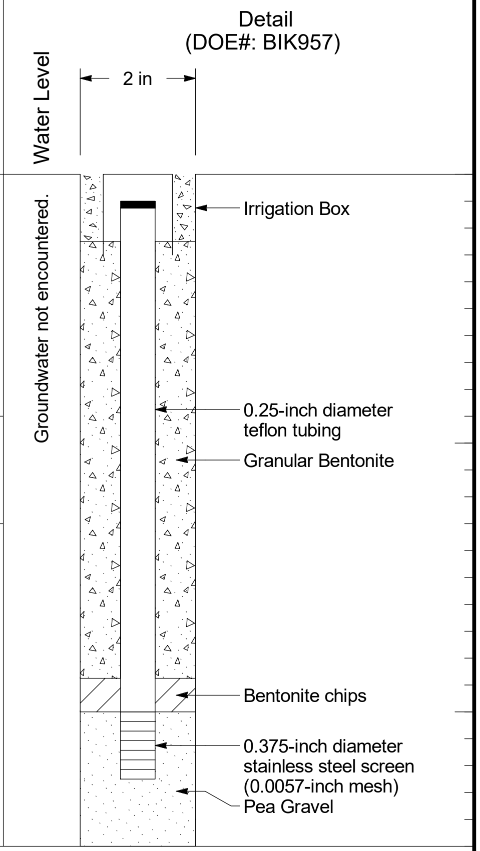


Drilling Method: Geoprobe™

Ground Elevation (ft):

USCS Symbol	Description
SM	Brown, silty fine SAND (medium dense, moist) (no odor, no sheen) [FILL]
SP-SM	Brown, rust-mottled, fine to coarse SAND with silt (medium dense, moist) (no odor, no sheen)
DB	Brown, red, rust-mottled DEBRIS (medium dense, moist) (no odor, no sheen) [MUNICIPAL SOLID WASTE] No recovery

Water Level: Groundwater not encountered.



Boring Completed 06/11/15
Total Depth of Boring = 5.0 ft.

Completed 06/11/15
Total Depth of = 5.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

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Cornwall Landfill
Bellingham, WA

Log of P-7

Figure
A-7

P-8

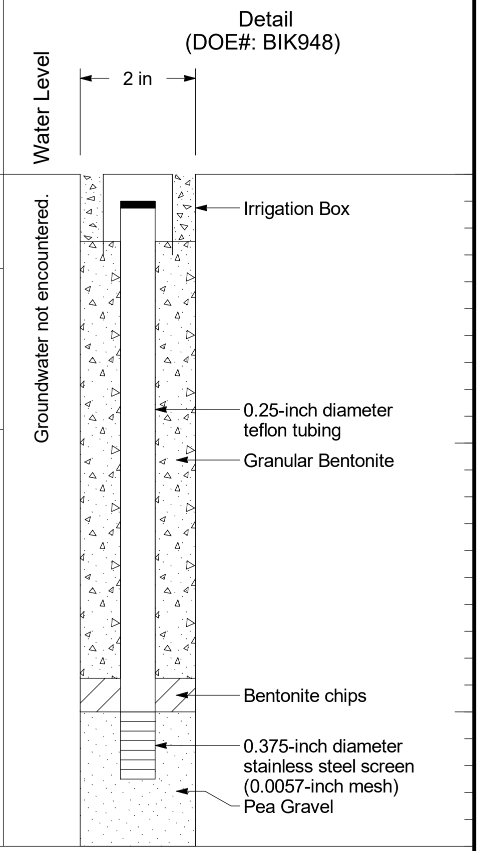
SAMPLE DATA | SOIL PROFILE | GROUNDWATER

Drilling Method: Geoprobe™

Ground Elevation (ft):

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	
0						SM	Brown, silty, fine to coarse SAND with gravel and trace roots (loose, moist) (no odor, no sheen) [FILL]
						SP-SM	Black, fine to medium SAND with coarse sand, silt and trace fine gravel and glass (medium dense, damp) (no odor, no sheen)
2						SM	Brownish black, silty SAND with roots and trace wood debris (medium dense, damp) (no odor, no sheen)
						ML	Dark gray SILT with fine sand with trace roots and wood debris (dense, wet) (no odor, no sheen)
							No recovery
4							

Boring Completed 06/10/15
Total Depth of Boring = 5.0 ft.



Completed 06/10/15
Total Depth of = 5.0 ft.

6

8

10

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

P-9

SAMPLE DATA

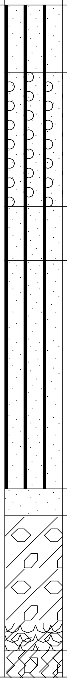
Depth (ft) | Sample Number & Interval | Sampler Type | Blows/Foot | PID (ppm)

SOIL PROFILE

Graphic Symbol | USCS Symbol

Drilling Method: Geoprobe™

Ground Elevation (ft):



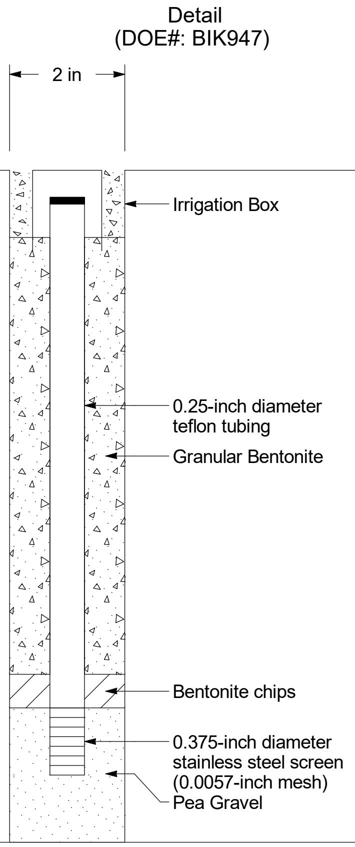
USCS Symbol	Description
SM	Brownish gray, silty fine to coarse SAND with trace fine gravel (medium dense, moist) (no odor, no sheen) [FILL]
GM	Gray, very silty GRAVEL with fine to coarse sand (medium dense, moist) (no odor, no sheen)
SM	Black, silty fine SAND with wood chips and fine gravel (medium dense, moist) (no odor, no sheen)
SM	Silty, fine to coarse SAND with gravel (medium dense, damp) (no odor, no sheen)
SP	Brown, fine SAND with glass, trace metal, and wood debris (medium dense, damp) (no odor, no sheen) [MUNICIPAL SOLID WASTE]
DB	Broken CONCRETE with medium gravel and trace glass (no odor, no sheen)
WD	WOOD DEBRIS (no odor, no sheen)
OL	Brownish-black ORGANIC matter (no odor, no sheen)

Boring Completed 06/10/15
Total Depth of Boring = 5.0 ft.

GROUNDWATER

Water Level

Groundwater not encountered.



Completed 06/10/15
Total Depth of = 5.0 ft.

Depth scale: 0, 2, 4, 6, 8, 10

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

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Cornwall Landfill
Bellingham, WA

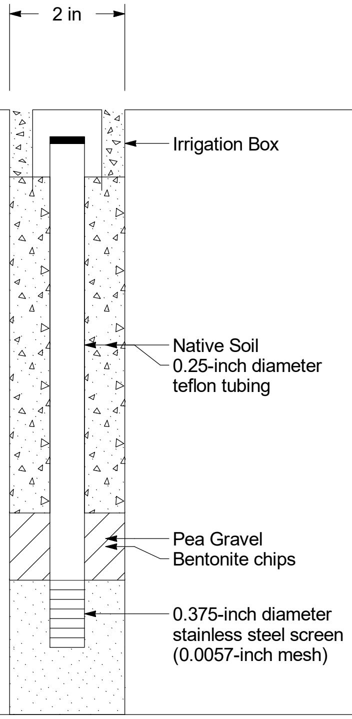
Log of P-9

Figure
A-9

P-10

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	PID (ppm)	Graphic Symbol	USCS Symbol	Drilling Method: Geoprobe™ Ground Elevation (ft):	Water Level
0						SP	Brown fine to coarse SAND with gravel (loose to medium dense, damp) (no odor, no sheen)	Groundwater not encountered.
						DB	DEBRIS (brick fragments, glass fragments, metal fragments) (no odor, no sheen) [Municipal Solid Waste]	

Detail
(DOE#: BIK958)



Boring Completed 06/11/15
Total Depth of Boring = 4.5 ft.

Completed 06/11/15
Total Depth of = 4.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill
Bellingham, WA

Log of P-10

Figure
A-10

P-11

SAMPLE DATA

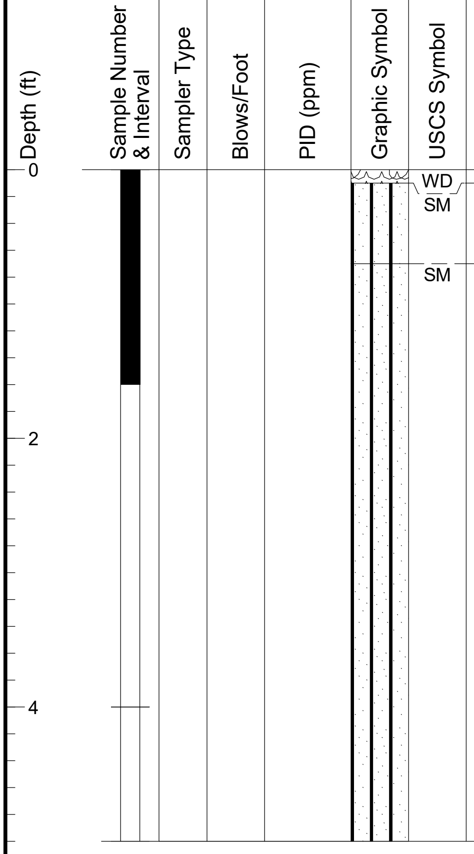
Depth (ft) | Sample Number & Interval | Sampler Type | Blows/Foot | PID (ppm)

SOIL PROFILE

Graphic Symbol | USCS Symbol

Drilling Method: Geoprobe™

Ground Elevation (ft):



USCS Symbol	Description
WD SM	ORGANICS (leaves, grass) (loose to medium dense, moist) (no odor, no sheen) [FILL]
SM	Brown, silty, fine to medium SAND with fine gravel (loose, moist) (no odor, no sheen)
	Brownish-black, fine SAND with wood chips and trace coarse sand (medium dense, damp) (no odor, no sheen)
	No Recovery

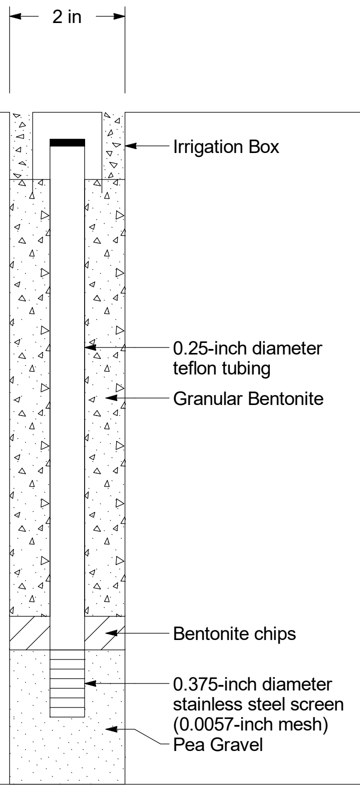
Boring Completed 06/11/15
Total Depth of Boring = 5.0 ft.

GROUNDWATER

Water Level

Groundwater not encountered.

Detail
(DOE#: BIK951)



Completed 06/11/15
Total Depth of = 5.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill
Bellingham, WA

Log of P-11

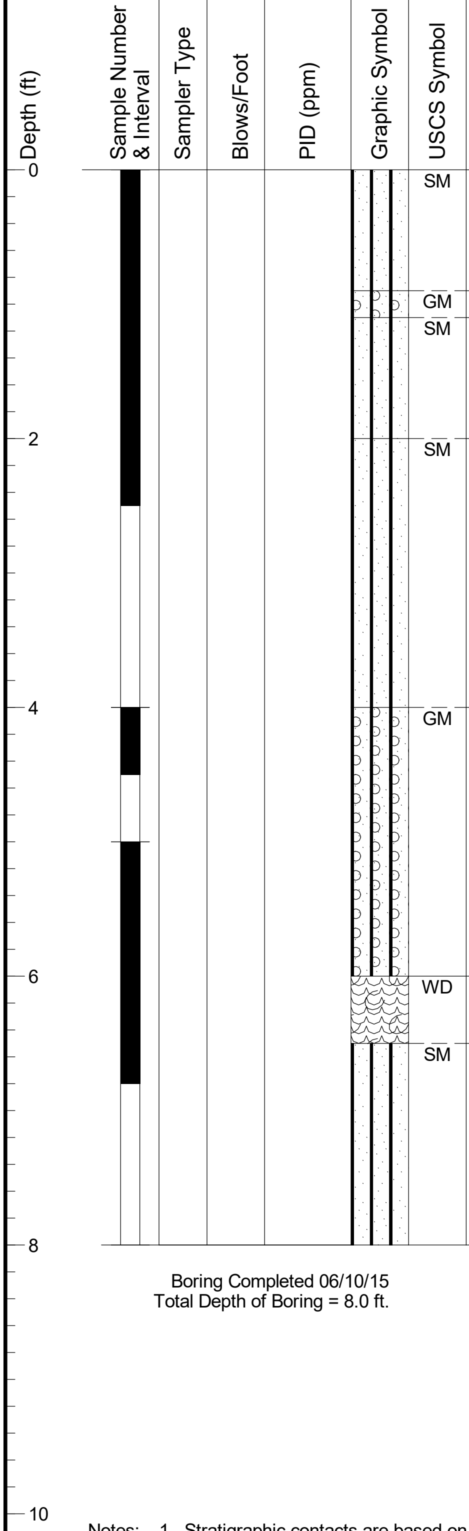
Figure
A-11

P-12

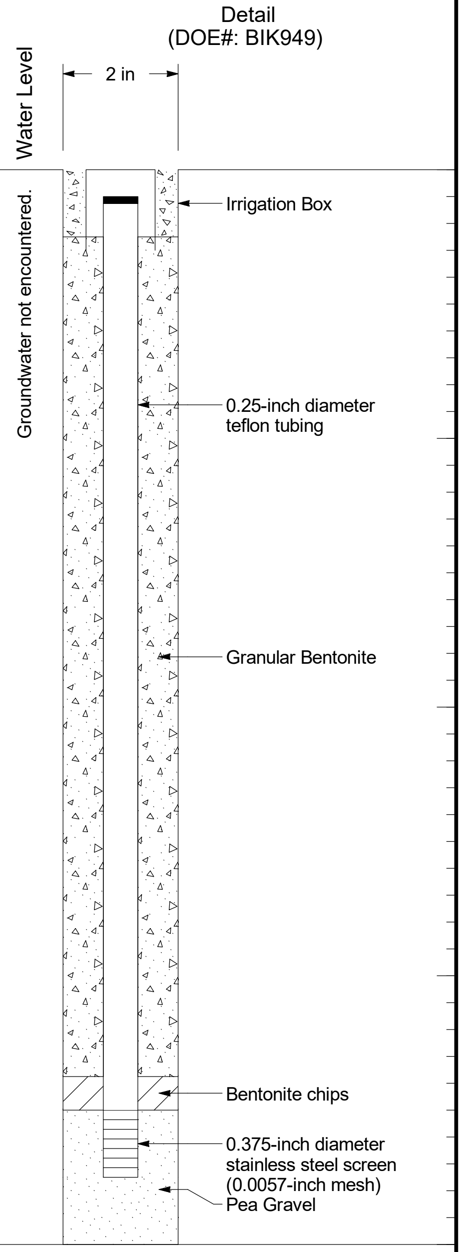
SAMPLE DATA	SOIL PROFILE	GROUNDWATER

Drilling Method: Geoprobe™

Ground Elevation (ft):



USCS Symbol	
SM	Brown, silty, fine SAND with trace wood chips and fine gravel (medium dense, moist) (no odor, no sheen) [FILL]
GM	Grayish, white GRAVEL with silt (loose, moist) (no odor, no sheen)
SM	Brown, fine to coarse SAND with fine gravel (medium dense, damp) (no odor, no sheen)
SM	Brown, fine SAND with trace fine gravel (medium dense, damp) (no odor, no sheen) No Recovery
GM	Gray, fine GRAVEL with silt and fine to coarse sand (medium dense, dry) (no odor, no sheen)
WD	Black WOOD DEBRIS (loose, moist) (petroleum-like odor, no sheen)
SM	Blackish-brown, fine SAND with silt and gravel (medium dense, damp) No Recovery



Boring Completed 06/10/15
Total Depth of Boring = 8.0 ft.

Completed 06/10/15
Total Depth of = 8.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

LANDAU ASSOCIATES

Cornwall Landfill
Bellingham, WA

Log of P-12

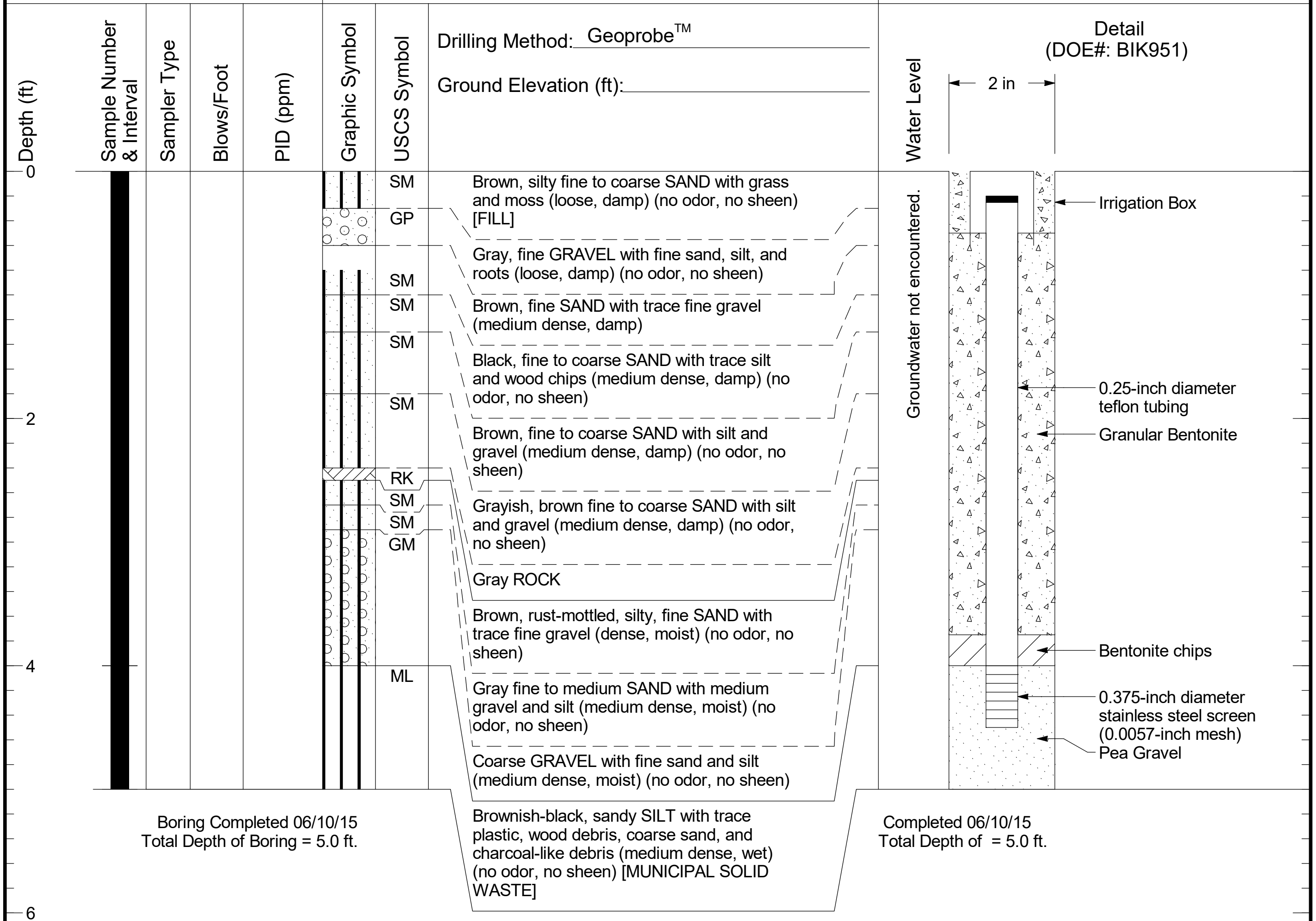
Figure
A-12

P-13

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Drilling Method: Geoprobe™

Ground Elevation (ft):



SM	Brown, silty fine to coarse SAND with grass and moss (loose, damp) (no odor, no sheen) [FILL]
GP	Gray, fine GRAVEL with fine sand, silt, and roots (loose, damp) (no odor, no sheen)
SM	Brown, fine SAND with trace fine gravel (medium dense, damp)
SM	Black, fine to coarse SAND with trace silt and wood chips (medium dense, damp) (no odor, no sheen)
SM	Brown, fine to coarse SAND with silt and gravel (medium dense, damp) (no odor, no sheen)
SM	Grayish, brown fine to coarse SAND with silt and gravel (medium dense, damp) (no odor, no sheen)
RK	Gray ROCK
SM	Brown, rust-mottled, silty, fine SAND with trace fine gravel (dense, moist) (no odor, no sheen)
SM	Gray fine to medium SAND with medium gravel and silt (medium dense, moist) (no odor, no sheen)
GM	Coarse GRAVEL with fine sand and silt (medium dense, moist) (no odor, no sheen)
ML	Brownish-black, sandy SILT with trace plastic, wood debris, coarse sand, and charcoal-like debris (medium dense, wet) (no odor, no sheen) [MUNICIPAL SOLID WASTE]

Boring Completed 06/10/15
Total Depth of Boring = 5.0 ft.

Completed 06/10/15
Total Depth of = 5.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

001037. 8/12/15 N:\PROJECTS\001037.030.033.GPJ WELL LOG

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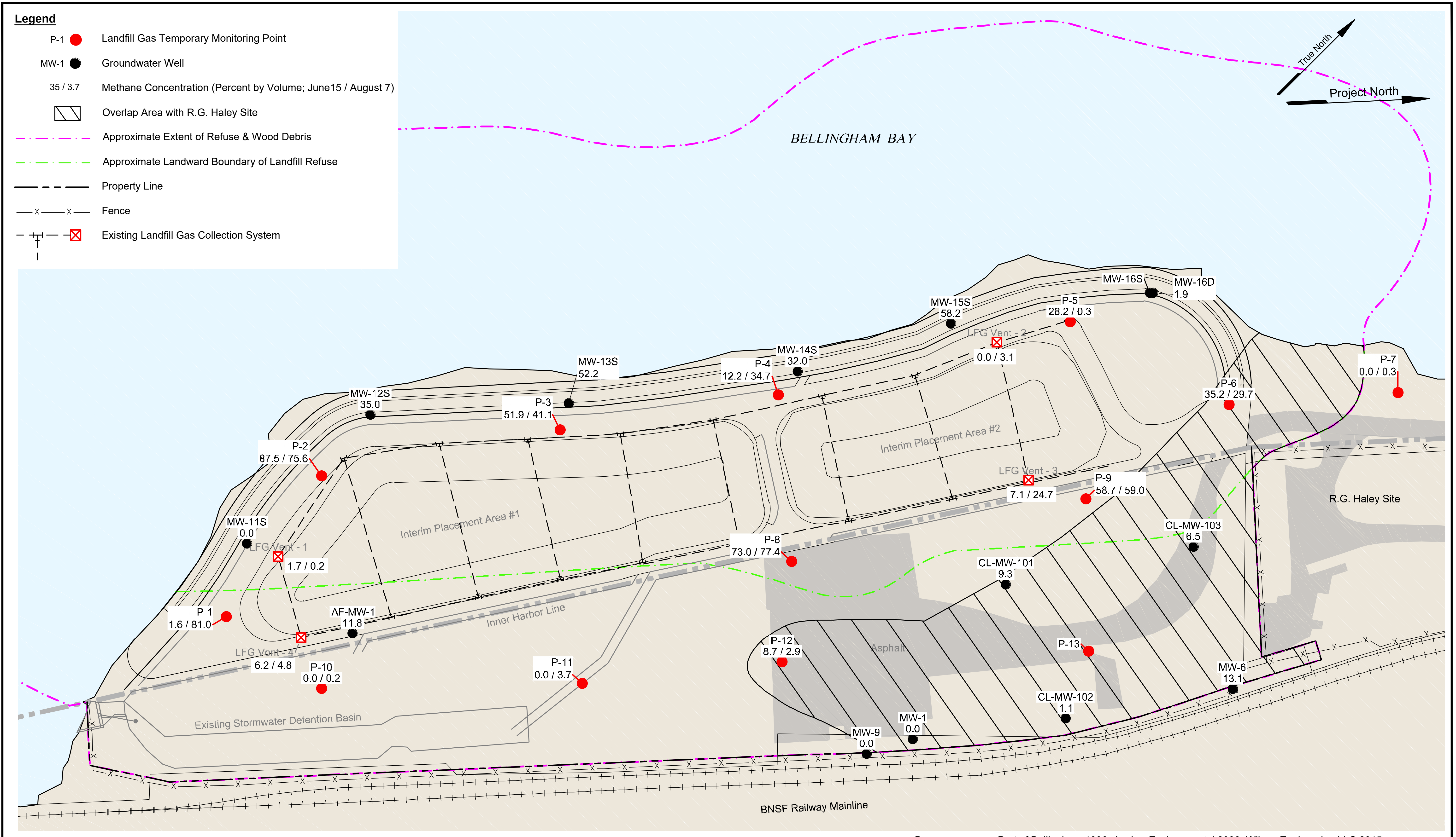
Cornwall Landfill
Bellingham, WA

Log of P-13

Figure
A-13

ATTACHMENT A.3

Landfill Gas Monitoring Data



Basemap source: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering LLC 2015

Landau Associates, Inc. | G:\Projects\001\037\040\041\EDR Appendix A\F0A2 LFGasMonitoringResults.dwg (A) "Figure A-2" 11/30/2015

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Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Landfill Gas Monitoring Results
Methane Concentration

Figure
A-2

Table A-1
Landfill Gas Monitoring Data - June 15, 2015
Cornwall Avenue Landfill
Bellingham, Washington

Location	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Balance (%)	H_2 (ppm)	CO (ppm)	H_2S (ppm)	Static Pressure (inches WC)	TO-15 (Y/N)	VOCs (ppm)
Groundwater Monitoring Wells											
AF-MW-1	6/15/2015	11.8	12.5	00.1	75.5	low	0	9	0.24	N	0
CL-MW-101	6/15/2015	9.3	10.3	00.4	80.0	low	0	2	0.20	N	0
CL-MW-102	6/15/2015	1.1	12.2	00.4	86.3	low	0	1	0.21	**Y**	8.7
CL-MW-103	6/15/2015	6.5	14.1	00.3	79.1	low	0	4	0.16	N	2.3
MW-1	6/15/2015	0	13.3	1.4	85.2	low	0	0	0.21	N	0
MW-11S	6/15/2015	0	4.3	14.6	81.0	low	0	0	0.25	N	0
MW-12S	6/15/2015	35.0	6.2	11.0	48.9	low	0	1	0.34	N	0.9
MW-13S	6/15/2015	52.2	11.3	5.7	30.3	low	0	0	0.35	N	0
MW-14S	6/15/2015	32.0	18.2	4.5	45.1	low	0	1	0.24	N	0
MW-15S	6/15/2015	58.2	16.9	0	24.1	low	0	6	0.24	N	2.0
MW-16S	6/15/2015	1.9	10.1	6.3	81.8	low	17[a]	0	1.55	N	0.8
MW-6	6/15/2015	13.1	6.9	00.5	79.6	low	0	4	0.16	N	0.9
MW-9	6/15/2015	0	8.1	11.3	80.6	low	0	0	0.59	N	0
Landfill Gas Vents											
VENT 1	6/15/2015	1.7	00.1	19.8	78.3	low	0	0	0.24	N	0
VENT 2	6/15/2015	0	0	20.4	79.4	low	0	0	0.25	N	0
VENT 3	6/15/2015	7.1	1.2	16.5	75.2	low	0	42	0.21	**Y**	0
VENT 4	6/15/2015	6.2	7.0	9.0	77.8	low	0	0	0.25	**Y**	0

Table A-1
Landfill Gas Monitoring Data - June 15, 2015
Cornwall Avenue Landfill
Bellingham, Washington

Location	Date	CH_4 (%)	CO_2 (%)	O_2 (%)	Balance (%)	H_2 (ppm)	CO (ppm)	H_2S (ppm)	Static Pressure (inches WC)	TO-15 (Y/N)	VOCs (ppm)
Temporary Landfill Gas Probes											
P-1	6/15/2015	1.6	1.4	19.4	77.5	low	0	1	0.25	N	0
P-2	6/15/2015	87.5	12.3	00.1	00.2	low	0	1	0.25	N	0
P-3	6/15/2015	51.9	35.7	1.6	10.8	low	0	1	4.79	**Y**	0
P-4	6/15/2015	12.2	15.2	13.6	59.4	low	0	0	0.31	N	0
P-5	6/15/2015	28.2	3.6	15.3	52.8	low	29	2	0.75	N	0
P-6	6/15/2015	35.2	19.3	0	45.4	low	0	0	0.25	N	0.4
P-7	6/15/2015	0	11.8	4.2	83.7	low	0	0	0.24	N	0
P-8	6/15/2015	73.0	10.2	00.3	16.6	low	0	0	0.26	N	0
P-9	6/15/2015	58.7	12.9	0	28.3	low	0	0	0.18	N	0.9
P-10	6/15/2015	0	12.2	7.8	80.0	low	0[b]	0	0.24	N	0
P-11	6/15/2015	0	9.7	6.7	83.5	low	0	0	0.24	N	0
P-12	6/15/2015	8.7	8.2	00.2	82.9	low	0	0	8.77	**Y**	1.8
P-13	6/15/2015	0	12.0	3.0	85.1	low	0	0	0.16	N	1.5

[a] Peaked at 180 ppm.

[b] Peaked at 210 ppm.

CH_4 = methane
CO_2 = carbon dioxide
H_2 = hydrogen
H_2S = hydrogen sulfide
N/A = not applicable.
O_2 = oxygen
ppm = parts per million
WC = water column
Y/N = yes/no

Barometric Pressure Data: Sample Event Number 1 - Monday, June 15, 2015

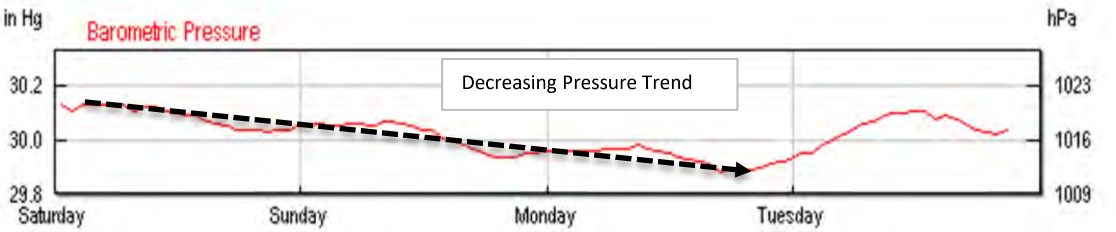

Table A-2
Landfill Gas Monitoring Data - August 7, 2015
Cornwall Avenue Landfill
Bellingham, Washington

Location	Date	Time (in seconds)	Purge Volume	CH$_4$ (%)	CO$_2$ (%)	O$_2$ (%)	Balance (%)	H$_2$ (ppm)	CO (ppm)	H$_2$S (ppm)	Static Pressure (inches WC)	TO-15 (Y/N)	VOCs (ppm)
Landfill Gas Vents													
VENT 1	8/7/2015	53	~0.5817	0.2	0.4	20.3	79.1	low	0	0.0	0.01	N	4.3
VENT 2	8/7/2015	50	0.5817	3.1	0.5	20.1	76.3	low	0	0.0	0.03	N	3.0
VENT 3	8/7/2015	50	0.5817	24.7	8.3	9.1	57.9	low	0	0.0	0.01	N	0.0
VENT 4	8/7/2015	81	0.6103	4.8	10.7	7.8	76.7	low	0	0.0	0.03	N	2.0
Temporary Landfill Gas Probes													
P-1	8/7/2015	80	N/A	81.0	10.7	1.5	6.8	low	0	0.0	-1.01	N	0.0
P-2	8/7/2015	111	N/A	75.6	7.9	5.2	11.3	low	5	2.8	0.13	**Y**	0.0
P-3	8/7/2015	67	N/A	41.1	39.8	4.4	14.6	low	0	0.0	-0.04	**Y**	0.7
P-4	8/7/2015	108	N/A	34.7	24.4	8.9	32.0	low	0	0.0	0.08	N	0.1
P-5	8/7/2015	53	N/A	0.3	0.1	20.7	79.0	low	0	0.0	0.07	N	0.1
P-6	8/7/2015	60	N/A	29.7	19.8	0.3	50.3	low	0	0.0	0.02	**Y**	0.0
P-7	8/7/2015	53	N/A	0.3	12.0	8.8	78.9	low	0	0.0	-0.02	N	5.7
P-8	8/7/2015	93	N/A	77.4	14.0	0.1	8.5	low	0	0.0	-0.02	N	0.2
P-9	8/7/2015	160	N/A	59.0	17.3	0.1	23.7	low	0	4.5	-0.01	N	0.8
P-10	8/7/2015	55	N/A	0.2	12.1	9.2	78.5	low	0	0.0	0.02	N	10.0
P-11	8/7/2015	63	N/A	3.7	6.5	0.1	89.8	low	0	0.0	-0.01	N	0.0
P-12	8/7/2015	45	N/A	2.9	14.6	0.2	82.3	low	0	3.8	-0.01	**Y**	6.4
P-13	8/7/2015	80	N/A	0.00	9.6	8.1	82.3	low	0	0.0	-0.04	N	0.0

CH$_4$ = methane
CO$_2$ = carbon dioxide
H$_2$ = hydrogen
H$_2$S = hydrogen sulfide
N/A = not applicable.
O$_2$ = oxygen
ppm = parts per million
WC = water column
Y/N = yes/no

Barometric Pressure Data: Sample Event Number 2 - Friday, August 7, 2015

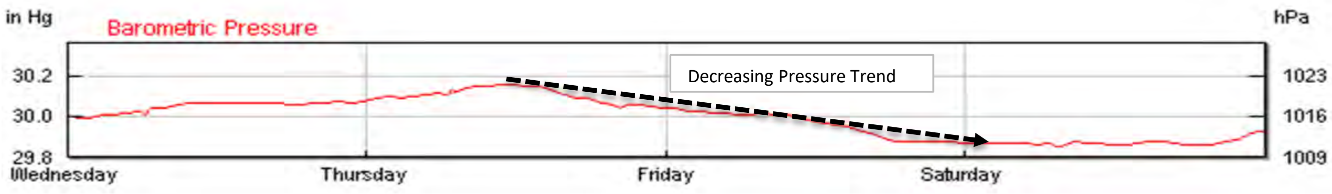

Table A-3
Landfill Gas Monitoring Data - TO-15 Analytical Results
Cornwall Avenue Landfill
Bellingham, Washington

Analyte	MTCA Method B Cleanup Level	Sample ID, Laboratory ID, Sample Date, and Results									
		CL-LFG- BACKGROUND P1502473-001 6/15/2015	CL-LFG- MW-102 P1502473-006 6/15/2015	CL-LFG- P-2 P1503343-03 8/7/2015	CL-LFG- P-3 P1502473-003 6/15/2015	CL-LFG- P-3 P1503343-04 8/7/2015	CL-LFG- P-6 P1503343-01 8/7/2015	CL-LFG- P-12 P1502473-004 6/15/2015	CL-LFG- P-12 P1503343-02 8/7/2015	CL-LFG- VENT-3 P1502473-005 6/15/2015	CL-LFG- VENT-4 P1502473-002 6/15/2015
Volatiles (µg/m³) EPA Method TO-15											
Propene	No Criteria	0.21 U	6.9 U	**1300**	**190**	**120**	**540**	**84**	**26** J1	**6.5**	0.21 U
Dichlorodifluoromethane (CFC 12)	45.71	**2.3**	8.4 U	**45** J1	1.3 U	2.6 U	**54**	8.0 U	10 U	**1.9**	**1.0**
Chloromethane	41.14	0.22 U	7.4 U	15 U	1.2 U	2.3 U	14 U	7.1 U	9.2 U	**0.33** J1	**0.49** J1
1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	No Criteria	0.28 U	9.4 U	**440**	**14**	2.9 U	**200**	8.9 U	12 U	0.28 U	**0.39** J1
Vinyl chloride	0.28	NA	NA	**170**	NA	NA	**150**	NA	NA	NA	NA
1,3-Butadiene	0.08	0.33 U	11 U	22 U	1.7 U	3.3 U	20 U	10 U	14 U	0.33 U	0.33 U
Bromomethane	2.29	0.28 U	9.4 U	19 U	1.5 U	2.9 U	18 U	8.9 U	12 U	0.28 U	0.28 U
Chloroethane	4571.43	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	0.25 U	0.25 U
Ethanol	No Criteria	**6.3** J1	**270**	79 U	**79**	12 U	74 U	**860**	49 U	**100**	**60**
Acetonitrile	27.43	0.27 U	8.9 U	18 U	1.4 U	2.7 U	17 U	8.5 U	11 U	**1.6**	0.27 U
Acrolein	0.01	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	**3.2**	0.25 U
Acetone	14171.43	**7.5**	38 U	76 U	**97**	12 U	71 U	**200** J1	47 U	**180**	**40**
Trichlorofluoromethane	320.00	**1.3** J	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	**1.4** J	**0.66** J, J1
2-Propanol (Isopropyl Alcohol)	No Criteria	0.63 U	21 U	42 U	**5.4** J1	6.3 U	39 U	**56** J1	26 U	**6.7** J1	**5.8** J1
Acrylonitrile	0.04	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	0.25 U	0.25 U
1,1-Dichloroethene	91.43	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	0.25 U	0.25 U
Methylene Chloride	250.00	**0.41** J1	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	**0.48** J1	**0.39** J1
3-Chloro-1-propene (Allyl Chloride)	0.42	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Trichlorotrifluoroethane	No Criteria	**0.52** J1	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	**0.53** J1	0.25 U
Carbon Disulfide	320.00	0.22 U	**8.6** J1	15 U	**29** J1	**45** J1	**20** J1	**45** J1	9.2 U	**4.9** J1	**2.4** J1
trans-1,2-Dichloroethene	No Criteria	0.28 U	9.4 U	19 U	1.5 U	2.9 U	18 U	8.9 U	12 U	0.28 U	0.28 U
1,1-Dichloroethane	1.56	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Methyl tert-Butyl Ether	9.62	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	0.25 U	0.25 U
Vinyl Acetate	91.43	0.97 U	32 U	65 U	5.0 U	9.8 U	60 U	31 U	40 U	**2.7** J1	0.96 U
2-Butanone (MEK)	2285.71	**0.65** J1	10 U	21 U	**4.4** J1	**3.4** J1	19 U	9.9 U	13 U	**42**	**14**
cis-1,2-Dichloroethene	No Criteria	0.24 U	7.9 U	**24** J1	**7.0**	**3.2** J1	**25** J1	7.5 U	9.9 U	0.24 U	0.24 U
Ethyl Acetate	32.00	**1.4** J1	17 U	35 U	2.7 U	5.3 U	**61** J1	16 U	22 U	**4.8**	**3.0**
n-Hexane	320.00	**0.79**	**86**	**5500**	**450**	**170**	**1000**	**84**	**110**	**1.4**	**25**
Chloroform	0.11	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	**0.32** J1	**10**
Tetrahydrofuran (THF)	No Criteria	0.30 U	9.9 U	20 U	**4.3**	3.0 U	19 U	9.4 U	12 U	**280**	**100**
1,2-Dichloroethane	0.10	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
1,1,1-Trichloroethane	2285.71	0.25 U	8.4 U	17 U	1.3 U	2.6 U	16 U	8.0 U	10 U	0.25 U	0.25 U
Benzene	0.32	**0.61** J1	**12** J1	**60**	**120**	**16**	**100**	7.5 U	9.9 U	**2.8**	**3.2**
Carbon Tetrachloride	0.42	**0.53** J, J1	7.4 U	15 U	1.2 U	2.3 U	14 U	7.1 U	9.2 U	**0.55** J, J1	0.22 U
Cyclohexane	2742.86	0.43 U	**51**	**570**	**180**	**65**	**850**	**120**	**130**	**4.5**	**8.7**
1,2-Dichloropropane	0.25	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Bromodichloromethane	0.07	0.22 U	7.4 U	15 U	1.2 U	2.3 U	14 U	7.1 U	9.2 U	0.22 U	0.22 U
Trichloroethene	0.37	0.21 U	6.9 U	14 U	**1.9** J1	2.1 U	13 U	6.6 U	8.6 U	0.21 U	0.21 U
1,4-Dioxane	0.50	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Methyl Methacrylate	320.00	0.46 U	15 U	31 U	2.4 U	4.7 U	29 U	15 U	19 U	0.46 U	0.46 U
n-Heptane	No Criteria	**1.0**	**210**	**2000**	**240**	**74**	**730**	**26**	**32**	**2.6**	**5.5**
cis-1,3-Dichloropropene	0.63	0.21 U	6.9 U	14 U	1.1 U	2.1 U	13 U	6.6 U	8.6 U	0.21 U	0.21 U
4-Methyl-2-pentanone	1371.43	0.24 U	7.9 U	16 U	**2.0** J1	2.4 U	15 U	7.5 U	9.9 U	**1.8**	**0.82**
trans-1,3-Dichloropropene	No Criteria	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
1,1,2-Trichloroethane	0.09	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Toluene	2285.71	**5.6**	**98**	**36** J1	**270**	**3.4** J1	**30** J1	**190**	10 U	**330**	**280**
2-Hexanone	No Criteria	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Dibromochloromethane	0.09	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
1,2-Dibromoethane	0.0042	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
n-Butyl Acetate	No Criteria	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	**7.7**	**6.4**
n-Octane	No Criteria	**0.57** J1	8.9 U	**220**	**130**	**29**	**220**	8.5 U	11 U	**4.3**	**3.5**
Tetrachloroethene	9.62	0.21 U	6.9 U	14 U	1.1 U	2.1 U	13 U	6.6 U	8.6 U	0.21 U	0.21 U
Chlorobenzene	22.86	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Ethylbenzene	457.14	**1.1**	**36**	**16** J1	**55**	**2.5** J1	15 U	**27**	9.9 U	**32**	**28**
m,p-Xylenes	45.71	**3.9**	**110**	**34** J1	**77**	**9.2** J1	**34** J1	**55**	18 U	**49**	**43**
Bromoform	2.27	0.22 U	7.4 U	15 U	1.2 U	2.3 U	14 U	7.1 U	9.2 U	0.22 U	0.22 U
Styrene	457.14	0.22 U	7.4 U	15 U	**2.6** J1	2.3 U	14 U	7.1 U	9.2 U	**2.7**	**4.2**
o-Xylene	45.71	**1.4**	**33**	**40** J1	**51**	2.3 U	**28** J1	**24**	**21** J1	**17**	**16**
n-Nonane	No Criteria	0.22 U	7.4 U	15 U	**61**	**11**	**160**	7.1 U	9.2 U	**2.0**	**1.9**
1,1,2,2-Tetrachloroethane	0.04	0.22 U	7.4 U	15 U	1.2 U	2.3 U	14 U	7.1 U	9.2 U	0.22 U	0.22 U
Cumene	182.86	0.22 U	**220**	**58**	**9.9**	2.3 U	**64**	**230**	**62**	**0.79**	**1.6**
alpha-Pinene	No Criteria	0.21 U	6.9 U	14 U	**50**	**18**	**250**	**2,000**	**250**	**1.3**	**1.3**
n-Propylbenzene	457.14	0.24 U	**270**	16 U	**5.2**	2.4 U	15 U	**140**	9.9 U	**2.4**	**2.6**
4-Ethyltoluene	No Criteria	**0.30** J1	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	**3.6**	**3.7**
1,3,5-Trimethylbenzene	No Criteria	**0.30** J1	**11** J1	**17** J1	**16**	**3.1** J1	**19** J1	7.5 U	9.9 U	**3.3**	**3.6**
1,2,4-Trimethylbenzene	3.20	**0.98**	**25** J1	**28** J1	**29**	**5.6** J1	**39** J1	**17** J1	9.2 U	**11**	**13**
Benzyl Chloride	0.05	0.16 U	5.4 U	11 U	0.85 U	1.7 U	10 U	5.2 U	6.8 U	0.16 U	0.16 U
1,3-Dichlorobenzene	No Criteria	0.22 U	7.4 U	15 U	**1.4** J1	2.3 U	14 U	7.1 U	9.2 U	**1.3**	**0.90**
1,4-Dichlorobenzene	0.23	0.21 U	6.9 U	**32** J1	1.1 U	2.1 U	13 U	6.6 U	8.6 U	0.21 U	0.21 U
1,2-Dichlorobenzene	91.43	0.22 U	7.4 U	15 U	1.2 U	2.3 U	14 U	7.1 U	9.2 U	0.22 U	0.22 U
d-Limonene	No Criteria	0.21 U	6.9 U	14 U	**18**	2.1 U	13 U	**150**	8.6 U	**10**	**11**
1,2-Dibromo-3-chloropropane	0.0004	0.15 U	4.9 U	9.8 U	0.77 U	1.5 U	9.2 U	4.7 U	6.1 U	0.15 U	0.15 U
1,2,4-Trichlorobenzene	0.91	0.24 U	7.9 U	16 U	1.2 U	2.4 U	15 U	7.5 U	9.9 U	0.24 U	0.24 U
Naphthalene	0.07	0.27 U	8.9 U	18 U	**2.7** J1	2.7 U	17 U	8.5 U	11 U	**0.49** J1	**2.2**
Hexachlorobutadiene	0.11	0.21 U	6.9 U	14 U	1.1 U	2.1 U	13 U	6.6 U	8.6 U	0.21 U	0.21 U
Volatiles (µg/m³) EPA Method TO-15 SIM											
Vinyl Chloride	0.28	0.011 U	0.37 U	NA	**0.68**	**0.67** J	NA	0.36 U	1.5 U	**0.061**	**0.039**
Cumulative Sum of VOCs		**52**	**2,000**	**11,736**	**2,263**	**755**	**5,599**	**4,781**	**1,444**	**1,138**	**714**

Nondetected compound show the method detection limit (MDL) as the reporting limit.
J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
J1 = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
U = Indicates the compound was not detected at the reported concentration.
Bold = Detected compound.
Blue Shading = Laboratory reporting limit is above cleanup level for ambient air.
Green Shading = Detected above cleanup level for ambient air.
NA = Not analyzed.
EPA = U.S. Environmental Protection Agency
µg/m³ = micrograms per cubic meter
SIM = selected ion monitoring

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LABORATORY REPORT

July 7, 2015

Anne Halvorsen
Landau Associates, Inc.
130 2nd Ave. South
Edmonds, WA 98020

RE: Cornwall LF / 001037.030.033

Dear Anne:

Enclosed are the results of the samples submitted to our laboratory on June 19, 2015. For your reference, these analyses have been assigned our service request number P1502473.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Kate Aguilera

By Kate Aguilera at 3:26 pm, Jul 07, 2015

Kate Aguilera
Project Manager

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Client: Landau Associates, Inc.
Project: Cornwall LF / 001037.030.033
Service Request No: P1502473

CASE NARRATIVE

The samples were received intact under chain of custody on June 19, 2015 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

Volatile Organic Compound Analysis

The samples were analyzed for volatile organic compounds in SIM and SCAN mode in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. This method is included on the laboratory's NELAP and DoD-ELAP scope of accreditation, however it is not part of the AIHA-LAP accreditation. Any analytes flagged with an X are not included on the NELAP or DoD-ELAP accreditation.

The minimum control criterion for propene analyzed on July 1, 2015 was outside the continuing calibration verification (CCV) method requirements. Since the method reporting check standard verified the instrument sensitivity and the compound in question was not detected in the sample, the quality is not significantly affected.

The spike recoveries of trichlorofluoromethane and carbon tetrachloride in the Laboratory Control Sample (LCS) analyzed on June 30, 2015 and the spike recoveries of bromomethane, trichlorofluoromethane and carbon tetrachloride in the Laboratory Control Sample (LCS) analyzed on July 1, 2015 were outside the Laboratory generated control criteria. The recovery errors equate to a potential high bias. However, the recoveries in question were within the method criteria, therefore the data quality is not significantly affected. No corrective action was taken.

The surrogate bromofluorobenzene was outside control criteria in the SIM analysis of the samples labeled "CL-LFG-P-12" and "CL-LFG-MW-102." This surrogate is not associated with the target analyte, therefore, results were not affected. No corrective action was taken.

The canisters were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

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The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

Use of ALS Environmental (ALS)'s Name. Client shall not use ALS's name or trademark in any marketing or reporting materials, press releases or in any other manner ("Materials") whatsoever and shall not attribute to ALS any test result, tolerance or specification derived from ALS's data ("Attribution") without ALS's prior written consent, which may be withheld by ALS for any reason in its sole discretion. To request ALS's consent, Client shall provide copies of the proposed Materials or Attribution and describe in writing Client's proposed use of such Materials or Attribution. If ALS has not provided written approval of the Materials or Attribution within ten (10) days of receipt from Client, Client's request to use ALS's name or trademark in any Materials or Attribution shall be deemed denied. ALS may, in its discretion, reasonably charge Client for its time in reviewing Materials or Attribution requests. Client acknowledges and agrees that the unauthorized use of ALS's name or trademark may cause ALS to incur irreparable harm for which the recovery of money damages will be inadequate. Accordingly, Client acknowledges and agrees that a violation shall justify preliminary injunctive relief. For questions contact the laboratory.

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ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	876241
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	4068-001
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-14-5
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272014-4
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Landau Associates, Inc.
Service Request: P1502473
Project ID: Cornwall LF / 001037.030.033

Date Received: 6/19/2015
Time Received: 10:00

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	TO-15 - VOC Cans	TO-15 - VOC SIM
CL-LFG-BACKGROUND	P1502473-001	Air	6/15/2015	18:16	AS00166	-2.34	3.74	X	X
CL-LFG-VENT-4	P1502473-002	Air	6/15/2015	18:28	AS00840	-2.37	3.55	X	X
CL-LFG-P-3	P1502473-003	Air	6/15/2015	18:42	AC01775	-5.31	3.55	X	X
CL-LFG-P-12	P1502473-004	Air	6/15/2015	18:55	AS00490	-1.46	3.93	X	X
CL-LFG-VENT-3	P1502473-005	Air	6/15/2015	19:35	AS00442	-2.41	3.60	X	X
CL-LFG-MW-102	P1502473-006	Air	6/15/2015	19:44	AS00457	-2.31	3.64	X	X

ALS

Air - Chain of Custody Record & Analytical Service Request

Page 1 of 1

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Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) [✓ 10-Day-Standard]

ALS Project No P1502473

Company Name & Address (Reporting Information): LANDAU ASSOCIATES ~~INC~~
130 2nd Ave. South
Edmonds, WA 98020

Project Name: Cornwall LF

Project Number: 001037.030.033

ALS Contact:

Project Manager: Jeremy Davis / Kent Wilken

P.O. # / Billing Information: same as above

Phone: (425) 778-0907

Fax:

Email Address for Result Reporting: Jdavis@landauinc.com, Kwilken@landauinc.com

Sampler (Print & Sign): Stephanie Renando

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected (MIN.)	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method TO-15 (SIM VC)	Comments e.g. Actual Preservative or specific instructions START / STOP
CL-LFG-BACKGROUND	①	6/15/15	30	AS00166	FCA00905	-30	-5	6L	X	1746 / 1816
CL-LFG-VENT-~~2~~ 4 SAR	②	↓	28	AS00840	FCA 00620	-25	-2	↓	↓	1800 / 1828
CL-LFG-P-3	③		30	AS01775	FCA00770	-30	-13			1812 / 1842
CL-LFG-P-12	④		30	AS00490	FCA00850	-29	-2			1825 / 1855
CL-LFG-VENT-3	⑤		30	AS00442	FCA00816	-30	-7			1905 / 1935
CL-LFG-MW-102	⑥		30	AS00457	FCA00663	-29	-5			1914 / 1944

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) X
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES / No
Type: ____ Units: ____

Chain of Custody Seal: (Circle)
[✓ INTACT] BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature) Date: 6/16/15 Time: 0930

Received by: (Signature) FedEx Date: Time:

Relinquished by: (Signature) FedEx Date: Time:

Received by: (Signature) Date: 6/19/15 Time: 1000

Cooler / Blank Temperature ____°C

ALS Environmental
Sample Acceptance Check Form

Client: Landau Associates, Inc. Work order: P1502473
Project: Cornwall LF
Sample(s) received on: 6/19/15 Date opened: 6/19/15 by: KKELPE

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

		Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☒	☐	☐
	Location of seal(s)? SEALING BOX Sealing Lid?	☒	☐	☐
	Were signature and date included?	☒	☐	☐
	Were seals intact?	☒	☐	☐
	Were custody seals on outside of sample container?	☐	☒	☐
	Location of seal(s)? Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **VOA vials** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and if necessary alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1502473-001.01	6.0 L Silonite Can					
P1502473-002.01	6.0 L Silonite Can					
P1502473-003.01	6.0 L Ambient Can					
P1502473-004.01	6.0 L Silonite Can					
P1502473-005.01	6.0 L Silonite Can					
P1502473-006.01	6.0 L Silonite Can					

Explain any discrepancies: (include lab sample ID numbers):

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Page 1 of 1

Client: **Landau Associates, Inc.**
Client Project ID: **Cornwall LF / 001037.030.033**
ALS Project ID: P1502473

Vinyl Chloride

Test Code: EPA TO-15 SIM
Instrument ID: Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister(s)
Test Notes:

Date(s) Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 7/2 - 7/6/15

Client Sample ID	ALS Sample ID	Injection Volume Liter(s)	Canister Dilution Factor	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
CL-LFG-BACKGROUND	P1502473-001	1.00	1.49	ND	0.037	0.011	ND	0.015	0.0044	
CL-LFG-VENT-4	P1502473-002	0.50	1.48	**0.039**	0.074	0.022	**0.015**	0.029	0.0088	J
CL-LFG-P-3	P1502473-003	0.15	1.94	**0.68**	0.32	0.098	**0.27**	0.13	0.038	
CL-LFG-P-12	P1502473-004	0.030	1.41	ND	1.2	0.36	ND	0.46	0.14	
CL-LFG-VENT-3	P1502473-005	1.00	1.49	**0.061**	0.037	0.011	**0.024**	0.015	0.0044	
CL-LFG-MW-102	P1502473-006	0.030	1.48	ND	1.2	0.37	ND	0.48	0.15	
Method Blank	P150702-MB	1.00	1.00	ND	0.025	0.0076	ND	0.0098	0.0030	
Method Blank	P150706-MB	1.00	1.00	ND	0.025	0.0076	ND	0.0098	0.0030	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The analyte was positively identified below the laboratory method reporting limit; the associated numerical value is considered estimated.

ALS ENVIRONMENTAL

SURROGATE SPIKE RECOVERY RESULTS

Page 1 of 1

Client: **Landau Associates, Inc.**
Client Project ID: **Cornwall LF / 001037.030.033**
ALS Project ID: P1502473

Test Code: EPA TO-15 SIM
Instrument ID: Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister(s)
Test Notes:

Date(s) Collected: 6/15/15
Date(s) Received: 6/19/15
Date(s) Analyzed: 7/2 - 7/6/15

Client Sample ID	ALS Sample ID	1,2-Dichloroethane-d4 % Recovered	Toluene-d8 % Recovered	Bromofluorobenzene % Recovered	Acceptance Limits	Data Qualifier
Method Blank	P150702-MB	**112**	**111**	**86**	70-130	
Method Blank	P150706-MB	**103**	**107**	**95**	70-130	
Lab Control Sample	P150702-LCS	**112**	**105**	**92**	70-130	
Lab Control Sample	P150706-LCS	**104**	**103**	**97**	70-130	
CL-LFG-BACKGROUND	P1502473-001	**101**	**109**	**106**	70-130	
CL-LFG-VENT-4	P1502473-002	**99**	**112**	**97**	70-130	
CL-LFG-P-3	P1502473-003	**96**	**116**	**99**	70-130	
CL-LFG-P-12	P1502473-004	**98**	**112**	**39**	70-130	S
CL-LFG-VENT-3	P1502473-005	**98**	**104**	**105**	70-130	
CL-LFG-MW-102	P1502473-006	**100**	**115**	**19**	70-130	S

Surrogate percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly from the on-column percent recovery.
S = Surrogate recovery not within specified limits.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY
Page 1 of 1

Client: **Landau Associates, Inc.**
Client Sample ID: **Lab Control Sample**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P150702-LCS

Test Code: EPA TO-15 SIM
Instrument ID: Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:

Date Collected: NA
Date Received: NA
Date Analyzed: 7/2/15
Volume(s) Analyzed: 0.125 Liter(s)

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
75-01-4	Vinyl Chloride	4.04	**4.65**	**115**	64-118	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 1 of 1

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150706-LCS
Test Code:	EPA TO-15 SIM	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	7/6/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
75-01-4	Vinyl Chloride	4.04	**4.55**	**113**	64-118	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-BACKGROUND** ALS Project ID: P1502473
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P1502473-001

Test Code: EPA TO-15 Date Collected: 6/15/15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8 Date Received: 6/19/15
Analyst: Wida Ang Date Analyzed: 6/30/15
Sample Type: 6.0 L Silonite Canister Volume(s) Analyzed: 1.00 Liter(s)
Test Notes:
Container ID: AS00166

Initial Pressure (psig): -2.34 Final Pressure (psig): 3.74

Canister Dilution Factor: 1.49

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	ND	0.75	0.21	ND	0.43	0.12	
75-71-8	Dichlorodifluoromethane (CFC 12)	**2.3**	0.75	0.25	**0.47**	0.15	0.051	
74-87-3	Chloromethane	ND	0.75	0.22	ND	0.36	0.11	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	0.75	0.28	ND	0.11	0.041	
106-99-0	1,3-Butadiene	ND	0.75	0.33	ND	0.34	0.15	
74-83-9	Bromomethane	ND	0.75	0.28	ND	0.19	0.073	
75-00-3	Chloroethane	ND	0.75	0.25	ND	0.28	0.096	
64-17-5	Ethanol	**6.3**	7.5	1.2	**3.3**	4.0	0.63	**J**
75-05-8	Acetonitrile	ND	0.75	0.27	ND	0.44	0.16	
107-02-8	Acrolein	ND	3.0	0.25	ND	1.3	0.11	
67-64-1	Acetone	**7.5**	7.5	1.1	**3.1**	3.1	0.48	
75-69-4	Trichlorofluoromethane	**1.3**	0.75	0.25	**0.24**	0.13	0.045	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	7.5	0.63	ND	3.0	0.25	
107-13-1	Acrylonitrile	ND	0.75	0.25	ND	0.34	0.12	
75-35-4	1,1-Dichloroethene	ND	0.75	0.25	ND	0.19	0.064	
75-09-2	Methylene Chloride	**0.41**	0.75	0.25	**0.12**	0.21	0.073	**J**
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.75	0.24	ND	0.24	0.076	
76-13-1	Trichlorotrifluoroethane	**0.52**	0.75	0.25	**0.068**	0.097	0.033	**J**
75-15-0	Carbon Disulfide	ND	7.5	0.22	ND	2.4	0.072	
156-60-5	trans-1,2-Dichloroethene	ND	0.75	0.28	ND	0.19	0.071	
75-34-3	1,1-Dichloroethane	ND	0.75	0.24	ND	0.18	0.059	
1634-04-4	Methyl tert-Butyl Ether	ND	0.75	0.25	ND	0.21	0.070	
108-05-4	Vinyl Acetate	ND	7.5	0.97	ND	2.1	0.28	
78-93-3	2-Butanone (MEK)	**0.65**	7.5	0.31	**0.22**	2.5	0.11	**J**

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Page 2 of 3

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-BACKGROUND**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-001

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			
Container ID:	AS00166		

Initial Pressure (psig): -2.34 Final Pressure (psig): 3.74

Canister Dilution Factor: 1.49

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	0.75	0.24	ND	0.19	0.060	
141-78-6	Ethyl Acetate	**1.4**	1.5	0.52	**0.39**	0.41	0.14	**J**
110-54-3	n-Hexane	**0.79**	0.75	0.22	**0.22**	0.21	0.063	
67-66-3	Chloroform	ND	0.75	0.25	ND	0.15	0.052	
109-99-9	Tetrahydrofuran (THF)	ND	0.75	0.30	ND	0.25	0.10	
107-06-2	1,2-Dichloroethane	ND	0.75	0.24	ND	0.18	0.059	
71-55-6	1,1,1-Trichloroethane	ND	0.75	0.25	ND	0.14	0.046	
71-43-2	Benzene	**0.61**	0.75	0.24	**0.19**	0.23	0.075	**J**
56-23-5	Carbon Tetrachloride	**0.53**	0.75	0.22	**0.084**	0.12	0.036	**J**
110-82-7	Cyclohexane	ND	1.5	0.43	ND	0.43	0.13	
78-87-5	1,2-Dichloropropane	ND	0.75	0.24	ND	0.16	0.052	
75-27-4	Bromodichloromethane	ND	0.75	0.22	ND	0.11	0.033	
79-01-6	Trichloroethene	ND	0.75	0.21	ND	0.14	0.039	
123-91-1	1,4-Dioxane	ND	0.75	0.24	ND	0.21	0.066	
80-62-6	Methyl Methacrylate	ND	1.5	0.46	ND	0.36	0.11	
142-82-5	n-Heptane	**1.0**	0.75	0.25	**0.25**	0.18	0.062	
10061-01-5	cis-1,3-Dichloropropene	ND	0.75	0.21	ND	0.16	0.046	
108-10-1	4-Methyl-2-pentanone	ND	0.75	0.24	ND	0.18	0.058	
10061-02-6	trans-1,3-Dichloropropene	ND	0.75	0.24	ND	0.16	0.053	
79-00-5	1,1,2-Trichloroethane	ND	0.75	0.24	ND	0.14	0.044	
108-88-3	Toluene	**5.6**	0.75	0.25	**1.5**	0.20	0.067	
591-78-6	2-Hexanone	ND	0.75	0.24	ND	0.18	0.058	
124-48-1	Dibromochloromethane	ND	0.75	0.24	ND	0.087	0.028	
106-93-4	1,2-Dibromoethane	ND	0.75	0.24	ND	0.097	0.031	
123-86-4	n-Butyl Acetate	ND	0.75	0.24	ND	0.16	0.050	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
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J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-BACKGROUND**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-001

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			
Container ID:	AS00166		

Initial Pressure (psig): -2.34 Final Pressure (psig): 3.74

Canister Dilution Factor: 1.49

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	**0.57**	0.75	0.27	**0.12**	0.16	0.057	J
127-18-4	Tetrachloroethene	ND	0.75	0.21	ND	0.11	0.031	
108-90-7	Chlorobenzene	ND	0.75	0.24	ND	0.16	0.052	
100-41-4	Ethylbenzene	**1.1**	0.75	0.24	**0.24**	0.17	0.055	
179601-23-1	m,p-Xylenes	**3.9**	1.5	0.45	**0.90**	0.34	0.10	
75-25-2	Bromoform	ND	0.75	0.22	ND	0.072	0.022	
100-42-5	Styrene	ND	0.75	0.22	ND	0.18	0.053	
95-47-6	o-Xylene	**1.4**	0.75	0.22	**0.31**	0.17	0.051	
111-84-2	n-Nonane	ND	0.75	0.22	ND	0.14	0.043	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.75	0.22	ND	0.11	0.033	
98-82-8	Cumene	ND	0.75	0.22	ND	0.15	0.045	
80-56-8	alpha-Pinene	ND	0.75	0.21	ND	0.13	0.037	
103-65-1	n-Propylbenzene	ND	0.75	0.24	ND	0.15	0.049	
622-96-8	4-Ethyltoluene	**0.30**	0.75	0.24	**0.061**	0.15	0.049	J
108-67-8	1,3,5-Trimethylbenzene	**0.30**	0.75	0.24	**0.062**	0.15	0.049	J
95-63-6	1,2,4-Trimethylbenzene	**0.98**	0.75	0.22	**0.20**	0.15	0.045	
100-44-7	Benzyl Chloride	ND	0.75	0.16	ND	0.14	0.032	
541-73-1	1,3-Dichlorobenzene	ND	0.75	0.22	ND	0.12	0.037	
106-46-7	1,4-Dichlorobenzene	ND	0.75	0.21	ND	0.12	0.035	
95-50-1	1,2-Dichlorobenzene	ND	0.75	0.22	ND	0.12	0.037	
5989-27-5	d-Limonene	ND	0.75	0.21	ND	0.13	0.037	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.75	0.15	ND	0.077	0.015	
120-82-1	1,2,4-Trichlorobenzene	ND	0.75	0.24	ND	0.10	0.032	
91-20-3	Naphthalene	ND	0.75	0.27	ND	0.14	0.051	
87-68-3	Hexachlorobutadiene	ND	0.75	0.21	ND	0.070	0.020	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-VENT-4**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-002

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			0.050 Liter(s)
Container ID:	AS00840		

Initial Pressure (psig): -2.37 Final Pressure (psig): 3.55

Canister Dilution Factor: 1.48

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	ND	0.74	0.21	ND	0.43	0.12	
75-71-8	Dichlorodifluoromethane (CFC 12)	**1.0**	0.74	0.25	**0.21**	0.15	0.051	
74-87-3	Chloromethane	**0.49**	0.74	0.22	**0.24**	0.36	0.11	J
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	**0.39**	0.74	0.28	**0.055**	0.11	0.040	J
106-99-0	1,3-Butadiene	ND	0.74	0.33	ND	0.33	0.15	
74-83-9	Bromomethane	ND	0.74	0.28	ND	0.19	0.072	
75-00-3	Chloroethane	ND	0.74	0.25	ND	0.28	0.095	
64-17-5	Ethanol	**60**	7.4	1.2	**32**	3.9	0.63	
75-05-8	Acetonitrile	ND	0.74	0.27	ND	0.44	0.16	
107-02-8	Acrolein	ND	3.0	0.25	ND	1.3	0.11	
67-64-1	Acetone	**40**	7.4	1.1	**17**	3.1	0.48	
75-69-4	Trichlorofluoromethane	**0.66**	0.74	0.25	**0.12**	0.13	0.045	J
67-63-0	2-Propanol (Isopropyl Alcohol)	**5.8**	7.4	0.62	**2.3**	3.0	0.25	J
107-13-1	Acrylonitrile	ND	0.74	0.25	ND	0.34	0.12	
75-35-4	1,1-Dichloroethene	ND	0.74	0.25	ND	0.19	0.063	
75-09-2	Methylene Chloride	**0.39**	0.74	0.25	**0.11**	0.21	0.072	J
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.74	0.24	ND	0.24	0.076	
76-13-1	Trichlorotrifluoroethane	ND	0.74	0.25	ND	0.097	0.033	
75-15-0	Carbon Disulfide	**2.4**	7.4	0.22	**0.79**	2.4	0.071	J
156-60-5	trans-1,2-Dichloroethene	ND	0.74	0.28	ND	0.19	0.071	
75-34-3	1,1-Dichloroethane	ND	0.74	0.24	ND	0.18	0.059	
1634-04-4	Methyl tert-Butyl Ether	ND	0.74	0.25	ND	0.21	0.070	
108-05-4	Vinyl Acetate	ND	7.4	0.96	ND	2.1	0.27	
78-93-3	2-Butanone (MEK)	**14**	7.4	0.31	**4.9**	2.5	0.11	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.

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J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-VENT-4**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-002

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			0.050 Liter(s)
Container ID:	AS00840		

Initial Pressure (psig): -2.37 Final Pressure (psig): 3.55

Canister Dilution Factor: 1.48

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	Data Qualifier
156-59-2	cis-1,2-Dichloroethene	ND	0.74	0.24	ND	0.19	0.060	
141-78-6	Ethyl Acetate	**3.0**	1.5	0.52	**0.82**	0.41	0.14	
110-54-3	n-Hexane	**25**	0.74	0.22	**7.1**	0.21	0.063	
67-66-3	Chloroform	**10**	0.74	0.25	**2.0**	0.15	0.052	
109-99-9	Tetrahydrofuran (THF)	**100**	0.74	0.30	**35**	0.25	0.10	
107-06-2	1,2-Dichloroethane	ND	0.74	0.24	ND	0.18	0.059	
71-55-6	1,1,1-Trichloroethane	ND	0.74	0.25	ND	0.14	0.046	
71-43-2	Benzene	**3.2**	0.74	0.24	**1.0**	0.23	0.074	
56-23-5	Carbon Tetrachloride	ND	0.74	0.22	ND	0.12	0.035	
110-82-7	Cyclohexane	**8.7**	1.5	0.43	**2.5**	0.43	0.12	
78-87-5	1,2-Dichloropropane	ND	0.74	0.24	ND	0.16	0.051	
75-27-4	Bromodichloromethane	ND	0.74	0.22	ND	0.11	0.033	
79-01-6	Trichloroethene	ND	0.74	0.21	ND	0.14	0.039	
123-91-1	1,4-Dioxane	ND	0.74	0.24	ND	0.21	0.066	
80-62-6	Methyl Methacrylate	ND	1.5	0.46	ND	0.36	0.11	
142-82-5	n-Heptane	**5.5**	0.74	0.25	**1.3**	0.18	0.061	
10061-01-5	cis-1,3-Dichloropropene	ND	0.74	0.21	ND	0.16	0.046	
108-10-1	4-Methyl-2-pentanone	**0.82**	0.74	0.24	**0.20**	0.18	0.058	
10061-02-6	trans-1,3-Dichloropropene	ND	0.74	0.24	ND	0.16	0.052	
79-00-5	1,1,2-Trichloroethane	ND	0.74	0.24	ND	0.14	0.043	
108-88-3	Toluene	**280**	15	5.0	**73**	3.9	1.3	**D**
591-78-6	2-Hexanone	ND	0.74	0.24	ND	0.18	0.058	
124-48-1	Dibromochloromethane	ND	0.74	0.24	ND	0.087	0.028	
106-93-4	1,2-Dibromoethane	ND	0.74	0.24	ND	0.096	0.031	
123-86-4	n-Butyl Acetate	**6.4**	0.74	0.24	**1.3**	0.16	0.050	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
D = The reported result is from a dilution.

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-VENT-4**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-002

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			0.050 Liter(s)
Container ID:	AS00840		

Initial Pressure (psig): -2.37 Final Pressure (psig): 3.55

Canister Dilution Factor: 1.48

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	**3.5**	0.74	0.27	**0.75**	0.16	0.057	
127-18-4	Tetrachloroethene	ND	0.74	0.21	ND	0.11	0.031	
108-90-7	Chlorobenzene	ND	0.74	0.24	ND	0.16	0.051	
100-41-4	Ethylbenzene	**28**	0.74	0.24	**6.5**	0.17	0.055	
179601-23-1	m,p-Xylenes	**43**	1.5	0.44	**9.9**	0.34	0.10	
75-25-2	Bromoform	ND	0.74	0.22	ND	0.072	0.021	
100-42-5	Styrene	**4.2**	0.74	0.22	**0.98**	0.17	0.052	
95-47-6	o-Xylene	**16**	0.74	0.22	**3.6**	0.17	0.051	
111-84-2	n-Nonane	**1.9**	0.74	0.22	**0.36**	0.14	0.042	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.74	0.22	ND	0.11	0.032	
98-82-8	Cumene	**1.6**	0.74	0.22	**0.33**	0.15	0.045	
80-56-8	alpha-Pinene	**1.3**	0.74	0.21	**0.23**	0.13	0.037	
103-65-1	n-Propylbenzene	**2.6**	0.74	0.24	**0.52**	0.15	0.048	
622-96-8	4-Ethyltoluene	**3.7**	0.74	0.24	**0.76**	0.15	0.048	
108-67-8	1,3,5-Trimethylbenzene	**3.6**	0.74	0.24	**0.74**	0.15	0.048	
95-63-6	1,2,4-Trimethylbenzene	**13**	0.74	0.22	**2.7**	0.15	0.045	
100-44-7	Benzyl Chloride	ND	0.74	0.16	ND	0.14	0.031	
541-73-1	1,3-Dichlorobenzene	**0.90**	0.74	0.22	**0.15**	0.12	0.037	
106-46-7	1,4-Dichlorobenzene	ND	0.74	0.21	ND	0.12	0.034	
95-50-1	1,2-Dichlorobenzene	ND	0.74	0.22	ND	0.12	0.037	
5989-27-5	d-Limonene	**11**	0.74	0.21	**2.0**	0.13	0.037	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.74	0.15	ND	0.077	0.015	
120-82-1	1,2,4-Trichlorobenzene	ND	0.74	0.24	ND	0.10	0.032	
91-20-3	Naphthalene	**2.2**	0.74	0.27	**0.41**	0.14	0.051	
87-68-3	Hexachlorobutadiene	ND	0.74	0.21	ND	0.069	0.019	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
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ALS ENVIRONMENTAL

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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-3**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-003

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister
Test Notes:
Container ID: AC01775

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 6/30/15
Volume(s) Analyzed: 0.25 Liter(s)

Initial Pressure (psig): -5.31 Final Pressure (psig): 3.55

Canister Dilution Factor: 1.94

CAS #	Compound	Result µg/m^3	MRL µg/m^3	MDL µg/m^3	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	**190**	3.9	1.1	**110**	2.3	0.63	
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	3.9	1.3	ND	0.78	0.27	
74-87-3	Chloromethane	ND	3.9	1.2	ND	1.9	0.56	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	**14**	3.9	1.5	**2.0**	0.56	0.21	
106-99-0	1,3-Butadiene	ND	3.9	1.7	ND	1.8	0.77	
74-83-9	Bromomethane	ND	3.9	1.5	ND	1.0	0.38	
75-00-3	Chloroethane	ND	3.9	1.3	ND	1.5	0.50	
64-17-5	Ethanol	**79**	39	6.2	**42**	21	3.3	
75-05-8	Acetonitrile	ND	3.9	1.4	ND	2.3	0.83	
107-02-8	Acrolein	ND	16	1.3	ND	6.8	0.58	
67-64-1	Acetone	**97**	39	6.0	**41**	16	2.5	
75-69-4	Trichlorofluoromethane	ND	3.9	1.3	ND	0.69	0.23	
67-63-0	2-Propanol (Isopropyl Alcohol)	**5.4**	39	3.3	**2.2**	16	1.3	**J**
107-13-1	Acrylonitrile	ND	3.9	1.3	ND	1.8	0.61	
75-35-4	1,1-Dichloroethene	ND	3.9	1.3	ND	0.98	0.33	
75-09-2	Methylene Chloride	ND	3.9	1.3	ND	1.1	0.38	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	3.9	1.2	ND	1.2	0.40	
76-13-1	Trichlorotrifluoroethane	ND	3.9	1.3	ND	0.51	0.17	
75-15-0	Carbon Disulfide	**29**	39	1.2	**9.4**	12	0.37	**J**
156-60-5	trans-1,2-Dichloroethene	ND	3.9	1.5	ND	0.98	0.37	
75-34-3	1,1-Dichloroethane	ND	3.9	1.2	ND	0.96	0.31	
1634-04-4	Methyl tert-Butyl Ether	ND	3.9	1.3	ND	1.1	0.37	
108-05-4	Vinyl Acetate	ND	39	5.0	ND	11	1.4	
78-93-3	2-Butanone (MEK)	**4.4**	39	1.6	**1.5**	13	0.55	**J**

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
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J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

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RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-3**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-003
Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.25 Liter(s)
Test Notes:			
Container ID:	AC01775		

Initial Pressure (psig): -5.31 Final Pressure (psig): 3.55

Canister Dilution Factor: 1.94

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
156-59-2	cis-1,2-Dichloroethene	**7.0**	3.9	1.2	**1.8**	0.98	0.31	
141-78-6	Ethyl Acetate	ND	7.8	2.7	ND	2.2	0.75	
110-54-3	n-Hexane	**450**	3.9	1.2	**130**	1.1	0.33	
67-66-3	Chloroform	ND	3.9	1.3	ND	0.79	0.27	
109-99-9	Tetrahydrofuran (THF)	**4.3**	3.9	1.6	**1.5**	1.3	0.53	
107-06-2	1,2-Dichloroethane	ND	3.9	1.2	ND	0.96	0.31	
71-55-6	1,1,1-Trichloroethane	ND	3.9	1.3	ND	0.71	0.24	
71-43-2	Benzene	**120**	3.9	1.2	**38**	1.2	0.39	
56-23-5	Carbon Tetrachloride	ND	3.9	1.2	ND	0.62	0.19	
110-82-7	Cyclohexane	**180**	7.8	2.3	**52**	2.3	0.65	
78-87-5	1,2-Dichloropropane	ND	3.9	1.2	ND	0.84	0.27	
75-27-4	Bromodichloromethane	ND	3.9	1.2	ND	0.58	0.17	
79-01-6	Trichloroethene	**1.9**	3.9	1.1	**0.36**	0.72	0.20	**J**
123-91-1	1,4-Dioxane	ND	3.9	1.2	ND	1.1	0.34	
80-62-6	Methyl Methacrylate	ND	7.8	2.4	ND	1.9	0.59	
142-82-5	n-Heptane	**240**	3.9	1.3	**59**	0.95	0.32	
10061-01-5	cis-1,3-Dichloropropene	ND	3.9	1.1	ND	0.85	0.24	
108-10-1	4-Methyl-2-pentanone	**2.0**	3.9	1.2	**0.48**	0.95	0.30	**J**
10061-02-6	trans-1,3-Dichloropropene	ND	3.9	1.2	ND	0.85	0.27	
79-00-5	1,1,2-Trichloroethane	ND	3.9	1.2	ND	0.71	0.23	
108-88-3	Toluene	**270**	3.9	1.3	**72**	1.0	0.35	
591-78-6	2-Hexanone	ND	3.9	1.2	ND	0.95	0.30	
124-48-1	Dibromochloromethane	ND	3.9	1.2	ND	0.46	0.15	
106-93-4	1,2-Dibromoethane	ND	3.9	1.2	ND	0.51	0.16	
123-86-4	n-Butyl Acetate	ND	3.9	1.2	ND	0.82	0.26	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-3**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-003

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister
Test Notes:
Container ID: AC01775

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 6/30/15
Volume(s) Analyzed: 0.25 Liter(s)

Initial Pressure (psig): -5.31 Final Pressure (psig): 3.55

Canister Dilution Factor: 1.94

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
111-65-9	n-Octane	**130**	3.9	1.4	**27**	0.83	0.30	
127-18-4	Tetrachloroethene	ND	3.9	1.1	ND	0.57	0.16	
108-90-7	Chlorobenzene	ND	3.9	1.2	ND	0.84	0.27	
100-41-4	Ethylbenzene	**55**	3.9	1.2	**13**	0.89	0.29	
179601-23-1	m,p-Xylenes	**77**	7.8	2.3	**18**	1.8	0.54	
75-25-2	Bromoform	ND	3.9	1.2	ND	0.38	0.11	
100-42-5	Styrene	**2.6**	3.9	1.2	**0.60**	0.91	0.27	**J**
95-47-6	o-Xylene	**51**	3.9	1.2	**12**	0.89	0.27	
111-84-2	n-Nonane	**61**	3.9	1.2	**12**	0.74	0.22	
79-34-5	1,1,2,2-Tetrachloroethane	ND	3.9	1.2	ND	0.57	0.17	
98-82-8	Cumene	**9.9**	3.9	1.2	**2.0**	0.79	0.24	
80-56-8	alpha-Pinene	**50**	3.9	1.1	**9.0**	0.70	0.20	
103-65-1	n-Propylbenzene	**5.2**	3.9	1.2	**1.1**	0.79	0.25	
622-96-8	4-Ethyltoluene	ND	3.9	1.2	ND	0.79	0.25	
108-67-8	1,3,5-Trimethylbenzene	**16**	3.9	1.2	**3.3**	0.79	0.25	
95-63-6	1,2,4-Trimethylbenzene	**29**	3.9	1.2	**5.9**	0.79	0.24	
100-44-7	Benzyl Chloride	ND	3.9	0.85	ND	0.75	0.16	
541-73-1	1,3-Dichlorobenzene	**1.4**	3.9	1.2	**0.23**	0.65	0.19	**J**
106-46-7	1,4-Dichlorobenzene	ND	3.9	1.1	ND	0.65	0.18	
95-50-1	1,2-Dichlorobenzene	ND	3.9	1.2	ND	0.65	0.19	
5989-27-5	d-Limonene	**18**	3.9	1.1	**3.3**	0.70	0.20	
96-12-8	1,2-Dibromo-3-chloropropane	ND	3.9	0.77	ND	0.40	0.080	
120-82-1	1,2,4-Trichlorobenzene	ND	3.9	1.2	ND	0.52	0.17	
91-20-3	Naphthalene	**2.7**	3.9	1.4	**0.51**	0.74	0.27	**J**
87-68-3	Hexachlorobutadiene	ND	3.9	1.1	ND	0.36	0.10	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-12**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-004

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00490

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 6/30/15
Volume(s) Analyzed: 0.030 Liter(s)

Initial Pressure (psig): -1.46 Final Pressure (psig): 3.93

Canister Dilution Factor: 1.41

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	**84**	24	6.6	**49**	14	3.8	
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	24	8.0	ND	4.8	1.6	
74-87-3	Chloromethane	ND	24	7.1	ND	11	3.4	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	24	8.9	ND	3.4	1.3	
106-99-0	1,3-Butadiene	ND	24	10	ND	11	4.7	
74-83-9	Bromomethane	ND	24	8.9	ND	6.1	2.3	
75-00-3	Chloroethane	ND	24	8.0	ND	8.9	3.0	
64-17-5	Ethanol	**860**	240	38	**460**	120	20	
75-05-8	Acetonitrile	ND	24	8.5	ND	14	5.0	
107-02-8	Acrolein	ND	94	8.0	ND	41	3.5	
67-64-1	Acetone	**200**	240	36	**83**	99	15	**J**
75-69-4	Trichlorofluoromethane	ND	24	8.0	ND	4.2	1.4	
67-63-0	2-Propanol (Isopropyl Alcohol)	**56**	240	20	**23**	96	8.0	**J**
107-13-1	Acrylonitrile	ND	24	8.0	ND	11	3.7	
75-35-4	1,1-Dichloroethene	ND	24	8.0	ND	5.9	2.0	
75-09-2	Methylene Chloride	ND	24	8.0	ND	6.8	2.3	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	24	7.5	ND	7.5	2.4	
76-13-1	Trichlorotrifluoroethane	ND	24	8.0	ND	3.1	1.0	
75-15-0	Carbon Disulfide	**45**	240	7.1	**14**	75	2.3	**J**
156-60-5	trans-1,2-Dichloroethene	ND	24	8.9	ND	5.9	2.3	
75-34-3	1,1-Dichloroethane	ND	24	7.5	ND	5.8	1.9	
1634-04-4	Methyl tert-Butyl Ether	ND	24	8.0	ND	6.5	2.2	
108-05-4	Vinyl Acetate	ND	240	31	ND	67	8.7	
78-93-3	2-Butanone (MEK)	ND	240	9.9	ND	80	3.3	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-12**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-004

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.030 Liter(s)
Test Notes:			
Container ID:	AS00490		

Initial Pressure (psig): -1.46 Final Pressure (psig): 3.93

Canister Dilution Factor: 1.41

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	24	7.5	ND	5.9	1.9	
141-78-6	Ethyl Acetate	ND	47	16	ND	13	4.6	
110-54-3	n-Hexane	**84**	24	7.1	**24**	6.7	2.0	
67-66-3	Chloroform	ND	24	8.0	ND	4.8	1.6	
109-99-9	Tetrahydrofuran (THF)	ND	24	9.4	ND	8.0	3.2	
107-06-2	1,2-Dichloroethane	ND	24	7.5	ND	5.8	1.9	
71-55-6	1,1,1-Trichloroethane	ND	24	8.0	ND	4.3	1.5	
71-43-2	Benzene	ND	24	7.5	ND	7.4	2.4	
56-23-5	Carbon Tetrachloride	ND	24	7.1	ND	3.7	1.1	
110-82-7	Cyclohexane	**120**	47	14	**35**	14	4.0	
78-87-5	1,2-Dichloropropane	ND	24	7.5	ND	5.1	1.6	
75-27-4	Bromodichloromethane	ND	24	7.1	ND	3.5	1.1	
79-01-6	Trichloroethene	ND	24	6.6	ND	4.4	1.2	
123-91-1	1,4-Dioxane	ND	24	7.5	ND	6.5	2.1	
80-62-6	Methyl Methacrylate	ND	47	15	ND	11	3.6	
142-82-5	n-Heptane	**26**	24	8.0	**6.3**	5.7	2.0	
10061-01-5	cis-1,3-Dichloropropene	ND	24	6.6	ND	5.2	1.4	
108-10-1	4-Methyl-2-pentanone	ND	24	7.5	ND	5.7	1.8	
10061-02-6	trans-1,3-Dichloropropene	ND	24	7.5	ND	5.2	1.7	
79-00-5	1,1,2-Trichloroethane	ND	24	7.5	ND	4.3	1.4	
108-88-3	Toluene	**190**	24	8.0	**51**	6.2	2.1	
591-78-6	2-Hexanone	ND	24	7.5	ND	5.7	1.8	
124-48-1	Dibromochloromethane	ND	24	7.5	ND	2.8	0.88	
106-93-4	1,2-Dibromoethane	ND	24	7.5	ND	3.1	0.98	
123-86-4	n-Butyl Acetate	ND	24	7.5	ND	4.9	1.6	

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RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-12**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-004

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00490

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 6/30/15
Volume(s) Analyzed: 0.030 Liter(s)

Initial Pressure (psig): -1.46 Final Pressure (psig): 3.93

Canister Dilution Factor: 1.41

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	ND	24	8.5	ND	5.0	1.8	
127-18-4	Tetrachloroethene	ND	24	6.6	ND	3.5	0.97	
108-90-7	Chlorobenzene	ND	24	7.5	ND	5.1	1.6	
100-41-4	Ethylbenzene	**27**	24	7.5	**6.3**	5.4	1.7	
179601-23-1	m,p-Xylenes	**55**	47	14	**13**	11	3.2	
75-25-2	Bromoform	ND	24	7.1	ND	2.3	0.68	
100-42-5	Styrene	ND	24	7.1	ND	5.5	1.7	
95-47-6	o-Xylene	**24**	24	7.1	**5.4**	5.4	1.6	
111-84-2	n-Nonane	ND	24	7.1	ND	4.5	1.3	
79-34-5	1,1,2,2-Tetrachloroethane	ND	24	7.1	ND	3.4	1.0	
98-82-8	Cumene	**230**	24	7.1	**47**	4.8	1.4	
80-56-8	alpha-Pinene	**2,000**	24	6.6	**360**	4.2	1.2	
103-65-1	n-Propylbenzene	**140**	24	7.5	**28**	4.8	1.5	
622-96-8	4-Ethyltoluene	ND	24	7.5	ND	4.8	1.5	
108-67-8	1,3,5-Trimethylbenzene	ND	24	7.5	ND	4.8	1.5	
95-63-6	1,2,4-Trimethylbenzene	**17**	24	7.1	**3.4**	4.8	1.4	**J**
100-44-7	Benzyl Chloride	ND	24	5.2	ND	4.5	1.0	
541-73-1	1,3-Dichlorobenzene	ND	24	7.1	ND	3.9	1.2	
106-46-7	1,4-Dichlorobenzene	ND	24	6.6	ND	3.9	1.1	
95-50-1	1,2-Dichlorobenzene	ND	24	7.1	ND	3.9	1.2	
5989-27-5	d-Limonene	**150**	24	6.6	**27**	4.2	1.2	
96-12-8	1,2-Dibromo-3-chloropropane	ND	24	4.7	ND	2.4	0.48	
120-82-1	1,2,4-Trichlorobenzene	ND	24	7.5	ND	3.2	1.0	
91-20-3	Naphthalene	ND	24	8.5	ND	4.5	1.6	
87-68-3	Hexachlorobutadiene	ND	24	6.6	ND	2.2	0.62	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-VENT-3**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-005

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00442

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 6/30 - 7/1/15
Volume(s) Analyzed: 1.00 Liter(s)
0.050 Liter(s)

Initial Pressure (psig): -2.41 Final Pressure (psig): 3.60

Canister Dilution Factor: 1.49

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
115-07-1	Propene	**6.5**	0.75	0.21	**3.8**	0.43	0.12	
75-71-8	Dichlorodifluoromethane (CFC 12)	**1.9**	0.75	0.25	**0.39**	0.15	0.051	
74-87-3	Chloromethane	**0.33**	0.75	0.22	**0.16**	0.36	0.11	**J**
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	0.75	0.28	ND	0.11	0.041	
106-99-0	1,3-Butadiene	ND	0.75	0.33	ND	0.34	0.15	
74-83-9	Bromomethane	ND	0.75	0.28	ND	0.19	0.073	
75-00-3	Chloroethane	ND	0.75	0.25	ND	0.28	0.096	
64-17-5	Ethanol	**100**	7.5	1.2	**55**	4.0	0.63	
75-05-8	Acetonitrile	**1.6**	0.75	0.27	**0.97**	0.44	0.16	
107-02-8	Acrolein	**3.2**	3.0	0.25	**1.4**	1.3	0.11	
67-64-1	Acetone	**180**	7.5	1.1	**75**	3.1	0.48	
75-69-4	Trichlorofluoromethane	**1.4**	0.75	0.25	**0.24**	0.13	0.045	
67-63-0	2-Propanol (Isopropyl Alcohol)	**6.7**	7.5	0.63	**2.7**	3.0	0.25	**J**
107-13-1	Acrylonitrile	ND	0.75	0.25	ND	0.34	0.12	
75-35-4	1,1-Dichloroethene	ND	0.75	0.25	ND	0.19	0.064	
75-09-2	Methylene Chloride	**0.48**	0.75	0.25	**0.14**	0.21	0.073	**J**
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.75	0.24	ND	0.24	0.076	
76-13-1	Trichlorotrifluoroethane	**0.53**	0.75	0.25	**0.069**	0.097	0.033	**J**
75-15-0	Carbon Disulfide	**4.9**	7.5	0.22	**1.6**	2.4	0.072	**J**
156-60-5	trans-1,2-Dichloroethene	ND	0.75	0.28	ND	0.19	0.071	
75-34-3	1,1-Dichloroethane	ND	0.75	0.24	ND	0.18	0.059	
1634-04-4	Methyl tert-Butyl Ether	ND	0.75	0.25	ND	0.21	0.070	
108-05-4	Vinyl Acetate	**2.7**	7.5	0.97	**0.77**	2.1	0.28	**J**
78-93-3	2-Butanone (MEK)	**42**	7.5	0.31	**14**	2.5	0.11	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-VENT-3**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-005

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00442

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 6/30 - 7/1/15
Volume(s) Analyzed: 1.00 Liter(s)
0.050 Liter(s)

Initial Pressure (psig): -2.41 Final Pressure (psig): 3.60

Canister Dilution Factor: 1.49

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
156-59-2	cis-1,2-Dichloroethene	ND	0.75	0.24	ND	0.19	0.060	
141-78-6	Ethyl Acetate	**4.8**	1.5	0.52	**1.3**	0.41	0.14	
110-54-3	n-Hexane	**1.4**	0.75	0.22	**0.38**	0.21	0.063	
67-66-3	Chloroform	**0.32**	0.75	0.25	**0.066**	0.15	0.052	**J**
109-99-9	Tetrahydrofuran (THF)	**280**	15	6.0	**94**	5.1	2.0	**D**
107-06-2	1,2-Dichloroethane	ND	0.75	0.24	ND	0.18	0.059	
71-55-6	1,1,1-Trichloroethane	ND	0.75	0.25	ND	0.14	0.046	
71-43-2	Benzene	**2.8**	0.75	0.24	**0.88**	0.23	0.075	
56-23-5	Carbon Tetrachloride	**0.55**	0.75	0.22	**0.088**	0.12	0.036	**J**
110-82-7	Cyclohexane	**4.5**	1.5	0.43	**1.3**	0.43	0.13	
78-87-5	1,2-Dichloropropane	ND	0.75	0.24	ND	0.16	0.052	
75-27-4	Bromodichloromethane	ND	0.75	0.22	ND	0.11	0.033	
79-01-6	Trichloroethene	ND	0.75	0.21	ND	0.14	0.039	
123-91-1	1,4-Dioxane	ND	0.75	0.24	ND	0.21	0.066	
80-62-6	Methyl Methacrylate	ND	1.5	0.46	ND	0.36	0.11	
142-82-5	n-Heptane	**2.6**	0.75	0.25	**0.63**	0.18	0.062	
10061-01-5	cis-1,3-Dichloropropene	ND	0.75	0.21	ND	0.16	0.046	
108-10-1	4-Methyl-2-pentanone	**1.8**	0.75	0.24	**0.43**	0.18	0.058	
10061-02-6	trans-1,3-Dichloropropene	ND	0.75	0.24	ND	0.16	0.053	
79-00-5	1,1,2-Trichloroethane	ND	0.75	0.24	ND	0.14	0.044	
108-88-3	Toluene	**330**	15	5.1	**87**	4.0	1.3	**D**
591-78-6	2-Hexanone	ND	0.75	0.24	ND	0.18	0.058	
124-48-1	Dibromochloromethane	ND	0.75	0.24	ND	0.087	0.028	
106-93-4	1,2-Dibromoethane	ND	0.75	0.24	ND	0.097	0.031	
123-86-4	n-Butyl Acetate	**7.7**	0.75	0.24	**1.6**	0.16	0.050	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
D = The reported result is from a dilution.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-VENT-3**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-005
Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	6/30 - 7/1/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			0.050 Liter(s)
Container ID:	AS00442		

Initial Pressure (psig): -2.41 Final Pressure (psig): 3.60

Canister Dilution Factor: 1.49

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	**4.3**	0.75	0.27	**0.92**	0.16	0.057	
127-18-4	Tetrachloroethene	ND	0.75	0.21	ND	0.11	0.031	
108-90-7	Chlorobenzene	ND	0.75	0.24	ND	0.16	0.052	
100-41-4	Ethylbenzene	**32**	0.75	0.24	**7.4**	0.17	0.055	
179601-23-1	m,p-Xylenes	**49**	1.5	0.45	**11**	0.34	0.10	
75-25-2	Bromoform	ND	0.75	0.22	ND	0.072	0.022	
100-42-5	Styrene	**2.7**	0.75	0.22	**0.64**	0.18	0.053	
95-47-6	o-Xylene	**17**	0.75	0.22	**3.9**	0.17	0.051	
111-84-2	n-Nonane	**2.0**	0.75	0.22	**0.38**	0.14	0.043	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.75	0.22	ND	0.11	0.033	
98-82-8	Cumene	**0.79**	0.75	0.22	**0.16**	0.15	0.045	
80-56-8	alpha-Pinene	**1.3**	0.75	0.21	**0.23**	0.13	0.037	
103-65-1	n-Propylbenzene	**2.4**	0.75	0.24	**0.48**	0.15	0.049	
622-96-8	4-Ethyltoluene	**3.6**	0.75	0.24	**0.74**	0.15	0.049	
108-67-8	1,3,5-Trimethylbenzene	**3.3**	0.75	0.24	**0.68**	0.15	0.049	
95-63-6	1,2,4-Trimethylbenzene	**11**	0.75	0.22	**2.3**	0.15	0.045	
100-44-7	Benzyl Chloride	ND	0.75	0.16	ND	0.14	0.032	
541-73-1	1,3-Dichlorobenzene	**1.3**	0.75	0.22	**0.21**	0.12	0.037	
106-46-7	1,4-Dichlorobenzene	ND	0.75	0.21	ND	0.12	0.035	
95-50-1	1,2-Dichlorobenzene	ND	0.75	0.22	ND	0.12	0.037	
5989-27-5	d-Limonene	**10**	0.75	0.21	**1.8**	0.13	0.037	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.75	0.15	ND	0.077	0.015	
120-82-1	1,2,4-Trichlorobenzene	ND	0.75	0.24	ND	0.10	0.032	
91-20-3	Naphthalene	**0.49**	0.75	0.27	**0.094**	0.14	0.051	**J**
87-68-3	Hexachlorobutadiene	ND	0.75	0.21	ND	0.070	0.020	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-MW-102**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P1502473-006

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00457

Date Collected: 6/15/15
Date Received: 6/19/15
Date Analyzed: 7/1/15
Volume(s) Analyzed: 0.030 Liter(s)

Initial Pressure (psig): -2.31 Final Pressure (psig): 3.64

Canister Dilution Factor: 1.48

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	ND	25	6.9	ND	14	4.0	V
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	25	8.4	ND	5.0	1.7	
74-87-3	Chloromethane	ND	25	7.4	ND	12	3.6	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	25	9.4	ND	3.5	1.3	
106-99-0	1,3-Butadiene	ND	25	11	ND	11	4.9	
74-83-9	Bromomethane	ND	25	9.4	ND	6.4	2.4	
75-00-3	Chloroethane	ND	25	8.4	ND	9.4	3.2	
64-17-5	Ethanol	**270**	250	39	**140**	130	21	
75-05-8	Acetonitrile	ND	25	8.9	ND	15	5.3	
107-02-8	Acrolein	ND	99	8.4	ND	43	3.7	
67-64-1	Acetone	ND	250	38	ND	100	16	
75-69-4	Trichlorofluoromethane	ND	25	8.4	ND	4.4	1.5	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	250	21	ND	100	8.4	
107-13-1	Acrylonitrile	ND	25	8.4	ND	11	3.9	
75-35-4	1,1-Dichloroethene	ND	25	8.4	ND	6.2	2.1	
75-09-2	Methylene Chloride	ND	25	8.4	ND	7.1	2.4	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	25	7.9	ND	7.9	2.5	
76-13-1	Trichlorotrifluoroethane	ND	25	8.4	ND	3.2	1.1	
75-15-0	Carbon Disulfide	**8.6**	250	7.4	**2.8**	79	2.4	J
156-60-5	trans-1,2-Dichloroethene	ND	25	9.4	ND	6.2	2.4	
75-34-3	1,1-Dichloroethane	ND	25	7.9	ND	6.1	2.0	
1634-04-4	Methyl tert-Butyl Ether	ND	25	8.4	ND	6.8	2.3	
108-05-4	Vinyl Acetate	ND	250	32	ND	70	9.1	
78-93-3	2-Butanone (MEK)	ND	250	10	ND	84	3.5	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
V = The continuing calibration verification standard was outside (biased low) the specified limits for this compound.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-MW-102**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-006

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	7/1/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.030 Liter(s)
Test Notes:			
Container ID:	AS00457		

Initial Pressure (psig): -2.31 Final Pressure (psig): 3.64

Canister Dilution Factor: 1.48

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	25	7.9	ND	6.2	2.0	
141-78-6	Ethyl Acetate	ND	49	17	ND	14	4.8	
110-54-3	n-Hexane	**86**	25	7.4	**24**	7.0	2.1	
67-66-3	Chloroform	ND	25	8.4	ND	5.1	1.7	
109-99-9	Tetrahydrofuran (THF)	ND	25	9.9	ND	8.4	3.3	
107-06-2	1,2-Dichloroethane	ND	25	7.9	ND	6.1	2.0	
71-55-6	1,1,1-Trichloroethane	ND	25	8.4	ND	4.5	1.5	
71-43-2	Benzene	**12**	25	7.9	**3.8**	7.7	2.5	**J**
56-23-5	Carbon Tetrachloride	ND	25	7.4	ND	3.9	1.2	
110-82-7	Cyclohexane	**51**	49	14	**15**	14	4.2	
78-87-5	1,2-Dichloropropane	ND	25	7.9	ND	5.3	1.7	
75-27-4	Bromodichloromethane	ND	25	7.4	ND	3.7	1.1	
79-01-6	Trichloroethene	ND	25	6.9	ND	4.6	1.3	
123-91-1	1,4-Dioxane	ND	25	7.9	ND	6.8	2.2	
80-62-6	Methyl Methacrylate	ND	49	15	ND	12	3.7	
142-82-5	n-Heptane	**210**	25	8.4	**51**	6.0	2.0	
10061-01-5	cis-1,3-Dichloropropene	ND	25	6.9	ND	5.4	1.5	
108-10-1	4-Methyl-2-pentanone	ND	25	7.9	ND	6.0	1.9	
10061-02-6	trans-1,3-Dichloropropene	ND	25	7.9	ND	5.4	1.7	
79-00-5	1,1,2-Trichloroethane	ND	25	7.9	ND	4.5	1.4	
108-88-3	Toluene	**98**	25	8.4	**26**	6.5	2.2	
591-78-6	2-Hexanone	ND	25	7.9	ND	6.0	1.9	
124-48-1	Dibromochloromethane	ND	25	7.9	ND	2.9	0.93	
106-93-4	1,2-Dibromoethane	ND	25	7.9	ND	3.2	1.0	
123-86-4	n-Butyl Acetate	ND	25	7.9	ND	5.2	1.7	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-MW-102**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1502473-006

Test Code:	EPA TO-15	Date Collected:	6/15/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	6/19/15
Analyst:	Wida Ang	Date Analyzed:	7/1/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.030 Liter(s)
Test Notes:			
Container ID:	AS00457		

Initial Pressure (psig): -2.31 Final Pressure (psig): 3.64

Canister Dilution Factor: 1.48

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	ND	25	8.9	ND	5.3	1.9	
127-18-4	Tetrachloroethene	ND	25	6.9	ND	3.6	1.0	
108-90-7	Chlorobenzene	ND	25	7.9	ND	5.4	1.7	
100-41-4	Ethylbenzene	**36**	25	7.9	**8.3**	5.7	1.8	
179601-23-1	m,p-Xylenes	**110**	49	15	**26**	11	3.4	
75-25-2	Bromoform	ND	25	7.4	ND	2.4	0.72	
100-42-5	Styrene	ND	25	7.4	ND	5.8	1.7	
95-47-6	o-Xylene	**33**	25	7.4	**7.6**	5.7	1.7	
111-84-2	n-Nonane	ND	25	7.4	ND	4.7	1.4	
79-34-5	1,1,2,2-Tetrachloroethane	ND	25	7.4	ND	3.6	1.1	
98-82-8	Cumene	**220**	25	7.4	**45**	5.0	1.5	
80-56-8	alpha-Pinene	ND	25	6.9	ND	4.4	1.2	
103-65-1	n-Propylbenzene	**270**	25	7.9	**54**	5.0	1.6	
622-96-8	4-Ethyltoluene	ND	25	7.9	ND	5.0	1.6	
108-67-8	1,3,5-Trimethylbenzene	**11**	25	7.9	**2.3**	5.0	1.6	**J**
95-63-6	1,2,4-Trimethylbenzene	**25**	25	7.4	**5.0**	5.0	1.5	**J**
100-44-7	Benzyl Chloride	ND	25	5.4	ND	4.8	1.0	
541-73-1	1,3-Dichlorobenzene	ND	25	7.4	ND	4.1	1.2	
106-46-7	1,4-Dichlorobenzene	ND	25	6.9	ND	4.1	1.1	
95-50-1	1,2-Dichlorobenzene	ND	25	7.4	ND	4.1	1.2	
5989-27-5	d-Limonene	ND	25	6.9	ND	4.4	1.2	
96-12-8	1,2-Dibromo-3-chloropropane	ND	25	4.9	ND	2.6	0.51	
120-82-1	1,2,4-Trichlorobenzene	ND	25	7.9	ND	3.3	1.1	
91-20-3	Naphthalene	ND	25	8.9	ND	4.7	1.7	
87-68-3	Hexachlorobutadiene	ND	25	6.9	ND	2.3	0.65	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1502473
ALS Sample ID: P150630-MB

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:

Date Collected: NA
Date Received: NA
Date Analyzed: 6/30/15
Volume(s) Analyzed: 1.00 Liter(s)

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
115-07-1	Propene	ND	0.50	0.14	ND	0.29	0.081	
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	0.50	0.17	ND	0.10	0.034	
74-87-3	Chloromethane	ND	0.50	0.15	ND	0.24	0.073	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	0.50	0.19	ND	0.072	0.027	
106-99-0	1,3-Butadiene	ND	0.50	0.22	ND	0.23	0.099	
74-83-9	Bromomethane	ND	0.50	0.19	ND	0.13	0.049	
75-00-3	Chloroethane	ND	0.50	0.17	ND	0.19	0.064	
64-17-5	Ethanol	ND	5.0	0.80	ND	2.7	0.42	
75-05-8	Acetonitrile	ND	0.50	0.18	ND	0.30	0.11	
107-02-8	Acrolein	ND	2.0	0.17	ND	0.87	0.074	
67-64-1	Acetone	ND	5.0	0.77	ND	2.1	0.32	
75-69-4	Trichlorofluoromethane	ND	0.50	0.17	ND	0.089	0.030	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	5.0	0.42	ND	2.0	0.17	
107-13-1	Acrylonitrile	ND	0.50	0.17	ND	0.23	0.078	
75-35-4	1,1-Dichloroethene	ND	0.50	0.17	ND	0.13	0.043	
75-09-2	Methylene Chloride	ND	0.50	0.17	ND	0.14	0.049	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.50	0.16	ND	0.16	0.051	
76-13-1	Trichlorotrifluoroethane	ND	0.50	0.17	ND	0.065	0.022	
75-15-0	Carbon Disulfide	ND	5.0	0.15	ND	1.6	0.048	
156-60-5	trans-1,2-Dichloroethene	ND	0.50	0.19	ND	0.13	0.048	
75-34-3	1,1-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
1634-04-4	Methyl tert-Butyl Ether	ND	0.50	0.17	ND	0.14	0.047	
108-05-4	Vinyl Acetate	ND	5.0	0.65	ND	1.4	0.18	
78-93-3	2-Butanone (MEK)	ND	5.0	0.21	ND	1.7	0.071	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Method Blank**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150630-MB

Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	0.50	0.16	ND	0.13	0.040	
141-78-6	Ethyl Acetate	ND	1.0	0.35	ND	0.28	0.097	
110-54-3	n-Hexane	ND	0.50	0.15	ND	0.14	0.043	
67-66-3	Chloroform	ND	0.50	0.17	ND	0.10	0.035	
109-99-9	Tetrahydrofuran (THF)	ND	0.50	0.20	ND	0.17	0.068	
107-06-2	1,2-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
71-55-6	1,1,1-Trichloroethane	ND	0.50	0.17	ND	0.092	0.031	
71-43-2	Benzene	ND	0.50	0.16	ND	0.16	0.050	
56-23-5	Carbon Tetrachloride	ND	0.50	0.15	ND	0.080	0.024	
110-82-7	Cyclohexane	ND	1.0	0.29	ND	0.29	0.084	
78-87-5	1,2-Dichloropropane	ND	0.50	0.16	ND	0.11	0.035	
75-27-4	Bromodichloromethane	ND	0.50	0.15	ND	0.075	0.022	
79-01-6	Trichloroethene	ND	0.50	0.14	ND	0.093	0.026	
123-91-1	1,4-Dioxane	ND	0.50	0.16	ND	0.14	0.044	
80-62-6	Methyl Methacrylate	ND	1.0	0.31	ND	0.24	0.076	
142-82-5	n-Heptane	ND	0.50	0.17	ND	0.12	0.041	
10061-01-5	cis-1,3-Dichloropropene	ND	0.50	0.14	ND	0.11	0.031	
108-10-1	4-Methyl-2-pentanone	ND	0.50	0.16	ND	0.12	0.039	
10061-02-6	trans-1,3-Dichloropropene	ND	0.50	0.16	ND	0.11	0.035	
79-00-5	1,1,2-Trichloroethane	ND	0.50	0.16	ND	0.092	0.029	
108-88-3	Toluene	ND	0.50	0.17	ND	0.13	0.045	
591-78-6	2-Hexanone	ND	0.50	0.16	ND	0.12	0.039	
124-48-1	Dibromochloromethane	ND	0.50	0.16	ND	0.059	0.019	
106-93-4	1,2-Dibromoethane	ND	0.50	0.16	ND	0.065	0.021	
123-86-4	n-Butyl Acetate	ND	0.50	0.16	ND	0.11	0.034	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.

MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Method Blank**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150630-MB

Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			

Canister Dilution Factor: 1.00

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
111-65-9	n-Octane	ND	0.50	0.18	ND	0.11	0.039	
127-18-4	Tetrachloroethene	ND	0.50	0.14	ND	0.074	0.021	
108-90-7	Chlorobenzene	ND	0.50	0.16	ND	0.11	0.035	
100-41-4	Ethylbenzene	ND	0.50	0.16	ND	0.12	0.037	
179601-23-1	m,p-Xylenes	ND	1.0	0.30	ND	0.23	0.069	
75-25-2	Bromoform	ND	0.50	0.15	ND	0.048	0.015	
100-42-5	Styrene	ND	0.50	0.15	ND	0.12	0.035	
95-47-6	o-Xylene	ND	0.50	0.15	ND	0.12	0.035	
111-84-2	n-Nonane	ND	0.50	0.15	ND	0.095	0.029	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.50	0.15	ND	0.073	0.022	
98-82-8	Cumene	ND	0.50	0.15	ND	0.10	0.031	
80-56-8	alpha-Pinene	ND	0.50	0.14	ND	0.090	0.025	
103-65-1	n-Propylbenzene	ND	0.50	0.16	ND	0.10	0.033	
622-96-8	4-Ethyltoluene	ND	0.50	0.16	ND	0.10	0.033	
108-67-8	1,3,5-Trimethylbenzene	ND	0.50	0.16	ND	0.10	0.033	
95-63-6	1,2,4-Trimethylbenzene	ND	0.50	0.15	ND	0.10	0.031	
100-44-7	Benzyl Chloride	ND	0.50	0.11	ND	0.097	0.021	
541-73-1	1,3-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
106-46-7	1,4-Dichlorobenzene	ND	0.50	0.14	ND	0.083	0.023	
95-50-1	1,2-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
5989-27-5	d-Limonene	ND	0.50	0.14	ND	0.090	0.025	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.50	0.099	ND	0.052	0.010	
120-82-1	1,2,4-Trichlorobenzene	ND	0.50	0.16	ND	0.067	0.022	
91-20-3	Naphthalene	ND	0.50	0.18	ND	0.095	0.034	
87-68-3	Hexachlorobutadiene	ND	0.50	0.14	ND	0.047	0.013	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.

MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank** ALS Project ID: P1502473
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150701-MB

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8 Date Received: NA
Analyst: Wida Ang Date Analyzed: 7/1/15
Sample Type: 6.0 L Silonite Canister Volume(s) Analyzed: 1.00 Liter(s)
Test Notes:

Canister Dilution Factor: 1.00

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	**0.36**	0.50	0.14	**0.21**	0.29	0.081	**J, V**
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	0.50	0.17	ND	0.10	0.034	
74-87-3	Chloromethane	ND	0.50	0.15	ND	0.24	0.073	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	0.50	0.19	ND	0.072	0.027	
106-99-0	1,3-Butadiene	ND	0.50	0.22	ND	0.23	0.099	
74-83-9	Bromomethane	ND	0.50	0.19	ND	0.13	0.049	
75-00-3	Chloroethane	ND	0.50	0.17	ND	0.19	0.064	
64-17-5	Ethanol	ND	5.0	0.80	ND	2.7	0.42	
75-05-8	Acetonitrile	ND	0.50	0.18	ND	0.30	0.11	
107-02-8	Acrolein	ND	2.0	0.17	ND	0.87	0.074	
67-64-1	Acetone	ND	5.0	0.77	ND	2.1	0.32	
75-69-4	Trichlorofluoromethane	ND	0.50	0.17	ND	0.089	0.030	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	5.0	0.42	ND	2.0	0.17	
107-13-1	Acrylonitrile	ND	0.50	0.17	ND	0.23	0.078	
75-35-4	1,1-Dichloroethene	ND	0.50	0.17	ND	0.13	0.043	
75-09-2	Methylene Chloride	**0.26**	0.50	0.17	**0.074**	0.14	0.049	**J**
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.50	0.16	ND	0.16	0.051	
76-13-1	Trichlorotrifluoroethane	ND	0.50	0.17	ND	0.065	0.022	
75-15-0	Carbon Disulfide	ND	5.0	0.15	ND	1.6	0.048	
156-60-5	trans-1,2-Dichloroethene	ND	0.50	0.19	ND	0.13	0.048	
75-34-3	1,1-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
1634-04-4	Methyl tert-Butyl Ether	ND	0.50	0.17	ND	0.14	0.047	
108-05-4	Vinyl Acetate	ND	5.0	0.65	ND	1.4	0.18	
78-93-3	2-Butanone (MEK)	ND	5.0	0.21	ND	1.7	0.071	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
V = The continuing calibration verification standard was outside (biased low) the specified limits for this compound.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Method Blank**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150701-MB
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	7/1/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result** **µg/m³**	MRL µg/m³	MDL µg/m³	**Result** **ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	0.50	0.16	ND	0.13	0.040	
141-78-6	Ethyl Acetate	ND	1.0	0.35	ND	0.28	0.097	
110-54-3	n-Hexane	ND	0.50	0.15	ND	0.14	0.043	
67-66-3	Chloroform	ND	0.50	0.17	ND	0.10	0.035	
109-99-9	Tetrahydrofuran (THF)	ND	0.50	0.20	ND	0.17	0.068	
107-06-2	1,2-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
71-55-6	1,1,1-Trichloroethane	ND	0.50	0.17	ND	0.092	0.031	
71-43-2	Benzene	ND	0.50	0.16	ND	0.16	0.050	
56-23-5	Carbon Tetrachloride	ND	0.50	0.15	ND	0.080	0.024	
110-82-7	Cyclohexane	ND	1.0	0.29	ND	0.29	0.084	
78-87-5	1,2-Dichloropropane	ND	0.50	0.16	ND	0.11	0.035	
75-27-4	Bromodichloromethane	ND	0.50	0.15	ND	0.075	0.022	
79-01-6	Trichloroethene	ND	0.50	0.14	ND	0.093	0.026	
123-91-1	1,4-Dioxane	ND	0.50	0.16	ND	0.14	0.044	
80-62-6	Methyl Methacrylate	ND	1.0	0.31	ND	0.24	0.076	
142-82-5	n-Heptane	ND	0.50	0.17	ND	0.12	0.041	
10061-01-5	cis-1,3-Dichloropropene	ND	0.50	0.14	ND	0.11	0.031	
108-10-1	4-Methyl-2-pentanone	ND	0.50	0.16	ND	0.12	0.039	
10061-02-6	trans-1,3-Dichloropropene	ND	0.50	0.16	ND	0.11	0.035	
79-00-5	1,1,2-Trichloroethane	ND	0.50	0.16	ND	0.092	0.029	
108-88-3	Toluene	ND	0.50	0.17	ND	0.13	0.045	
591-78-6	2-Hexanone	ND	0.50	0.16	ND	0.12	0.039	
124-48-1	Dibromochloromethane	ND	0.50	0.16	ND	0.059	0.019	
106-93-4	1,2-Dibromoethane	ND	0.50	0.16	ND	0.065	0.021	
123-86-4	n-Butyl Acetate	ND	0.50	0.16	ND	0.11	0.034	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
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Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank** ALS Project ID: P1502473
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150701-MB

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8 Date Received: NA
Analyst: Wida Ang Date Analyzed: 7/1/15
Sample Type: 6.0 L Silonite Canister Volume(s) Analyzed: 1.00 Liter(s)
Test Notes:

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	ND	0.50	0.18	ND	0.11	0.039	
127-18-4	Tetrachloroethene	ND	0.50	0.14	ND	0.074	0.021	
108-90-7	Chlorobenzene	ND	0.50	0.16	ND	0.11	0.035	
100-41-4	Ethylbenzene	ND	0.50	0.16	ND	0.12	0.037	
179601-23-1	m,p-Xylenes	ND	1.0	0.30	ND	0.23	0.069	
75-25-2	Bromoform	ND	0.50	0.15	ND	0.048	0.015	
100-42-5	Styrene	ND	0.50	0.15	ND	0.12	0.035	
95-47-6	o-Xylene	ND	0.50	0.15	ND	0.12	0.035	
111-84-2	n-Nonane	ND	0.50	0.15	ND	0.095	0.029	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.50	0.15	ND	0.073	0.022	
98-82-8	Cumene	ND	0.50	0.15	ND	0.10	0.031	
80-56-8	alpha-Pinene	ND	0.50	0.14	ND	0.090	0.025	
103-65-1	n-Propylbenzene	ND	0.50	0.16	ND	0.10	0.033	
622-96-8	4-Ethyltoluene	ND	0.50	0.16	ND	0.10	0.033	
108-67-8	1,3,5-Trimethylbenzene	ND	0.50	0.16	ND	0.10	0.033	
95-63-6	1,2,4-Trimethylbenzene	ND	0.50	0.15	ND	0.10	0.031	
100-44-7	Benzyl Chloride	ND	0.50	0.11	ND	0.097	0.021	
541-73-1	1,3-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
106-46-7	1,4-Dichlorobenzene	ND	0.50	0.14	ND	0.083	0.023	
95-50-1	1,2-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
5989-27-5	d-Limonene	ND	0.50	0.14	ND	0.090	0.025	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.50	0.099	ND	0.052	0.010	
120-82-1	1,2,4-Trichlorobenzene	ND	0.50	0.16	ND	0.067	0.022	
91-20-3	Naphthalene	ND	0.50	0.18	ND	0.095	0.034	
87-68-3	Hexachlorobutadiene	ND	0.50	0.14	ND	0.047	0.013	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

SURROGATE SPIKE RECOVERY RESULTS

Page 1 of 1

Client: **Landau Associates, Inc.**
Client Project ID: **Cornwall LF / 001037.030.033**
ALS Project ID: P1502473

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister(s)
Test Notes:

Date(s) Collected: 6/15/15
Date(s) Received: 6/19/15
Date(s) Analyzed: 6/30 - 7/1/15

Client Sample ID	ALS Sample ID	1,2-Dichloroethane-d4 Percent Recovered	Toluene-d8 Percent Recovered	Bromofluorobenzene Percent Recovered	Acceptance Limits	Data Qualifier
Method Blank	P150630-MB	**124**	**94**	**101**	70-130	
Method Blank	P150701-MB	**120**	**94**	**101**	70-130	
Lab Control Sample	P150630-LCS	**122**	**92**	**103**	70-130	
Lab Control Sample	P150701-LCS	**122**	**93**	**103**	70-130	
CL-LFG-BACKGROUND	P1502473-001	**115**	**95**	**98**	70-130	
CL-LFG-VENT-4	P1502473-002	**113**	**93**	**99**	70-130	
CL-LFG-P-3	P1502473-003	**115**	**87**	**89**	70-130	
CL-LFG-P-12	P1502473-004	**116**	**85**	**89**	70-130	
CL-LFG-VENT-3	P1502473-005	**113**	**92**	**99**	70-130	
CL-LFG-MW-102	P1502473-006	**119**	**73**	**81**	70-130	

Surrogate percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly from the on-column percent recovery.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150630-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
115-07-1	Propene	200	**151**	**76**	50-128	
75-71-8	Dichlorodifluoromethane (CFC 12)	204	**207**	**101**	66-117	
74-87-3	Chloromethane	198	**166**	**84**	51-133	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	206	**205**	**100**	65-117	
106-99-0	1,3-Butadiene	214	**208**	**97**	65-132	
74-83-9	Bromomethane	202	**229**	**113**	62-114	
75-00-3	Chloroethane	202	**202**	**100**	64-122	
64-17-5	Ethanol	1,020	**906**	**89**	57-131	
75-05-8	Acetonitrile	204	**168**	**82**	52-135	
107-02-8	Acrolein	214	**216**	**101**	64-124	
67-64-1	Acetone	1,080	**905**	**84**	60-113	
75-69-4	Trichlorofluoromethane	198	**250**	**126**	64-112	**L**
67-63-0	2-Propanol (Isopropyl Alcohol)	420	**404**	**96**	62-129	
107-13-1	Acrylonitrile	208	**181**	**87**	69-133	
75-35-4	1,1-Dichloroethene	214	**198**	**93**	70-114	
75-09-2	Methylene Chloride	216	**196**	**91**	63-103	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	218	**192**	**88**	57-135	
76-13-1	Trichlorotrifluoroethane	216	**209**	**97**	69-116	
75-15-0	Carbon Disulfide	196	**199**	**102**	66-118	
156-60-5	trans-1,2-Dichloroethene	212	**215**	**101**	69-123	
75-34-3	1,1-Dichloroethane	208	**209**	**100**	65-118	
1634-04-4	Methyl tert-Butyl Ether	212	**212**	**100**	57-125	
108-05-4	Vinyl Acetate	1,020	**901**	**88**	69-131	
78-93-3	2-Butanone (MEK)	216	**192**	**89**	63-121	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.
L = Laboratory control sample recovery outside the specified limits, results may be biased high.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 2 of 3

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150630-LCS

Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	6/30/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount μg/m³	**Result μg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	214	**215**	**100**	69-119	
141-78-6	Ethyl Acetate	428	**336**	**79**	65-129	
110-54-3	n-Hexane	210	**158**	**75**	55-116	
67-66-3	Chloroform	216	**224**	**104**	68-111	
109-99-9	Tetrahydrofuran (THF)	206	**196**	**95**	69-120	
107-06-2	1,2-Dichloroethane	210	**244**	**116**	67-117	
71-55-6	1,1,1-Trichloroethane	208	**236**	**113**	74-116	
71-43-2	Benzene	220	**184**	**84**	61-109	
56-23-5	Carbon Tetrachloride	214	**278**	**130**	76-120	**L**
110-82-7	Cyclohexane	422	**360**	**85**	72-115	
78-87-5	1,2-Dichloropropane	212	**195**	**92**	67-119	
75-27-4	Bromodichloromethane	216	**238**	**110**	78-124	
79-01-6	Trichloroethene	208	**199**	**96**	69-115	
123-91-1	1,4-Dioxane	218	**188**	**86**	69-127	
80-62-6	Methyl Methacrylate	420	**394**	**94**	76-128	
142-82-5	n-Heptane	214	**193**	**90**	66-118	
10061-01-5	cis-1,3-Dichloropropene	226	**224**	**99**	77-124	
108-10-1	4-Methyl-2-pentanone	218	**206**	**94**	66-134	
10061-02-6	trans-1,3-Dichloropropene	216	**235**	**109**	80-130	
79-00-5	1,1,2-Trichloroethane	212	**207**	**98**	75-119	
108-88-3	Toluene	212	**173**	**82**	68-114	
591-78-6	2-Hexanone	222	**185**	**83**	60-136	
124-48-1	Dibromochloromethane	220	**223**	**101**	75-132	
106-93-4	1,2-Dibromoethane	216	**199**	**92**	72-122	
123-86-4	n-Butyl Acetate	224	**194**	**87**	60-137	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.
L = Laboratory control sample recovery outside the specified limits, results may be biased high.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 3 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Lab Control Sample** ALS Project ID: P1502473
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150630-LCS

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8 Date Received: NA
Analyst: Wida Ang Date Analyzed: 6/30/15
Sample Type: 6.0 L Silonite Canister Volume(s) Analyzed: 0.125 Liter(s)
Test Notes:

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
111-65-9	n-Octane	208	**169**	**81**	66-120	
127-18-4	Tetrachloroethene	198	**176**	**89**	67-120	
108-90-7	Chlorobenzene	216	**183**	**85**	69-114	
100-41-4	Ethylbenzene	212	**186**	**88**	71-117	
179601-23-1	m,p-Xylenes	420	**375**	**89**	71-118	
75-25-2	Bromoform	216	**242**	**112**	76-149	
100-42-5	Styrene	218	**184**	**84**	71-128	
95-47-6	o-Xylene	206	**183**	**89**	72-118	
111-84-2	n-Nonane	204	**169**	**83**	63-123	
79-34-5	1,1,2,2-Tetrachloroethane	202	**179**	**89**	73-124	
98-82-8	Cumene	204	**181**	**89**	71-118	
80-56-8	alpha-Pinene	208	**184**	**88**	71-123	
103-65-1	n-Propylbenzene	202	**177**	**88**	71-120	
622-96-8	4-Ethyltoluene	212	**190**	**90**	71-121	
108-67-8	1,3,5-Trimethylbenzene	212	**193**	**91**	72-121	
95-63-6	1,2,4-Trimethylbenzene	210	**190**	**90**	71-122	
100-44-7	Benzyl Chloride	218	**224**	**103**	79-143	
541-73-1	1,3-Dichlorobenzene	218	**193**	**89**	67-121	
106-46-7	1,4-Dichlorobenzene	212	**186**	**88**	68-121	
95-50-1	1,2-Dichlorobenzene	214	**190**	**89**	68-121	
5989-27-5	d-Limonene	210	**186**	**89**	69-137	
96-12-8	1,2-Dibromo-3-chloropropane	206	**221**	**107**	73-145	
120-82-1	1,2,4-Trichlorobenzene	210	**203**	**97**	60-135	
91-20-3	Naphthalene	196	**198**	**101**	63-142	
87-68-3	Hexachlorobutadiene	214	**216**	**101**	65-127	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY
Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Lab Control Sample** ALS Project ID: P1502473
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150701-LCS

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8 Date Received: NA
Analyst: Wida Ang Date Analyzed: 7/1/15
Sample Type: 6.0 L Silonite Canister Volume(s) Analyzed: 0.125 Liter(s)
Test Notes:

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
115-07-1	Propene	200	**151**	**76**	50-128	
75-71-8	Dichlorodifluoromethane (CFC 12)	204	**204**	**100**	66-117	
74-87-3	Chloromethane	198	**150**	**76**	51-133	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	206	**210**	**102**	65-117	
106-99-0	1,3-Butadiene	214	**222**	**104**	65-132	
74-83-9	Bromomethane	202	**245**	**121**	62-114	**L**
75-00-3	Chloroethane	202	**204**	**101**	64-122	
64-17-5	Ethanol	1,020	**896**	**88**	57-131	
75-05-8	Acetonitrile	204	**166**	**81**	52-135	
107-02-8	Acrolein	214	**214**	**100**	64-124	
67-64-1	Acetone	1,080	**902**	**84**	60-113	
75-69-4	Trichlorofluoromethane	198	**248**	**125**	64-112	**L**
67-63-0	2-Propanol (Isopropyl Alcohol)	420	**399**	**95**	62-129	
107-13-1	Acrylonitrile	208	**177**	**85**	69-133	
75-35-4	1,1-Dichloroethene	214	**196**	**92**	70-114	
75-09-2	Methylene Chloride	216	**196**	**91**	63-103	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	218	**188**	**86**	57-135	
76-13-1	Trichlorotrifluoroethane	216	**209**	**97**	69-116	
75-15-0	Carbon Disulfide	196	**198**	**101**	66-118	
156-60-5	trans-1,2-Dichloroethene	212	**213**	**100**	69-123	
75-34-3	1,1-Dichloroethane	208	**206**	**99**	65-118	
1634-04-4	Methyl tert-Butyl Ether	212	**212**	**100**	57-125	
108-05-4	Vinyl Acetate	1,020	**898**	**88**	69-131	
78-93-3	2-Butanone (MEK)	216	**188**	**87**	63-121	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.
L = Laboratory control sample recovery outside the specified limits, results may be biased high.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 2 of 3

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150701-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	7/1/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	214	**213**	**100**	69-119	
141-78-6	Ethyl Acetate	428	**340**	**79**	65-129	
110-54-3	n-Hexane	210	**159**	**76**	55-116	
67-66-3	Chloroform	216	**222**	**103**	68-111	
109-99-9	Tetrahydrofuran (THF)	206	**193**	**94**	69-120	
107-06-2	1,2-Dichloroethane	210	**242**	**115**	67-117	
71-55-6	1,1,1-Trichloroethane	208	**234**	**113**	74-116	
71-43-2	Benzene	220	**180**	**82**	61-109	
56-23-5	Carbon Tetrachloride	214	**272**	**127**	76-120	**L**
110-82-7	Cyclohexane	422	**360**	**85**	72-115	
78-87-5	1,2-Dichloropropane	212	**194**	**92**	67-119	
75-27-4	Bromodichloromethane	216	**237**	**110**	78-124	
79-01-6	Trichloroethene	208	**197**	**95**	69-115	
123-91-1	1,4-Dioxane	218	**186**	**85**	69-127	
80-62-6	Methyl Methacrylate	420	**392**	**93**	76-128	
142-82-5	n-Heptane	214	**189**	**88**	66-118	
10061-01-5	cis-1,3-Dichloropropene	226	**223**	**99**	77-124	
108-10-1	4-Methyl-2-pentanone	218	**202**	**93**	66-134	
10061-02-6	trans-1,3-Dichloropropene	216	**231**	**107**	80-130	
79-00-5	1,1,2-Trichloroethane	212	**202**	**95**	75-119	
108-88-3	Toluene	212	**171**	**81**	68-114	
591-78-6	2-Hexanone	222	**184**	**83**	60-136	
124-48-1	Dibromochloromethane	220	**218**	**99**	75-132	
106-93-4	1,2-Dibromoethane	216	**196**	**91**	72-122	
123-86-4	n-Butyl Acetate	224	**192**	**86**	60-137	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
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L = Laboratory control sample recovery outside the specified limits, results may be biased high.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1502473
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150701-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973inert/6890N/MS8	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	7/1/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
111-65-9	n-Octane	208	**167**	**80**	66-120	
127-18-4	Tetrachloroethene	198	**172**	**87**	67-120	
108-90-7	Chlorobenzene	216	**180**	**83**	69-114	
100-41-4	Ethylbenzene	212	**184**	**87**	71-117	
179601-23-1	m,p-Xylenes	420	**369**	**88**	71-118	
75-25-2	Bromoform	216	**237**	**110**	76-149	
100-42-5	Styrene	218	**181**	**83**	71-128	
95-47-6	o-Xylene	206	**180**	**87**	72-118	
111-84-2	n-Nonane	204	**167**	**82**	63-123	
79-34-5	1,1,2,2-Tetrachloroethane	202	**175**	**87**	73-124	
98-82-8	Cumene	204	**178**	**87**	71-118	
80-56-8	alpha-Pinene	208	**180**	**87**	71-123	
103-65-1	n-Propylbenzene	202	**173**	**86**	71-120	
622-96-8	4-Ethyltoluene	212	**186**	**88**	71-121	
108-67-8	1,3,5-Trimethylbenzene	212	**187**	**88**	72-121	
95-63-6	1,2,4-Trimethylbenzene	210	**186**	**89**	71-122	
100-44-7	Benzyl Chloride	218	**218**	**100**	79-143	
541-73-1	1,3-Dichlorobenzene	218	**188**	**86**	67-121	
106-46-7	1,4-Dichlorobenzene	212	**182**	**86**	68-121	
95-50-1	1,2-Dichlorobenzene	214	**185**	**86**	68-121	
5989-27-5	d-Limonene	210	**182**	**87**	69-137	
96-12-8	1,2-Dibromo-3-chloropropane	206	**213**	**103**	73-145	
120-82-1	1,2,4-Trichlorobenzene	210	**196**	**93**	60-135	
91-20-3	Naphthalene	196	**192**	**98**	63-142	
87-68-3	Hexachlorobutadiene	214	**208**	**97**	65-127	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

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LABORATORY REPORT

August 27, 2015

Jeremy Davis
Landau Associates, Inc.
130 2nd Ave. South
Edmonds, WA 98020

RE: Cornwall LF / 001037.030.033

Dear Jeremy:

Enclosed are the results of the samples submitted to our laboratory on August 13, 2015. For your reference, these analyses have been assigned our service request number P1503343.

All analyses were performed according to our laboratory's NELAP and DoD-ELAP-approved quality assurance program. The test results meet requirements of the current NELAP and DoD-ELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP and DoD-ELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. Results are intended to be considered in their entirety and apply only to the samples analyzed and reported herein.

If you have any questions, please call me at (805) 526-7161.

Respectfully submitted,

ALS | Environmental

Kate Aguilera

By Kate Aguilera at 9:46 am, Aug 27, 2015

Kate Aguilera
Project Manager

2655 Park Center Dr., Suite A
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F: +1 805 526 7270
www.alsglobal.com

Client: Landau Associates, Inc.
Project: Cornwall LF / 001037.030.033

Service Request No: P1503343

CASE NARRATIVE

The samples were received intact under chain of custody on August 13, 2015 and were stored in accordance with the analytical method requirements. Please refer to the sample acceptance check form for additional information. The results reported herein are applicable only to the condition of the samples at the time of sample receipt.

Volatile Organic Compound Analysis

The samples were analyzed in Scan and SIM mode for volatile organic compounds in accordance with EPA Method TO-15 from the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition (EPA/625/R-96/010b), January, 1999. This procedure is described in laboratory SOP VOA-TO15. The analytical system was comprised of a gas chromatograph / mass spectrometer (GC/MS) interfaced to a whole-air preconcentrator. This method is included on the laboratory's NELAP and DoD-ELAP scope of accreditation, however it is not part of the AIHA-LAP accreditation. Any analytes flagged with an X are not included on the NELAP or DoD-ELAP accreditation.

The Bromofluorobenzene surrogate spike recovery in the SIM analysis for sample CL-LFG-P-12 (P1503343-002) was outside control criteria. However, this surrogate is not associated with Vinyl Chloride, therefore the result was not affected. No corrective action was necessary.

The canisters were cleaned, prior to sampling, down to the method reporting limit (MRL) reported for this project. Please note, projects which require reporting below the MRL could have results between the MRL and method detection limit (MDL) that are biased high.

The results of analyses are given in the attached laboratory report. All results are intended to be considered in their entirety, and ALS Environmental (ALS) is not responsible for utilization of less than the complete report.

Use of ALS Environmental (ALS)'s Name. Client shall not use ALS's name or trademark in any marketing or reporting materials, press releases or in any other manner ("Materials") whatsoever and shall not attribute to ALS any test result, tolerance or specification derived from ALS's data ("Attribution") without ALS's prior written consent, which may be withheld by ALS for any reason in its sole discretion. To request ALS's consent, Client shall provide copies of the proposed Materials or Attribution and describe in writing Client's proposed use of such Materials or Attribution. If ALS has not provided written approval of the Materials or Attribution within ten (10) days of receipt from Client, Client's request to use ALS's name or trademark in any Materials or Attribution shall be deemed denied. ALS may, in its discretion, reasonably charge Client for its time in reviewing Materials or Attribution requests. Client acknowledges and agrees that the unauthorized use of ALS's name or trademark may cause ALS to incur irreparable harm for which the recovery of money damages will be inadequate. Accordingly, Client acknowledges and agrees that a violation shall justify preliminary injunctive relief. For questions contact the laboratory.

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ALS Environmental – Simi Valley

CERTIFICATIONS, ACCREDITATIONS, AND REGISTRATIONS

Agency	Web Site	Number
AIHA	http://www.aihaaccreditedlabs.org	101661
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0694
DoD ELAP	http://www.pjlabs.com/search-accredited-labs	L14-2
Florida DOH (NELAP)	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E871020
Maine DHHS	http://www.maine.gov/dhhs/mecdc/environmental-health/water/dwp-services/labcert/labcert.htm	2014025
Minnesota DOH (NELAP)	http://www.health.state.mn.us/accreditation	876241
New Jersey DEP (NELAP)	http://www.nj.gov/dep/oqa/	CA009
New York DOH (NELAP)	http://www.wadsworth.org/labcert/elap/elap.html	11221
Oregon PHD (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	4068-001
Pennsylvania DEP	http://www.depweb.state.pa.us/labs	68-03307 (Registration)
Texas CEQ (NELAP)	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704413-15-6
Utah DOH (NELAP)	http://www.health.utah.gov/lab/labimp/certification/index.html	CA016272015-5
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C946

Analyses were performed according to our laboratory's NELAP and DoD-ELAP approved quality assurance program. A complete listing of specific NELAP and DoD-ELAP certified analytes can be found in the certifications section at www.alsglobal.com, or at the accreditation body's website.

Each of the certifications listed above have an explicit Scope of Accreditation that applies to specific matrices/methods/analytes; therefore, please contact the laboratory for information corresponding to a particular certification.

ALS ENVIRONMENTAL

DETAIL SUMMARY REPORT

Client: Landau Associates, Inc.

Service Request: P1503343

Project ID: Cornwall LF / 001037.030.033

Date Received: 8/13/2015

Time Received: 08:50

Client Sample ID	Lab Code	Matrix	Date Collected	Time Collected	Container ID	Pi1 (psig)	Pf1 (psig)	TO-15 - VOC Cans	TO-15 - VOC SIM
CL-LFG-P-6	P1503343-001	Air	8/7/2015	15:55	AC01169	-1.50	3.70	X	
CL-LFG-P-12	P1503343-002	Air	8/7/2015	16:09	AC01300	-2.68	3.80	X	X
CL-LFG-P-2	P1503343-003	Air	8/7/2015	16:12	AS00615	-2.32	3.72	X	
CL-LFG-P-3	P1503343-004	Air	8/7/2015	16:28	AS00820	-2.62	3.50	X	X

Air - Chain of Custody Record & Analytical Service Request

Page 1 of 1

ALS

2655 Park Center Drive, Suite A
Simi Valley, California 93065
Phone (805) 526-7161
Fax (805) 526-7270

Requested Turnaround Time in Business Days (Surcharges) please circle
1 Day (100%) 2 Day (75%) 3 Day (50%) 4 Day (35%) 5 Day (25%) [✓ 10-Day-Standard]

ALS Project No. P1503343

ALS Contact:

Company Name & Address (Reporting Information)
LANDAU ASSOCIATES
130 2nd Ave. South
Edmonds, WA 98020

Project Name: Cornwall LF

Project Number: 001037.030.033

Project Manager: Jeremy Davis / Kent Wiken

P.O. # / Billing Information: SAME AS ABOVE

Phone: (425) 778-0907

Fax:

Email Address for Result Reporting: JDavis@landauinc.com, KWiken@landauinc.com

Sampler (Print & Sign): Stephanie Renando

Client Sample ID	Laboratory ID Number	Date Collected	Time Collected (min.)	Canister ID (Bar code # - AC, SC, etc.)	Flow Controller ID (Bar code # - FC #)	Canister Start Pressure "Hg	Canister End Pressure "Hg/psig	Sample Volume	Analysis Method TO-15 (SIM VC)		Comments e.g. Actual Preservative or specific instructions Time of Collection Start / Stop
CL-LFG-P-6	①	8/7/15	25	AC01169	FC400751	-27.85	-3.75	6L	X		1530/1555
CL-LFG-P-12	②	8/7/15	30	AC01300	FCA01003	-29.89	-5.56	6L	X		1539/1609
CL-LFG-P-2	③	8/7/15	24	AS00615	FCA01002	-29.90	-4.72	6L	X		1548/1612
CL-LFG-P-3	④	8/7/15	33	AS00820	FCA00831	-29.96	-5.47	6L	X		1555/1628

Report Tier Levels - please select
Tier I - Results (Default in not specified) ____
Tier II (Results + QC Summaries ____
Tier III (Results + QC & Calibration Summaries) X
Tier IV (Date Validation Package) 10% Surcharge ____

EDD required YES / No
Type: ________ Units: ________

Chain of Custody Seal: (Circle)
[✓ INTACT] BROKEN ABSENT

Project Requirements (MRLs, QAPP)

Relinquished by: (Signature) Date: 8/7/15 Time:
Received by: (Signature) Date: 8/7/15 Time: 20:00

Relinquished by: (Signature) Date: 8/10/15 Time: 1000
Received by: (Signature) Date: 8/13/15 Time: 0850

Cooler / Blank Temperature ____°C

ALS Environmental
Sample Acceptance Check Form

Client: Landau Associates, Inc. Work order: P1503343
Project: Cornwall LF / 001037.030.033
Sample(s) received on: 8/13/15 Date opened: 8/13/15 by: ADAVID

Note: This form is used for all samples received by ALS. The use of this form for custody seals is strictly meant to indicate presence/absence and not as an indication of compliance or nonconformity. Thermal preservation and pH will only be evaluated either at the request of the client and/or as required by the method/SOP.

		Yes	No	N/A
1	Were **sample containers** properly marked with client sample ID?	☒	☐	☐
2	Container(s) **supplied by ALS**?	☒	☐	☐
3	Did **sample containers** arrive in good condition?	☒	☐	☐
4	Were **chain-of-custody** papers used and filled out?	☒	☐	☐
5	Did **sample container labels** and/or tags agree with custody papers?	☒	☐	☐
6	Was **sample volume** received adequate for analysis?	☒	☐	☐
7	Are samples within specified holding times?	☒	☐	☐
8	Was proper **temperature** (thermal preservation) of cooler at receipt adhered to?	☐	☐	☒
9	Was a **trip blank** received?	☐	☒	☐
10	Were **custody seals** on outside of cooler/Box?	☐	☒	☐
	Location of seal(s)? ________ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
	Were custody seals on outside of sample container?	☐	☐	☒
	Location of seal(s)? ________ Sealing Lid?	☐	☐	☒
	Were signature and date included?	☐	☐	☒
	Were seals intact?	☐	☐	☒
11	Do containers have appropriate **preservation**, according to method/SOP or Client specified information?	☐	☐	☒
	Is there a client indication that the submitted samples are **pH** preserved?	☐	☐	☒
	Were **<u>VOA vials</u>** checked for presence/absence of air bubbles?	☐	☐	☒
	Does the client/method/SOP require that the analyst check the sample pH and <u>if necessary</u> alter it?	☐	☐	☒
12	**Tubes:** Are the tubes capped and intact?	☐	☐	☒
	Do they contain moisture?	☐	☐	☒
13	**Badges:** Are the badges properly capped and intact?	☐	☐	☒
	Are dual bed badges separated and individually capped and intact?	☐	☐	☒

Lab Sample ID	Container Description	Required pH *	Received pH	Adjusted pH	VOA Headspace (Presence/Absence)	Receipt / Preservation Comments
P1503343-001.01	6.0 L Ambient Can					
P1503343-002.01	6.0 L Ambient Can					
P1503343-003.01	6.0 L Silonite Can					
P1503343-004.01	6.0 L Silonite Can					

Explain any discrepancies: (include lab sample ID numbers):
Sample -001 is labeled CL-LFG-P-12 and listed CL-LFG-6 on the COC.

RSK - MEEPP, HCL (pH<2); RSK - CO2, (pH 5-8); Sulfur (pH>4)

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-6**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1503343
ALS Sample ID: P1503343-001

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister
Test Notes:
Container ID: AC01169

Date Collected: 8/7/15
Date Received: 8/13/15
Date Analyzed: 8/19/15
Volume(s) Analyzed: 0.015 Liter(s)

Initial Pressure (psig): -1.50 Final Pressure (psig): 3.70

Canister Dilution Factor: 1.39

CAS #	**Compound**	**Result** µg/m³	MRL µg/m³	MDL µg/m³	**Result** ppbV	MRL ppbV	MDL ppbV	**Data Qualifier**
115-07-1	Propene	**540**	46	13	**320**	27	7.5	
75-71-8	Dichlorodifluoromethane (CFC 12)	**54**	46	16	**11**	9.4	3.2	
74-87-3	Chloromethane	ND	46	14	ND	22	6.7	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	**200**	46	18	**29**	6.6	2.5	
75-01-4	Vinyl Chloride	**150**	46	16	**58**	18	6.2	
106-99-0	1,3-Butadiene	ND	46	20	ND	21	9.2	
74-83-9	Bromomethane	ND	46	18	ND	12	4.5	
75-00-3	Chloroethane	ND	46	16	ND	18	6.0	
64-17-5	Ethanol	ND	460	74	ND	250	39	
75-05-8	Acetonitrile	ND	46	17	ND	28	9.9	
107-02-8	Acrolein	ND	190	16	ND	81	6.9	
67-64-1	Acetone	ND	460	71	ND	200	30	
75-69-4	Trichlorofluoromethane	ND	46	16	ND	8.2	2.8	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	460	39	ND	190	16	
107-13-1	Acrylonitrile	ND	46	16	ND	21	7.3	
75-35-4	1,1-Dichloroethene	ND	46	16	ND	12	4.0	
75-09-2	Methylene Chloride	ND	46	16	ND	13	4.5	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	46	15	ND	15	4.7	
76-13-1	Trichlorotrifluoroethane	ND	46	16	ND	6.0	2.1	
75-15-0	Carbon Disulfide	**20**	460	14	**6.3**	150	4.5	**J, B**
156-60-5	trans-1,2-Dichloroethene	ND	46	18	ND	12	4.4	
75-34-3	1,1-Dichloroethane	ND	46	15	ND	11	3.7	
1634-04-4	Methyl tert-Butyl Ether	ND	46	16	ND	13	4.4	
108-05-4	Vinyl Acetate	ND	460	60	ND	130	17	
78-93-3	2-Butanone (MEK)	ND	460	19	ND	160	6.6	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.
B = Analyte detected in both the sample and associated method blank.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-6**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1503343
ALS Sample ID: P1503343-001

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister
Test Notes:
Container ID: AC01169

Date Collected: 8/7/15
Date Received: 8/13/15
Date Analyzed: 8/19/15
Volume(s) Analyzed: 0.015 Liter(s)

Initial Pressure (psig): -1.50 Final Pressure (psig): 3.70

Canister Dilution Factor: 1.39

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	**25**	46	15	**6.3**	12	3.7	**J**
141-78-6	Ethyl Acetate	**61**	93	32	**17**	26	9.0	**J**
110-54-3	n-Hexane	**1,000**	46	14	**290**	13	3.9	
67-66-3	Chloroform	ND	46	16	ND	9.5	3.2	
109-99-9	Tetrahydrofuran (THF)	ND	46	19	ND	16	6.3	
107-06-2	1,2-Dichloroethane	ND	46	15	ND	11	3.7	
71-55-6	1,1,1-Trichloroethane	ND	46	16	ND	8.5	2.9	
71-43-2	Benzene	**100**	46	15	**32**	15	4.6	
56-23-5	Carbon Tetrachloride	ND	46	14	ND	7.4	2.2	
110-82-7	Cyclohexane	**850**	93	27	**250**	27	7.8	
78-87-5	1,2-Dichloropropane	ND	46	15	ND	10	3.2	
75-27-4	Bromodichloromethane	ND	46	14	ND	6.9	2.1	
79-01-6	Trichloroethene	ND	46	13	ND	8.6	2.4	
123-91-1	1,4-Dioxane	ND	46	15	ND	13	4.1	
80-62-6	Methyl Methacrylate	ND	93	29	ND	23	7.0	
142-82-5	n-Heptane	**730**	46	16	**180**	11	3.8	
10061-01-5	cis-1,3-Dichloropropene	ND	46	13	ND	10	2.9	
108-10-1	4-Methyl-2-pentanone	ND	46	15	ND	11	3.6	
10061-02-6	trans-1,3-Dichloropropene	ND	46	15	ND	10	3.3	
79-00-5	1,1,2-Trichloroethane	ND	46	15	ND	8.5	2.7	
108-88-3	Toluene	**30**	46	16	**8.1**	12	4.2	**J**
591-78-6	2-Hexanone	ND	46	15	ND	11	3.6	
124-48-1	Dibromochloromethane	ND	46	15	ND	5.4	1.7	
106-93-4	1,2-Dibromoethane	ND	46	15	ND	6.0	1.9	
123-86-4	n-Butyl Acetate	ND	46	15	ND	9.8	3.1	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-6**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-001

Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.015 Liter(s)
Test Notes:			
Container ID:	AC01169		

Initial Pressure (psig): -1.50 Final Pressure (psig): 3.70

Canister Dilution Factor: 1.39

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	**220**	46	17	**47**	9.9	3.6	
127-18-4	Tetrachloroethene	ND	46	13	ND	6.8	1.9	
108-90-7	Chlorobenzene	ND	46	15	ND	10	3.2	
100-41-4	Ethylbenzene	ND	46	15	ND	11	3.4	
179601-23-1	m,p-Xylenes	**34**	93	28	**7.9**	21	6.4	**J**
75-25-2	Bromoform	ND	46	14	ND	4.5	1.3	
100-42-5	Styrene	ND	46	14	ND	11	3.3	
95-47-6	o-Xylene	**28**	46	14	**6.6**	11	3.2	**J**
111-84-2	n-Nonane	**160**	46	14	**30**	8.8	2.7	
79-34-5	1,1,2,2-Tetrachloroethane	ND	46	14	ND	6.7	2.0	
98-82-8	Cumene	**64**	46	14	**13**	9.4	2.8	
80-56-8	alpha-Pinene	**250**	46	13	**45**	8.3	2.3	
103-65-1	n-Propylbenzene	ND	46	15	ND	9.4	3.0	
622-96-8	4-Ethyltoluene	ND	46	15	ND	9.4	3.0	
108-67-8	1,3,5-Trimethylbenzene	**19**	46	15	**4.0**	9.4	3.0	**J**
95-63-6	1,2,4-Trimethylbenzene	**39**	46	14	**7.9**	9.4	2.8	**J**
100-44-7	Benzyl Chloride	ND	46	10	ND	9.0	2.0	
541-73-1	1,3-Dichlorobenzene	ND	46	14	ND	7.7	2.3	
106-46-7	1,4-Dichlorobenzene	ND	46	13	ND	7.7	2.2	
95-50-1	1,2-Dichlorobenzene	ND	46	14	ND	7.7	2.3	
5989-27-5	d-Limonene	ND	46	13	ND	8.3	2.3	
96-12-8	1,2-Dibromo-3-chloropropane	ND	46	9.2	ND	4.8	0.95	
120-82-1	1,2,4-Trichlorobenzene	ND	46	15	ND	6.2	2.0	
91-20-3	Naphthalene	ND	46	17	ND	8.8	3.2	
87-68-3	Hexachlorobutadiene	ND	46	13	ND	4.3	1.2	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.

MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

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RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-12**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-002

Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.025 Liter(s)
Test Notes:			
Container ID:	AC01300		

Initial Pressure (psig): -2.68 Final Pressure (psig): 3.80

Canister Dilution Factor: 1.54

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	**26**	31	8.6	**15**	18	5.0	**J**
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	31	10	ND	6.2	2.1	
74-87-3	Chloromethane	ND	31	9.2	ND	15	4.5	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	31	12	ND	4.4	1.7	
106-99-0	1,3-Butadiene	ND	31	14	ND	14	6.1	
74-83-9	Bromomethane	ND	31	12	ND	7.9	3.0	
75-00-3	Chloroethane	ND	31	10	ND	12	4.0	
64-17-5	Ethanol	ND	310	49	ND	160	26	
75-05-8	Acetonitrile	ND	31	11	ND	18	6.6	
107-02-8	Acrolein	ND	120	10	ND	54	4.6	
67-64-1	Acetone	ND	310	47	ND	130	20	
75-69-4	Trichlorofluoromethane	ND	31	10	ND	5.5	1.9	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	310	26	ND	130	11	
107-13-1	Acrylonitrile	ND	31	10	ND	14	4.8	
75-35-4	1,1-Dichloroethene	ND	31	10	ND	7.8	2.6	
75-09-2	Methylene Chloride	ND	31	10	ND	8.9	3.0	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	31	9.9	ND	9.8	3.2	
76-13-1	Trichlorotrifluoroethane	ND	31	10	ND	4.0	1.4	
75-15-0	Carbon Disulfide	ND	310	9.2	ND	99	3.0	
156-60-5	trans-1,2-Dichloroethene	ND	31	12	ND	7.8	3.0	
75-34-3	1,1-Dichloroethane	ND	31	9.9	ND	7.6	2.4	
1634-04-4	Methyl tert-Butyl Ether	ND	31	10	ND	8.5	2.9	
108-05-4	Vinyl Acetate	ND	310	40	ND	88	11	
78-93-3	2-Butanone (MEK)	ND	310	13	ND	100	4.4	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-12**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-002

Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.025 Liter(s)
Test Notes:			
Container ID:	AC01300		

Initial Pressure (psig): -2.68 Final Pressure (psig): 3.80

Canister Dilution Factor: 1.54

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	Data Qualifier
156-59-2	cis-1,2-Dichloroethene	ND	31	9.9	ND	7.8	2.5	
141-78-6	Ethyl Acetate	ND	62	22	ND	17	6.0	
110-54-3	n-Hexane	**110**	31	9.2	**31**	8.7	2.6	
67-66-3	Chloroform	ND	31	10	ND	6.3	2.1	
109-99-9	Tetrahydrofuran (THF)	ND	31	12	ND	10	4.2	
107-06-2	1,2-Dichloroethane	ND	31	9.9	ND	7.6	2.4	
71-55-6	1,1,1-Trichloroethane	ND	31	10	ND	5.6	1.9	
71-43-2	Benzene	ND	31	9.9	ND	9.6	3.1	
56-23-5	Carbon Tetrachloride	ND	31	9.2	ND	4.9	1.5	
110-82-7	Cyclohexane	**130**	62	18	**38**	18	5.2	
78-87-5	1,2-Dichloropropane	ND	31	9.9	ND	6.7	2.1	
75-27-4	Bromodichloromethane	ND	31	9.2	ND	4.6	1.4	
79-01-6	Trichloroethene	ND	31	8.6	ND	5.7	1.6	
123-91-1	1,4-Dioxane	ND	31	9.9	ND	8.6	2.7	
80-62-6	Methyl Methacrylate	ND	62	19	ND	15	4.7	
142-82-5	n-Heptane	**32**	31	10	**7.8**	7.5	2.6	
10061-01-5	cis-1,3-Dichloropropene	ND	31	8.6	ND	6.8	1.9	
108-10-1	4-Methyl-2-pentanone	ND	31	9.9	ND	7.5	2.4	
10061-02-6	trans-1,3-Dichloropropene	ND	31	9.9	ND	6.8	2.2	
79-00-5	1,1,2-Trichloroethane	ND	31	9.9	ND	5.6	1.8	
108-88-3	Toluene	ND	31	10	ND	8.2	2.8	
591-78-6	2-Hexanone	ND	31	9.9	ND	7.5	2.4	
124-48-1	Dibromochloromethane	ND	31	9.9	ND	3.6	1.2	
106-93-4	1,2-Dibromoethane	ND	31	9.9	ND	4.0	1.3	
123-86-4	n-Butyl Acetate	ND	31	9.9	ND	6.5	2.1	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-12** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P1503343-002

Test Code: EPA TO-15 Date Collected: 8/7/15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13 Date Received: 8/13/15
Analyst: Wida Ang Date Analyzed: 8/19/15
Sample Type: 6.0 L Summa Canister Volume(s) Analyzed: 0.025 Liter(s)
Test Notes:
Container ID: AC01300

Initial Pressure (psig): -2.68 Final Pressure (psig): 3.80

Canister Dilution Factor: 1.54

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	ND	31	11	ND	6.6	2.4	
127-18-4	Tetrachloroethene	ND	31	8.6	ND	4.5	1.3	
108-90-7	Chlorobenzene	ND	31	9.9	ND	6.7	2.1	
100-41-4	Ethylbenzene	ND	31	9.9	ND	7.1	2.3	
179601-23-1	m,p-Xylenes	ND	62	18	ND	14	4.3	
75-25-2	Bromoform	ND	31	9.2	ND	3.0	0.89	
100-42-5	Styrene	ND	31	9.2	ND	7.2	2.2	
95-47-6	o-Xylene	**21**	31	9.2	**4.8**	7.1	2.1	**J**
111-84-2	n-Nonane	ND	31	9.2	ND	5.9	1.8	
79-34-5	1,1,2,2-Tetrachloroethane	ND	31	9.2	ND	4.5	1.3	
98-82-8	Cumene	**62**	31	9.2	**13**	6.3	1.9	
80-56-8	alpha-Pinene	**250**	31	8.6	**44**	5.5	1.5	
103-65-1	n-Propylbenzene	ND	31	9.9	ND	6.3	2.0	
622-96-8	4-Ethyltoluene	ND	31	9.9	ND	6.3	2.0	
108-67-8	1,3,5-Trimethylbenzene	ND	31	9.9	ND	6.3	2.0	
95-63-6	1,2,4-Trimethylbenzene	ND	31	9.2	ND	6.3	1.9	
100-44-7	Benzyl Chloride	ND	31	6.8	ND	6.0	1.3	
541-73-1	1,3-Dichlorobenzene	ND	31	9.2	ND	5.1	1.5	
106-46-7	1,4-Dichlorobenzene	ND	31	8.6	ND	5.1	1.4	
95-50-1	1,2-Dichlorobenzene	ND	31	9.2	ND	5.1	1.5	
5989-27-5	d-Limonene	ND	31	8.6	ND	5.5	1.5	
96-12-8	1,2-Dibromo-3-chloropropane	ND	31	6.1	ND	3.2	0.63	
120-82-1	1,2,4-Trichlorobenzene	ND	31	9.9	ND	4.2	1.3	
91-20-3	Naphthalene	ND	31	11	ND	5.9	2.1	
87-68-3	Hexachlorobutadiene	ND	31	8.6	ND	2.9	0.81	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-2**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-003
Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.015 Liter(s)
Test Notes:			
Container ID:	AS00615		

Initial Pressure (psig): -2.32 Final Pressure (psig): 3.72

Canister Dilution Factor: 1.49

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
115-07-1	Propene	**1,300**	50	14	**730**	29	8.1	
75-71-8	Dichlorodifluoromethane (CFC 12)	**45**	50	17	**9.1**	10	3.4	J
74-87-3	Chloromethane	ND	50	15	ND	24	7.2	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	**440**	50	19	**62**	7.1	2.7	
75-01-4	Vinyl Chloride	**170**	50	17	**65**	19	6.6	
106-99-0	1,3-Butadiene	ND	50	22	ND	22	9.9	
74-83-9	Bromomethane	ND	50	19	ND	13	4.9	
75-00-3	Chloroethane	ND	50	17	ND	19	6.4	
64-17-5	Ethanol	ND	500	79	ND	260	42	
75-05-8	Acetonitrile	ND	50	18	ND	30	11	
107-02-8	Acrolein	ND	200	17	ND	87	7.4	
67-64-1	Acetone	ND	500	76	ND	210	32	
75-69-4	Trichlorofluoromethane	ND	50	17	ND	8.8	3.0	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	500	42	ND	200	17	
107-13-1	Acrylonitrile	ND	50	17	ND	23	7.8	
75-35-4	1,1-Dichloroethene	ND	50	17	ND	13	4.3	
75-09-2	Methylene Chloride	ND	50	17	ND	14	4.9	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	50	16	ND	16	5.1	
76-13-1	Trichlorotrifluoroethane	ND	50	17	ND	6.5	2.2	
75-15-0	Carbon Disulfide	ND	500	15	ND	160	4.8	
156-60-5	trans-1,2-Dichloroethene	ND	50	19	ND	13	4.8	
75-34-3	1,1-Dichloroethane	ND	50	16	ND	12	3.9	
1634-04-4	Methyl tert-Butyl Ether	ND	50	17	ND	14	4.7	
108-05-4	Vinyl Acetate	ND	500	65	ND	140	18	
78-93-3	2-Butanone (MEK)	ND	500	21	ND	170	7.1	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

RESULTS OF ANALYSIS

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-2**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-003
Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.015 Liter(s)
Test Notes:			
Container ID:	AS00615		

Initial Pressure (psig): -2.32 Final Pressure (psig): 3.72

Canister Dilution Factor: 1.49

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
156-59-2	cis-1,2-Dichloroethene	**24**	50	16	**6.2**	13	4.0	**J**
141-78-6	Ethyl Acetate	ND	99	35	ND	28	9.7	
110-54-3	n-Hexane	**5,500**	50	15	**1,600**	14	4.2	
67-66-3	Chloroform	ND	50	17	ND	10	3.5	
109-99-9	Tetrahydrofuran (THF)	ND	50	20	ND	17	6.7	
107-06-2	1,2-Dichloroethane	ND	50	16	ND	12	3.9	
71-55-6	1,1,1-Trichloroethane	ND	50	17	ND	9.1	3.1	
71-43-2	Benzene	**60**	50	16	**19**	16	5.0	
56-23-5	Carbon Tetrachloride	ND	50	15	ND	7.9	2.4	
110-82-7	Cyclohexane	**570**	99	29	**170**	29	8.4	
78-87-5	1,2-Dichloropropane	ND	50	16	ND	11	3.4	
75-27-4	Bromodichloromethane	ND	50	15	ND	7.4	2.2	
79-01-6	Trichloroethene	ND	50	14	ND	9.2	2.6	
123-91-1	1,4-Dioxane	ND	50	16	ND	14	4.4	
80-62-6	Methyl Methacrylate	ND	99	31	ND	24	7.5	
142-82-5	n-Heptane	**2,000**	50	17	**480**	12	4.1	
10061-01-5	cis-1,3-Dichloropropene	ND	50	14	ND	11	3.1	
108-10-1	4-Methyl-2-pentanone	ND	50	16	ND	12	3.9	
10061-02-6	trans-1,3-Dichloropropene	ND	50	16	ND	11	3.5	
79-00-5	1,1,2-Trichloroethane	ND	50	16	ND	9.1	2.9	
108-88-3	Toluene	**36**	50	17	**9.5**	13	4.5	**J**
591-78-6	2-Hexanone	ND	50	16	ND	12	3.9	
124-48-1	Dibromochloromethane	ND	50	16	ND	5.8	1.9	
106-93-4	1,2-Dibromoethane	ND	50	16	ND	6.5	2.1	
123-86-4	n-Butyl Acetate	ND	50	16	ND	10	3.3	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-2**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1503343
ALS Sample ID: P1503343-003

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00615

Date Collected: 8/7/15
Date Received: 8/13/15
Date Analyzed: 8/19/15
Volume(s) Analyzed: 0.015 Liter(s)

Initial Pressure (psig): -2.32 Final Pressure (psig): 3.72

Canister Dilution Factor: 1.49

CAS #	Compound	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	**220**	50	18	**47**	11	3.8	
127-18-4	Tetrachloroethene	ND	50	14	ND	7.3	2.1	
108-90-7	Chlorobenzene	ND	50	16	ND	11	3.5	
100-41-4	Ethylbenzene	**16**	50	16	**3.7**	11	3.7	**J**
179601-23-1	m,p-Xylenes	**34**	99	30	**7.8**	23	6.9	**J**
75-25-2	Bromoform	ND	50	15	ND	4.8	1.4	
100-42-5	Styrene	ND	50	15	ND	12	3.5	
95-47-6	o-Xylene	**40**	50	15	**9.3**	11	3.4	**J**
111-84-2	n-Nonane	ND	50	15	ND	9.5	2.8	
79-34-5	1,1,2,2-Tetrachloroethane	ND	50	15	ND	7.2	2.2	
98-82-8	Cumene	**58**	50	15	**12**	10	3.0	
80-56-8	alpha-Pinene	ND	50	14	ND	8.9	2.5	
103-65-1	n-Propylbenzene	ND	50	16	ND	10	3.2	
622-96-8	4-Ethyltoluene	ND	50	16	ND	10	3.2	
108-67-8	1,3,5-Trimethylbenzene	**17**	50	16	**3.4**	10	3.2	**J**
95-63-6	1,2,4-Trimethylbenzene	**28**	50	15	**5.7**	10	3.0	**J**
100-44-7	Benzyl Chloride	ND	50	11	ND	9.6	2.1	
541-73-1	1,3-Dichlorobenzene	ND	50	15	ND	8.3	2.5	
106-46-7	1,4-Dichlorobenzene	**32**	50	14	**5.4**	8.3	2.3	**J**
95-50-1	1,2-Dichlorobenzene	ND	50	15	ND	8.3	2.5	
5989-27-5	d-Limonene	ND	50	14	ND	8.9	2.5	
96-12-8	1,2-Dibromo-3-chloropropane	ND	50	9.8	ND	5.1	1.0	
120-82-1	1,2,4-Trichlorobenzene	ND	50	16	ND	6.7	2.1	
91-20-3	Naphthalene	ND	50	18	ND	9.5	3.4	
87-68-3	Hexachlorobutadiene	ND	50	14	ND	4.7	1.3	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Client: **Landau Associates, Inc.**
Client Sample ID: **CL-LFG-P-3**
Client Project ID: **Cornwall LF / 001037.030.033**

ALS Project ID: P1503343
ALS Sample ID: P1503343-004

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13
Analyst: Wida Ang
Sample Type: 6.0 L Silonite Canister
Test Notes:
Container ID: AS00820

Date Collected: 8/7/15
Date Received: 8/13/15
Date Analyzed: 8/20/15
Volume(s) Analyzed: 0.10 Liter(s)

Initial Pressure (psig): -2.62 Final Pressure (psig): 3.50

Canister Dilution Factor: 1.51

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	**120**	7.6	2.1	**67**	4.4	1.2	
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	7.6	2.6	ND	1.5	0.52	
74-87-3	Chloromethane	ND	7.6	2.3	ND	3.7	1.1	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	7.6	2.9	ND	1.1	0.41	
106-99-0	1,3-Butadiene	ND	7.6	3.3	ND	3.4	1.5	
74-83-9	Bromomethane	ND	7.6	2.9	ND	1.9	0.74	
75-00-3	Chloroethane	ND	7.6	2.6	ND	2.9	0.97	
64-17-5	Ethanol	ND	76	12	ND	40	6.4	
75-05-8	Acetonitrile	ND	7.6	2.7	ND	4.5	1.6	
107-02-8	Acrolein	ND	30	2.6	ND	13	1.1	
67-64-1	Acetone	ND	76	12	ND	32	4.9	
75-69-4	Trichlorofluoromethane	ND	7.6	2.6	ND	1.3	0.46	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	76	6.3	ND	31	2.6	
107-13-1	Acrylonitrile	ND	7.6	2.6	ND	3.5	1.2	
75-35-4	1,1-Dichloroethene	ND	7.6	2.6	ND	1.9	0.65	
75-09-2	Methylene Chloride	ND	7.6	2.6	ND	2.2	0.74	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	7.6	2.4	ND	2.4	0.77	
76-13-1	Trichlorotrifluoroethane	ND	7.6	2.6	ND	0.99	0.34	
75-15-0	Carbon Disulfide	**45**	76	2.3	**14**	24	0.73	**J**
156-60-5	trans-1,2-Dichloroethene	ND	7.6	2.9	ND	1.9	0.72	
75-34-3	1,1-Dichloroethane	ND	7.6	2.4	ND	1.9	0.60	
1634-04-4	Methyl tert-Butyl Ether	ND	7.6	2.6	ND	2.1	0.71	
108-05-4	Vinyl Acetate	ND	76	9.8	ND	21	2.8	
78-93-3	2-Butanone (MEK)	**3.4**	76	3.2	**1.1**	26	1.1	**J**

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-3**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-004

Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/20/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.10 Liter(s)
Test Notes:			
Container ID:	AS00820		

Initial Pressure (psig): -2.62 Final Pressure (psig): 3.50

Canister Dilution Factor: 1.51

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
156-59-2	cis-1,2-Dichloroethene	**3.2**	7.6	2.4	**0.80**	1.9	0.61	**J**
141-78-6	Ethyl Acetate	ND	15	5.3	ND	4.2	1.5	
110-54-3	n-Hexane	**170**	7.6	2.3	**47**	2.1	0.64	
67-66-3	Chloroform	ND	7.6	2.6	ND	1.5	0.53	
109-99-9	Tetrahydrofuran (THF)	ND	7.6	3.0	ND	2.6	1.0	
107-06-2	1,2-Dichloroethane	ND	7.6	2.4	ND	1.9	0.60	
71-55-6	1,1,1-Trichloroethane	ND	7.6	2.6	ND	1.4	0.47	
71-43-2	Benzene	**16**	7.6	2.4	**5.0**	2.4	0.76	
56-23-5	Carbon Tetrachloride	ND	7.6	2.3	ND	1.2	0.36	
110-82-7	Cyclohexane	**65**	15	4.4	**19**	4.4	1.3	
78-87-5	1,2-Dichloropropane	ND	7.6	2.4	ND	1.6	0.52	
75-27-4	Bromodichloromethane	ND	7.6	2.3	ND	1.1	0.34	
79-01-6	Trichloroethene	ND	7.6	2.1	ND	1.4	0.39	
123-91-1	1,4-Dioxane	ND	7.6	2.4	ND	2.1	0.67	
80-62-6	Methyl Methacrylate	ND	15	4.7	ND	3.7	1.1	
142-82-5	n-Heptane	**74**	7.6	2.6	**18**	1.8	0.63	
10061-01-5	cis-1,3-Dichloropropene	ND	7.6	2.1	ND	1.7	0.47	
108-10-1	4-Methyl-2-pentanone	ND	7.6	2.4	ND	1.8	0.59	
10061-02-6	trans-1,3-Dichloropropene	ND	7.6	2.4	ND	1.7	0.53	
79-00-5	1,1,2-Trichloroethane	ND	7.6	2.4	ND	1.4	0.44	
108-88-3	Toluene	**3.4**	7.6	2.6	**0.90**	2.0	0.68	**J**
591-78-6	2-Hexanone	ND	7.6	2.4	ND	1.8	0.59	
124-48-1	Dibromochloromethane	ND	7.6	2.4	ND	0.89	0.28	
106-93-4	1,2-Dibromoethane	ND	7.6	2.4	ND	0.98	0.31	
123-86-4	n-Butyl Acetate	ND	7.6	2.4	ND	1.6	0.51	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**CL-LFG-P-3**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P1503343-004
Test Code:	EPA TO-15	Date Collected:	8/7/15
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	8/13/15
Analyst:	Wida Ang	Date Analyzed:	8/20/15
Sample Type:	6.0 L Silonite Canister	Volume(s) Analyzed:	0.10 Liter(s)
Test Notes:			
Container ID:	AS00820		

Initial Pressure (psig): -2.62 Final Pressure (psig): 3.50

Canister Dilution Factor: 1.51

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	**29**	7.6	2.7	**6.2**	1.6	0.58	
127-18-4	Tetrachloroethene	ND	7.6	2.1	ND	1.1	0.31	
108-90-7	Chlorobenzene	ND	7.6	2.4	ND	1.6	0.52	
100-41-4	Ethylbenzene	**2.5**	7.6	2.4	**0.57**	1.7	0.56	**J**
179601-23-1	m,p-Xylenes	**9.2**	15	4.5	**2.1**	3.5	1.0	**J**
75-25-2	Bromoform	ND	7.6	2.3	ND	0.73	0.22	
100-42-5	Styrene	ND	7.6	2.3	ND	1.8	0.53	
95-47-6	o-Xylene	ND	7.6	2.3	ND	1.7	0.52	
111-84-2	n-Nonane	**11**	7.6	2.3	**2.0**	1.4	0.43	
79-34-5	1,1,2,2-Tetrachloroethane	ND	7.6	2.3	ND	1.1	0.33	
98-82-8	Cumene	ND	7.6	2.3	ND	1.5	0.46	
80-56-8	alpha-Pinene	**18**	7.6	2.1	**3.2**	1.4	0.38	
103-65-1	n-Propylbenzene	ND	7.6	2.4	ND	1.5	0.49	
622-96-8	4-Ethyltoluene	ND	7.6	2.4	ND	1.5	0.49	
108-67-8	1,3,5-Trimethylbenzene	**3.1**	7.6	2.4	**0.63**	1.5	0.49	**J**
95-63-6	1,2,4-Trimethylbenzene	**5.6**	7.6	2.3	**1.1**	1.5	0.46	**J**
100-44-7	Benzyl Chloride	ND	7.6	1.7	ND	1.5	0.32	
541-73-1	1,3-Dichlorobenzene	ND	7.6	2.3	ND	1.3	0.38	
106-46-7	1,4-Dichlorobenzene	ND	7.6	2.1	ND	1.3	0.35	
95-50-1	1,2-Dichlorobenzene	ND	7.6	2.3	ND	1.3	0.38	
5989-27-5	d-Limonene	ND	7.6	2.1	ND	1.4	0.38	
96-12-8	1,2-Dibromo-3-chloropropane	ND	7.6	1.5	ND	0.78	0.15	
120-82-1	1,2,4-Trichlorobenzene	ND	7.6	2.4	ND	1.0	0.33	
91-20-3	Naphthalene	ND	7.6	2.7	ND	1.4	0.52	
87-68-3	Hexachlorobutadiene	ND	7.6	2.1	ND	0.71	0.20	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150819-MB

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13 Date Received: NA
Analyst: Wida Ang Date Analyzed: 8/19/15
Sample Type: 6.0 L Summa Canister Volume(s) Analyzed: 1.00 Liter(s)
Test Notes:

Canister Dilution Factor: 1.00

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	ND	0.50	0.14	ND	0.29	0.081	
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	0.50	0.17	ND	0.10	0.034	
74-87-3	Chloromethane	ND	0.50	0.15	ND	0.24	0.073	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	0.50	0.19	ND	0.072	0.027	
75-01-4	Vinyl Chloride	ND	0.50	0.17	ND	0.20	0.067	
106-99-0	1,3-Butadiene	ND	0.50	0.22	ND	0.23	0.099	
74-83-9	Bromomethane	ND	0.50	0.19	ND	0.13	0.049	
75-00-3	Chloroethane	ND	0.50	0.17	ND	0.19	0.064	
64-17-5	Ethanol	ND	5.0	0.80	ND	2.7	0.42	
75-05-8	Acetonitrile	ND	0.50	0.18	ND	0.30	0.11	
107-02-8	Acrolein	ND	2.0	0.17	ND	0.87	0.074	
67-64-1	Acetone	ND	5.0	0.77	ND	2.1	0.32	
75-69-4	Trichlorofluoromethane	ND	0.50	0.17	ND	0.089	0.030	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	5.0	0.42	ND	2.0	0.17	
107-13-1	Acrylonitrile	ND	0.50	0.17	ND	0.23	0.078	
75-35-4	1,1-Dichloroethene	ND	0.50	0.17	ND	0.13	0.043	
75-09-2	Methylene Chloride	ND	0.50	0.17	ND	0.14	0.049	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.50	0.16	ND	0.16	0.051	
76-13-1	Trichlorotrifluoroethane	ND	0.50	0.17	ND	0.065	0.022	
75-15-0	Carbon Disulfide	**0.28**	5.0	0.15	**0.090**	1.6	0.048	**J**
156-60-5	trans-1,2-Dichloroethene	ND	0.50	0.19	ND	0.13	0.048	
75-34-3	1,1-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
1634-04-4	Methyl tert-Butyl Ether	ND	0.50	0.17	ND	0.14	0.047	
108-05-4	Vinyl Acetate	ND	5.0	0.65	ND	1.4	0.18	
78-93-3	2-Butanone (MEK)	ND	5.0	0.21	ND	1.7	0.071	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Method Blank**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150819-MB

Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	0.50	0.16	ND	0.13	0.040	
141-78-6	Ethyl Acetate	ND	1.0	0.35	ND	0.28	0.097	
110-54-3	n-Hexane	ND	0.50	0.15	ND	0.14	0.043	
67-66-3	Chloroform	ND	0.50	0.17	ND	0.10	0.035	
109-99-9	Tetrahydrofuran (THF)	ND	0.50	0.20	ND	0.17	0.068	
107-06-2	1,2-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
71-55-6	1,1,1-Trichloroethane	ND	0.50	0.17	ND	0.092	0.031	
71-43-2	Benzene	ND	0.50	0.16	ND	0.16	0.050	
56-23-5	Carbon Tetrachloride	ND	0.50	0.15	ND	0.080	0.024	
110-82-7	Cyclohexane	ND	1.0	0.29	ND	0.29	0.084	
78-87-5	1,2-Dichloropropane	ND	0.50	0.16	ND	0.11	0.035	
75-27-4	Bromodichloromethane	ND	0.50	0.15	ND	0.075	0.022	
79-01-6	Trichloroethene	ND	0.50	0.14	ND	0.093	0.026	
123-91-1	1,4-Dioxane	ND	0.50	0.16	ND	0.14	0.044	
80-62-6	Methyl Methacrylate	ND	1.0	0.31	ND	0.24	0.076	
142-82-5	n-Heptane	ND	0.50	0.17	ND	0.12	0.041	
10061-01-5	cis-1,3-Dichloropropene	ND	0.50	0.14	ND	0.11	0.031	
108-10-1	4-Methyl-2-pentanone	ND	0.50	0.16	ND	0.12	0.039	
10061-02-6	trans-1,3-Dichloropropene	ND	0.50	0.16	ND	0.11	0.035	
79-00-5	1,1,2-Trichloroethane	ND	0.50	0.16	ND	0.092	0.029	
108-88-3	Toluene	ND	0.50	0.17	ND	0.13	0.045	
591-78-6	2-Hexanone	ND	0.50	0.16	ND	0.12	0.039	
124-48-1	Dibromochloromethane	ND	0.50	0.16	ND	0.059	0.019	
106-93-4	1,2-Dibromoethane	ND	0.50	0.16	ND	0.065	0.021	
123-86-4	n-Butyl Acetate	ND	0.50	0.16	ND	0.11	0.034	

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ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
Page 3 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150819-MB

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13 Date Received: NA
Analyst: Wida Ang Date Analyzed: 8/19/15
Sample Type: 6.0 L Summa Canister Volume(s) Analyzed: 1.00 Liter(s)
Test Notes:

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	ND	0.50	0.18	ND	0.11	0.039	
127-18-4	Tetrachloroethene	ND	0.50	0.14	ND	0.074	0.021	
108-90-7	Chlorobenzene	ND	0.50	0.16	ND	0.11	0.035	
100-41-4	Ethylbenzene	ND	0.50	0.16	ND	0.12	0.037	
179601-23-1	m,p-Xylenes	ND	1.0	0.30	ND	0.23	0.069	
75-25-2	Bromoform	ND	0.50	0.15	ND	0.048	0.015	
100-42-5	Styrene	ND	0.50	0.15	ND	0.12	0.035	
95-47-6	o-Xylene	ND	0.50	0.15	ND	0.12	0.035	
111-84-2	n-Nonane	ND	0.50	0.15	ND	0.095	0.029	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.50	0.15	ND	0.073	0.022	
98-82-8	Cumene	ND	0.50	0.15	ND	0.10	0.031	
80-56-8	alpha-Pinene	ND	0.50	0.14	ND	0.090	0.025	
103-65-1	n-Propylbenzene	ND	0.50	0.16	ND	0.10	0.033	
622-96-8	4-Ethyltoluene	ND	0.50	0.16	ND	0.10	0.033	
108-67-8	1,3,5-Trimethylbenzene	ND	0.50	0.16	ND	0.10	0.033	
95-63-6	1,2,4-Trimethylbenzene	ND	0.50	0.15	ND	0.10	0.031	
100-44-7	Benzyl Chloride	ND	0.50	0.11	ND	0.097	0.021	
541-73-1	1,3-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
106-46-7	1,4-Dichlorobenzene	ND	0.50	0.14	ND	0.083	0.023	
95-50-1	1,2-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
5989-27-5	d-Limonene	ND	0.50	0.14	ND	0.090	0.025	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.50	0.099	ND	0.052	0.010	
120-82-1	1,2,4-Trichlorobenzene	ND	0.50	0.16	ND	0.067	0.022	
91-20-3	Naphthalene	ND	0.50	0.18	ND	0.095	0.034	
87-68-3	Hexachlorobutadiene	ND	0.50	0.14	ND	0.047	0.013	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150820-MB

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13 Date Received: NA
Analyst: Wida Ang Date Analyzed: 8/20/15
Sample Type: 6.0 L Summa Canister Volume(s) Analyzed: 1.00 Liter(s)
Test Notes:

Canister Dilution Factor: 1.00

CAS #	Compound	Result µg/m³	MRL µg/m³	MDL µg/m³	Result ppbV	MRL ppbV	MDL ppbV	Data Qualifier
115-07-1	Propene	ND	0.50	0.14	ND	0.29	0.081	
75-71-8	Dichlorodifluoromethane (CFC 12)	ND	0.50	0.17	ND	0.10	0.034	
74-87-3	Chloromethane	ND	0.50	0.15	ND	0.24	0.073	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	ND	0.50	0.19	ND	0.072	0.027	
106-99-0	1,3-Butadiene	ND	0.50	0.22	ND	0.23	0.099	
74-83-9	Bromomethane	ND	0.50	0.19	ND	0.13	0.049	
75-00-3	Chloroethane	ND	0.50	0.17	ND	0.19	0.064	
64-17-5	Ethanol	ND	5.0	0.80	ND	2.7	0.42	
75-05-8	Acetonitrile	ND	0.50	0.18	ND	0.30	0.11	
107-02-8	Acrolein	ND	2.0	0.17	ND	0.87	0.074	
67-64-1	Acetone	**0.85**	5.0	0.77	**0.36**	2.1	0.32	J
75-69-4	Trichlorofluoromethane	ND	0.50	0.17	ND	0.089	0.030	
67-63-0	2-Propanol (Isopropyl Alcohol)	ND	5.0	0.42	ND	2.0	0.17	
107-13-1	Acrylonitrile	ND	0.50	0.17	ND	0.23	0.078	
75-35-4	1,1-Dichloroethene	ND	0.50	0.17	ND	0.13	0.043	
75-09-2	Methylene Chloride	ND	0.50	0.17	ND	0.14	0.049	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	ND	0.50	0.16	ND	0.16	0.051	
76-13-1	Trichlorotrifluoroethane	ND	0.50	0.17	ND	0.065	0.022	
75-15-0	Carbon Disulfide	ND	5.0	0.15	ND	1.6	0.048	
156-60-5	trans-1,2-Dichloroethene	ND	0.50	0.19	ND	0.13	0.048	
75-34-3	1,1-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
1634-04-4	Methyl tert-Butyl Ether	ND	0.50	0.17	ND	0.14	0.047	
108-05-4	Vinyl Acetate	ND	5.0	0.65	ND	1.4	0.18	
78-93-3	2-Butanone (MEK)	ND	5.0	0.21	ND	1.7	0.071	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The result is an estimated concentration that is less than the MRL but greater than or equal to the MDL.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

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Client: **Landau Associates, Inc.**
Client Sample ID: **Method Blank** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150820-MB

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister
Test Notes:

Date Collected: NA
Date Received: NA
Date Analyzed: 8/20/15
Volume(s) Analyzed: 1.00 Liter(s)

Canister Dilution Factor: 1.00

CAS #	**Compound**	**Result** **µg/m³**	MRL µg/m³	MDL µg/m³	**Result** **ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	ND	0.50	0.16	ND	0.13	0.040	
141-78-6	Ethyl Acetate	ND	1.0	0.35	ND	0.28	0.097	
110-54-3	n-Hexane	ND	0.50	0.15	ND	0.14	0.043	
67-66-3	Chloroform	ND	0.50	0.17	ND	0.10	0.035	
109-99-9	Tetrahydrofuran (THF)	ND	0.50	0.20	ND	0.17	0.068	
107-06-2	1,2-Dichloroethane	ND	0.50	0.16	ND	0.12	0.040	
71-55-6	1,1,1-Trichloroethane	ND	0.50	0.17	ND	0.092	0.031	
71-43-2	Benzene	ND	0.50	0.16	ND	0.16	0.050	
56-23-5	Carbon Tetrachloride	ND	0.50	0.15	ND	0.080	0.024	
110-82-7	Cyclohexane	ND	1.0	0.29	ND	0.29	0.084	
78-87-5	1,2-Dichloropropane	ND	0.50	0.16	ND	0.11	0.035	
75-27-4	Bromodichloromethane	ND	0.50	0.15	ND	0.075	0.022	
79-01-6	Trichloroethene	ND	0.50	0.14	ND	0.093	0.026	
123-91-1	1,4-Dioxane	ND	0.50	0.16	ND	0.14	0.044	
80-62-6	Methyl Methacrylate	ND	1.0	0.31	ND	0.24	0.076	
142-82-5	n-Heptane	ND	0.50	0.17	ND	0.12	0.041	
10061-01-5	cis-1,3-Dichloropropene	ND	0.50	0.14	ND	0.11	0.031	
108-10-1	4-Methyl-2-pentanone	ND	0.50	0.16	ND	0.12	0.039	
10061-02-6	trans-1,3-Dichloropropene	ND	0.50	0.16	ND	0.11	0.035	
79-00-5	1,1,2-Trichloroethane	ND	0.50	0.16	ND	0.092	0.029	
108-88-3	Toluene	ND	0.50	0.17	ND	0.13	0.045	
591-78-6	2-Hexanone	ND	0.50	0.16	ND	0.12	0.039	
124-48-1	Dibromochloromethane	ND	0.50	0.16	ND	0.059	0.019	
106-93-4	1,2-Dibromoethane	ND	0.50	0.16	ND	0.065	0.021	
123-86-4	n-Butyl Acetate	ND	0.50	0.16	ND	0.11	0.034	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS

Page 3 of 3

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Method Blank**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150820-MB
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/20/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	1.00 Liter(s)
Test Notes:			

Canister Dilution Factor: 1.00

CAS #	Compound	**Result** **µg/m³**	MRL µg/m³	MDL µg/m³	**Result** **ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
111-65-9	n-Octane	ND	0.50	0.18	ND	0.11	0.039	
127-18-4	Tetrachloroethene	ND	0.50	0.14	ND	0.074	0.021	
108-90-7	Chlorobenzene	ND	0.50	0.16	ND	0.11	0.035	
100-41-4	Ethylbenzene	ND	0.50	0.16	ND	0.12	0.037	
179601-23-1	m,p-Xylenes	ND	1.0	0.30	ND	0.23	0.069	
75-25-2	Bromoform	ND	0.50	0.15	ND	0.048	0.015	
100-42-5	Styrene	ND	0.50	0.15	ND	0.12	0.035	
95-47-6	o-Xylene	ND	0.50	0.15	ND	0.12	0.035	
111-84-2	n-Nonane	ND	0.50	0.15	ND	0.095	0.029	
79-34-5	1,1,2,2-Tetrachloroethane	ND	0.50	0.15	ND	0.073	0.022	
98-82-8	Cumene	ND	0.50	0.15	ND	0.10	0.031	
80-56-8	alpha-Pinene	ND	0.50	0.14	ND	0.090	0.025	
103-65-1	n-Propylbenzene	ND	0.50	0.16	ND	0.10	0.033	
622-96-8	4-Ethyltoluene	ND	0.50	0.16	ND	0.10	0.033	
108-67-8	1,3,5-Trimethylbenzene	ND	0.50	0.16	ND	0.10	0.033	
95-63-6	1,2,4-Trimethylbenzene	ND	0.50	0.15	ND	0.10	0.031	
100-44-7	Benzyl Chloride	ND	0.50	0.11	ND	0.097	0.021	
541-73-1	1,3-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
106-46-7	1,4-Dichlorobenzene	ND	0.50	0.14	ND	0.083	0.023	
95-50-1	1,2-Dichlorobenzene	ND	0.50	0.15	ND	0.083	0.025	
5989-27-5	d-Limonene	ND	0.50	0.14	ND	0.090	0.025	
96-12-8	1,2-Dibromo-3-chloropropane	ND	0.50	0.099	ND	0.052	0.010	
120-82-1	1,2,4-Trichlorobenzene	ND	0.50	0.16	ND	0.067	0.022	
91-20-3	Naphthalene	ND	0.50	0.18	ND	0.095	0.034	
87-68-3	Hexachlorobutadiene	ND	0.50	0.14	ND	0.047	0.013	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.

ALS ENVIRONMENTAL

SURROGATE SPIKE RECOVERY RESULTS

Page 1 of 1

Client: **Landau Associates, Inc.**
Client Project ID: **Cornwall LF / 001037.030.033**
ALS Project ID: P1503343

Test Code: EPA TO-15
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13
Analyst: Wida Ang
Sample Type: 6.0 L Summa Canister(s)
Test Notes:

Date(s) Collected: 8/7/15
Date(s) Received: 8/13/15
Date(s) Analyzed: 8/19 - 8/20/15

Client Sample ID	ALS Sample ID	1,2-Dichloroethane-d4 Percent Recovered	Toluene-d8 Percent Recovered	Bromofluorobenzene Percent Recovered	Acceptance Limits	Data Qualifier
Method Blank	P150819-MB	**104**	**100**	**95**	70-130	
Method Blank	P150820-MB	**107**	**100**	**89**	70-130	
Lab Control Sample	P150819-LCS	**106**	**99**	**97**	70-130	
Lab Control Sample	P150820-LCS	**107**	**98**	**93**	70-130	
CL-LFG-P-6	P1503343-001	**108**	**84**	**89**	70-130	
CL-LFG-P-12	P1503343-002	**106**	**77**	**83**	70-130	
CL-LFG-P-2	P1503343-003	**107**	**92**	**94**	70-130	
CL-LFG-P-3	P1503343-004	**108**	**99**	**92**	70-130	

Surrogate percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly from the on-column percent recovery.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150819-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
115-07-1	Propene	196	**160**	**82**	50-128	
75-71-8	Dichlorodifluoromethane (CFC 12)	188	**185**	**98**	66-117	
74-87-3	Chloromethane	200	**188**	**94**	51-133	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	204	**214**	**105**	65-117	
75-01-4	Vinyl Chloride	200	**224**	**112**	61-127	
106-99-0	1,3-Butadiene	206	**196**	**95**	65-132	
74-83-9	Bromomethane	202	**197**	**98**	62-114	
75-00-3	Chloroethane	200	**192**	**96**	64-122	
64-17-5	Ethanol	998	**1040**	**104**	57-131	
75-05-8	Acetonitrile	212	**174**	**82**	52-135	
107-02-8	Acrolein	214	**174**	**81**	64-124	
67-64-1	Acetone	1,080	**1150**	**106**	60-113	
75-69-4	Trichlorofluoromethane	216	**183**	**85**	64-112	
67-63-0	2-Propanol (Isopropyl Alcohol)	418	**428**	**102**	62-129	
107-13-1	Acrylonitrile	212	**208**	**98**	69-133	
75-35-4	1,1-Dichloroethene	216	**205**	**95**	70-114	
75-09-2	Methylene Chloride	222	**200**	**90**	63-103	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	218	**196**	**90**	57-135	
76-13-1	Trichlorotrifluoroethane	220	**197**	**90**	69-116	
75-15-0	Carbon Disulfide	210	**176**	**84**	66-118	
156-60-5	trans-1,2-Dichloroethene	210	**203**	**97**	69-123	
75-34-3	1,1-Dichloroethane	212	**205**	**97**	65-118	
1634-04-4	Methyl tert-Butyl Ether	216	**195**	**90**	57-125	
108-05-4	Vinyl Acetate	1,040	**1070**	**103**	69-131	
78-93-3	2-Butanone (MEK)	220	**215**	**98**	63-121	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

LABORATORY CONTROL SAMPLE SUMMARY

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150819-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	218	**217**	**100**	69-119	
141-78-6	Ethyl Acetate	428	**512**	**120**	65-129	
110-54-3	n-Hexane	212	**220**	**104**	55-116	
67-66-3	Chloroform	224	**222**	**99**	68-111	
109-99-9	Tetrahydrofuran (THF)	220	**215**	**98**	69-120	
107-06-2	1,2-Dichloroethane	214	**214**	**100**	67-117	
71-55-6	1,1,1-Trichloroethane	210	**196**	**93**	74-116	
71-43-2	Benzene	226	**211**	**93**	61-109	
56-23-5	Carbon Tetrachloride	230	**207**	**90**	76-120	
110-82-7	Cyclohexane	424	**440**	**104**	72-115	
78-87-5	1,2-Dichloropropane	216	**215**	**100**	67-119	
75-27-4	Bromodichloromethane	218	**219**	**100**	78-124	
79-01-6	Trichloroethene	216	**203**	**94**	69-115	
123-91-1	1,4-Dioxane	210	**219**	**104**	69-127	
80-62-6	Methyl Methacrylate	422	**416**	**99**	76-128	
142-82-5	n-Heptane	216	**210**	**97**	66-118	
10061-01-5	cis-1,3-Dichloropropene	208	**207**	**100**	77-124	
108-10-1	4-Methyl-2-pentanone	220	**215**	**98**	66-134	
10061-02-6	trans-1,3-Dichloropropene	210	**210**	**100**	80-130	
79-00-5	1,1,2-Trichloroethane	216	**212**	**98**	75-119	
108-88-3	Toluene	218	**202**	**93**	68-114	
591-78-6	2-Hexanone	220	**199**	**90**	60-136	
124-48-1	Dibromochloromethane	220	**210**	**95**	75-132	
106-93-4	1,2-Dibromoethane	218	**209**	**96**	72-122	
123-86-4	n-Butyl Acetate	226	**198**	**88**	60-137	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

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Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150819-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/19/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
111-65-9	n-Octane	210	**194**	**92**	66-120	
127-18-4	Tetrachloroethene	202	**178**	**88**	67-120	
108-90-7	Chlorobenzene	220	**208**	**95**	69-114	
100-41-4	Ethylbenzene	218	**215**	**99**	71-117	
179601-23-1	m,p-Xylenes	428	**443**	**104**	71-118	
75-25-2	Bromoform	228	**209**	**92**	76-149	
100-42-5	Styrene	222	**218**	**98**	71-128	
95-47-6	o-Xylene	210	**218**	**104**	72-118	
111-84-2	n-Nonane	204	**204**	**100**	63-123	
79-34-5	1,1,2,2-Tetrachloroethane	210	**222**	**106**	73-124	
98-82-8	Cumene	208	**206**	**99**	71-118	
80-56-8	alpha-Pinene	212	**201**	**95**	71-123	
103-65-1	n-Propylbenzene	204	**217**	**106**	71-120	
622-96-8	4-Ethyltoluene	214	**229**	**107**	71-121	
108-67-8	1,3,5-Trimethylbenzene	214	**224**	**105**	72-121	
95-63-6	1,2,4-Trimethylbenzene	218	**257**	**118**	71-122	
100-44-7	Benzyl Chloride	220	**235**	**107**	79-143	
541-73-1	1,3-Dichlorobenzene	228	**245**	**107**	67-121	
106-46-7	1,4-Dichlorobenzene	208	**228**	**110**	68-121	
95-50-1	1,2-Dichlorobenzene	220	**243**	**110**	68-121	
5989-27-5	d-Limonene	210	**213**	**101**	69-137	
96-12-8	1,2-Dibromo-3-chloropropane	218	**207**	**95**	73-145	
120-82-1	1,2,4-Trichlorobenzene	230	**210**	**91**	60-135	
91-20-3	Naphthalene	218	**222**	**102**	63-142	
87-68-3	Hexachlorobutadiene	230	**206**	**90**	65-127	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 1 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Lab Control Sample** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150820-LCS

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13 Date Received: NA
Analyst: Wida Ang Date Analyzed: 8/20/15
Sample Type: 6.0 L Summa Canister Volume(s) Analyzed: 0.125 Liter(s)
Test Notes:

CAS #	**Compound**	Spike Amount μg/m³	**Result μg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
115-07-1	Propene	196	**163**	**83**	50-128	
75-71-8	Dichlorodifluoromethane (CFC 12)	188	**183**	**97**	66-117	
74-87-3	Chloromethane	200	**223**	**112**	51-133	
76-14-2	1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	204	**214**	**105**	65-117	
106-99-0	1,3-Butadiene	206	**205**	**100**	65-132	
74-83-9	Bromomethane	202	**203**	**100**	62-114	
75-00-3	Chloroethane	200	**193**	**97**	64-122	
64-17-5	Ethanol	998	**1060**	**106**	57-131	
75-05-8	Acetonitrile	212	**178**	**84**	52-135	
107-02-8	Acrolein	214	**176**	**82**	64-124	
67-64-1	Acetone	1,080	**1160**	**107**	60-113	
75-69-4	Trichlorofluoromethane	216	**180**	**83**	64-112	
67-63-0	2-Propanol (Isopropyl Alcohol)	418	**450**	**108**	62-129	
107-13-1	Acrylonitrile	212	**210**	**99**	69-133	
75-35-4	1,1-Dichloroethene	216	**203**	**94**	70-114	
75-09-2	Methylene Chloride	222	**199**	**90**	63-103	
107-05-1	3-Chloro-1-propene (Allyl Chloride)	218	**198**	**91**	57-135	
76-13-1	Trichlorotrifluoroethane	220	**191**	**87**	69-116	
75-15-0	Carbon Disulfide	210	**176**	**84**	66-118	
156-60-5	trans-1,2-Dichloroethene	210	**204**	**97**	69-123	
75-34-3	1,1-Dichloroethane	212	**205**	**97**	65-118	
1634-04-4	Methyl tert-Butyl Ether	216	**196**	**91**	57-125	
108-05-4	Vinyl Acetate	1,040	**1060**	**102**	69-131	
78-93-3	2-Butanone (MEK)	220	**214**	**97**	63-121	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
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ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 2 of 3

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150820-LCS
Test Code:	EPA TO-15	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/20/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
156-59-2	cis-1,2-Dichloroethene	218	**218**	**100**	69-119	
141-78-6	Ethyl Acetate	428	**517**	**121**	65-129	
110-54-3	n-Hexane	212	**225**	**106**	55-116	
67-66-3	Chloroform	224	**220**	**98**	68-111	
109-99-9	Tetrahydrofuran (THF)	220	**214**	**97**	69-120	
107-06-2	1,2-Dichloroethane	214	**212**	**99**	67-117	
71-55-6	1,1,1-Trichloroethane	210	**193**	**92**	74-116	
71-43-2	Benzene	226	**211**	**93**	61-109	
56-23-5	Carbon Tetrachloride	230	**203**	**88**	76-120	
110-82-7	Cyclohexane	424	**442**	**104**	72-115	
78-87-5	1,2-Dichloropropane	216	**216**	**100**	67-119	
75-27-4	Bromodichloromethane	218	**216**	**99**	78-124	
79-01-6	Trichloroethene	216	**198**	**92**	69-115	
123-91-1	1,4-Dioxane	210	**218**	**104**	69-127	
80-62-6	Methyl Methacrylate	422	**408**	**97**	76-128	
142-82-5	n-Heptane	216	**211**	**98**	66-118	
10061-01-5	cis-1,3-Dichloropropene	208	**206**	**99**	77-124	
108-10-1	4-Methyl-2-pentanone	220	**215**	**98**	66-134	
10061-02-6	trans-1,3-Dichloropropene	210	**208**	**99**	80-130	
79-00-5	1,1,2-Trichloroethane	216	**208**	**96**	75-119	
108-88-3	Toluene	218	**199**	**91**	68-114	
591-78-6	2-Hexanone	220	**198**	**90**	60-136	
124-48-1	Dibromochloromethane	220	**204**	**93**	75-132	
106-93-4	1,2-Dibromoethane	218	**202**	**93**	72-122	
123-86-4	n-Butyl Acetate	226	**198**	**88**	60-137	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY

Page 3 of 3

Client: **Landau Associates, Inc.**
Client Sample ID: **Lab Control Sample** ALS Project ID: P1503343
Client Project ID: **Cornwall LF / 001037.030.033** ALS Sample ID: P150820-LCS

Test Code: EPA TO-15 Date Collected: NA
Instrument ID: Tekmar AUTOCAN/Agilent 5975Binert/6890N/MS13 Date Received: NA
Analyst: Wida Ang Date Analyzed: 8/20/15
Sample Type: 6.0 L Summa Canister Volume(s) Analyzed: 0.125 Liter(s)
Test Notes:

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
111-65-9	n-Octane	210	**194**	**92**	66-120	
127-18-4	Tetrachloroethene	202	**170**	**84**	67-120	
108-90-7	Chlorobenzene	220	**203**	**92**	69-114	
100-41-4	Ethylbenzene	218	**209**	**96**	71-117	
179601-23-1	m,p-Xylenes	428	**434**	**101**	71-118	
75-25-2	Bromoform	228	**197**	**86**	76-149	
100-42-5	Styrene	222	**210**	**95**	71-128	
95-47-6	o-Xylene	210	**212**	**101**	72-118	
111-84-2	n-Nonane	204	**205**	**100**	63-123	
79-34-5	1,1,2,2-Tetrachloroethane	210	**217**	**103**	73-124	
98-82-8	Cumene	208	**200**	**96**	71-118	
80-56-8	alpha-Pinene	212	**196**	**92**	71-123	
103-65-1	n-Propylbenzene	204	**210**	**103**	71-120	
622-96-8	4-Ethyltoluene	214	**217**	**101**	71-121	
108-67-8	1,3,5-Trimethylbenzene	214	**215**	**100**	72-121	
95-63-6	1,2,4-Trimethylbenzene	218	**250**	**115**	71-122	
100-44-7	Benzyl Chloride	220	**226**	**103**	79-143	
541-73-1	1,3-Dichlorobenzene	228	**232**	**102**	67-121	
106-46-7	1,4-Dichlorobenzene	208	**218**	**105**	68-121	
95-50-1	1,2-Dichlorobenzene	220	**233**	**106**	68-121	
5989-27-5	d-Limonene	210	**208**	**99**	69-137	
96-12-8	1,2-Dibromo-3-chloropropane	218	**194**	**89**	73-145	
120-82-1	1,2,4-Trichlorobenzene	230	**197**	**86**	60-135	
91-20-3	Naphthalene	218	**212**	**97**	63-142	
87-68-3	Hexachlorobutadiene	230	**191**	**83**	65-127	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

EA 7/28/15

```
                          Response Factor Report MS13

Method Path : I:\MS13\METHODS\
Method File : R13072715.M
Title       : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
Last Update : Tue Jul 28 09:12:05 2015
Response Via : Initial Calibration

Calibration Files
0.08=07271502.D  0.10=07271503.D  0.20=07271504.D  0.40=07271505.D  1.0 =07271506.D  5.0 =07271507.D  25   =07271508.D
50   =07271509.D  100 =07271510.D

      Compound            0.08  0.10  0.20  0.40  1.0   5.0   25    50    100   Avg     %RSD
-----------------------------------------------------------------------------------------------

 1) IR  Bromochloromethane... ----------------ISTD--------------------
 2) T   Propene            1.429 1.405 1.227 1.422 1.213 1.423 1.413 1.506 1.624 1.407    8.98
 3) T   Dichlorodifluo... 2.869 2.878 2.864 3.002 2.990 2.939 2.902 2.798 2.573 2.868    4.46
 4) T   Chloromethane      2.149 2.096 2.114 2.108 2.116 1.904 1.875 1.670 1.248 1.920   15.52
 5) T   1,2-Dichloro-1... 1.529 1.653 1.591 1.657 1.686 1.671 1.649 1.604 1.521 1.618    3.75
 6) T   Vinyl Chloride     2.066 2.047 2.070 2.102 2.129 2.042 2.032 1.965 1.854 2.034    4.01
 7) T   1,3-Butadiene      1.438 1.361 1.425 1.469 1.497 1.458 1.500 1.477 1.367 1.444    3.54
 8) T   Bromomethane       1.305 1.237 1.257 1.325 1.374 1.263 1.295 1.292 1.201 1.283    3.98
 9) T   Chloroethane       0.967 0.975 0.935 1.058 1.023 1.004 1.002 0.987 0.951 0.989    3.81
10) T   Ethanol            0.892 0.880 0.863 0.890 0.915 0.898 0.902 0.871 0.809 0.880    3.51
11) T   Acetonitrile       2.901 2.459 2.432 2.516 2.458 2.241 2.258 2.188 2.133 2.398    9.70
12) T   Acrolein           1.013 0.898 0.854 0.915 0.816 0.771 0.816 0.806 0.784 0.852    9.05
13) T   Acetone                  0.991 0.961 0.980 0.985 0.947 0.916 0.850 0.714 0.918   10.29
14) T   Trichlorofluor... 2.496 2.570 2.505 2.699 2.646 2.612 2.623 2.550 2.413 2.568    3.41
15) T   2-Propanol (Is...              3.175 3.023 3.202 2.600 2.665 2.326 1.785 2.682   19.06
16) T   Acrylonitrile      1.497 1.576 1.502 1.682 1.686 1.677 1.719 1.677 1.622 1.626    5.10
17) T   1,1-Dichloroet... 1.217 1.273 1.237 1.329 1.305 1.287 1.313 1.292 1.253 1.278    2.89
18) T   2-Methyl-2-Pro...       3.254 3.338 3.404 3.406 3.128 3.150 2.650 1.625 2.994   20.19
19) T   Methylene Chlo...                   1.644 1.432 1.320 1.320 1.284 1.229 1.372   10.88
20) T   3-Chloro-1-pro... 1.880 1.953 1.767 1.753 1.730 1.687 1.721 1.684 1.623 1.755    5.82
21) T   Trichlorotrifl... 1.169 1.160 1.191 1.304 1.300 1.290 1.327 1.314 1.282 1.260    5.28
22) T   Carbon Disulfide               5.699 5.750 5.390 5.157 5.156 4.948 4.579 5.240    7.90
23) T   trans-1,2-Dich... 1.744 1.842 1.823 1.948 1.944 1.911 1.932 1.865 1.766 1.864    4.09
24) T   1,1-Dichloroet... 2.248 2.300 2.256 2.376 2.378 2.343 2.351 2.270 2.151 2.297    3.22
25) T   Methyl tert-Bu... 4.200 4.237 4.155 4.292 4.151 4.052 4.071 3.914 3.612 4.076    5.07
26) T   Vinyl Acetate            0.310 0.303 0.330 0.318 0.322 0.353 0.325 0.264 0.316    8.09
27) T   2-Butanone (MEK)   0.879 0.769 0.811 0.847 0.890 0.891 0.907 0.892 0.856 0.860    5.26
28) T   cis-1,2-Dichlo... 1.634 1.711 1.718 1.770 1.767 1.766 1.800 1.734 1.638 1.726    3.40
29) T   Diisopropyl Ether 1.138 1.214 1.233 1.291 1.315 1.318 1.351 1.254 1.040 1.239    7.96
30) T   Ethyl Acetate      0.406 0.435 0.427 0.479 0.469 0.474 0.480 0.442 0.352 0.440    9.58
31) T   n-Hexane           2.148 2.092 2.131 2.208 2.116 2.065 2.032 1.905 1.652 2.039    8.25
32) T   Chloroform         2.251 2.293 2.259 2.351 2.307 2.258 2.282 2.186 2.022 2.245    4.23
33) S   1,2-Dichloroet... 1.641 1.654 1.652 1.637 1.612 1.609 1.573 1.566 1.541 1.609    2.55
34) T   Tetrahydrofura... 0.755 0.826 0.812 0.853 0.868 0.848 0.876 0.857 0.825 0.836    4.42
35) T   Ethyl tert-But... 1.523 1.503 1.542 1.639 1.650 1.646 1.687 1.643 1.541 1.597    4.30
36) T   1,2-Dichloroet... 1.601 1.689 1.681 1.792 1.755 1.739 1.752 1.685 1.564 1.695    4.40

37) IR  1,4-Difluorobenzen... ----------------ISTD--------------------
38) T   1,1,1-Trichlor... 0.398 0.410 0.402 0.417 0.414 0.412 0.423 0.409 0.386 0.408    2.70
39) T   Isopropyl Acetate 0.138 0.157 0.153 0.156 0.162 0.159 0.160 0.147 0.123 0.151    8.42
40) T   1-Butanol          0.202 0.197 0.205 0.223 0.235 0.248 0.249 0.228 0.185 0.219   10.53
41) T   Benzene            1.269 1.269 1.047 1.047 0.998 0.971 0.977 0.893 0.692 1.018   17.49
42) T   Carbon Tetrach... 0.322 0.346 0.329 0.357 0.363 0.364 0.385 0.375 0.356 0.355    5.70

R13072715.M Tue Jul 28 09:18:54 2015                                                   Page: 1
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Response Factor Report MS13

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 Method Path : I:\MS13\METHODS\
 Method File : R13072715.M
 Title       : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
 43) T   Cyclohexane        0.371 0.382 0.380 0.398 0.401 0.397 0.405 0.376 0.314 0.380    7.31
 44) T   tert-Amyl Meth... 0.825 0.823 0.776 0.783 0.776 0.760 0.772 0.737 0.670 0.769    6.05
 45) T   1,2-Dichloropr... 0.228 0.246 0.232 0.253 0.250 0.246 0.251 0.243 0.231 0.242    3.93
 46) T   Bromodichlorom... 0.332 0.342 0.332 0.342 0.350 0.356 0.366 0.353 0.330 0.345    3.53
 47) T   Trichloroethene   0.278 0.278 0.283 0.301 0.309 0.303 0.319 0.311 0.285 0.296    5.27
 48) T   1,4-Dioxane       0.190 0.196 0.201 0.205 0.215 0.213 0.221 0.215 0.200 0.206    5.00
 49) T   2,2,4-Trimethy... 0.999 1.032 1.031 1.055 1.051 1.030 1.044 0.977 0.863 1.009    5.96
 50) T   Methyl Methacr... 0.099 0.096 0.101 0.107 0.111 0.111 0.117 0.112 0.101 0.106    6.81
 51) T   n-Heptane         0.238 0.251 0.246 0.261 0.255 0.252 0.259 0.250 0.231 0.249    3.77
 52) T   cis-1,3-Dichlo... 0.379 0.394 0.379 0.398 0.416 0.414 0.429 0.414 0.385 0.401    4.53
 53) T   4-Methyl-2-pen... 0.205 0.208 0.216 0.228 0.229 0.225 0.232 0.223 0.210 0.220    4.50
 54) T   trans-1,3-Dich... 0.336 0.328 0.345 0.358 0.381 0.383 0.402 0.388 0.365 0.365    6.97
 55) T   1,1,2-Trichlor... 0.235 0.247 0.240 0.252 0.255 0.253 0.264 0.256 0.242 0.249    3.66

 56) IR  Chlorobenzene-d5 (... ----------------ISTD--------------------
 57) S   Toluene-d8 (SS2)  2.311 2.309 2.311 2.316 2.316 2.328 2.309 2.326 2.336 2.318    0.42
 58) T   Toluene           2.660 2.686 2.566 2.653 2.652 2.613 2.659 2.520 2.238 2.583    5.41
 59) T   2-Hexanone        1.352 1.312 1.247 1.288 1.327 1.293 1.297 1.229 1.128 1.275    5.21
 60) T   Dibromochlorom... 0.628 0.714 0.671 0.704 0.742 0.767 0.824 0.809 0.771 0.737    8.67
 61) T   1,2-Dibromoethane 0.662 0.647 0.676 0.703 0.735 0.737 0.772 0.751 0.724 0.712    5.98
 62) T   n-Butyl Acetate   1.190 1.419 1.402 1.397 1.410 1.380 1.407 1.336 1.228 1.352    6.30
 63) T   n-Octane          0.552 0.562 0.537 0.597 0.561 0.538 0.540 0.521 0.474 0.542    6.15
 64) T   Tetrachloroethene 0.799 0.789 0.798 0.853 0.857 0.861 0.912 0.902 0.847 0.846    5.21
 65) T   Chlorobenzene     1.604 1.646 1.634 1.726 1.783 1.789 1.842 1.757 1.583 1.707    5.43
 66) T   Ethylbenzene      2.745 2.858 2.772 2.912 2.963 2.974 3.042 2.837 2.421 2.836    6.46
 67) T   m- & p-Xylenes    2.321 2.374 2.251 2.392 2.438 2.456 2.502 2.283 1.834 2.317    8.58
 68) T   Bromoform         0.571 0.593 0.597 0.639 0.669 0.713 0.796 0.789 0.747 0.679   12.66
 69) T   Styrene           1.572 1.649 1.569 1.693 1.830 1.876 1.971 1.867 1.638 1.740    8.50
 70) T   o-Xylene          2.306 2.372 2.275 2.429 2.500 2.512 2.591 2.406 1.993 2.376    7.38
 71) T   n-Nonane          1.231 1.236 1.171 1.230 1.188 1.183 1.205 1.112 0.944 1.167    7.88
 72) T   1,1,2,2-Tetrac... 1.044 1.094 1.098 1.155 1.162 1.181 1.227 1.163 1.011 1.126    6.15
 73) S   Bromofluoroben... 0.985 0.984 0.981 0.993 0.997 1.016 1.025 1.036 1.049 1.007    2.50
 74) T   Cumene            2.880 3.071 2.898 3.146 3.205 3.209 3.271 3.003 2.464 3.016    8.25
 75) T   alpha-Pinene      1.319 1.480 1.467 1.571 1.570 1.601 1.647 1.553 1.331 1.504    7.69
 76) T   n-Propylbenzene   3.419 3.557 3.439 3.710 3.833 3.848 3.884 3.521 2.834 3.561    9.14
 77) T   3-Ethyltoluene    2.809 2.889 2.777 2.986 3.159 3.179 3.191 3.044 2.380 2.935    8.86
 78) T   4-Ethyltoluene    2.591 2.685 2.548 2.792 2.925 2.982 3.128 2.714 2.263 2.736    9.47
 79) T   1,3,5-Trimethy... 2.375 2.326 2.281 2.454 2.571 2.632 2.711 2.501 2.047 2.433    8.32
 80) T   alpha-Methylst...       1.213 1.181 1.278 1.433 1.505 1.561 1.473 1.247 1.361   10.86
 81) T   2-Ethyltoluene    2.647 2.730 2.734 2.883 3.020 3.072 3.153 2.880 2.338 2.829    8.83
 82) T   1,2,4-Trimethy... 2.347 2.355 2.289 2.446 2.620 2.699 2.709 2.279 1.592 2.371   14.24
 83) T   n-Decane          1.328 1.342 1.268 1.496 1.319 1.349 1.377 1.254 0.981 1.301   10.68
 84) T   Benzyl Chloride   2.084 1.780 1.734 1.834 2.206 2.315 2.469 2.236 1.702 2.040   13.92
 85) T   1,3-Dichlorobe... 1.293 1.243 1.208 1.323 1.523 1.580 1.701 1.577 1.287 1.415   12.71
 86) T   1,4-Dichlorobe... 1.263 1.251 1.190 1.289 1.567 1.628 1.751 1.673 1.441 1.450   14.51
 87) T   sec-Butylbenzene  2.954 3.116 3.099 3.295 3.403 3.473 3.539 3.182 2.519 3.176    9.81
 88) T   4-Isopropyltol...                   3.132 3.265 3.394 3.343 2.739 1.852 2.954   19.93
 89) T   1,2,3-Trimethy... 2.363 2.456 2.404 2.551 2.719 2.796 2.824 2.360 1.628 2.456   14.66
 90) T   1,2-Dichlorobe... 1.288 1.251 1.238 1.341 1.516 1.566 1.654 1.495 1.112 1.384   13.01
 91) T   d-Limonene        0.743 0.842 0.864 0.958 0.973 0.989 0.995 0.884 0.638 0.876   13.92
 92) T   1,2-Dibromo-3-... 0.471 0.458 0.454 0.518 0.587 0.620 0.673 0.664 0.619 0.563   15.71
 93) T   n-Undecane        1.243 1.459 1.275 1.397 1.365 1.413 1.456 1.333 1.071 1.335    9.29
 94) T   1,2,4-Trichlor...                   0.760 1.154 1.201 1.315 1.261 1.109 1.133   17.38
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                              Response Factor Report MS13

   Method Path : I:\MS13\METHODS\
   Method File : R13072715.M
   Title      : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
  95) T   Naphthalene                        2.012 3.752 3.887 4.124 3.546 2.463 3.297   25.91
  96) T   n-Dodecane        1.308 1.237 1.258 1.369 1.289 1.316 1.395 1.190 0.808 1.241   14.03
  97) T   Hexachlorobuta... 0.616 0.595 0.649 0.706 0.719 0.754 0.817 0.793 0.689 0.704   10.81
  98) T   Cyclohexanone     0.699 0.863 0.815 0.829 0.824 0.840 0.854 0.822 0.764 0.812    6.25
  99) T   tert-Butylbenzene 2.154 2.363 2.316 2.479 2.557 2.626 2.592 2.182 1.552 2.313   14.39
 100) T   n-Butylbenzene    2.226 2.293 2.318 2.439 2.663 2.723 2.759 2.494 1.991 2.434   10.45
 ----------------------------------------------------------------------------
  (#) = Out of Range
```

```
                       Evaluate Continuing Calibration Report

  Data File : I:\MS13\DATA\2015 08\19\08191501.D          Vial: 16
  Acq On    : 19 Aug 2015  00:48                      Operator: WA/NL
  Sample    : CCV R13081915 25ng                      Inst    : MS13
  Misc      : S29-08101501/S29-07311501 (8/28)

  Quant Time: Aug 19 11:02:25 2015
  Quant Method : I:\MS13\METHODS\R13072715.M
  Quant Title  : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
  QLast Update : Tue Jul 28 09:12:05 2015
  Response via : Initial Calibration
  DataAcq Meth:TO15.M


  Min. RRF     :   0.000  Min. Rel. Area :  50%  Max. R.T. Dev  0.33min
  Max. RRF Dev :  30%     Max. Rel. Area : 200%

         Compound                          AvgRF   CCRF      %Dev Area% Dev(min)
  -----------------------------------------------------------------------------
   1 IR   Bromochloromethane (IS1)         1.000   1.000       0.0    57  -0.01
   2 T    Propene                          1.407   1.120      20.4    45# -0.01
   3 T    Dichlorodifluoromethane (CF      2.868   2.972      -3.6    58  -0.01
   4 T    Chloromethane                    1.920   2.255     -17.4    69  -0.01
   5 T    1,2-Dichloro-1,1,2,2-tetraf      1.618   1.825     -12.8    63  -0.01
   6 T    Vinyl Chloride                   2.034   2.365     -16.3    66  -0.01
   7 T    1,3-Butadiene                    1.444   1.701     -17.8    65  -0.01
   8 T    Bromomethane                     1.283   1.374      -7.1    60  -0.01
   9 T    Chloroethane                     0.989   1.004      -1.5    57  -0.01
  10 T    Ethanol                          0.880   0.970     -10.2    61  -0.02
  11 T    Acetonitrile                     2.398   2.170       9.5    55  -0.02
  12 T    Acrolein                         0.852   0.799       6.2    56  -0.02
  13 T    Acetone                          0.918   1.021     -11.2    63  -0.02
  14 T    Trichlorofluoromethane           2.568   2.581      -0.5    56  -0.01
  15 T    2-Propanol (Isopropanol)         2.682   3.077     -14.7    66  -0.02
  16 T    Acrylonitrile                    1.626   1.708      -5.0    57  -0.01
  17 T    1,1-Dichloroethene               1.278   1.290      -0.9    56   0.00
  18 T    2-Methyl-2-Propanol (tert-B      2.994   3.489     -16.5    63  -0.02
  19 T    Methylene Chloride               1.372   1.330       3.1    57  -0.01
  20 T    3-Chloro-1-propene (Allyl C      1.755   1.640       6.6    54  -0.01
  21 T    Trichlorotrifluoroethane         1.260   1.227       2.6    53  -0.01
  22 T    Carbon Disulfide                 5.240   5.314      -1.4    59  -0.01
  23 T    trans-1,2-Dichloroethene         1.864   1.913      -2.6    56  -0.01
  24 T    1,1-Dichloroethane               2.297   2.331      -1.5    57   0.00
  25 T    Methyl tert-Butyl Ether          4.076   3.917       3.9    55  -0.01
  26 T    Vinyl Acetate                    0.316   0.390     -23.4    63  -0.01
  27 T    2-Butanone (MEK)                 0.860   0.903      -5.0    57  -0.01
  28 T    cis-1,2-Dichloroethene           1.726   1.816      -5.2    57  -0.01
  29 T    Diisopropyl Ether                1.239   1.433     -15.7    60  -0.01
  30 T    Ethyl Acetate                    0.440   0.548     -24.5    65  -0.01
  31 T    n-Hexane                         2.039   2.194      -7.6    62   0.00
  32 T    Chloroform                       2.245   2.376      -5.8    59  -0.01
  33 S    1,2-Dichloroethane-d4(SS1)       1.609   1.697      -5.5    61  -0.01
  34 T    Tetrahydrofuran (THF)            0.836   0.861      -3.0    56  -0.01
  35 T    Ethyl tert-Butyl Ether           1.597   1.616      -1.2    55  -0.01
  36 T    1,2-Dichloroethane               1.695   1.783      -5.2    58  -0.01

  37 IR   1,4-Difluorobenzene (IS2)        1.000   1.000       0.0    58  -0.01
  38 T    1,1,1-Trichloroethane            0.408   0.404       1.0    55  -0.01
  39 T    Isopropyl Acetate                0.151   0.178     -17.9    65  -0.01
  40 T    1-Butanol                        0.219   0.287     -31.1#   66  -0.01
  41 T    Benzene                          1.018   1.028      -1.0    61   0.00
  42 T    Carbon Tetrachloride             0.355   0.368      -3.7    55   0.00
  43 T    Cyclohexane                      0.380   0.417      -9.7    60   0.00
  44 T    tert-Amyl Methyl Ether           0.769   0.756       1.7    57  -0.01
  45 T    1,2-Dichloropropane              0.242   0.251      -3.7    58  -0.01
  46 T    Bromodichloromethane             0.345   0.370      -7.2    58  -0.01
  47 T    Trichloroethene                  0.296   0.305      -3.0    55  -0.01
  48 T    1,4-Dioxane                      0.206   0.219      -6.3    57   0.00
  49 T    2,2,4-Trimethylpentane (Iso      1.009   1.048      -3.9    58  -0.01
  50 T    Methyl Methacrylate              0.106   0.112      -5.7    55   0.00
  51 T    n-Heptane                        0.249   0.255      -2.4    57   0.00
  52 T    cis-1,3-Dichloropropene          0.401   0.427      -6.5    57  -0.01
  53 T    4-Methyl-2-pentanone             0.220   0.237      -7.7    59  -0.01
  54 T    trans-1,3-Dichloropropene        0.365   0.389      -6.6    56   0.00
  55 T    1,1,2-Trichloroethane            0.249   0.259      -4.0    57  -0.01
```

LH 8/20/15

```
                        Evaluate Continuing Calibration Report

  Data File : I:\MS13\DATA\2015 08\19\08191501.D          Vial: 16
  Acq On    : 19 Aug 2015  00:48                       Operator: WA/NL
  Sample    : CCV R13081915 25ng                       Inst    : MS13
  Misc      : S29-08101501/S29-07311501 (8/28)

  Quant Time: Aug 19 11:02:25 2015
  Quant Method : I:\MS13\METHODS\R13072715.M
  Quant Title  : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
  QLast Update : Tue Jul 28 09:12:05 2015
  Response via : Initial Calibration
  DataAcq Meth:TO15.M


  Min. RRF      :   0.000  Min. Rel. Area :  50%  Max. R.T. Dev  0.33min
  Max. RRF Dev :  30%     Max. Rel. Area : 200%

         Compound                        AvgRF   CCRF      %Dev Area% Dev(min)
  ----------------------------------------------------------------------------

 56 IR   Chlorobenzene-d5 (IS3)          1.000   1.000       0.0   60  -0.01
 57 S    Toluene-d8 (SS2)                2.318   2.278       1.7   59  -0.01
 58 T    Toluene                         2.583   2.545       1.5   57  -0.01
 59 T    2-Hexanone                      1.275   1.310      -2.7   60  -0.01
 60 T    Dibromochloromethane            0.737   0.757      -2.7   55  -0.01
 61 T    1,2-Dibromoethane               0.712   0.726      -2.0   56  -0.01
 62 T    n-Butyl Acetate                 1.352   1.416      -4.7   60  -0.01
 63 T    n-Octane                        0.542   0.527       2.8   58  -0.01
 64 T    Tetrachloroethene               0.846   0.805       4.8   53  -0.01
 65 T    Chlorobenzene                   1.707   1.708      -0.1   55  -0.01
 66 T    Ethylbenzene                    2.836   2.962      -4.4   58  -0.01
 67 T    m- & p-Xylenes                  2.317   2.537      -9.5   61  -0.01
 68 T    Bromoform                       0.679   0.736      -8.4   55  -0.01
 69 T    Styrene                         1.740   1.846      -6.1   56  -0.01
 70 T    o-Xylene                        2.376   2.611      -9.9   60  -0.01
 71 T    n-Nonane                        1.167   1.222      -4.7   61  -0.01
 72 T    1,1,2,2-Tetrachloroethane       1.126   1.290     -14.6   63  -0.01
 73 S    Bromofluorobenzene (SS3)        1.007   1.011      -0.4   59  -0.01
 74 T    Cumene                          3.016   3.220      -6.8   59  -0.01
 75 T    alpha-Pinene                    1.504   1.518      -0.9   55  -0.02
 76 T    n-Propylbenzene                 3.561   3.994     -12.2   62  -0.01
 77 T    3-Ethyltoluene                  2.935   3.236     -10.3   61  -0.02
 78 T    4-Ethyltoluene                  2.736   3.102     -13.4   59  -0.01
 79 T    1,3,5-Trimethylbenzene          2.433   2.708     -11.3   60  -0.01
 80 T    alpha-Methylstyrene             1.361   1.421      -4.4   54  -0.01
 81 T    2-Ethyltoluene                  2.829   3.196     -13.0   61  -0.02
 82 T    1,2,4-Trimethylbenzene          2.371   2.983     -25.8   66  -0.02
 83 T    n-Decane                        1.301   1.474     -13.3   64  -0.01
 84 T    Benzyl Chloride                 2.040   2.474     -21.3   60  -0.01
 85 T    1,3-Dichlorobenzene             1.415   1.649     -16.5   58  -0.01
 86 T    1,4-Dichlorobenzene             1.450   1.657     -14.3   57  -0.02
 87 T    sec-Butylbenzene                3.176   3.587     -12.9   61  -0.01
 88 T    4-Isopropyltoluene (p-Cymen     2.954   3.673     -24.3   66  -0.01
 89 T    1,2,3-Trimethylbenzene          2.456   3.121     -27.1   66  -0.02
 90 T    1,2-Dichlorobenzene             1.384   1.646     -18.9   60  -0.01
 91 T    d-Limonene                      0.876   1.019     -16.3   61  -0.02
 92 T    1,2-Dibromo-3-Chloropropane     0.563   0.615      -9.2   55  -0.01
 93 T    n-Undecane                      1.335   1.514     -13.4   62  -0.01
 94 T    1,2,4-Trichlorobenzene          1.133   1.189      -4.9   54  -0.02
 95 T    Naphthalene                     3.297   4.149     -25.8   60  -0.02
 96 T    n-Dodecane                      1.241   1.527     -23.0   65  -0.02
 97 T    Hexachlorobutadiene             0.704   0.718      -2.0   53  -0.02
 98 T    Cyclohexanone                   0.812   0.866      -6.7   61  -0.01
 99 T    tert-Butylbenzene               2.313   2.819     -21.9   65  -0.01
100 T    n-Butylbenzene                  2.434   2.907     -19.4   63  -0.02
  ----------------------------------------------------------------------------

    (#) = Out of Range               SPCC's out = 0  CCC's out = 0
```

```
                     Evaluate Continuing Calibration Report

Data File: I:\MS13\DATA\2015 08\20\08201501.D
Acq On    : 20 Aug 2015   4:35                   Operator: WA/NL
Sample    : CCV R13082015 25ng
Misc      : S29-08101501/S29-07311501 (8/28)
ALS Vial  : 16   Sample Multiplier: 1

Quant Time: Aug 20 07:18:38 2015
Quant Method : I:\MS13\METHODS\R13072715.M
Quant Title  : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
QLast Update : Tue Jul 28 09:12:05 2015
Response via : Initial Calibration
DataAcq Meth:TO15.M
```

WA 8/21/15

```
Min. RRF     :   0.000  Min. Rel. Area :  50%  Max. R.T. Dev  0.33min
Max. RRF Dev :  30%     Max. Rel. Area : 200%

       Compound                      AvgRF   CCRF     %Dev Area% Dev(min)
----------------------------------------------------------------------------
 1 IR   Bromochloromethane (IS1)      1.000   1.000       0.0   57  -0.01
 2 T    Propene                       1.407   1.261      10.4   51   0.00
 3 T    Dichlorodifluoromethane (CF   2.868   3.007      -4.8   59   0.00
 4 T    Chloromethane                 1.920   2.318     -20.7   71  -0.01
 5 T    1,2-Dichloro-1,1,2,2-tetraf   1.618   1.834     -13.3   64  -0.01
 6 T    Vinyl Chloride                2.034   2.426     -19.3   68   0.00
 7 T    1,3-Butadiene                 1.444   1.816     -25.8   69  -0.01
 8 T    Bromomethane                  1.283   1.577     -22.9   70  -0.01
 9 T    Chloroethane                  0.989   1.034      -4.6   59   0.00
10 T    Ethanol                       0.880   1.001     -13.7   63  -0.02
11 T    Acetonitrile                  2.398   2.252       6.1   57  -0.02
12 T    Acrolein                      0.852   0.827       2.9   58  -0.01
13 T    Acetone                       0.918   1.045     -13.8   65  -0.01
14 T    Trichlorofluoromethane        2.568   2.587      -0.7   56  -0.01
15 T    2-Propanol (Isopropanol)      2.682   3.146     -17.3   68  -0.01
16 T    Acrylonitrile                 1.626   1.742      -7.1   58  -0.01
17 T    1,1-Dichloroethene            1.278   1.286      -0.6   56   0.00
18 T    2-Methyl-2-Propanol (tert-B   2.994   3.517     -17.5   64  -0.01
19 T    Methylene Chloride            1.372   1.342       2.2   58  -0.01
20 T    3-Chloro-1-propene (Allyl C   1.755   1.702       3.0   57   0.00
21 T    Trichlorotrifluoroethane      1.260   1.206       4.3   52  -0.01
22 T    Carbon Disulfide              5.240   5.303      -1.2   59  -0.01
23 T    trans-1,2-Dichloroethene      1.864   1.947      -4.5   58  -0.01
24 T    1,1-Dichloroethane            2.297   2.370      -3.2   58   0.00
25 T    Methyl tert-Butyl Ether       4.076   3.958       2.9   56  -0.01
26 T    Vinyl Acetate                 0.316   0.389     -23.1   63   0.00
27 T    2-Butanone (MEK)              0.860   0.900      -4.7   57  -0.01
28 T    cis-1,2-Dichloroethene        1.726   1.832      -6.1   58  -0.01
29 T    Diisopropyl Ether             1.239   1.447     -16.8   61  -0.01
30 T    Ethyl Acetate                 0.440   0.558     -26.8   66  -0.01
31 T    n-Hexane                      2.039   2.240      -9.9   63   0.00
32 T    Chloroform                    2.245   2.379      -6.0   60  -0.01
33 S    1,2-Dichloroethane-d4(SS1)    1.609   1.726      -7.3   63  -0.01
34 T    Tetrahydrofuran (THF)         0.836   0.864      -3.3   56  -0.01
35 T    Ethyl tert-Butyl Ether        1.597   1.626      -1.8   55  -0.01
36 T    1,2-Dichloroethane            1.695   1.795      -5.9   59  -0.01

37 IR   1,4-Difluorobenzene (IS2)     1.000   1.000       0.0   58  -0.01
38 T    1,1,1-Trichloroethane         0.408   0.400       2.0   55  -0.01
39 T    Isopropyl Acetate             0.151   0.180     -19.2   66  -0.01
40 T    1-Butanol                     0.219   0.289     -32.0#  68  -0.01
41 T    Benzene                       1.018   1.023      -0.5   61  -0.01
42 T    Carbon Tetrachloride          0.355   0.362      -2.0   55   0.00
43 T    Cyclohexane                   0.380   0.419     -10.3   60   0.00
44 T    tert-Amyl Methyl Ether        0.769   0.757       1.6   57  -0.01
45 T    1,2-Dichloropropane           0.242   0.254      -5.0   59  -0.01
46 T    Bromodichloromethane          0.345   0.369      -7.0   59  -0.01
47 T    Trichloroethene               0.296   0.303      -2.4   55  -0.01
48 T    1,4-Dioxane                   0.206   0.221      -7.3   58   0.00
49 T    2,2,4-Trimethylpentane (Iso   1.009   1.063      -5.4   59  -0.01
50 T    Methyl Methacrylate           0.106   0.111      -4.7   56  -0.01
51 T    n-Heptane                     0.249   0.257      -3.2   58  -0.01
52 T    cis-1,3-Dichloropropene       0.401   0.427      -6.5   58  -0.01
53 T    4-Methyl-2-pentanone          0.220   0.240      -9.1   60  -0.01
54 T    trans-1,3-Dichloropropene     0.365   0.390      -6.8   56   0.00
```

```
                    Evaluate Continuing Calibration Report

 Data File: I:\MS13\DATA\2015 08\20\08201501.D
 Acq On    : 20 Aug 2015   4:35                    Operator: WA/NL
 Sample    : CCV R13082015 25ng
 Misc      : S29-08101501/S29-07311501 (8/28)
 ALS Vial  : 16   Sample Multiplier: 1

 Quant Time: Aug 20 07:18:38 2015
 Quant Method : I:\MS13\METHODS\R13072715.M
 Quant Title  : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
 QLast Update : Tue Jul 28 09:12:05 2015
 Response via : Initial Calibration
 DataAcq Meth:TO15.M


 Min. RRF     :   0.000  Min. Rel. Area :  50%  Max. R.T. Dev  0.33min
 Max. RRF Dev :  30%     Max. Rel. Area : 200%

        Compound                       AvgRF   CCRF      %Dev Area% Dev(min)
-----------------------------------------------------------------------------
 55 T    1,1,2-Trichloroethane         0.249   0.256       -2.8   56  -0.01

 56 IR   Chlorobenzene-d5 (IS3)        1.000   1.000        0.0   60  -0.01
 57 S    Toluene-d8 (SS2)              2.318   2.282        1.6   60  -0.01
 58 T    Toluene                       2.583   2.521        2.4   57  -0.01
 59 T    2-Hexanone                    1.275   1.331       -4.4   62  -0.01
 60 T    Dibromochloromethane          0.737   0.744       -0.9   54  -0.01
 61 T    1,2-Dibromoethane             0.712   0.718       -0.8   56  -0.01
 62 T    n-Butyl Acetate               1.352   1.442       -6.7   62  -0.02
 63 T    n-Octane                      0.542   0.532        1.8   59  -0.01
 64 T    Tetrachloroethene             0.846   0.786        7.1   52  -0.01
 65 T    Chlorobenzene                 1.707   1.691        0.9   55  -0.01
 66 T    Ethylbenzene                  2.836   2.923       -3.1   58  -0.02
 67 T    m- & p-Xylenes                2.317   2.505       -8.1   60  -0.02
 68 T    Bromoform                     0.679   0.713       -5.0   54  -0.01
 69 T    Styrene                       1.740   1.802       -3.6   55  -0.01
 70 T    o-Xylene                      2.376   2.574       -8.3   60  -0.01
 71 T    n-Nonane                      1.167   1.233       -5.7   62  -0.02
 72 T    1,1,2,2-Tetrachloroethane     1.126   1.273      -13.1   62  -0.01
 73 S    Bromofluorobenzene (SS3)      1.007   0.967        4.0   57  -0.01
 74 T    Cumene                        3.016   3.145       -4.3   58  -0.01
 75 T    alpha-Pinene                  1.504   1.543       -2.6   56  -0.02
 76 T    n-Propylbenzene               3.561   3.898       -9.5   60  -0.01
 77 T    3-Ethyltoluene                2.935   3.191       -8.7   60  -0.02
 78 T    4-Ethyltoluene                2.736   2.981       -9.0   57  -0.02
 79 T    1,3,5-Trimethylbenzene        2.433   2.631       -8.1   58  -0.01
 80 T    alpha-Methylstyrene           1.361   1.388       -2.0   54  -0.02
 81 T    2-Ethyltoluene                2.829   3.099       -9.5   59  -0.02
 82 T    1,2,4-Trimethylbenzene        2.371   2.938      -23.9   65  -0.02
 83 T    n-Decane                      1.301   1.455      -11.8   64  -0.02
 84 T    Benzyl Chloride               2.040   2.453      -20.2   60  -0.01
 85 T    1,3-Dichlorobenzene           1.415   1.588      -12.2   56  -0.02
 86 T    1,4-Dichlorobenzene           1.450   1.597      -10.1   55  -0.02
 87 T    sec-Butylbenzene              3.176   3.498      -10.1   60  -0.01
 88 T    4-Isopropyltoluene (p-Cymen   2.954   3.596      -21.7   65  -0.02
 89 T    1,2,3-Trimethylbenzene        2.456   3.074      -25.2   66  -0.02
 90 T    1,2-Dichlorobenzene           1.384   1.599      -15.5   58  -0.01
 91 T    d-Limonene                    0.876   1.025      -17.0   62  -0.02
 92 T    1,2-Dibromo-3-Chloropropane   0.563   0.583       -3.6   52  -0.01
 93 T    n-Undecane                    1.335   1.490      -11.6   62  -0.01
 94 T    1,2,4-Trichlorobenzene        1.133   1.131        0.2   52  -0.02
 95 T    Naphthalene                   3.297   3.997      -21.2   58  -0.02
 96 T    n-Dodecane                    1.241   1.507      -21.4   65  -0.02
 97 T    Hexachlorobutadiene           0.704   0.683        3.0   50  -0.02
 98 T    Cyclohexanone                 0.812   0.867       -6.8   61  -0.01
 99 T    tert-Butylbenzene             2.313   2.763      -19.5   64  -0.01
100 T    n-Butylbenzene                2.434   2.824      -16.0   62  -0.02
-----------------------------------------------------------------------------

   (#) = Out of Range               SPCC's out = 0  CCC's out = 0
```

ALS ENVIRONMENTAL

RESULTS OF ANALYSIS
Page 1 of 1

Client: **Landau Associates, Inc.**
Client Project ID: **Cornwall LF / 001037.030.033** ALS Project ID: P1503343

Vinyl Chloride

Test Code: EPA TO-15 SIM
Instrument ID: Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19 Date(s) Collected: 8/7/15
Analyst: Wida Ang Date Received: 8/13/15
Sample Type: 6.0 L Summa Canister(s) Date Analyzed: 8/20/15
Test Notes:

Client Sample ID	ALS Sample ID	Injection Volume Liter(s)	Canister Dilution Factor	**Result µg/m³**	MRL µg/m³	MDL µg/m³	**Result ppbV**	MRL ppbV	MDL ppbV	**Data Qualifier**
CL-LFG-P-12	P1503343-002	0.025	1.54	ND	1.5	0.47	ND	0.60	0.18	
CL-LFG-P-3	P1503343-004	0.050	1.51	**0.67**	0.76	0.23	**0.26**	0.30	0.090	**J**
Method Blank	P150820-MB	1.00	1.00	ND	0.025	0.0076	ND	0.0098	0.0030	

ND = Compound was analyzed for, but not detected above the laboratory detection limit.
MRL = Method Reporting Limit - The minimum quantity of a target analyte that can be confidently determined by the referenced method.
J = The analyte was positively identified below the laboratory method reporting limit; the associated numerical value is considered estimated.

ALS ENVIRONMENTAL

SURROGATE SPIKE RECOVERY RESULTS

Page 1 of 1

Client: **Landau Associates, Inc.**
Client Project ID: **Cornwall LF / 001037.030.033**
ALS Project ID: P1503343

Test Code:	EPA TO-15 SIM		
Instrument ID:	Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19	Date(s) Collected:	8/7/15
Analyst:	Wida Ang	Date(s) Received:	8/13/15
Sample Type:	6.0 L Summa Canister(s)	Date(s) Analyzed:	8/20/15
Test Notes:			

Client Sample ID	**ALS Sample ID**	**1,2-Dichloroethane-d4 % Recovered**	**Toluene-d8 % Recovered**	**Bromofluorobenzene % Recovered**	Acceptance Limits	**Data Qualifier**
Method Blank	P150820-MB	**105**	**104**	**99**	70-130	
Lab Control Sample	P150820-LCS	**104**	**99**	**107**	70-130	
CL-LFG-P-12	P1503343-002	**105**	**110**	**42**	70-130	**S**
CL-LFG-P-3	P1503343-004	**105**	**106**	**106**	70-130	

Surrogate percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly from the on-column percent recovery.
S = Surrogate recovery not within specified limits.

ALS ENVIRONMENTAL

LABORATORY CONTROL SAMPLE SUMMARY
Page 1 of 1

Client:	**Landau Associates, Inc.**		
Client Sample ID:	**Lab Control Sample**	ALS Project ID:	P1503343
Client Project ID:	**Cornwall LF / 001037.030.033**	ALS Sample ID:	P150820-LCS
Test Code:	EPA TO-15 SIM	Date Collected:	NA
Instrument ID:	Tekmar AUTOCAN/Agilent 5973N/HP6890A/MS19	Date Received:	NA
Analyst:	Wida Ang	Date Analyzed:	8/20/15
Sample Type:	6.0 L Summa Canister	Volume(s) Analyzed:	0.125 Liter(s)
Test Notes:			

CAS #	**Compound**	Spike Amount µg/m³	**Result µg/m³**	**% Recovery**	ALS Acceptance Limits	**Data Qualifier**
75-01-4	Vinyl Chloride	4.00	**3.39**	**85**	64-118	

Laboratory Control Sample percent recovery is verified and accepted based on the on-column result.
Reported results are shown in concentration units and as a result of the calculation, may vary slightly.

```
                         Response Factor Report MS19

Method Path : I:\MS19\METHODS\
Method File : S19071415.M
Title       : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
Last Update  : Wed Jul 15 07:17:15 2015
Response Via : Initial Calibration

Calibration Files
10  =07141505.D  20  =07141506.D  50  =07141507.D  100 =07141516.D  500 =07141509.D  2000=07141510.D  5000=07141511.D
10K =07141512.D  20K =07141513.D  50K =07141514.D

     Compound          10    20    50    100   500   2000  5000  10K   20K   50K   Avg      %RSD
-------------------------------------------------------------------------------------------------

 1) I   Bromochloromethane... ----------------ISTD--------------------
 2) T   Dichlorodifluo... 3.098 2.726 2.680 3.529 2.870 2.613 2.848 2.810 2.627 2.681 2.848    9.81
 3) T   Chloromethane     0.873 0.806 0.706 0.929 0.717 0.534 0.657 0.631 0.577 0.547 0.698   19.49
 4) T   1,2-Dichloro,1... 3.577 3.120 3.093 4.022 3.238 3.009 3.245 3.164 2.938 3.000 3.241   10.12
 5) T   Vinyl Chloride    2.963 2.548 2.534 3.336 2.709 2.534 2.717 2.667 2.457 2.483 2.695   10.05
 6) T   1,3-Butadiene     2.422 1.652 1.618 1.571 1.551 1.761 1.388 1.416 1.339 1.680 1.640   18.70
 7) T   Bromomethane      1.308 1.014 1.004 1.434 1.071 0.973 1.090 1.096 1.037 1.063 1.109   13.20
 8) T   Chloroethane      0.862 0.722 0.721 0.971 0.779 0.737 0.795 0.789 0.739 0.746 0.786    9.90
 9) T   Acrolein                0.759 0.699 0.777 0.550 0.526 0.587 0.585 0.546 0.540 0.619   15.96
10) T   Acetone                             0.898 0.669 0.640 0.730 0.741 0.784 0.845 0.758   12.14
11) T   Trichlorofluor... 2.462 2.087 2.044 2.733 2.174 2.043 2.260 2.232 2.098 2.145 2.228    9.77
12) T   1,1-Dichloroet... 1.217 1.000 0.996 1.382 1.099 1.051 1.187 1.187 1.115 1.149 1.138   10.12
13) T   Methylene Chlo...             1.529 1.526 1.172 1.104 1.223 1.213 1.121 1.118 1.251   14.09
14) T   Trichlorotrifl... 1.194 1.033 0.993 1.383 1.055 0.980 1.112 1.134 1.092 1.208 1.119   10.79
15) T   trans-1,2-Dich... 1.246 1.031 1.103 1.516 1.140 1.136 1.291 1.298 1.230 1.266 1.226   11.00
16) T   1,1-Dichloroet... 2.273 1.923 1.886 2.556 2.079 1.971 2.167 2.126 1.977 2.015 2.097    9.53
17) T   Methyl tert-Bu... 3.511 3.002 2.989 4.260 3.436 3.418 3.871 3.890 3.651 3.787 3.581   11.11
18) T   cis-1,2-Dichlo... 1.182 1.158 1.117 1.552 1.241 1.210 1.362 1.363 1.264 1.307 1.276    9.97
19) T   Chloroform                    2.941 3.156 2.228 2.038 2.236 2.204 2.025 2.078 2.363   18.40
20) S   1,2-Dichloroet... 1.846 1.854 1.869 1.850 1.845 1.820 1.779 1.734 1.677 1.623 1.790    4.75
21) T   1,2-Dichloroet... 1.751 1.478 1.507 2.043 1.652 1.559 1.721 1.684 1.549 1.581 1.653    9.96
22) T   1,1,1-Trichlor... 2.213 1.895 1.880 2.489 2.020 1.940 2.156 2.138 2.001 2.064 2.080    8.75
23) T   Benzene                 5.417 4.814 5.965 4.520 4.329 4.798 4.741 4.461 4.650 4.855   10.69
24) T   Carbon Tetrach... 2.330 1.646 1.549 2.088 1.713 1.688 1.893 1.909 1.791 1.883 1.849   12.42

25) I   1,4-Difluorobenzen... ----------------ISTD--------------------
26) T   1,2-Dichloropr... 0.229 0.204 0.199 0.263 0.212 0.202 0.225 0.223 0.208 0.222 0.219    8.55
27) T   Bromodichlorom... 0.320 0.293 0.289 0.370 0.307 0.302 0.345 0.347 0.331 0.371 0.327    9.22
28) T   Trichloroethene   0.314 0.253 0.245 0.331 0.252 0.240 0.271 0.274 0.262 0.297 0.274   11.22
29) T   1,4-Dioxane       0.206 0.168 0.164 0.216 0.170 0.170 0.198 0.201 0.192 0.214 0.190   10.60
30) T   cis-1,3-Dichlo... 0.331 0.290 0.286 0.382 0.317 0.325 0.381 0.387 0.373 0.423 0.349   13.16
31) T   trans-1,3-Dich... 0.276 0.251 0.249 0.334 0.282 0.295 0.352 0.358 0.341 0.369 0.311   14.55
32) T   1,1,2-Trichlor... 0.203 0.178 0.173 0.224 0.182 0.177 0.201 0.199 0.187 0.201 0.193    8.23
33) S   Toluene-d8 (SS2)  0.941 0.943 0.940 0.926 0.915 0.916 0.923 0.912 0.913 0.912 0.924    1.39
34) T   Toluene           1.123 0.908 0.877 1.195 0.889 0.875 1.003 1.002 0.965 1.061 0.990   11.10
35) T   Dibromochlorom... 0.224 0.205 0.205 0.267 0.223 0.227 0.271 0.279 0.269 0.294 0.246   13.36
36) T   1,2-Dibromoethane 0.251 0.216 0.214 0.285 0.230 0.230 0.268 0.272 0.256 0.274 0.250   10.28
37) T   Tetrachloroethene 0.282 0.250 0.238 0.321 0.246 0.240 0.279 0.286 0.281 0.328 0.275   11.64

38) I   Chlorobenzene-d5 (... ----------------ISTD--------------------
39) T   Chlorobenzene     4.013 3.499 3.373 4.567 3.607 3.559 4.125 4.175 3.898 3.762 3.858    9.56
40) T   Ethylbenzene      6.342 5.341 5.134 7.232 5.894 6.151 7.274 7.369 6.922 6.796 6.446   12.50
41) T   m,p-Xylene        4.994 4.105 3.914 5.703 4.782 5.003 5.918 6.055 5.832 6.064 5.237   15.25
```

7/15/15

```
                    Response Factor Report MS19

 Method Path : I:\MS19\METHODS\
 Method File : S19071415.M
 Title      : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
42) T   Styrene            2.897 2.526 2.550 3.572 3.241 3.606 4.429 4.533 4.328 4.260 3.594    21.55
43) T   o-Xylene           2.528 1.994 2.050 2.880 2.419 2.528 3.010 3.043 2.898 2.971 2.632    14.83
44) T   1,1,2,2-Tetrac... 2.138 1.949 2.015 2.545 2.342 2.445 2.887 2.904 2.720 2.713 2.466    14.14
45) S   Bromofluoroben... 2.016 2.008 1.988 2.134 2.034 2.155 2.204 2.249 2.180 2.013 2.098     4.59
46) T   1,3,5-Trimethy... 4.445 3.831 3.947 5.820 5.064 5.398 6.444 6.646 6.312 6.468 5.437    19.75
47) T   1,2,4-Trimethy... 4.388 3.808 3.943 5.758 5.089 5.524 6.705 7.156 7.296 8.180 5.785    26.12
48) T   1,3-Dichlorobe... 2.945 2.548 2.527 3.530 2.879 2.998 3.673 3.879 3.752 4.050 3.278    17.16
49) T   1,4-Dichlorobe... 2.944 2.604 2.555 3.682 2.865 3.064 3.751 3.873 3.732 3.865 3.294    16.29
50) T   1,2-Dichlorobe... 2.779 2.426 2.464 3.444 2.786 2.959 3.610 3.840 3.852 4.447 3.261    20.77
51) T   1,2-Dibromo-3-... 0.582 0.533 0.575 0.776 0.775 0.948 1.212                   0.772    31.62
52) T   1,2,4-Trichlor... 1.775 1.519 1.552 2.112 1.601 1.702 2.031 2.188 2.223 2.477 1.918    17.29
53) T   Naphthalene        0.614 0.513 0.537 0.869 0.647 0.727 0.852 0.948 0.986 1.117 0.781 E1  26.17
54) T   Hexachlorobuta... 1.147 0.968 0.970 1.230 0.993 1.013 1.207 1.296 1.356 1.642 1.182    18.13
--------------------------------------------------------------------------------
(#) = Out of Range
```

```
                    Evaluate Continuing Calibration Report

Data File: I:\MS19\DATA\2015 08\20\08201503.D
Acq On    : 20 Aug 2015   4:30                     Operator: WA
Sample    : CCV S19082015 500pg
Misc      : S29-06231506/S29-07311512 (8/28)
ALS Vial  : 16   Sample Multiplier: 1

Quant Time: Aug 20 08:39:28 2015
Quant Method : I:\MS19\METHODS\S19071415.M
Quant Title  : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
QLast Update : Wed Jul 15 07:17:15 2015
Response via : Initial Calibration
DataAcq Meth:TO15SIM.M


Min. RRF     :   0.000  Min. Rel. Area :  50%  Max. R.T. Dev  0.33min        WA 8/20/15
Max. RRF Dev :  30%     Max. Rel. Area : 200%

       Compound                        AvgRF   CCRF      %Dev Area% Dev(min)
 -----------------------------------------------------------------------------
 1 I    Bromochloromethane (IS1)       1.000   1.000       0.0  123    0.00
 2 T    Dichlorodifluoromethane (CF    2.848   2.674       6.1  115    0.00
 3 T    Chloromethane                  0.698   0.672       3.7  115    0.01
 4 T    1,2-Dichloro,1,1,2,2-tetrac    3.241   2.690      17.0  102    0.01
 5 T    Vinyl Chloride                 2.695   2.407      10.7  109    0.01
 6 T    1,3-Butadiene                  1.640   1.670      -1.8  132    0.02
 7 T    Bromomethane                   1.109   1.026       7.5  118    0.01
 8 T    Chloroethane                   0.786   0.789      -0.4  125    0.01
 9 T    Acrolein                       0.619   0.565       8.7  126    0.01
10 T    Acetone                        0.750   0.831     -10.8  153    0.01
11 T    Trichlorofluoromethane         2.228   2.051       7.9  116    0.00
12 T    1,1-Dichloroethene             1.138   1.077       5.4  120    0.00
13 T    Methylene Chloride             1.251   1.126      10.0  118    0.00
14 T    Trichlorotrifluoroethane       1.119   1.064       4.9  124    0.00
15 T    trans-1,2-Dichloroethene       1.226   1.148       6.4  124    0.00
16 T    1,1-Dichloroethane             2.097   2.022       3.6  120    0.00
17 T    Methyl tert-Butyl Ether        3.581   3.194      10.8  114    0.00
18 T    cis-1,2-Dichloroethene         1.276   1.174       8.0  116    0.00
19 T    Chloroform                     2.363   2.065      12.6  114    0.00
20 S    1,2-Dichloroethane-d4 (SS1)    1.790   1.851      -3.4  123    0.00
21 T    1,2-Dichloroethane             1.653   1.615       2.3  120    0.00
22 T    1,1,1-Trichloroethane          2.080   1.904       8.5  116    0.00
23 T    Benzene                        4.855   4.646       4.3  126    0.00
24 T    Carbon Tetrachloride           1.849   1.618      12.5  116    0.00

25 I    1,4-Difluorobenzene (IS2)      1.000   1.000       0.0  124    0.00
26 T    1,2-Dichloropropane            0.219   0.209       4.6  123    0.00
27 T    Bromodichloromethane           0.327   0.297       9.2  120    0.00
28 T    Trichloroethene                0.274   0.244      10.9  120    0.00
29 T    1,4-Dioxane                    0.190   0.165      13.2  120    0.01
30 T    cis-1,3-Dichloropropene        0.349   0.307      12.0  120    0.00
31 T    trans-1,3-Dichloropropene      0.311   0.273      12.2  120    0.00
32 T    1,1,2-Trichloroethane          0.193   0.175       9.3  119    0.00
33 S    Toluene-d8 (SS2)               0.924   0.918       0.6  124    0.00
34 T    Toluene                        0.990   0.850      14.1  119    0.00
35 T    Dibromochloromethane           0.246   0.223       9.3  124    0.00
36 T    1,2-Dibromoethane              0.250   0.220      12.0  119    0.00
37 T    Tetrachloroethene              0.275   0.254       7.6  128    0.00

38 I    Chlorobenzene-d5 (IS3)         1.000   1.000       0.0  129    0.00
39 T    Chlorobenzene                  3.858   3.337      13.5  120    0.00
40 T    Ethylbenzene                   6.446   5.451      15.4  120    0.00
41 T    m,p-Xylene                     5.237   4.306      17.8  116    0.00
42 T    Styrene                        3.594   2.985      16.9  119    0.00
43 T    o-Xylene                       2.632   2.214      15.9  118    0.00
44 T    1,1,2,2-Tetrachloroethane      2.466   2.178      11.7  120    0.00
45 S    Bromofluorobenzene (SS3)       2.098   2.263      -7.9  144    0.00
46 T    1,3,5-Trimethylbenzene         5.437   4.648      14.5  119    0.00
47 T    1,2,4-Trimethylbenzene         5.785   4.645      19.7  118    0.00
48 T    1,3-Dichlorobenzene            3.278   2.725      16.9  122    0.00
49 T    1,4-Dichlorobenzene            3.294   2.733      17.0  123    0.00
50 T    1,2-Dichlorobenzene            3.261   2.684      17.7  125    0.00
51 T    1,2-Dibromo-3-chloropropane    0.772   0.840      -8.8  140    0.00
52 T    1,2,4-Trichlorobenzene         1.918   1.571      18.1  127    0.00
53 T    Naphthalene                    7.808   5.489      29.7  110    0.00
```

```
                    Evaluate Continuing Calibration Report

 Data File: I:\MS19\DATA\2015 08\20\08201503.D
 Acq On    : 20 Aug 2015   4:30                    Operator: WA
 Sample    : CCV S19082015 500pg
 Misc      : S29-06231506/S29-07311512 (8/28)
 ALS Vial  : 16   Sample Multiplier: 1

 Quant Time: Aug 20 08:39:28 2015
 Quant Method : I:\MS19\METHODS\S19071415.M
 Quant Title  : EPA TO-15 per SOP VOA-TO15 (CASS TO-15/GC-MS)
 QLast Update : Wed Jul 15 07:17:15 2015
 Response via : Initial Calibration
 DataAcq Meth:TO15SIM.M


 Min. RRF     :   0.000  Min. Rel. Area :  50%  Max. R.T. Dev  0.33min
 Max. RRF Dev :  30%     Max. Rel. Area : 200%

        Compound                             AvgRF   CCRF      %Dev Area% Dev(min)
 ---------------------------------------------------------------------------
54 T    Hexachlorobutadiene                  1.182   1.103      6.7  144   0.00
----------------------------------------------------------------------------

   (#) = Out of Range                 SPCC's out = 0  CCC's out = 0
```

ATTACHMENT A.4

Landfill Gas Emissions

Table A-4
Landfill Gas Emissions
Cornwall Avenue Landfill
Bellingham, Washington

	Averaging Period	ASIL (µg/m3)	SQER (lb/averaging period)	De Minimis (lb/averaging period)	WAC Regulatory Action (Report/ Model?)	Emissions Rate		Breathing Zone- Maximum Ambient Concentration[c]
						Maximum[a]	Average[b]	
Chemical	**WAC 173-460 TAPs**					**(lb/day)**	**(lb/year)**	**(µg/m^3)**
Propene	24-hr	3000	394	19.7	no	**5.44E-04**	3.86E-02	4.88E-02
Dichlorodifluoromethane (CFC 12)					not regulated	2.26E-05	2.25E-03	2.03E-03
Chloromethane	24-hr	90	11.8	0.591	no	**6.28E-06**	9.69E-04	5.63E-04
1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)					not regulated	1.84E-04	1.17E-02	1.65E-02
1,3-Butadiene	year	0.00588	1.13	0.0564	no	9.21E-06	**1.40E-03**	8.26E-04
Bromomethane	24-hr	5	0.657	0.0629	no	**7.96E-06**	1.23E-03	7.13E-04
Chloroethane	24-hr	30000	3940	197	no	**7.12E-06**	1.08E-03	6.38E-04
Ethanol					not regulated	3.60E-04	2.69E-02	3.23E-02
Acetonitrile	year	60	11500	576	no	7.54E-06	**1.18E-03**	6.76E-04
Acrolein	24-hr	0.06	0.00789	0.000394	no	**7.12E-06**	1.13E-03	6.38E-04
Acetone					not regulated	8.38E-05	1.29E-02	7.51E-03
Trichlorofluoromethane					not regulated	7.12E-06	1.11E-03	6.38E-04
2-Propanol (Isopropyl Alcohol)	1-hr	3200	7.01	0.35	no	2.35E-05	3.54E-03	2.10E-03
Acrylonitrile	year	0.00345	0.662	0.0331	no	7.12E-06	**1.08E-03**	6.38E-04
1,1-Dichloroethene	24-hr	200	26.3	1.31	no	**7.12E-06**	1.08E-03	6.38E-04
Methylene Chloride	year	1	192	9.59	no	7.12E-06	**1.09E-03**	6.38E-04
3-Chloro-1-propene (Allyl Chloride)	year	0.167	32	1.6	no	6.70E-06	**1.03E-03**	6.01E-04
Trichlorotrifluoroethane					not regulated	7.12E-06	1.09E-03	6.38E-04
Carbon Disulfide	24-hr	800	105	5.26	no	**1.88E-05**	3.04E-03	1.69E-03
trans-1,2-Dichloroethene					not regulated	7.96E-06	1.23E-03	7.13E-04
1,1-Dichloroethane	year	0.625	120	6	no	6.70E-06	**1.03E-03**	6.01E-04
Methyl tert-Butyl Ether	year	3.85	739	36.9	no	7.12E-06	**1.08E-03**	6.38E-04
Vinyl Acetate	24-hr	200	26.3	1.31	no	**2.72E-05**	4.19E-03	2.44E-03
2-Butanone (MEK)	24-hr	5000	657	32.9	no	**1.76E-05**	2.32E-03	1.58E-03
cis-1,2-Dichloroethene					not regulated	1.05E-05	1.44E-03	9.39E-04
Ethyl Acetate					not regulated	2.55E-05	2.83E-03	2.29E-03
n-Hexane	24-hr	700	92	4.6	no	**2.30E-03**	1.26E-01	2.07E-01
Chloroform	year	0.0435	8.35	0.417	no	7.12E-06	**1.25E-03**	6.38E-04
Tetrahydrofuran (THF)					not regulated	1.17E-04	7.77E-03	1.05E-02
1,2-Dichloroethane	year	0.0385	7.39	0.369	no	6.70E-06	**1.03E-03**	6.01E-04
1,1,1-Trichloroethane	24-hr	1000	131	6.57	no	**7.12E-06**	1.08E-03	6.38E-04
Benzene	year	0.0345	6.62	0.331	no	5.03E-05	**5.63E-03**	4.51E-03
Carbon Tetrachloride	year	0.0238	4.57	0.228	no	6.28E-06	**9.68E-04**	5.63E-04
Cyclohexane	24-hr	6000	789	39.4	no	**3.56E-04**	3.36E-02	3.19E-02
1,2-Dichloropropane	year	0.1	19.2	0.959	no	6.70E-06	**1.03E-03**	6.01E-04
Bromodichloromethane	year	0.027	5.18	0.259	no	6.28E-06	**9.62E-04**	5.63E-04
Trichloroethene	year	0.5	95.9	4.8	no	5.86E-06	**9.09E-04**	5.26E-04
1,4-Dioxane	year	0.13	24.9	1.25	no	6.70E-06	**1.03E-03**	6.01E-04
Methyl Methacrylate	24-hr	700	92	4.6	no	**1.30E-05**	1.99E-03	1.16E-03
n-Heptane					not regulated	8.38E-04	5.64E-02	7.51E-02
cis-1,3-Dichloropropene	year	0.0625	12	0.6	no	5.86E-06	**8.95E-04**	5.26E-04
4-Methyl-2-pentanone	24-hr	3000	394	19.7	no	**6.70E-06**	1.08E-03	6.01E-04
trans-1,3-Dichloropropene					not regulated	6.70E-06	1.03E-03	6.01E-04
1,1,2-Trichloroethane	year	0.0625	12	0.6	no	6.70E-06	**1.03E-03**	6.01E-04
Toluene	24-hr	5000	657	32.9	no	**1.38E-04**	2.12E-02	1.24E-02
2-Hexanone					not regulated	6.70E-06	1.03E-03	6.01E-04
Dibromochloromethane	year	0.037	7.1	0.355	no	6.70E-06	**1.03E-03**	6.01E-04
1,2-Dibromoethane	year	0.0141	2.71	0.135	no	6.70E-06	**1.03E-03**	6.01E-04
n-Butyl Acetate					not regulated	6.70E-06	1.26E-03	6.01E-04
n-Octane					not regulated	9.21E-05	1.08E-02	8.26E-03
Tetrachloroethene	year	0.169	32.4	1.62	no	5.86E-06	**8.95E-04**	5.26E-04
Chlorobenzene	24-hr	1000	131	6.57	no	**6.70E-06**	1.03E-03	6.01E-04
Ethylbenzene	year	0.4	76.8	3.84	no	2.30E-05	**3.76E-03**	2.07E-03
m,p-Xylenes					not regulated	4.61E-05	7.29E-03	4.13E-03
Bromoform	year	0.909	174	8.72	no	6.28E-06	**9.62E-04**	5.63E-04
Styrene	24-hr	900	118	5.91	no	**6.28E-06**	1.10E-03	5.63E-04
o-Xylene	24-hr	221	29	1.45	no	**2.14E-05**	3.95E-03	1.91E-03
n-Nonane					not regulated	6.70E-05	4.66E-03	6.01E-03
1,1,2,2-Tetrachloroethane	year	0.0172	3.3	0.165	no	6.28E-06	**9.62E-04**	5.63E-04
Cumene	24-hr	400	52.6	2.63	no	**9.63E-05**	1.10E-02	8.64E-03
alpha-Pinene					not regulated	8.38E-04	4.40E-02	7.51E-02
n-Propylbenzene					not regulated	1.13E-04	7.87E-03	1.01E-02
4-Ethyltoluene					not regulated	6.70E-06	1.14E-03	6.01E-04
1,3,5-Trimethylbenzene					not regulated	7.96E-06	1.54E-03	7.13E-04
1,2,4-Trimethylbenzene					not regulated	1.63E-05	3.00E-03	1.46E-03
Benzyl Chloride	year	0.0204	3.91	0.196	no	4.61E-06	**7.01E-04**	4.13E-04
1,3-Dichlorobenzene					not regulated	6.28E-06	9.95E-04	5.63E-04
1,4-Dichlorobenzene	year	0.0909	17.4	0.872	no	1.34E-05	**1.20E-03**	1.20E-03
1,2-Dichlorobenzene					not regulated	6.28E-06	9.62E-04	5.63E-04
d-Limonene					not regulated	6.28E-05	3.97E-03	5.63E-03
1,2-Dibromo-3-chloropropane	year	0.000526	0.101	0.00505	no	4.10E-06	**6.33E-04**	3.68E-04
1,2,4-Trichlorobenzene					not regulated	6.70E-06	1.03E-03	6.01E-04
Naphthalene	year	0.0294	5.64	0.282	no	7.54E-06	**1.21E-03**	6.76E-04
Hexachlorobutadiene	year	0.0455	8.73	0.437	no	5.86E-06	**8.95E-04**	5.3E-04
Vinyl Chloride	year	0.0128	2.46	0.123	no	7.12E-05	**5.50E-03**	6.4E-03

(a) Maximum emissions rate calculated by applying the maximum detected concentration (each individual compound) to the entire LFG flow rate.

(b) Average annual emissions rate calcuated using average detected concentrations for each compound

(c) Maximum estimated breathing zone concentration provided for comparison to ASILs

Emissions rates shown in **bold** for comparison to applicable averaging period.

ASIL = Ambient Source Impact Level
CAS = Chemical Abstracts Service
lb = pound

µg/m^3 = micrograms per cubic meter
SQER = Small Quantity Emissions Rate
TAPs = Toxic Air Pollutants

WAC = Washington Administrative Code

ATTACHMENT A.5

Landfill Gas Cleanup Levels

Table A-5
Development of MTCA Method B Cleanup Levels for Landfill Gas
Cornwall Avenue Landfill
Bellingham, Washington

Chemical Parameter	Air Method B Non-Cancer (µg/m³)	Air Method B Cancer (µg/m³)	RfDi Inhalation Reference Dose (mg/kg-day)	CPFi Inhalation Cancer Potency Factor (kg-day/mg)
Propene	not listed			
Dichlorodifluoromethane (CFC 12)	4.57E+01		2.86E-02	
Chloromethane	4.11E+01		2.57E-02	
1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	not listed			
1,3-Butadiene	9.14E-01	8.33E-02	5.71E-04	1.50E-01
Bromomethane	2.29E+00		1.43E-03	
Chloroethane	4.57E+03		2.86E+00	
Ethanol	not listed			
Acetonitrile	2.74E+01		1.71E-02	
Acrolein	9.14E-03		5.71E-06	
Acetone	1.42E+04		8.86E+00	
Trichlorofluoromethane	3.20E+02		2.00E-01	
2-Propanol (Isopropyl Alcohol)	not listed			
Acrylonitrile	9.14E-01	3.68E-02	5.71E-04	2.38E-01
1,1-Dichloroethene	9.14E+01		5.71E-02	
Methylene Chloride	2.74E+02	2.50E+02	1.71E-01	3.50E-01
3-Chloro-1-propene (Allyl Chloride)	4.57E-01	4.17E-01	2.86E-04	2.10E-02
Trichlorotrifluoroethane	not listed			
Carbon Disulfide	3.20E+02		2.00E-01	
trans-1,2-Dichloroethene	not listed			
1,1-Dichloroethane		1.56E+00		5.60E-03
Methyl tert-Butyl Ether	1.37E+03	9.62E+00	8.57E-01	9.10E-04
Vinyl Acetate	9.14E+01		5.71E-01	
2-Butanone (MEK)	2.29E+03		1.43E+00	
cis-1,2-Dichloroethene	not listed			
Ethyl Acetate	3.20E+01		2.00E-02	
n-Hexane	3.20E+02		2.00E-01	
Chloroform	4.48E+01	1.09E-01	2.80E-02	8.05E-02
Tetrahydrofuran (THF)	not listed			
1,2-Dichloroethane	3.20E+00	9.62E-02	2.00E-03	9.10E-02
1,1,1-Trichloroethane	2.29E+03		1.43E+00	
Benzene	1.37E+01	3.21E-01	8.57E-03	2.73E-02
Carbon Tetrachloride	4.57E+01	4.17E-01	2.86E-02	2.10E-01
Cyclohexane	2.74E+03		1.71E+00	
1,2-Dichloropropane	1.83E+00	2.50E-01	1.14E-03	3.50E-02
Bromodichloromethane		6.76E-02		1.30E-01
Trichloroethene	9.14E-01	3.70E-01	5.71E-04	Guidance
1,4-Dioxane	1.37E+01	5.00E-01	8.57E-03	1.75E-02
Methyl Methacrylate	3.20E+02		2.00E-01	
n-Heptane	not listed			
cis-1,3-Dichloropropene	9.14E+00	6.25E-01	5.71E-03	1.40E-02
4-Methyl-2-pentanone	1.37E+03		8.57E-01	
trans-1,3-Dichloropropene	not listed			
1,1,2-Trichloroethane	9.14E-02	1.56E-01	5.71E-05	5.60E-02
Toluene	2.29E+03		1.43E+00	
2-Hexanone	not listed			
Dibromochloromethane		9.26E-02		9.45E-02
1,2-Dibromoethane	4.11E+00	4.17E-03	2.57E-03	2.10E+00
n-Butyl Acetate	not listed			
n-Octane	not listed			
Tetrachloroethene	1.83E+01	9.62E+00	1.14E-02	9.10E-04
Chlorobenzene	2.29E+01		1.43E-02	
Ethylbenzene	4.57E+02		2.86E-01	
m,p-Xylenes	4.57E+01		2.86E-02	
Bromoform		2.27E+00		3.85E-01
Styrene	4.57E+02		2.86E-01	
o-Xylene	4.57E+01		2.86E-02	
n-Nonane	not listed			
1,1,2,2-Tetrachloroethane		4.31E-02		2.30E-01
Cumene	1.83E+02		1.14E-01	
alpha-Pinene	not listed			
n-Propylbenzene	4.57E+02		2.86E-01	
4-Ethyltoluene	not listed			
1,3,5-Trimethylbenzene	not listed			
1,2,4-Trimethylbenzene	3.20E+00		2.00E-03	
Benzyl Chloride	4.57E-01	5.10E-02	2.86E-04	1.72E-01
1,3-Dichlorobenzene	not listed			
1,4-Dichlorobenzene	3.66E+02	2.27E-01	2.29E-01	3.85E-02
1,2-Dichlorobenzene	9.14E+01		5.71E-02	
d-Limonene	not listed			
1,2-Dibromo-3-chloropropane	9.14E-02	4.17E-04	5.71E-05	2.10E+01
1,2,4-Trichlorobenzene	9.14E-01		5.71E-04	
Naphthalene	1.37E+00	7.35E-02	8.57E-04	1.19E-01
Hexachlorobutadiene		1.14E-01		7.70E-02
Vinyl Chloride	4.57E+01	2.80E-01	2.86E-02	3.10E-02

Table A-5
Development of MTCA Method B Cleanup Levels for Landfill Gas
Cornwall Avenue Landfill
Bellingham, Washington

Equation 750-1 (Method B Air Cleanup Levels (non-cancer)	
Average Body Weight (ABW) Ecology Default, non-cancer (kg)	16
Unit Conversion Factor (1,000 ug/mg)	1000
Breathing Rate (BR) Ecology Default (m3/day)	10
Inhalation Absorption Fraction (ABS) Ecology Default (unitless)	1.0
Hazard Quotient (unitless)	1
Averaging Time (years)	6
Exposure Duration (years)	6
Exposure Frequency (unitless) (a)	1.00
Equation 750-2 (Method B Air Cleanup Levels (cancer)	
Maximum Cancer Risk Level	1.00E-06
ABW (kg)	70
Averaging Time (years)	75
Unit Conversion Factor (1,000 ug/mg)	1000
Breathing Rate (BR) Ecology Default (m3/day)	20
Inhalation Absorption Fraction (ABS) Ecology Default (unitless)	1.0
Exposure Duration (years)	30
Exposure Frequency (unitless) (a)	1.00

[Equation 750-1]

Non-Cancer

$$\text{Air cleanup level (ug/m}^3\text{)} = \frac{\text{RfD x ABW x UCF x HQ x AT}}{\text{BR x ABS x ED x EF}}$$

[Equation 750-2]

Carcinogens

$$\text{Air cleanup level (ug/m}^3\text{)} = \frac{\text{RISK x ABW x AT x UCF}}{\text{CPF x BR x ABS x ED x EF}}$$

ABS = inhalation absorption fraction
ABW = average body weight
BR = breathing rate
CPFi = Carcinogenic Potency Factor
m3/day = cubic meters per day
Ecology = Washington State Department of Ecology
EPA = US Environmental Protection Agency

kg = kilogram
kg-day/mg = kilograms per day per milligram
ug/m3 = micrograms per cubic meter
ug/mg = micrograms per milligram
mg/kg-day = milligrams per kilogram per day
RfDi = Reference Dose

Table A-6
Landfill Gas Emissions Comparison to Cleanup Levels
Cornwall Avenue Landfill
Bellingham, Washington

	EMISSION RATE	Breathing Zone- Maximum Ambient Concentration		
Chemical	MAX (lb/hr)	5 cfm (each vent) (µg/m3)	Method B Cleanup Level (µg/m³)	Breathing Zone Concentration Above Cleanup Level? (Yes/No)
VOLATILES (lb/hr)				
EPA Method TO-15				
Propene	2.27E-05	4.9E-02	No Criteria	No
Dichlorodifluoromethane (CFC 12)	9.42E-07	2.0E-03	4.57E+01	No
Chloromethane	2.62E-07	5.6E-04	4.11E+01	No
1,2-Dichloro-1,1,2,2-tetrafluoroethane (CFC 114)	7.68E-06	1.7E-02	No Criteria	No
1,3-Butadiene	3.84E-07	8.3E-04	8.33E-02	No
Bromomethane	3.32E-07	7.1E-04	2.29E+00	No
Chloroethane	2.97E-07	6.4E-04	4.57E+03	No
Ethanol	1.50E-05	3.2E-02	No Criteria	No
Acetonitrile	3.14E-07	6.8E-04	2.74E+01	No
Acrolein	2.97E-07	6.4E-04	9.14E-03	No
Acetone	3.49E-06	7.5E-03	1.42E+04	No
Trichlorofluoromethane	2.97E-07	6.4E-04	3.20E+02	No
2-Propanol (Isopropyl Alcohol)	9.77E-07	2.1E-03	No Criteria	No
Acrylonitrile	2.97E-07	6.4E-04	3.68E-02	No
1,1-Dichloroethene	2.97E-07	6.4E-04	9.14E+01	No
Methylene Chloride	2.97E-07	6.4E-04	2.50E+02	No
3-Chloro-1-propene (Allyl Chloride)	2.79E-07	6.0E-04	4.17E-01	No
Trichlorotrifluoroethane	2.97E-07	6.4E-04	No Criteria	No
Carbon Disulfide	7.85E-07	1.7E-03	3.20E+02	No
trans-1,2-Dichloroethene	3.32E-07	7.1E-04	No Criteria	No
1,1-Dichloroethane	2.79E-07	6.0E-04	1.56E+00	No
Methyl tert-Butyl Ether	2.97E-07	6.4E-04	9.62E+00	No
Vinyl Acetate	1.13E-06	2.4E-03	9.14E+01	No
2-Butanone (MEK)	7.33E-07	1.6E-03	2.29E+03	No
cis-1,2-Dichloroethene	4.36E-07	9.4E-04	No Criteria	No
Ethyl Acetate	1.06E-06	2.3E-03	3.20E+01	No
n-Hexane	9.60E-05	2.1E-01	3.20E+02	No
Chloroform	2.97E-07	6.4E-04	1.09E-01	No
Tetrahydrofuran (THF)	4.89E-06	1.1E-02	No Criteria	No
1,2-Dichloroethane	2.79E-07	6.0E-04	9.62E-02	No
1,1,1-Trichloroethane	2.97E-07	6.4E-04	2.29E+03	No
Benzene	2.09E-06	4.5E-03	3.21E-01	No
Carbon Tetrachloride	2.62E-07	5.6E-04	4.17E-01	No
Cyclohexane	1.48E-05	3.2E-02	2.74E+03	No
1,2-Dichloropropane	2.79E-07	6.0E-04	2.50E-01	No
Bromodichloromethane	2.62E-07	5.6E-04	6.76E-02	No
Trichloroethene	2.44E-07	5.3E-04	3.70E-01	No
1,4-Dioxane	2.79E-07	6.0E-04	5.00E-01	No
Methyl Methacrylate	5.41E-07	1.2E-03	3.20E+02	No
n-Heptane	3.49E-05	7.5E-02	No Criteria	No
cis-1,3-Dichloropropene	2.44E-07	5.3E-04	6.25E-01	No
4-Methyl-2-pentanone	2.79E-07	6.0E-04	1.37E+03	No
trans-1,3-Dichloropropene	2.79E-07	6.0E-04	No Criteria	No
1,1,2-Trichloroethane	2.79E-07	6.0E-04	9.14E-02	No
Toluene	5.76E-06	1.2E-02	2.29E+03	No
2-Hexanone	2.79E-07	6.0E-04	No Criteria	No
Dibromochloromethane	2.79E-07	6.0E-04	9.26E-02	No
1,2-Dibromoethane	2.79E-07	6.0E-04	4.17E-03	No
n-Butyl Acetate	2.79E-07	6.0E-04	No Criteria	No
n-Octane	3.84E-06	8.3E-03	No Criteria	No
Tetrachloroethene	2.44E-07	5.3E-04	9.62E+00	No
Chlorobenzene	2.79E-07	6.0E-04	2.29E+01	No
Ethylbenzene	9.60E-07	2.1E-03	4.57E+02	No
m,p-Xylenes	1.92E-06	4.1E-03	4.57E+01	No
Bromoform	2.62E-07	5.6E-04	2.27E+00	No
Styrene	2.62E-07	5.6E-04	4.57E+02	No
o-Xylene	8.90E-07	1.9E-03	4.57E+01	No
n-Nonane	2.79E-06	6.0E-03	No Criteria	No
1,1,2,2-Tetrachloroethane	2.62E-07	5.6E-04	4.31E-02	No
Cumene	4.01E-06	8.6E-03	1.83E+02	No
alpha-Pinene	3.49E-05	7.5E-02	No Criteria	No
n-Propylbenzene	4.71E-06	1.0E-02	4.57E+02	No
4-Ethyltoluene	2.79E-07	6.0E-04	No Criteria	No
1,3,5-Trimethylbenzene	3.32E-07	7.1E-04	No Criteria	No
1,2,4-Trimethylbenzene	6.81E-07	1.5E-03	3.20E+00	No
Benzyl Chloride	1.92E-07	4.1E-04	5.10E-02	No
1,3-Dichlorobenzene	2.62E-07	5.6E-04	No Criteria	No
1,4-Dichlorobenzene	5.58E-07	1.2E-03	2.27E-01	No
1,2-Dichlorobenzene	2.62E-07	5.6E-04	9.14E+01	No
d-Limonene	2.62E-06	5.6E-03	No Criteria	No
1,2-Dibromo-3-chloropropane	1.71E-07	3.7E-04	4.17E-04	No
1,2,4-Trichlorobenzene	2.79E-07	6.0E-04	9.14E-01	No
Naphthalene	3.14E-07	6.8E-04	7.35E-02	No
Hexachlorobutadiene	2.44E-07	5.3E-04	1.14E-01	No
Vinyl Chloride	2.97E-06	6.4E-03	2.80E-01	No

EPA = US Environmental Protection Agency
lb/hr = pounds per hour
µg/m3 = micrograms per cubic meter

ATTACHMENT A.6

Landfill Gas System Design

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA. 98020
Phone: (425) 778-0907 Fax: (425) 778-6409

JOB NO.	0001037.030.031		
JOB NAME	Cornwall Ave Landfill		
SUBJECT	Landfill Gas Control		
CALC BY	JMD	DATE	10/14/2015
CHK BY	KWW	DATE	12/30/2015

Design Elements

1	**Cover System: LFG Collection Layer**	**2**	**Passive LFG Collection Well**
1a	**Transmissivity**	**3**	**LFG Vent**
1b	**Materials of Construction**		

---

1 Cover System: LFG Collection Layer

LFG collection layer will be a component of the cover system, designed to prevent the accumulation of LFG below the impermeable cover system to unsafe or unhealthy concentrations. This layer will be included across the entire Landfill, over both wood waste and MSW.

1a Calculate required transmissivity of LFG collection layer (Thiel 1998)

$$\theta_{gas} = \frac{(surface\ flux)(LFG\ density)}{(\max allowable\ pressure)} \frac{(pipe\ spacing)^2}{8}$$

* Per LandGem model (See attachment A.1), LFG production is approximately 4.6 cubic feet per minute (cfm); design assumption will be 10 cfm.

10 cfm 0.004716667 m^3/s

* LFG collection layer will be approximately 11 acres in area 11 acres 44,515.9 m^2

Surface Flux = > $q_s = \frac{flow}{area}$ 1.1E-07 $m^3 / [m^2 * s]$

* Typical LFG collection layer design includes capture layer, and conveyance pipe to route the captured LFG to vents. Typical pipe spacing is 10 meters. However, based on the very low LFG production and very low surface flux, calculations will assume pipe spacing of 20 meters.

Pipe Spacing = > 20 m

* LFG density = 12.8 N/m3

* Maximum allowable pressure:

Typical maximum pressure is based on protecting cover system from lift that would destabilize slopes.

For this landfill, a lower, more conservative maximum pressure is selected to limit accumulation and pressure buildup that might cause lateral migration.

Maximum Allowable Pressure = > 0.5 inches of water column 125 N/m^2

Minimum Gas Transmissivity = > 5.4E-07 m^2/s

* Multiply by 10 to approximate hydraulic conductivity (to match standard specifications for materials)

* Multiply by 2 for factor of safety to account for biofouling and moisture.

Minimum Hydraulic Transmissivity = > 1.1E-05 m^2/s

1b LFG Collection Layer: Materials of Construction

Concrete Rubble:

Concrete is available at the site that could be broken up and used as transmissive material.
The volume of available concrete is not sufficient to cover the entire 11 acres.
The volume of available concrete could be used to backfill trenches across the surface of the landfill, below the impermeable cover.
However, the cost of processing the concrete and constructing the trenches would be higher than using an imported material.
Additionally, LFG collection and conveyance typically avoids using calcareous media due to potential corrosivity reactions.

Sand:

Conservatively assuming sand has a hydraulic conductivity of 1.0E-04, approximately 0.12 meters (4.7 inches) of sand would provide an adequate collection layer.

Geocomposite:

Geocomposite products are readily available that could be used for the LFG collection layer, which meet the minimum hydraulic conductivity specification. These products could be rolled-out across the surface so have a reasonable installation cost, and some products have integrated conveyance tubing built into the product that could eliminate the need for additional trenching/piping.

---

2 Passive LFG Collection Wells

Four LFG collection wells will be installed into the subsurface of the landfill to provide internal pressure relief in areas where MSW is buried. The collection wells will be constructed to a depth just above the groundwater level. The wells will be completed in flush-mounted subsurface vaults with sampling ports and isolation valves. LFG collected in these wells will be routed directly to the LFG vents through 2-inch SDR-11 HDPE piping. Well construction details reflect the anticipated LFG flow rates, and are sized smaller than typical LFG extraction wells.

---

3 LFG Vents

Two LFG vents will be installed to provide a controlled release of LFG to the atmosphere. Based on the estimated LFP production rates (See A.1), analysis of LFG at the Site (See A.3), dispersion modeling (see A.4), and the cleanup levels developed for protection of human-health breathing ambient air at the Site (See A.5), the vent height will be 12 ft above ground surface, and no treatment of the LFG is required. A wind-powered turbine will be installed at the head of each vent to enhance flow through the LFG collection layer. A subsurface vault will be installed at each vent location which can be used in the future to provide carbon filtration if needed for odor control.

Sources: Thiel, R.S. "Design Methodology for a Gas Pressure Relief Layer Below a Geomembrane Cover to Improve Slope Stability", *Geosynthetics International, Vol 23, Number 2., 2005*

APPENDIX B

Upland Cover Design

Appendix B contains the following Attachments which are referenced in the Text:

- B.1 Boring and Test Pit Logs
- B.2 Geotechnical Testing on IPA Soil
- B.3 Landfill Stability Analysis
- B.4 Stormwater Management Design
  - B.4a Hydrology
  - B.4b Hydraulics
- B.5 HELP Model

ATTACHMENT B.1

Boring and Test Pit Logs

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		**GM**	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		**SW**	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		**SM**	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			**MH**	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK		**RK**	Rock (See Rock Classification)
WOOD		**WD**	Wood, lumber, wood chips
DEBRIS		**DB**	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
> 15% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents: > 5% and ≤ 15% - "with gravel," "with sand," "with silt," etc.
≤ 5% - "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

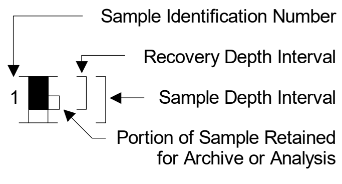
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽	Approximate water level at time of drilling (ATD)
▼	Approximate water level at time other than ATD

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Soil Classification System and Key

Figure
B-1.1

CL-STSED-B-1

LAI Project No: 0001037

SAMPLE DATA

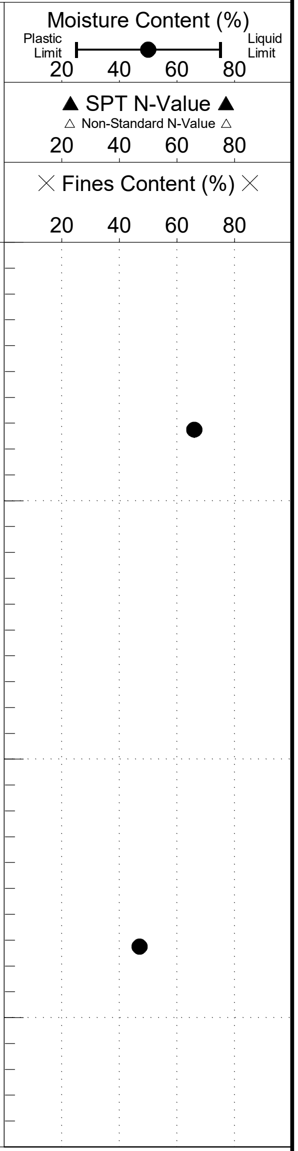
SOIL PROFILE

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 25.4

Logged By: MSM Date: 06/10/15

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Torvane	Graphic Symbol	USCS Symbol	Description	Groundwater
0	25	S1	c2				MH	Gray/brown SILT with trace sand, trace wood debris, and trace shell fragments (marine odor, no sheen) (very loose to loose, damp to moist) **(CEMENT-STABILIZED SEDIMENT)**	Groundwater Not Encountered
		S2	c2		TV = 6 W = 66 D = 59				
5	20	S3	c2		TV = 8				
		S4	c2		TV = 8				
10	15	S5	c2		TV = 8				
		S6	c2		TV = 9 W = 47 D = 68				
15	10								
20									
25									



Boring Completed 06/10/15
Total Depth of Boring = 17.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-1

Figure
B-1.2

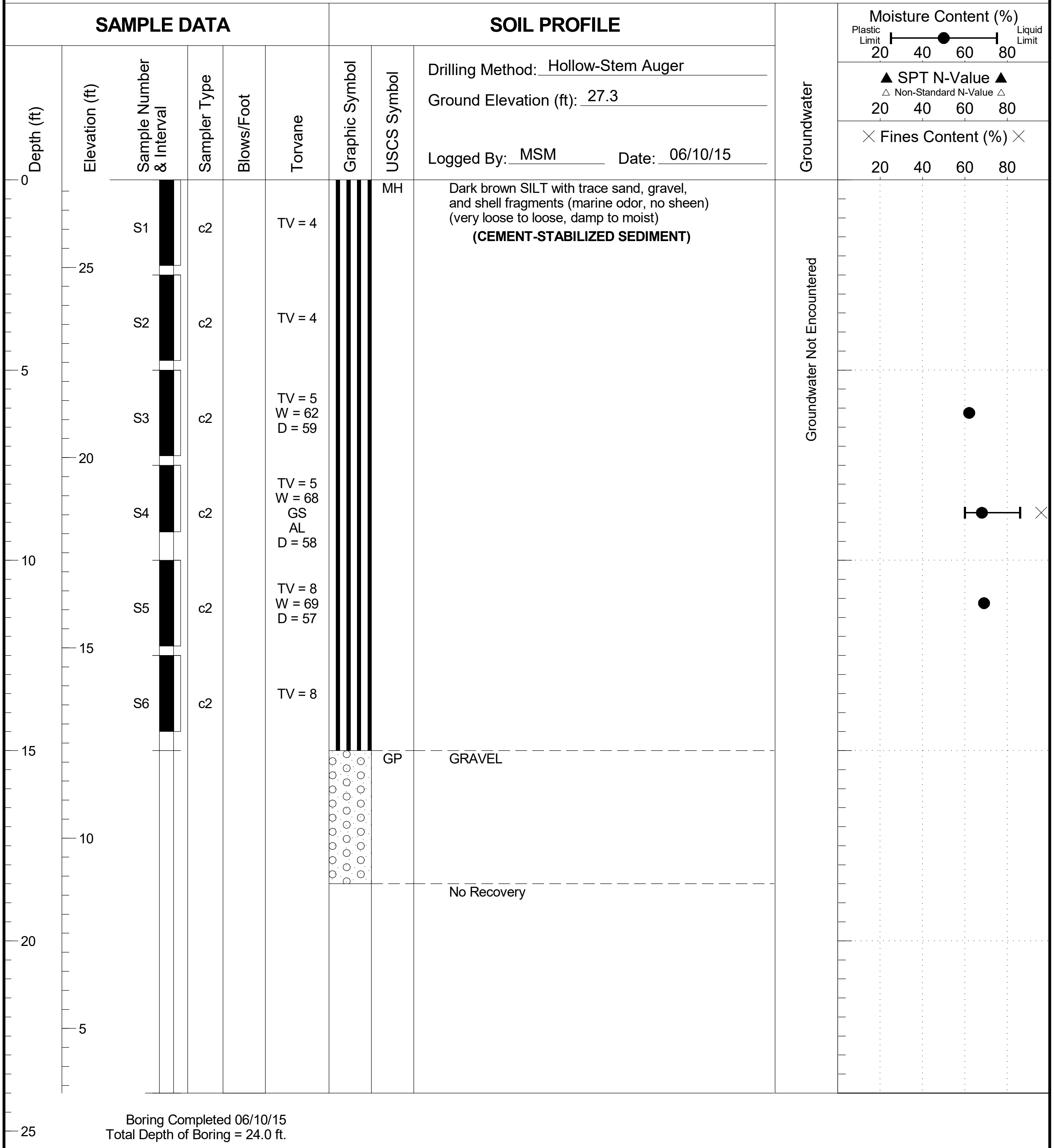
CL-STSED-B-2

LAI Project No: 0001037

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 27.3

Logged By: MSM Date: 06/10/15



Sample Number & Interval	Sampler Type	Blows/Foot	Torvane
S1	c2		TV = 4
S2	c2		TV = 4
S3	c2		TV = 5 W = 62 D = 59
S4	c2		TV = 5 W = 68 GS AL D = 58
S5	c2		TV = 8 W = 69 D = 57
S6	c2		TV = 8

MH Dark brown SILT with trace sand, gravel, and shell fragments (marine odor, no sheen) (very loose to loose, damp to moist)
(CEMENT-STABILIZED SEDIMENT)

GP GRAVEL

No Recovery

Boring Completed 06/10/15
Total Depth of Boring = 24.0 ft.

Notes:
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3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

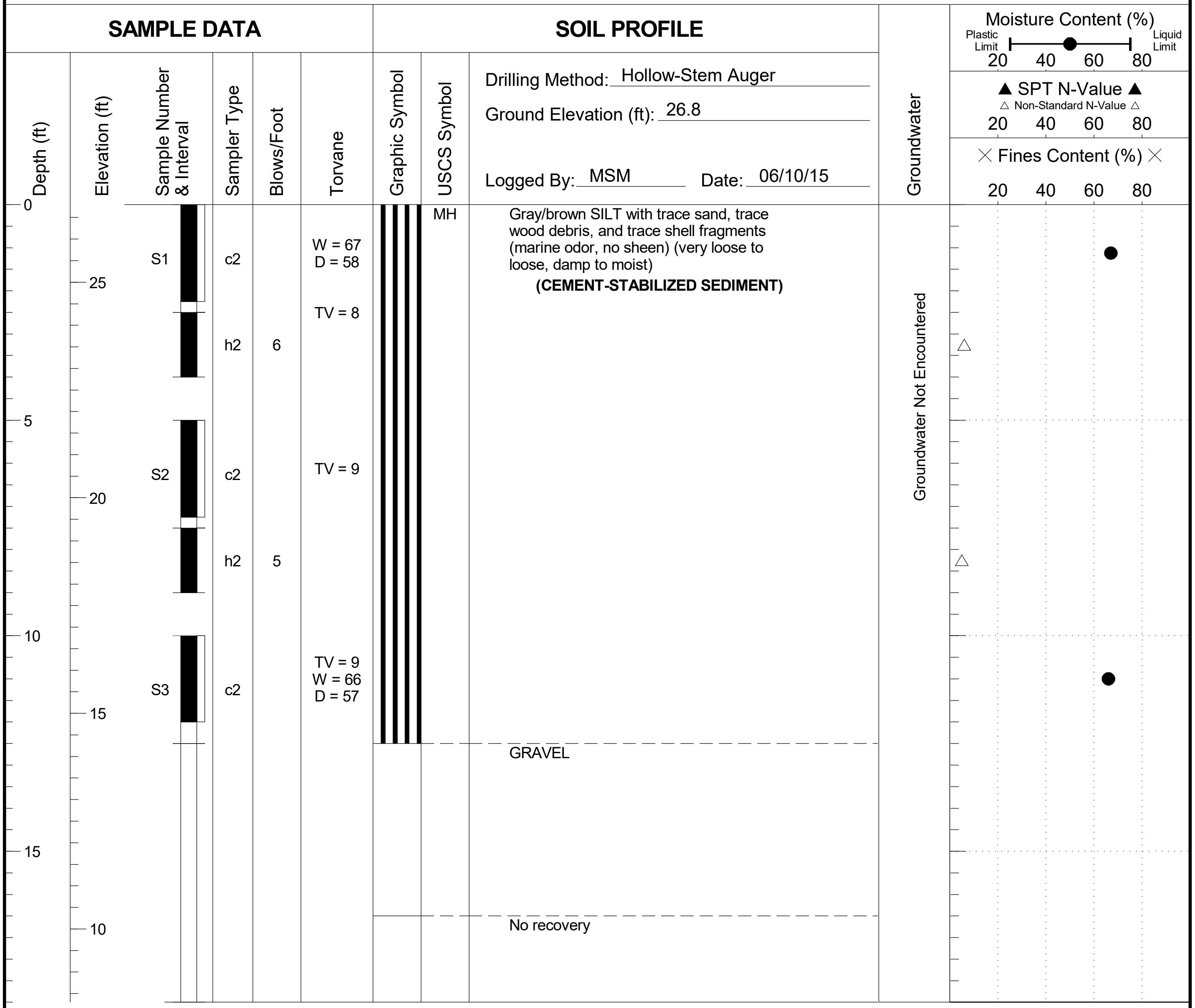
Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-2

Figure
B-1.3

CL-STSED-B-3

LAI Project No: 0001037



Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 26.8

Logged By: MSM Date: 06/10/15

Gray/brown SILT with trace sand, trace wood debris, and trace shell fragments (marine odor, no sheen) (very loose to loose, damp to moist)

(CEMENT-STABILIZED SEDIMENT)

GRAVEL

No recovery

Boring Completed 06/10/15
Total Depth of Boring = 18.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

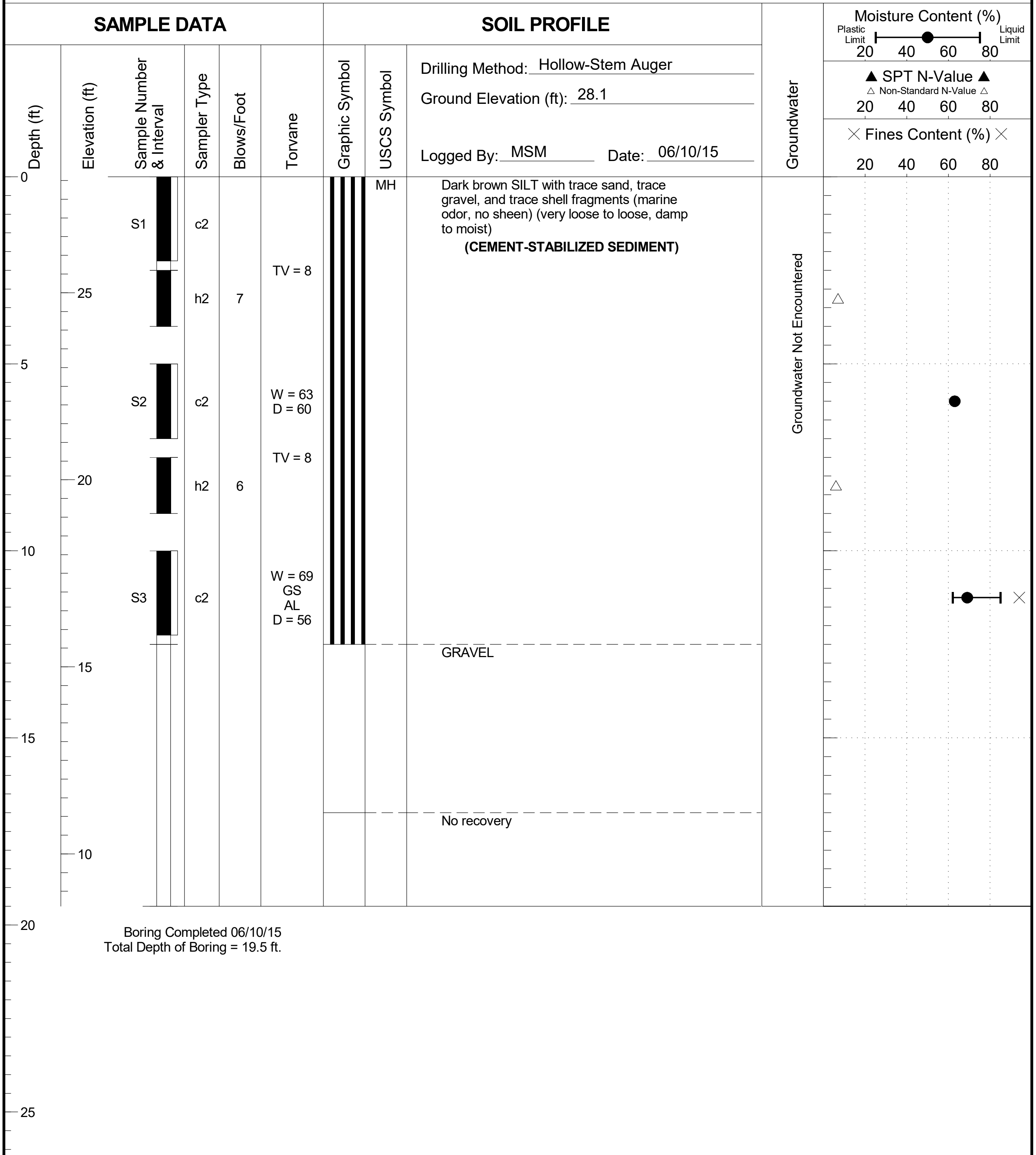
Log of Boring CL-STSED-B-3

Figure
B-1.4

CL-STSED-B-4

LAI Project No: 0001037

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 28.1
Logged By: MSM Date: 06/10/15



Dark brown SILT with trace sand, trace gravel, and trace shell fragments (marine odor, no sheen) (very loose to loose, damp to moist)

(CEMENT-STABILIZED SEDIMENT)

GRAVEL

No recovery

Boring Completed 06/10/15
Total Depth of Boring = 19.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-4

Figure
B-1.5

CL-STSED-B-5

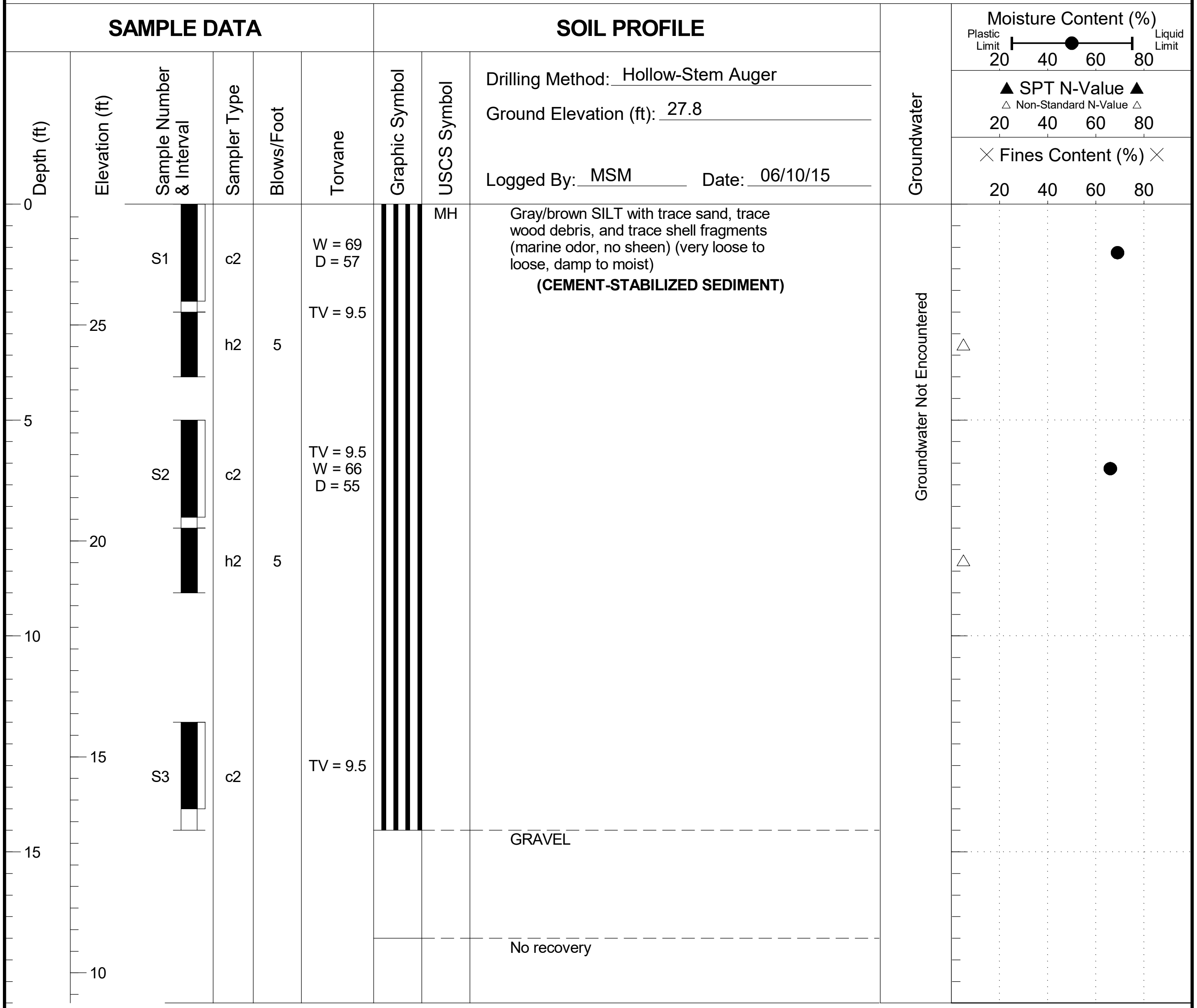
LAI Project No: 0001037

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 27.8

Logged By: MSM

Date: 06/10/15



Sample Number	Sampler Type	Blows/Foot	Torvane
S1	c2		W = 69 D = 57
			TV = 9.5
	h2	5	
S2	c2		TV = 9.5 W = 66 D = 55
	h2	5	
S3	c2		TV = 9.5

MH Gray/brown SILT with trace sand, trace wood debris, and trace shell fragments (marine odor, no sheen) (very loose to loose, damp to moist)
(CEMENT-STABILIZED SEDIMENT)

GRAVEL

No recovery

Boring Completed 06/10/15
Total Depth of Boring = 18.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-5

Figure
B-1.6

CL-STSED-B-6

LAI Project No: 0001037

SAMPLE DATA

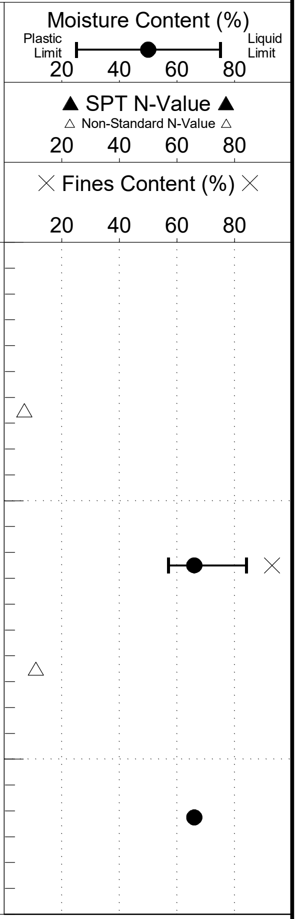
SOIL PROFILE

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 29.6

Logged By: MSM   Date: 06/10/15

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Torvane	USCS Symbol	Description	Groundwater
0		S1	c2		TV = 5	MH	Dark brown SILT with trace sand, trace gravel, and trace shell fragments (marine odor, no sheen) (loose/medium stiff to stiff, damp to moist) **(CEMENT-STABILIZED SEDIMENT)**	Groundwater Not Encountered
			h2	7				
5	25	S2	c2		W = 66 GS AL D = 60 TV = 6			
			h2	11				
10	20	S3	c2		TV = 8 W = 66 D = 58			
							GRAVEL	



Boring Completed 06/10/15
Total Depth of Boring = 13.0 ft.

15

20

25

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-6

Figure
B-1.7

CL-STSED-B-7

LAI Project No: 0001037

SAMPLE DATA

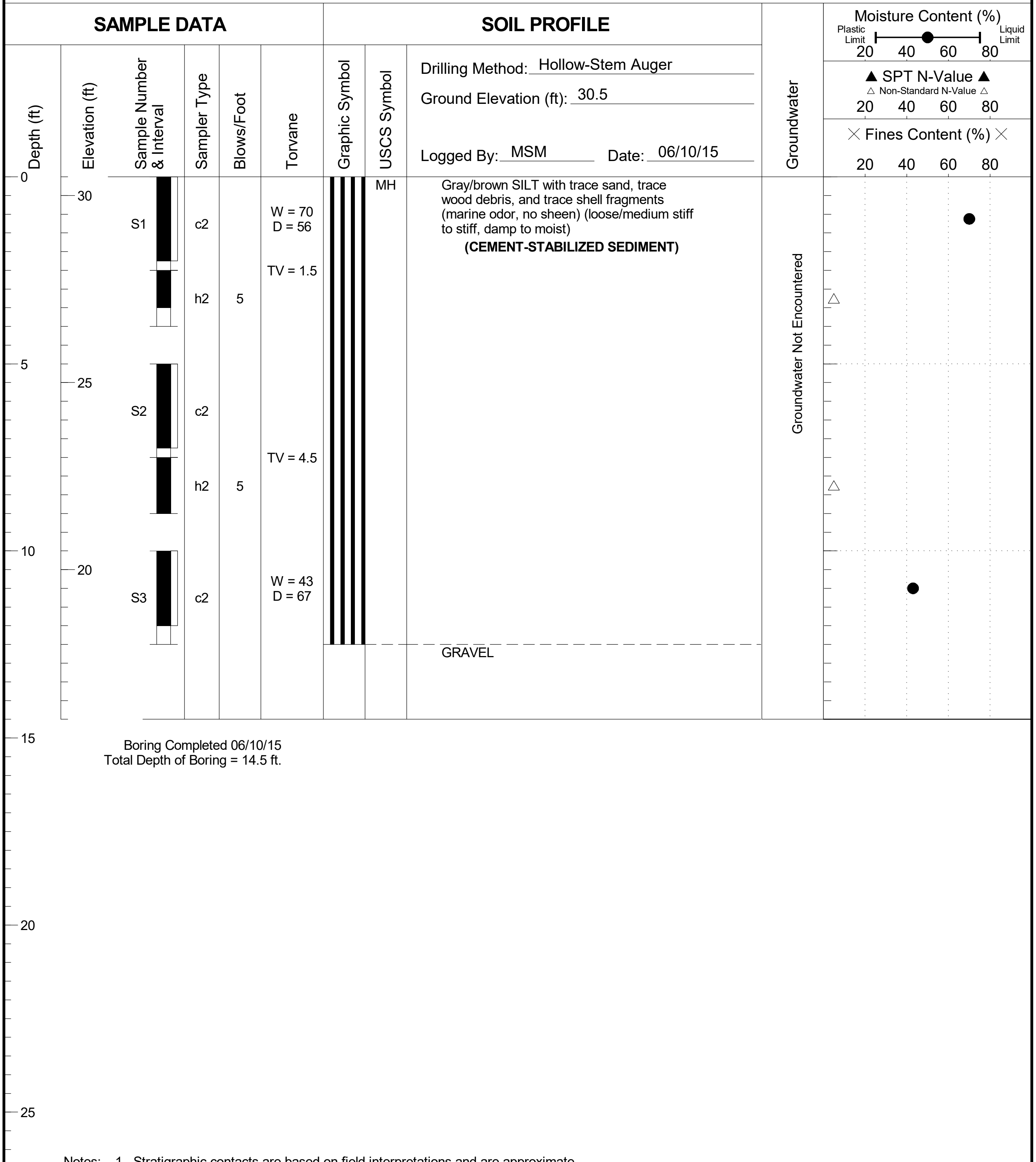
SOIL PROFILE

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): 30.5
Logged By: MSM
Date: 06/10/15

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Torvane
0–2.5	30	S1	c2		W = 70 D = 56
2.5					TV = 1.5
2.5–4			h2	5	
5–7.5	25	S2	c2		
7.5					TV = 4.5
7.5–9			h2	5	
10–12.5	20	S3	c2		W = 43 D = 67

USCS Symbol	Description
MH	Gray/brown SILT with trace sand, trace wood debris, and trace shell fragments (marine odor, no sheen) (loose/medium stiff to stiff, damp to moist) **(CEMENT-STABILIZED SEDIMENT)**
	GRAVEL

Groundwater Not Encountered



Boring Completed 06/10/15
Total Depth of Boring = 14.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-7

Figure
B-1.8

CL-STSED-B-8

LAI Project No: 0001037

SAMPLE DATA

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Torvane
0	30	S1	c2		W = 65 GS AL D = 61 TV = 5
			h2	4	
5	25	S2	c2		TV = 4
			h2	6	
10	20	S3	c2		TV = 6 W = 65 D = 59
15					

SOIL PROFILE

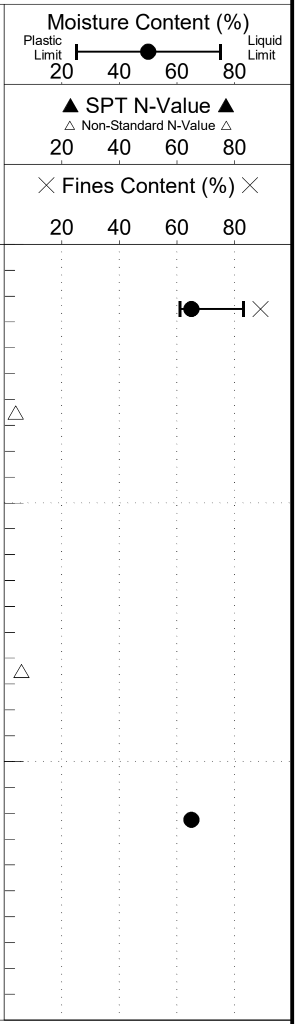
Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): 30.6

Logged By: MSM Date: 06/11/15

Graphic Symbol	USCS Symbol	Description
	MH	Dark brown SILT with trace sand, trace gravel, and trace shell fragments (marine odor, no sheen) (loose/medium stiff to stiff, damp to moist) **(CEMENT-STABILIZED SEDIMENT)**
		GRAVEL

Groundwater: Groundwater Not Encountered



Boring Completed 06/11/15
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized Sediment Borings
Bellingham, Washington

Log of Boring CL-STSED-B-8

Figure
B-1.9

CORNWALL AVENUE LANDFILL
TEST PIT EXCAVATIONS
JUNE 11, 2015

Location	Northing	Easting	Cover thickness (ft)	Surface Elevation (ft MLLW)	Top of Waste Elevation	Cover Soil	Underlying Waste Material
TP-1	638233.9	1239280	3	11.6	8.6	Brown, well graded gravelly sand	Wood debris, with old paper and rubber gasket material mixed in
TP-2	638228.1	1239358	2.5	11.9	9.4	Brown well graded gravelly sand	Wood debris
TP-3	638459.9	1239490	3.6	13.3	9.4	Brown well graded gravelly sand to 2 ft underlain by gray dense gravel	Demolition debris, rebar, concrete rubble, an demolished metal pipe
TP-4	638603.3	1239584	2.2	13.6	11.4	Gray sandy gravel	Demolition and wood debris, concrete rubble with rebar
TP-5	638713.3	1239662	2	13.2	11.2	Brown well graded gravelly sand	Demolition debris, wire and plastic
TP-6	638832.3	1239764	1	13.9	12.9	Gray sandy gravel	Demolition debris, brick, plastic, metal pieces
TP-7	638970.8	1239849	2.2	15.3	13.1	Gray brown, well graded gravelly sand	Demolition debris, concrete rubble, metal pieces
TP-8	639171.9	1239885	1.5	17.2	15.7	Gray gravel and cobbles	Wood debris
TP-9	639248.1	1239816	5.5	19.4	13.9	Brown well graded gravelly sand	Demolition debris, brick, plastic, metal pieces
TP-10	639194.9	1239966	2.3	16.3	14	Gray well graded gravelly sand	Demolition debris, wire and plastic
TP-11	639324.7	1239967	1.1	17	15.9	Brown, well graded gravelly sand	Demolition debris, glass, plastic, and metal pieces
TP-12	638117.9	12393330	2.3	12.3	10	Brown gravelly sand with trace cobbles	Wood debris
TP-13	638222.4	1239454	1.7	11.9	10.2	Dark brown to black fine to medium grained sand with organics	Wood debris and asphalt pieces
TP-14	638410.7	1239559	1.7	11.5	9.8	Brown well graded gravelly sand	Demolition and wood debris, including plastic pipe, and concrete pieces
TP-15	638543.8	1239720	3.1	12.9	9.8	Brown well graded gravelly sand	Demolition debris, with brick and charred wood pieces
TP-16	638624	1239687	3.6	12.4	8.8	Brown well graded gravelly sand	Wood debris with pieces of plastic
TP-17	638619.6	1239793	3.1	13.6	10.5	Brown well graded gravelly sand	Wood debris, with charred wood pieces
TP-18	638742.4	1239878	2.4	14.2	11.8	Asphalt 0.3 ft thick underlain by gray sandy gravel and silt	Demolition debris, with brick and glass, petroleum-like odor
TP-19	638871	1239862	3	14.1	11.1	Brown to gray gravelly sand with cobbles	Wood debris with pieces of concrete
TP-20	638859.4	1239987	1.6	14.4	12.8	Gray well graded gravelly sand	Wood debris with pieces of metal and glass
TP-21	639082.5	1240010	0.8	14.6	13.8	Asphalt 0.75 feet thick	Demolition debris, with brick, plywood and charred wood pieces
TP-22	639004.7	1240103	3	16.4	13.4	Gray brown, sandy gravel	Demolition debris, brick pieces

ATTACHMENT B.2

Geotechnical Testing on IPA Soil

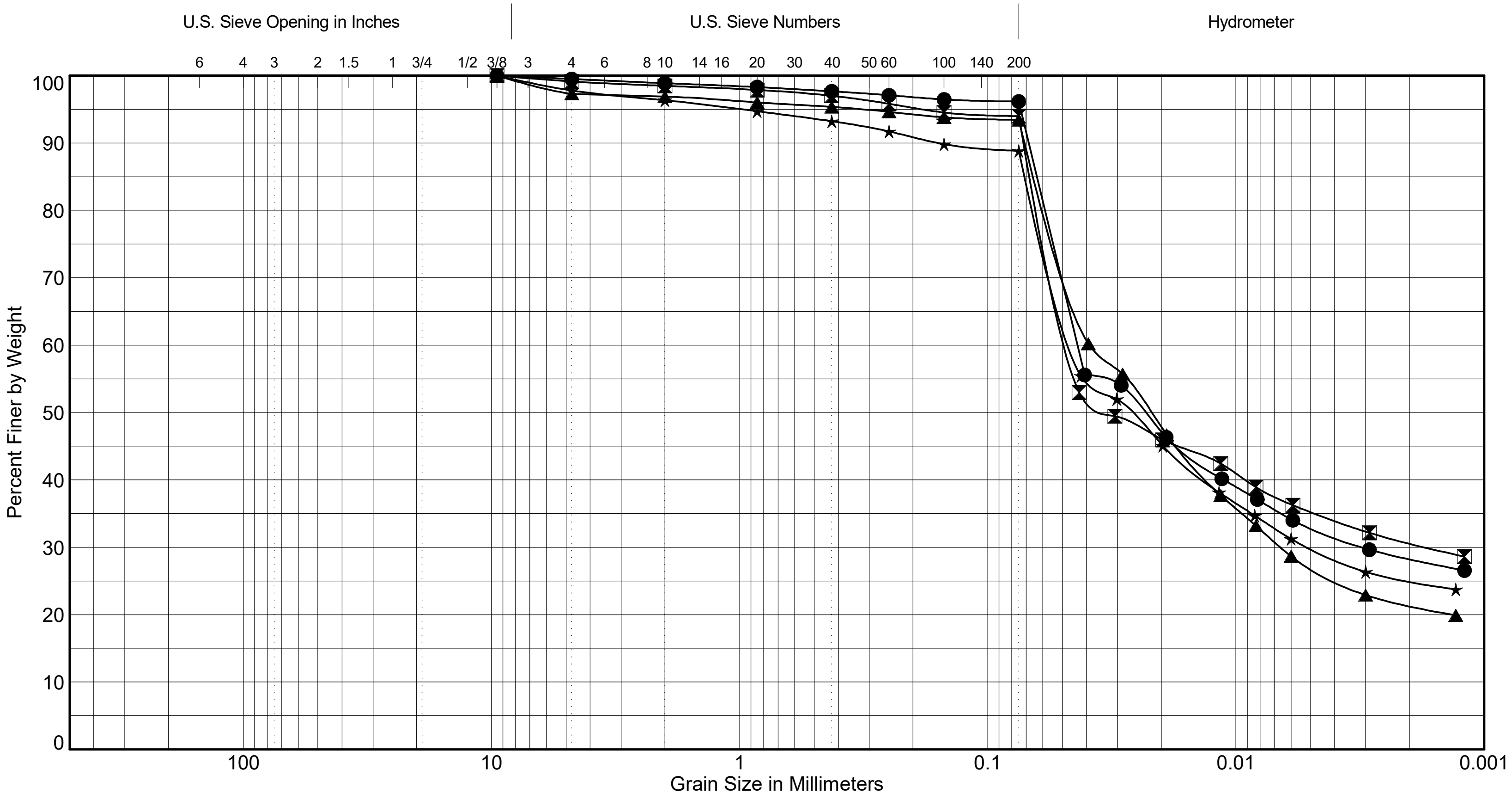
LANDAU ASSOCIATES
Environmental and Geotechnical Services

Laboratory Program Summary

Project Name: Cornwall Landfill - Stabilized Sediment Borings
Project Number: 0001037
Site Location: Bellingham, Washington
Date: 7/16/15
Client/Owner: Port of Bellingham
Landau Rep.: DSB
Report Results to: KWW
Date Results Due: 7/16/15

Exploration	Depth	Lab Specimen	Moisture Content	Unit Weight	Atterberg Limits	Sieve Analysis	- #200 Wash	Hydrometer	Compaction	Classification	Remarks
CL-STSED-B-1	2.5	S2	66.5	59.5							
CL-STSED-B-1	12.5	S6	46.8	67.6							
CL-STSED-B-2	5.0	S3	62.1	59.0							standard
CL-STSED-B-2	7.5	S4	67.6	58.0	PI = 26 PL = 60	Yes	96	Yes		MH	modified
CL-STSED-B-2	10.0	S5	68.7	56.9							
CL-STSED-B-3	0.0	S1	67.2	57.9							
CL-STSED-B-3	10.0	S3	65.8	57.2							
CL-STSED-B-4	5.0	S2	63.1	59.6							
CL-STSED-B-4	10.0	S3	68.6	55.7	PI = 23 PL = 62	Yes	94	Yes		MH	
CL-STSED-B-5	0.0	S1	68.7	57.0							
CL-STSED-B-5	5.0	S2	66.2	54.7							
CL-STSED-B-6	5.0	S2	65.5	60.1	PI = 27 PL = 57	Yes	93	Yes		MH	
CL-STSED-B-6	10.0	S3	65.7	57.9							
CL-STSED-B-7	0.0	S1	70.3	56.0							
CL-STSED-B-7	10.0	S3	43.2	66.8							
CL-STSED-B-8	0.0	S1	64.6	61.1	PI = 22 PL = 61	Yes	89	Yes		MH	
CL-STSED-B-8	10.0	S3	64.8	59.4							

0001037. 12/10/15 N:\PROJECTS\0001037.030.035.GPJ GRAIN SIZE FIGURE



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

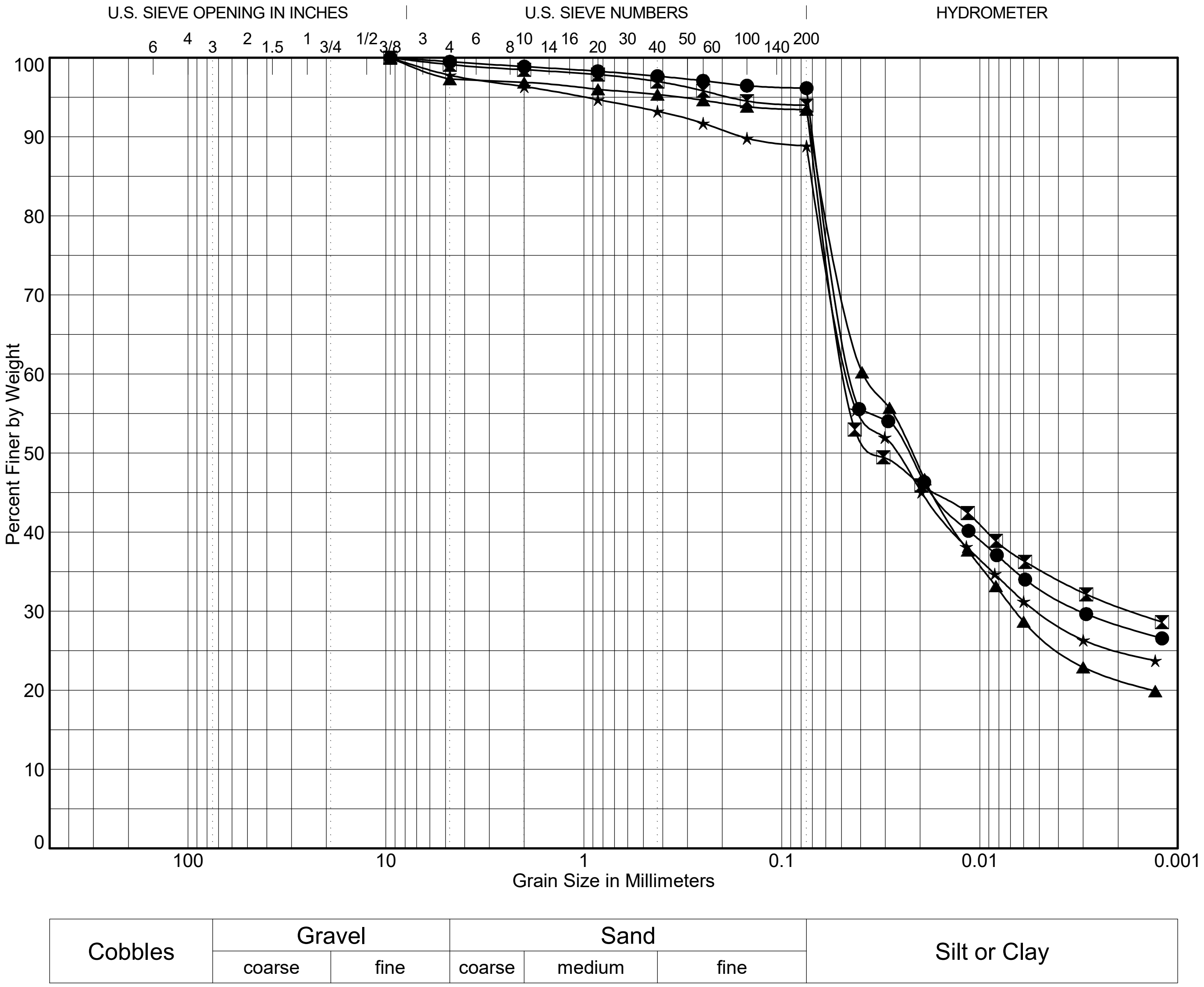
Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	CL-STSED-B-2	S4	7.5	68	Dark brown SILT with trace sand and gravel	MH
⧗	CL-STSED-B-4	S3	10.0	69	Dark brown SILT with trace sand and gravel	MH
▲	CL-STSED-B-6	S2	5.0	66	Dark Brown SILT with trace sand and gravel	MH
★	CL-STSED-B-8	S1	0	65	Dark brown SILT with sand and trace gravel	MH

Landau Associates

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Grain Size Distribution

Figure
B-2.1



Point	Depth	Classification	LL	PL	PI	C_c	C_u
● CL-STSED-B-2	7.5	Dark brown SILT with trace sand and gravel (MH)	86	60	26		
⧗ CL-STSED-B-4	10.0	Dark brown SILT with trace sand and gravel (MH)	85	62	23		
▲ CL-STSED-B-6	5.0	Dark Brown SILT with trace sand and gravel (MH)	84	57	27		
★ CL-STSED-B-8	0	Dark brown SILT with sand and trace gravel (MH)	83	61	22		

Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
● CL-STSED-B-2	7.5	9.5	0.044	0.023	0.003		0.0	0.5	0.6	1.2	1.5	96.1
⧗ CL-STSED-B-4	10.0	9.5	0.047	0.032	0.002		0.0	0.9	0.6	1.5	3.0	94.0
▲ CL-STSED-B-6	5.0	9.5	0.039	0.022	0.007		0.0	2.7	0.4	1.5	1.9	93.4
★ CL-STSED-B-8	0	9.5	0.046	0.027	0.005		0.0	2.2	1.4	3.1	4.4	88.8

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: $1 < C_c < 3$ and

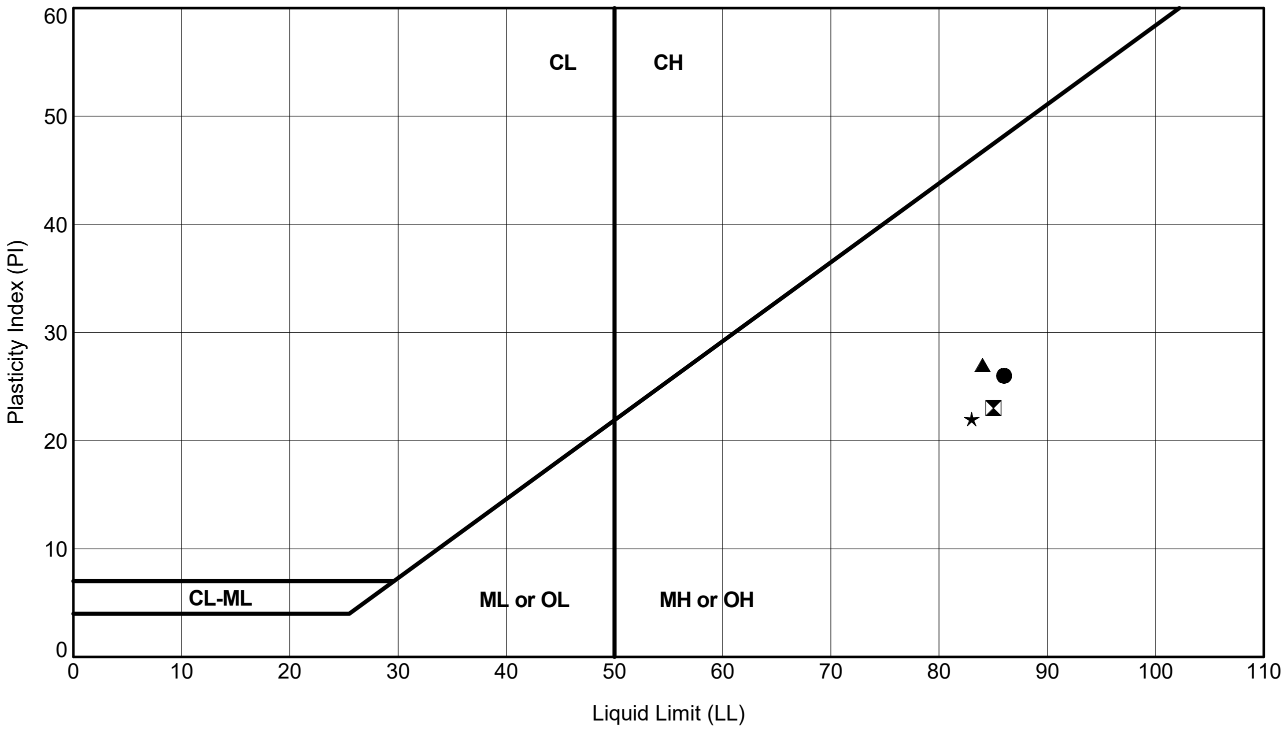
$C_u = D_{60}/D_{10}$ $C_u > 4$ for GW or $C_u > 6$ for SW

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Grain Size Test Data

Figure
B-2.2



ATTERBERG LIMIT TEST RESULTS

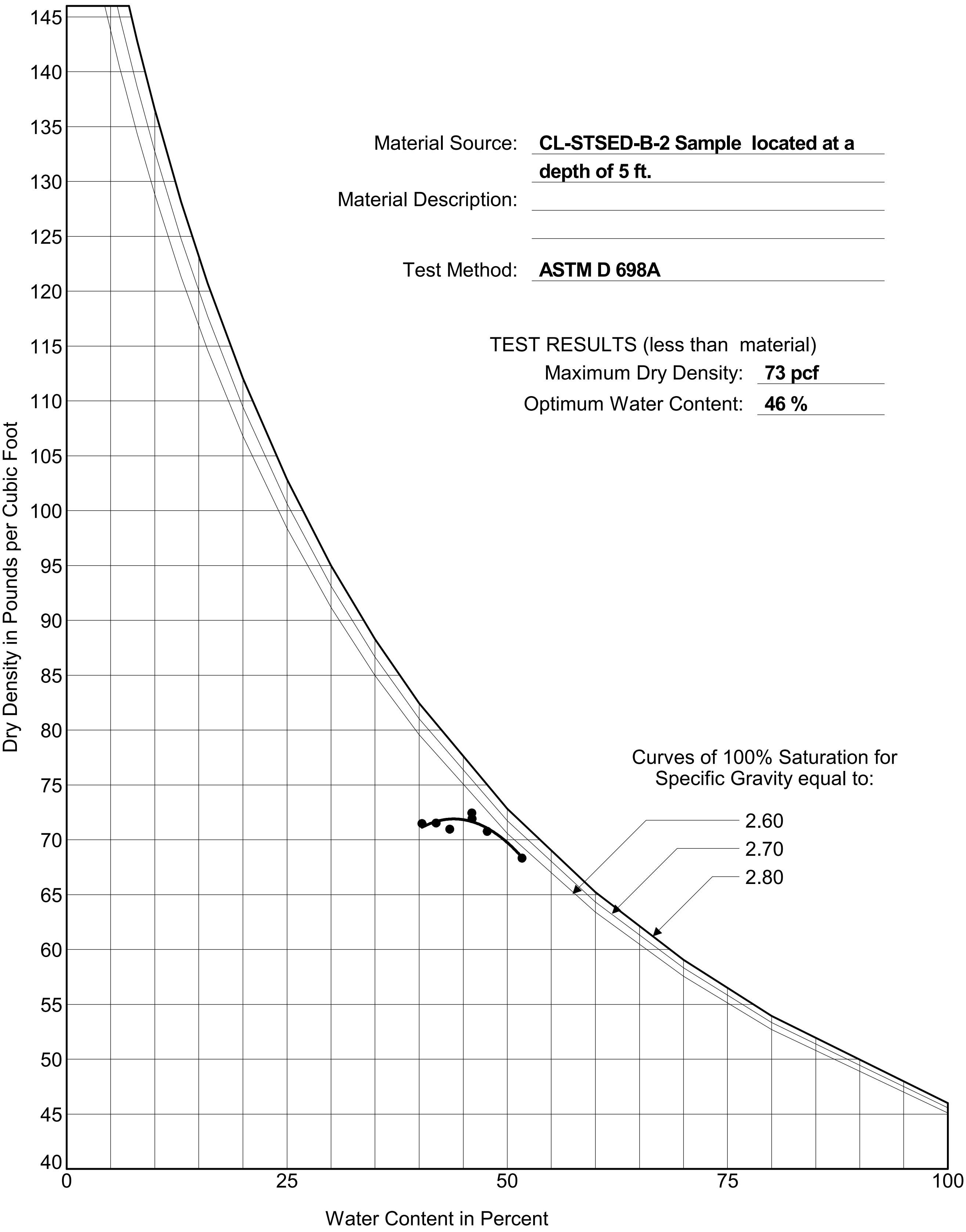
Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	CL-STSED-B-2	S4	7.5	86	60	26	68	Dark brown SILT with trace sand and gravel	MH
⧗	CL-STSED-B-4	S3	10.0	85	62	23	69	Dark brown SILT with trace sand and gravel	MH
▲	CL-STSED-B-6	S2	5.0	84	57	27	66	Dark Brown SILT with trace sand and gravel	MH
★	CL-STSED-B-8	S1	0	83	61	22	65	Dark brown SILT with sand and trace gravel	MH

ASTM D 4318 Test Method

0001037. 12/10/15 N:\PROJECTS\0001037.030.035.GPJ ATTERBERG LIMITS FIGURE

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized Sediment Borings Bellingham, Washington	Plasticity Chart	Figure B-2.3



Material Source: **CL-STSED-B-2 Sample located at a depth of 5 ft.**

Material Description:

Test Method: **ASTM D 698A**

TEST RESULTS (less than material)

Maximum Dry Density: **73 pcf**

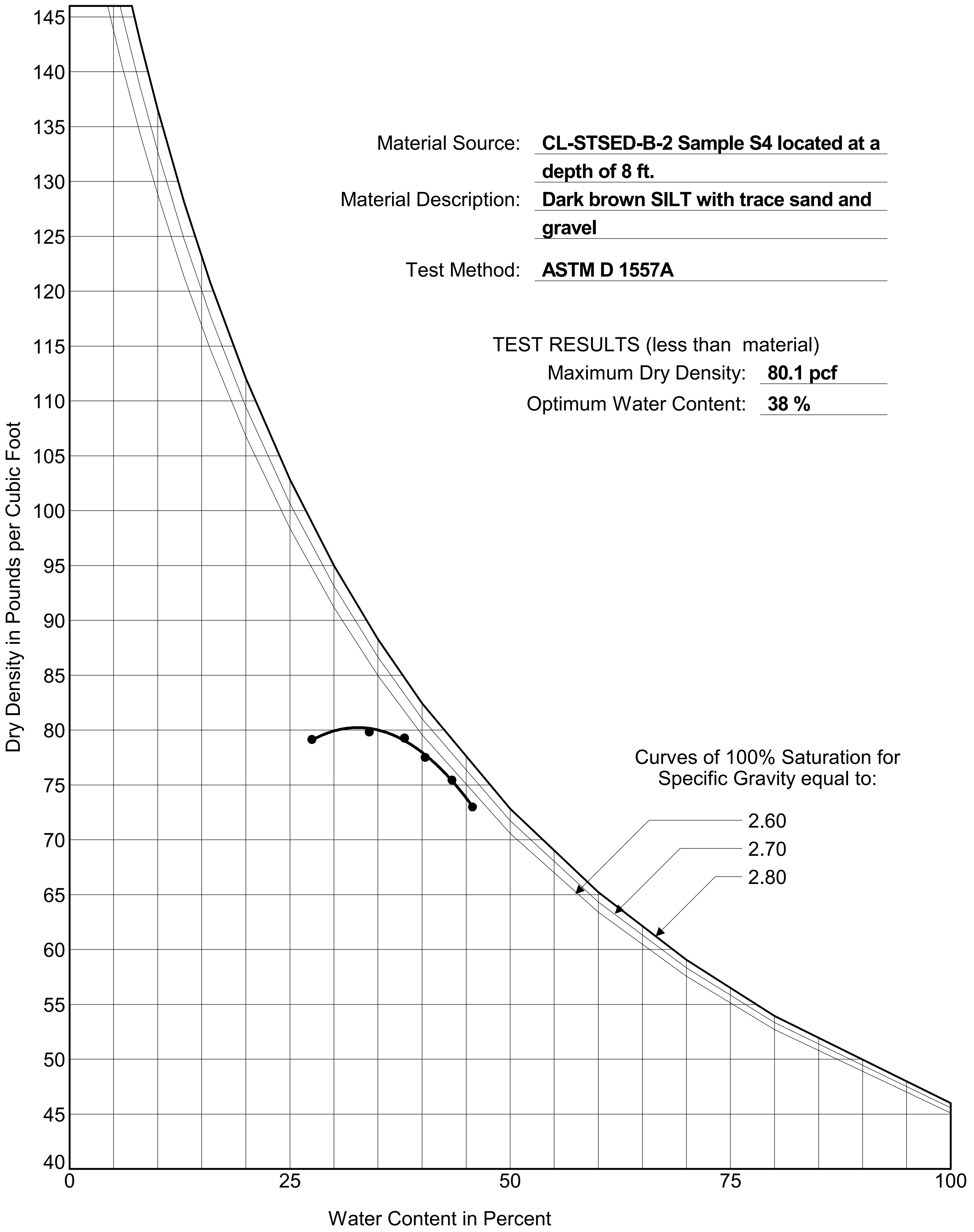
Optimum Water Content: **46 %**

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Moisture-Density Relationship

Figure
B-2.4



Material Source: **CL-STSED-B-2 Sample S4 located at a depth of 8 ft.**

Material Description: **Dark brown SILT with trace sand and gravel**

Test Method: **ASTM D 1557A**

TEST RESULTS (less than material)

Maximum Dry Density: **80.1 pcf**

Optimum Water Content: **38 %**

LANDAU ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Moisture-Density Relationship

Figure
B-2.5

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

Project Cornwall Ave Landfill Cover
Boring No. ASTM D 698 97.7% MaxDD
Sample No. 1
Depth (ft) Triax Cell #I

Proj. No. 1037.030.035
Tested by CTM On Jun 30-July 1, 2015
Comp by On
Checked by On

WATER CONTENT DATA:

	Before Test	After Test
Pan No.		
Wet+Tare	282.62	707.95
Dry+Tare	252.58	568.80
Tare	187.20	296.26
WC, %	45.9	51.1

DESCRIPTION:

Grey SILT with fine sand, trace coarse sand and shell fragments

SPECIMEN DATA:

	Imp. Units		SI Units
Height, in	4.603	cm	11.692
Diameter, in	2.046	cm^2	5.197
Wet Weight, g	414		
Volume, in3	15.13		
Area, in2	3.288	cm	21.211
Wet Unit Wt, pcf	104.216		
Dry Unit Wt, pcf	71.4		

Specific Gravity ☑ Assumed ☐ Measured = 2.7
B-Coefficient = 0.96

ASTM D 5084 CONSTANT HEAD METHOD (METHOD A)

k = Q/iA

Q = volumetric throughput, cm^3 per second, between the current and previous reading

i= hydraulic gradient across the specimen; i.e. the ratio of head-loss across the sample and the sample length, 1psi = 27.69in of head

A = cross-sectional area of the specimen, cm^2

MEASURED DATA:

Elapsed Time			Temp	Pressure Rdgs*			Burette Rdgs						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	k
			T	P_{cell}	P_{head}	Ptail	V_{cell}	V_{head}	V_{tail}				h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cumul.	(i)	
day	hr	min	(°C)	(psi)	(psi)	(psi)	(cm3)	(cm3)	(cm3)				(in)	(psi)	(psi)	(cm3)	(cm3)	(cm3)	Volume		**(cm/sec)**
1		0		64.02	61.30	56.50	17.10	0.00	10.00				132.927	7.5	2.7				0	28.9	
1		5		64.02	61.30	56.50	17.10	0.30	9.72				132.927	7.5	2.7	0.3	0.3	0.0	0.2900	28.9	**1.6E-06**
1		15		64.02	61.20	56.50	17.10	0.78	9.24				130.158	7.5	2.8	0.5	0.5	0.0	0.7700	28.3	**1.3E-06**
1		30		64.02	61.20	56.60	17.10	1.47	8.53				127.389	7.4	2.8	0.7	0.7	0.0	1.4700	27.7	**1.3E-06**
1		60		64.02	61.10	56.60	17.10	2.78	7.23				124.619	7.4	2.9	1.3	1.3	0.0	2.7750	27.1	**1.2E-06**
1		140		64.02	60.70	56.70	17.10	5.90	4.10				110.773	7.3	3.3	3.1	3.1	0.0	5.9000	24.1	**1.2E-06**
		stop	resume test for overnight run on external burrettes																		
2		0		64.07	61.00	56.30	17.10	0.00	306.00				130.158	7.8	3.1				0.0000	28.3	
2		1018		63.89	61.00	56.30	17.10	42.50	263.77				130.158	7.6	2.9	42.5	42.2	0.3	42.3650	28.3	**1.2E-06**
		stop	resume test for day run on small (internal) burrettes																		
2		0		63.90	61.20	56.30	17.10	0.00	10.00				135.696	7.6	2.7				0.0000	29.5	
2		8		63.90	61.20	56.30	17.10	0.38	9.62				135.696	7.6	2.7	0.4	0.4	0.0	0.3800	29.5	**1.3E-06**
2		19		63.89	61.20	56.30	17.10	0.84	9.14				135.696	7.6	2.7	0.5	0.5	0.0	0.8500	29.5	**1.1E-06**
2		39		63.88	61.00	56.40	17.10	1.63	8.34				127.389	7.5	2.9	0.8	0.8	0.0	1.6450	27.7	**1.1E-06**
2		70		63.88	61.00	56.40	17.10	2.83	7.12				127.389	7.5	2.9	1.2	1.2	0.0	2.8550	27.7	**1.1E-06**
2		130		63.88	60.80	56.60	17.10	4.90	5.04				116.311	7.3	3.1	2.1	2.1	0.0	4.9300	25.3	**1.0E-06**
2		208		63.87	60.60	57.10	17.10	7.62	2.32				96.926	6.8	3.3	2.7	2.7	0.0	7.6500	21.1	**1.2E-06**
		stop																			
*Pressure readings for headwater and tailwater from pressure transducer																					

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

Project	Cornwall Ave Landfill Cover	Proj. No.	1037.030.035		
Boring No.	ASTM D 1557 93.1% MaxDD	Tested by	CTM	On	July 1-2, 2015
Sample No.	2	Comp by		On	
Depth (ft)	Triax Cell #II	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.		
Wet+Tare	335.89	672.92
Dry+Tare	289.56	551.27
Tare	187.18	292.78
WC, %	45.3	47.1

DESCRIPTION:

Grey SILT with fine sand, trace coarse sand and shell fragments

SPECIMEN DATA:

	Imp. Units		SI Units
Height, in	4.2240	cm	10.7290
Diameter, in	2.0383	cm^2	5.1773
Wet Weight, g	380.9		
Volume, in3	13.8		
Area, in2	3.26307	cm	21.05201
Wet Unit Wt, pcf	105.278		
Dry Unit Wt, pcf	72.5		

OTHER INFORMATION:

Specific Gravity ☑ Assumed ☐ Measured = ________

B-Coefficient = 0.97 **NOTE:**

ASTM D 5084 CONSTANT HEAD METHOD (METHOD A)

k = Q/iA

Q = volumetric throughput, cm^3 per second, between the current and previous reading

i= hydraulic gradient across the specimen; i.e. the ratio of head-loss across the sample and the sample length, 1psi = 27.69in of head

A = cross-sectional area of the specimen, cm^2

MEASURED DATA:

Read Time			Temp	Pressure Rdgs*			Burette Rdgs						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	k
		Ti	T	P_{cell}	P_{head}	Ptail	V_{cell}	V_{head}	V_{tail}				h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cumul.	(i)	
day	hr	min	(°C)	(psi)	(psi)	(psi)	(cm3)	(cm3)	(cm3)				(in)	(psi)	(psi)	(cm3)	(cm3)	(cm3)	Volume		**(cm/sec)**
1		0		63.87	61.20	56.40	17.10	0.00	10.00				132.927	7.5	2.7				0	31.5	
1		32		63.87	61.00	56.30	17.10	0.96	9.16				130.158	7.6	2.9	1.0	0.8	0.1	0.9000	30.8	**7.1E-07**
1		64		63.87	60.80	56.20	17.10	1.81	8.21				127.389	7.7	3.1	0.9	0.9	-0.1	1.8000	30.2	**7.3E-07**
1		100		63.87	60.70	56.30	17.10	2.78	7.27				121.850	7.6	3.2	1.0	0.9	0.0	2.7550	28.8	**7.1E-07**
1		144		63.87	60.60	56.30	17.10	3.88	6.18				119.081	7.6	3.3	1.1	1.1	0.0	3.8500	28.2	**6.9E-07**
		stop	resume test for overnight run on external burrettes																		
2		0		63.87	60.90	56.10	17.10	0.00	306.00				132.927	7.8	3.0				0.0000	31.5	
2		1020		63.80	60.80	56.10	17.10	27.54	279.07				130.158	7.7	3.0	27.5	26.9	0.6	27.2340	30.8	**6.8E-07**
		stop	resume test for day run on small (internal) burrettes																		
2		0		63.80	60.90	56.20	17.10	0.00	10.00				130.158	7.6	2.9				0.0000	30.8	
2		6		63.80	60.90	56.20	17.10	0.19	9.83				130.158	7.6	2.9	0.2	0.2	0.0	0.1800	30.8	**7.7E-07**
2		126		63.79	60.70	56.30	17.10	3.03	6.98				121.850	7.5	3.1	2.8	2.9	0.0	3.0250	28.8	**6.3E-07**
2		235		63.78	60.50	56.50	17.10	5.40	4.60				110.773	7.3	3.3	2.4	2.4	0.0	5.4000	26.2	**6.3E-07**
2		360		63.78	60.20	56.60	17.10	7.92	2.10				99.695	7.2	3.6	2.5	2.5	0.0	7.9100	23.6	**6.4E-07**
		stop																			
3		0		68.06	60.70	55.90	17.10	0.00	306.00				132.927	12.2	7.4	0.0			0.0000	31.5	
3		2805		67.96	60.40	55.80	17.10	44.68	261.32				127.389	12.2	7.6	44.7	44.7	0.0	44.6760	30.2	**4.1E-07**
*Pressure readings for headwater and tailwater from pressure transducer																					

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

Project	Cornwall Ave Landfill Cover	Proj. No.	1037.030.035		
Boring No.	o 76 PCF target density (76.5 ac	Tested by	CTM	On	7/16/2015
Sample No.	3	Comp by		On	
Depth (ft)	Triax Cell #I	Checked by		On	

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	d-11	D-6
Wet+Tare	402.46	627.20
Dry+Tare	346.83	511.20
Tare	187.21	246.45
WC, %	34.9	43.8

SPECIMEN DATA:

	Imp. Units		SI Units
Height, in	4.0820	cm	10.3683
Diameter, in	2.0290	cm2	5.1537
Wet Weight, g	363.98		
Volume, in3	13.2		
Area, in2	3.23336	cm	20.86034
Wet Unit Wt, pcf	105.1		
Dry Unit Wt, pcf	77.9		

Specific Gravity ☑ Assumed ☐ Measured = 2.7

B-Coefficient = 0.97

NOTE:

DESCRIPTION:

Grey SILT with fine sand, trace coarse sand and shell fragments

ASTM D 5084 CONSTANT HEAD METHOD (METHOD A)

k = Q/iA

Q = volumetric throughput, cm^3 per second, between the current and previous reading

i= hydraulic gradient across the specimen; i.e. the ratio of head-loss across the sample and the sample length, 1psi = 27.69in of head

A = cross-sectional area of the specimen, cm^2

MEASURED DATA:

Read Time			Elapsed	Temp	Pressure Rdgs*			Burette Rdgs						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	k
			Time	T	P_{cell}	P_{head}	Ptail	V_{cell}	V_{head}	V_{tail}				h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cumul.	(i)	
day	hr	min	(hr)	(°C)	(psi)	(psi)	(psi)	(cm3)	(cm3)	(cm3)				(in)	(psi)	(psi)	(cm3)	(cm3)	(cm3)	Volume		**(cm/sec)**
1		0	0.00		69.12	66.30	62.50	20.40	0.00	10.00				105.234	6.6	2.8				0	25.8	
1		30	0.50		69.14	66.20	62.60	20.40	1.22	8.80				99.695	6.5	2.9	1.2	1.2	0.0	1.2100	24.4	**1.3E-06**
1		90	1.50		69.12	66.00	62.70	20.60	3.39	6.61				91.387	6.4	3.1	2.2	2.2	0.0	3.3900	22.4	**1.2E-06**
		stop		resume test for overnight run on external burrettes																		
2		0	24.00		69.12	66.30	62.40	20.60	0.00	306.00				108.003	6.7	2.8				0.0000	26.5	
2		928	39.47		69.03	66.00	62.40		35.50	270.50				99.695	6.6	3.0	35.5	35.5	0.0	35.4960	24.4	**1.2E-06**
		stop		resume test for day run on small (internal) burrettes																		
2		0	24.00		69.04	66.30	62.40	21.80	0.00	10.00				108.003	6.6	2.7				0.0000	26.5	
2		190	27.17		69.02	65.70	62.80	21.70	6.27	3.73				80.310	6.2	3.3	6.3	6.3	0.0	6.2700	19.7	**1.1E-06**
2		322	29.37		69.01	65.50	63.00	21.70	9.72	0.29				69.233	6.0	3.5	3.5	3.4	0.0	9.7150	17.0	**1.1E-06**
		stop																				
*Pressure readings for headwater and tailwater from pressure transducer																						

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MATERIALS USING A FLEXIBLE WALL PERMEAMETER
(ASTM Designation D 5084-90)

Project Cornwall Ave Landfill Cover
Boring No. 73 PCF target density (75.1 ac
Sample No. 4
Depth (ft) Triax Cell #II

Proj. No. 1037.030.035
Tested by CTM On 7/16/2015
Comp by On
Checked by On

WATER CONTENT DATA:

	Before Test	After Test
Pan No.	k8	D-8
Wet+Tare	562.18	610.41
Dry+Tare	453.97	494.02
Tare	195.69	245.81
WC, %	41.9	46.9

DESCRIPTION:

Grey SILT with fine sand, trace coarse sand and shell fragments

SPECIMEN DATA:

	Imp. Units		SI Units
Height, in	4.0820	cm	10.3683
Diameter, in	2.0290	cm^2	5.1537
Wet Weight, g	363.98		
Volume, in3	13.2		
Area, in2	3.23336	cm	20.86034
Wet Unit Wt, pcf	105.1		
Dry Unit Wt, pcf	74.0		

OTHER INFORMATION:

Specific Gravity ☑ Assumed ☐ Measured = 2.7
B-Coefficient = 0.97 **NOTE:**

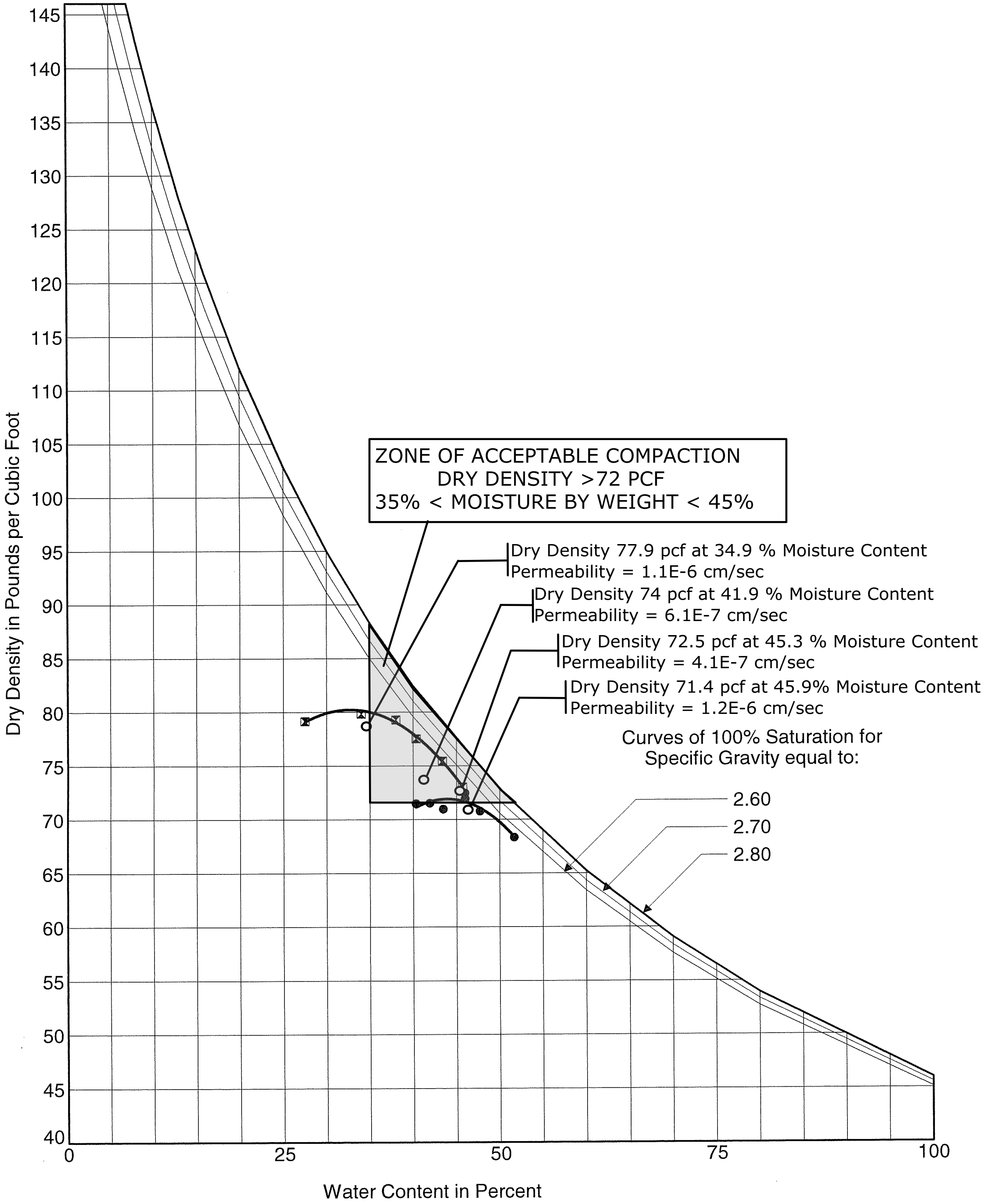
ASTM D 5084 CONSTANT HEAD METHOD (METHOD A)

k = Q/iA
Q = volumetric throughput, cm^3 per second, between the current and previous reading
i= hydraulic gradient across the specimen; i.e. the ratio of head-loss across the sample and the sample length, 1psi = 27.69in of head
A = cross-sectional area of the specimen, cm^2

MEASURED DATA:

Read Time			Temp	Pressure Rdgs*			Burette Rdgs						Head Loss	Effective Stresses		Calculated Flow Volumes				Gradient	**k**
			T	P_{cell}	P_{head}	Ptail	V_{cell}	V_{head}	V_{tail}				h	σ'_{max}	σ'_{min}	Inflow	Outflow	Storage	Cumul.	(i)	
day	hr	min	(^{o}C)	(psi)	(psi)	(psi)	(cm3)	(cm3)	(cm3)				(in)	(psi)	(psi)	(cm3)	(cm3)	(cm3)	Volume		**(cm/sec)**
1		0		68.82	66.10	61.30	6.00	0.04	9.96				132.927	7.5	2.7				0	32.6	
1		1		68.82	66.10	61.30	6.20	0.05	9.86				132.927	7.5	2.7	0.0	0.1	-0.1	0.0550	32.6	**1.3E-06**
1		5		68.82	66.10	61.30	6.30	0.24	9.68				132.927	7.5	2.7	0.2	0.2	0.0	0.2400	32.6	**1.1E-06**
1		68		68.81	65.80	61.40	6.20	2.38	7.52				121.850	7.4	3.0	2.1	2.2	0.0	2.3900	29.9	**8.7E-07**
		stop	resume test for overnight run on external burrettes																		
1		0		68.82	66.00	61.30	6.30	0.00	306.00				130.158	7.5	2.8				0.0000	31.9	
1		932		68.81	66.00	61.30	6.50	30.60	278.46				130.158	7.5	2.8	30.6	27.5	3.1	29.0700	31.9	**7.8E-07**
1		1442		68.78	65.90	61.30	6.60	45.90	264.69				127.389	7.5	2.9	15.3	13.8	1.5	43.6050	31.2	**7.2E-07**
2		2363		68.72	65.80	61.40	6.70	70.69	241.74				121.850	7.3	2.9	24.8	23.0	1.8	67.4730	29.9	**6.8E-07**
2		2760		68.72	65.80	61.40	6.80	81.09	232.25				121.850	7.3	2.9	10.4	9.5	0.9	77.4180	29.9	**6.7E-07**
3		3846		68.72	65.80	61.40	6.80	105.88	207.47				121.850	7.3	2.9	24.8	24.8	0.0	102.2040	29.9	**6.1E-07**
		stop																			

*Pressure readings for headwater and tailwater from pressure transducer



ZONE OF ACCEPTABLE COMPACTION
DRY DENSITY >72 PCF
35% < MOISTURE BY WEIGHT < 45%

Dry Density 77.9 pcf at 34.9 % Moisture Content
Permeability = 1.1E-6 cm/sec

Dry Density 74 pcf at 41.9 % Moisture Content
Permeability = 6.1E-7 cm/sec

Dry Density 72.5 pcf at 45.3 % Moisture Content
Permeability = 4.1E-7 cm/sec

Dry Density 71.4 pcf at 45.9% Moisture Content
Permeability = 1.2E-6 cm/sec

Curves of 100% Saturation for
Specific Gravity equal to:

LANDAU
ASSOCIATES

Cornwall Landfill - Stabilized
Sediment Borings
Bellingham, Washington

Zone of Acceptable Compaction

Figure
B-2.6

ATTACHMENT B.3

Landfill Stability Analysis

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA. 98020
Phone: (425) 778-0907 Fax: (425) 778-6409

JOB NO. 1037
JOB NAME Cornwall Ave Landfill
SUBJECT Slope Stability
CALC BY CE DATE 12/15/2015
CHK BY SZW & KWW DATE 9/29/2017

Problem Statement:

Determine that the proposed slopes and upland cover system proposed for the Cornwall Avenue landfill closure will have acceptable factors of safety considering static, saturated cover, and earthquake conditions

Requirements

* Design the cover system and slopes to have a factor of safety of greater than 1.25 for static, saturated conditions (WSDOT criteria) and more than 1.1 for seismic events with a predicted displacement of less than 3 feet (Typical landfill design criteria per Mikdasi and Seed, 1973)
* In accordance with the 2012 IBC, evaluate design earthquake event with a 2 percent probability of exceedance in 50 years (a 2,475-year return period event) this is equivalent to a ninety percent or greater probability that the acceleration will not be exceeded in two hundred fifty years, which is current landfill design criteria established by the EPA and Washington Department of Ecology.

Assumptions

Finished Landfill Slopes ranging from 2 percent to 25% as shown on EDR figures
Soil Properties Used in Slope Stability Analyses (derived from previous geotechnical studies at the site, Appendix B.2 and H.1)

Soil Unit	Total Unit Weight (pounds per cubic foot)	Effective Friction Angle (ϕ, degrees)	Cohesion (c, pounds per square foot)
Stabilized Sediment (proposed landfill low permeability cover layer)	100	32	250
Silty Gravel (proposed landfill cover soil)	125	36	-
Interface Strength between soil and geosynthetics	NA	30	-
Gravelly sand with silt to a sandy clay with gravel (imported fill material)	130	32	200
Wood Debris, Sawdust, Sand & Silt	75	28	-
Landfill Refuse	70	31	300
Reworked Sediments & Nooksack Deposits	80	28	150
Glaciomarine Deposits	125	32	150
Chuckanut Formation	130	45	1,000

From top to bottom, the proposed cover system above the fill will consists of:

- LFG collection layer geocomposite
- 24-inch thick cover soil layer, assumed maximum average vertical hydraulic conductivity = 1 x 10-6 cm/sec
- Geomembrane liner
- Drainage Geocomposite
- 24-inch-thick cover soil including top 6-inch thickness topsoil

Rainfall Event	6-Hr, 25-yr Precipitation = 1.65 inches	(US Dept. of Commerce, NOAA Atlas 2, Volume IX, 1973)
Runoff Coefficient	0.35	(WSDOT Hydraulics Manual Figure 2-4.2)
Design Earthquake	0.408g the peak ground acceleration (PGA)	(USGS 2015)

References

1. Bray, J.D., Rathje, E.M., Augell, A.J. and Merry, S.M., Simplified Seismic Design Procedure for Geosynthetic-Lined, Solid-Waste Landfills, Geosynthetics International 1998, Vol. 5, Nos 1-2

2. Makdisi, F.I., and H.B. Seed. 1977. *A Simplified Procedure for Estimating Earthquake-Induced Deformation in Dams and Embankments,* Report EERC-77/19. Earthquake Engineering Research Center, University of California, Berkeley.

3. Rocscience, Inc. 2005. SLIDE Computer Slope Stability Program, Version 5.0. Manufactured by Rocscience, Inc.

4. Soong, T.Y. and Koerner, R.M. 1997. The Design of Drainage Systems Over Geosynthetically Lined Slopes, GRI Report Number 19. Geosynthetics Research Institute, Drexel University. June 17.

Solution

A computer slope stability program, SLIDE version 5.0 (Rocscience Inc. 2005), was used to determine the factors of safety under both the existing and proposed conditions. SLIDE evaluates the stability of circular and non-circular failure surfaces in soil or rock using vertical slice limit equilibrium methods. For this application, the simplified Bishop's method of slices was used. This method estimates slope stability by assuming numerous failure surfaces and calculates the forces that would cause slope movement (driving forces) and the forces resisting slope movement (resisting forces) for each selected failure surface. The ratio of resisting force to driving force for a given failure surface is referred to as the factor of safety (FOS). SLIDE uses a searching routine to determine the critical failure surfaces (i.e., those surfaces with the lowest FOS) for a given slope.

A. Evaluation of global stability of proposed landfill slopes

1. Create a cross section through the highest point in the landfill with steepest slopes based on proposed contours and subsurface conditions determined in the RI/FS.
2. Using the SLIDE computer program, search for potential circular failure surface with the lowest factor of safety assuming static saturated cover conditions.

Lowest FOS found East Slope	3.039
Lowest FOS found West Slope	3.414

3. Per Reference 1. simulate the worst conditions, assume the cover system is at or close to saturation, and apply a psuedostatic seismic acceleration to horizontal active forces in the stability analyses.
4. Vary the psuedostatic seismic acceleration until the stability analyses reaches a factor of safety of 1.0. The seismic acceleration at which this occurs is called the yield acceleration, ky for the slope condition modeled.

Using the SLIDE version 5.0
ky = .44 to achieve FOS = 1.0 for east slope
ky = .29 to achieve FOS = 1.0 for west slope

5. From Reference 1, figure 2(a), determine the maximum horizontal acceleration (MHA) for the earthquake magnitude and distance of the event from the site. The design earthquake applicable to this site is:

Sandy Point Fault (Reverse Fault)
Distance to Site: ~15km
Historic Magnitude: 6-6.5
From Figure 2(a): MHA = 0.20 * 1.3 = 0.26g

6. Estimate the frequency content of the mean period, Tm , of the event using Reference 1, figure 2(b).

From Figure 2(b): Tm = 0.49 sec

7. Estimate the duration, D5-95 , of the event using Reference 1, figure (2c).

From Figure 2(c): D5-95 = 11 sec

8. Estimate the average height of the waste, H, under the cover system

East slope: H= 15 feet (4.6 m)
West Slope: H = 32 feet (9.75 m)

9. Estimate the shear wave velocity through municipal solid waste, Vs, from Reference 1, Figure 3 using the average height determined in step 8

East Slope: 175 m/s
West Slope: 195 m/s

10. Estimate the fundamental period of the waste, Ts , as Ts = 4H/Vs

East Slope: Ts = (4 * 4.6) / 175 = Ts =.11 sec
West Slope: Ts = (4 * 9.75) / 195 = Ts = .20 sec

11. Determine the nonlinear response factor, NRF, for the site using the table on Reference 1, figure 6.

NRF = 1.13

12. Estimate the maximum horizontal earthquake acceleration at the top of the waste, MHEAtop , using Figure 8 and the 16th probability of exceedance line, MHEAtop (upper) and the median line, . MHEAtop(median)

East Slope: Ts / Tm = 0.11 / .49 = .22
West Slope: Ts / Tm = 0.20 / .49 = .41
From Figure 8:
East Slope: MHEAtop (upper) / [(MHArock)(NRF) = 2.2
MHEAtop (median) / [(MHArock)(NRF) = 2.0
West Slope: MHEAtop (upper) / [(MHArock)(NRF) = 1.81
MHEAtop (median) / [(MHArock)(NRF) = 1.50

East Slope: MHEAtop (upper) = 2.2 * 1.13 * .26 = MHEAtop (upper) = 0.65
MHEAtop (median) = 2.0 * 1.13 * .26 = MHEAtop (upper) = 0.59

West Slope: MHEAtop (upper) = 1.81 * 1.13 * .26 = MHEAtop (upper) = 0.53

MHEAtop (median) = 1.50 * 1.13* .26 = MHEAtop (upper) = 0.44

13. For this design procedure, the MHEAtop is set equal to the maximum anticipated horizontal acceleration of the cover system, kmax . Divide the yield acceleration, ky, (from step 4) by the MHEAtop values in step 10 to get a range of ky/ kmax.

East Slope: ky/ kmax (upper) = .44 / .65= ky/ kmax (upper) = .68
ky/ kmax (median) = .44 / .59 = ky/ kmax (median) = .75
West Slope: ky/ kmax (upper) = .29/ .53 = ky/ kmax (upper) = .55
ky/ kmax (median) = .29 / .44 = ky/ kmax (median) = .66

14. Enter the Reference 2, figure with the ky/ kmax values from step 13 and the design earthquake magnitude (from step 5) to determine the range in predicted horizontal displacement of the cover system after the design earthquake. Predicted displacements less than 1 foot (300mm) are generally considered acceptable. For cover systems displacement as much as 3 feet may be acceptable as the cover is easily repaired.

East Slope Predicted Displacements: 0.2 to 4 cm
West Slope Predicted Displacements: 0.3 to 11 cm

B. Evaluation of the Stability of the Proposed Cover System

1. Using the EPA Hydrologic Evaluation of Landfill Performance (HELP) model, determine the maximum drainage length, L, (meters) for the drainage layer from review of the maximum distance between cross-slope collection ditches or berms.

HELP Model Results Attached

Cover Slope (%)	Maximum Collection Pipe Spacing (ft)
2	70
5	145
25	665

2. Per Reference 4, evaluate the cover stability (veneer stability) for the steepest final cover slope proposed (25%). The following text describes the equations used in the attached spreadsheet.

3. Using the assumed runoff coefficient, RC, determine the theoretical percolation, PERC, through the erosion layer assuming the 25-yr, 6-hr precipitation event occurs over one hour (P) using the following equation (which assumes the erosion layer is already at field capacity)

PERC = P(1-RC) (Ref 4, eq 20)

where:
P = probable maximum hourly precipitation (mm)
RC = runoff coefficient

4. Using the theoretical percolation and the assumed vertical hydraulic conductivity of the erosion layer, determine the Design Percolation Rate through the erosion layer using the following equations:

PERC = kv When PERC > kv (Ref 4, eq 21)
PERC = as calculated When PERC < kv
where: kv = is the average vertical hydraulic conductivity of the cover soil

5. Determine the hydraulic gradient, i, (assume equal to the slope)

6. Determine the flux required, q_{reqd} , (or rate of percolation per unit width times the drainage length) using the following equation:

q_{reqd} = (PERC/1000) x L(cos b) x w (m3/hour) (Ref 4, eq 22)
where: b = slope angle
w = unit width (m)

7. Select a hydraulic conductivity of the drainage layer, k_h = Transmissivity of Geocomposite/ thickness of drainage layer

8. Determine the allowable flux (or allowable flow rate through the layer) using the following equation:

$q_{allow} = k_h iA$
where: A = Unit width * drainage layer thickness

9. Determine if the drainage layer capacity, DLC, is exceeded using the following equation:

DLC = ($q_{allow}/_{qreqd}$) (Ref 4, eq 23)

10. If the drainage layer capacity is exceeded, increase kh until the drainage layer is at or near the capacity required.

11. Determine the average height of the water in the drainage layer, havg, using the following equation:

when DLC > 1.0

$h_{avg} = (q_{reqd}/3{,}600)/(k_h * i)$ (Ref 4, eq 24)

when DLC < 1.0

$h_{avg} =\{ [(q_{reqd}/(3600* i)] - [h_d (k_h -k_v)] \}/ k_v$ (Ref 4, eq 26)

where:
h_d = the thickness of the drainage layer (m)

12. Determine the parallel submergence ratio, PSR, using the following equation:

$PSR = h_{avg}/(h_{el} + h_d)$ (Ref 4, eq 27)

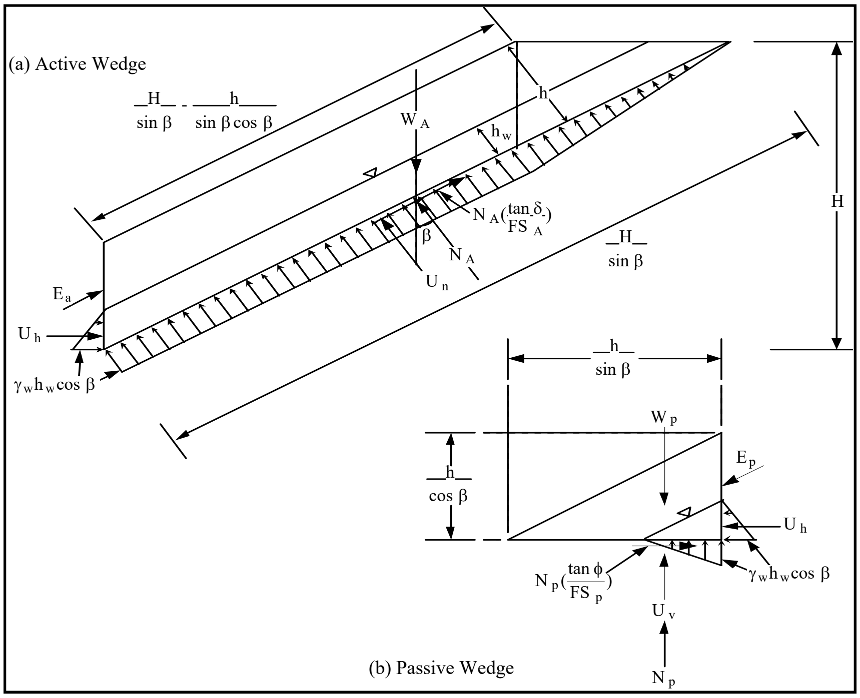
where:

h_{el} = thickness of the erosion layer (m)

13. If the PSR>1, Increase kh or the thickness of the drainage layer and return to step 8 or decrease the drainage length of the slope and return to step 3. Decreasing the drainage length will require placement of a cross-slope perforated collection pipe or collection berm

14. Determine the average dry unit weight, Ɣdry , and saturated unit weights, Ɣsat'd of the cover soils and drainage layer above the barrier soil layer.

15. Determine the stability of the slope using seepage forces with parallel to the slope seepage buildup and determine the Factor of safety using force equilibrium as shown following:



where the Factor of Safety, FS = $\dfrac{-b + \sqrt{b \ \ - 4ac}}{2a}$

where:

$a = W_A(\sin\beta)(\cos\beta) - U_h(\cos^2\beta) + U_h$

$b = - W_A(\sin^2\beta)(\tan\phi) + U_h(\cos\beta)(\sin\beta)(\tan\phi) - N_A(\cos\beta)(\tan\delta) - (W_P - U_V)(\tan\phi)$

$c = N_A(\sin\beta)(\tan\delta)(\tan\phi)$

in which

$W_A = \{\gamma_{dry}\ (h-h_w)[2H\cos\beta-(h+h_w)] + \gamma_{sat'd}\ (h_w)(2H\cos\beta-h_w)\}/\sin 2\beta$

$U_h = [\gamma_w\ (h_w)^2]/2$

$N_A = W_A\,(\cos\beta) + U_h(\sin\beta) - U_n$

$U_n = [\gamma_w\ (h_w)\ (\cos\beta)(2H\cos\beta - h_w)]/\ \sin 2\beta$

$W_P = [\gamma_{dry}\ (h^2-h_w^2) + \gamma_{sat'd}(h_w^2)]/\ \sin 2\beta$

$U_V = U_h\,(\cot\beta)$

16. If the factor of safety is less than 1.3, Increase kh or the thickness of the drainage layer and return to step 8 or decrease the drainage length of the slope and return to step 3. Decreasing the drainage length will require placement of a cross-slope perforated collection pipe or collection berm.

17. To simulate the worst conditions, assume the drainage layer is at or close to saturation, and apply a psuedostatic seismic acceleration to horizontal active forces in the stability analyses. The yield acceleration of the cover system is provided on the attached spreadsheet. The displacement analysis is included in step A. Evaluation of global stability of proposed slopes above.

Conclusions:

1. The proposed slopes have acceptable factors of safety during static and earthquake conditions.

2. The proposed cover system as designed is expected to have acceptable stability during static, high intensity rain events, and during an earthquake.

Sensitivity analysis for Rainfaill Intensity on 4H:1V (steepest) slope

The Factor of safety (FOS) decreased to 1.26 for the proposed 4H:1V slope with 24-hour, 100-year rainfall, but the stability of the flatter slopes proposed was not affected by increased rain fall assumptions. The FOS for the 4H:1V slope is slightly less than the minimum FOS of 1.3 accepted for saturated slope conditions.

Rainfall (inches)	FOS	Storm event
1.65	2.74	25 yr , 6 hr storm (design storm recommended by GRI)
2	2.74	100 yr, 6 hr storm
3	2.73	25 yr, 24 hr storm
3.75	2.73	100 yr, 24 hr storm

Adding an underdrain collection pipe to shorten the drainage path within the geocomposite drainage layer to less than 30 feet (per the revised calculations). increased the FOS to 2.73 minimum during the 24-hour, 100-year storm and larger precipitation events.

ATTACHMENT B.4

Stormwater Management Design

ATTACHMENT B.4a

Hydrology

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JOB NO. 1037
JOB NAME Cornwall Ave Landfill
SUBJECT Hydrology Analysis
CALC BY ALB DATE 10/13/2014
CHK BY KWW DATE 12/30/2015

Problem Statement

*Determine the hydrology of the closed landfill, the final grading of the landfill divides the landfill into two catchments: a southern catchment that discharges to a channel via sheet flow and a northern catchment that sheet flows to the shoreline

Requirements

* WAC 173-304-460(3)(iv) requires the runoff control system from active landfills to be able to collect and control at least the water volume resulting from a twenty-four hour, twenty-five year storm

*For long-term maintenance the runoff shall not exceed a velocity of 5 ft/sec or a standing water height of 2 feet

* Single storm event modeling will be used to determine the velocity

*Continuous simulation modelling of the site was not performed as there is not anticipated to be large amounts of changes to impervious surfaces, stormwater flow regimes. Additionally there is not any onsite storage of stormwater in ponds or other site specific BMPs that require design.

Assumptions

* 2-Year 24 hour Isopluvial Storm 20 tenths of an inch
* 10-Year 24 hour Isopluvial Storm 30 tenths of an inch
* 25-Year 24 hour Isopluvial Storm 35 tenths of an inch
* 100-Year 24 hour Isopluvial storm 40 tenths of an inch
* Area of the southern catchment contains a hillside (steep 4:1 slope) 71,455 sq. ft (from CAD)
* Area of the southern catchment with 5% slope 54,360 sq. ft (from CAD)
* Area of ditch in southern catchment 44,500 sq. ft (from CAD)
* Length of ditch in southern catchment 1650 ft (from CAD)
* Width of ditch in southern catchment 4ft on bottom with a 4:1 side slope and a 2:1 side slope (from CAD)
* Slope of ditch in southern catchment 0.5% (from CAD)
* Slope of hillside in southern catchment 25%
* Ditch and hillside in southern catchment will be covered with grass
* Northern catchment has three regimes: a 5% slope regime, a 2% slope regime, and a shoreline
* Northern catchment 5% slope regime has an area of 2.3 acres, 2 % slope regime has an area of 5 acres, and the shoreline regime has an area of 2.7 acres (from CAD)
* The northern catchment shoreline area has a slope of 4:1
* Northern catchment areas will be covered in grass with the exception of the shoreline areas that will be covered in rock

References

* WSDOT Hydraulics Manual 1997
* Western Washington Isopluvial Maps. SWMM Volume III Hydrological Analysis December 2014
* HYDROCAD Report Southern Catchment PDF
* HYDROCAD Report Northern Catchment PDF

Solutions

SOUTHERN CATCHMENT

The southern catchment and channel were modelled using HYDROCAD and the above assumptions
The maximum velocities and depths of the channel were calculated for the following events:

Return Event	Maximum Channel Velocity (feet/sec)	Maximum Channel Height (ft)	HYDROCAD Southern Catchment Page Reference
2-year	1.15	0.18	Page 5 and 9
10-year	1.71	0.37	Page 10 and 14
25-year	1.92	0.45	Page 15 and 19
100-year	2.09	0.53	Page 20 and 24

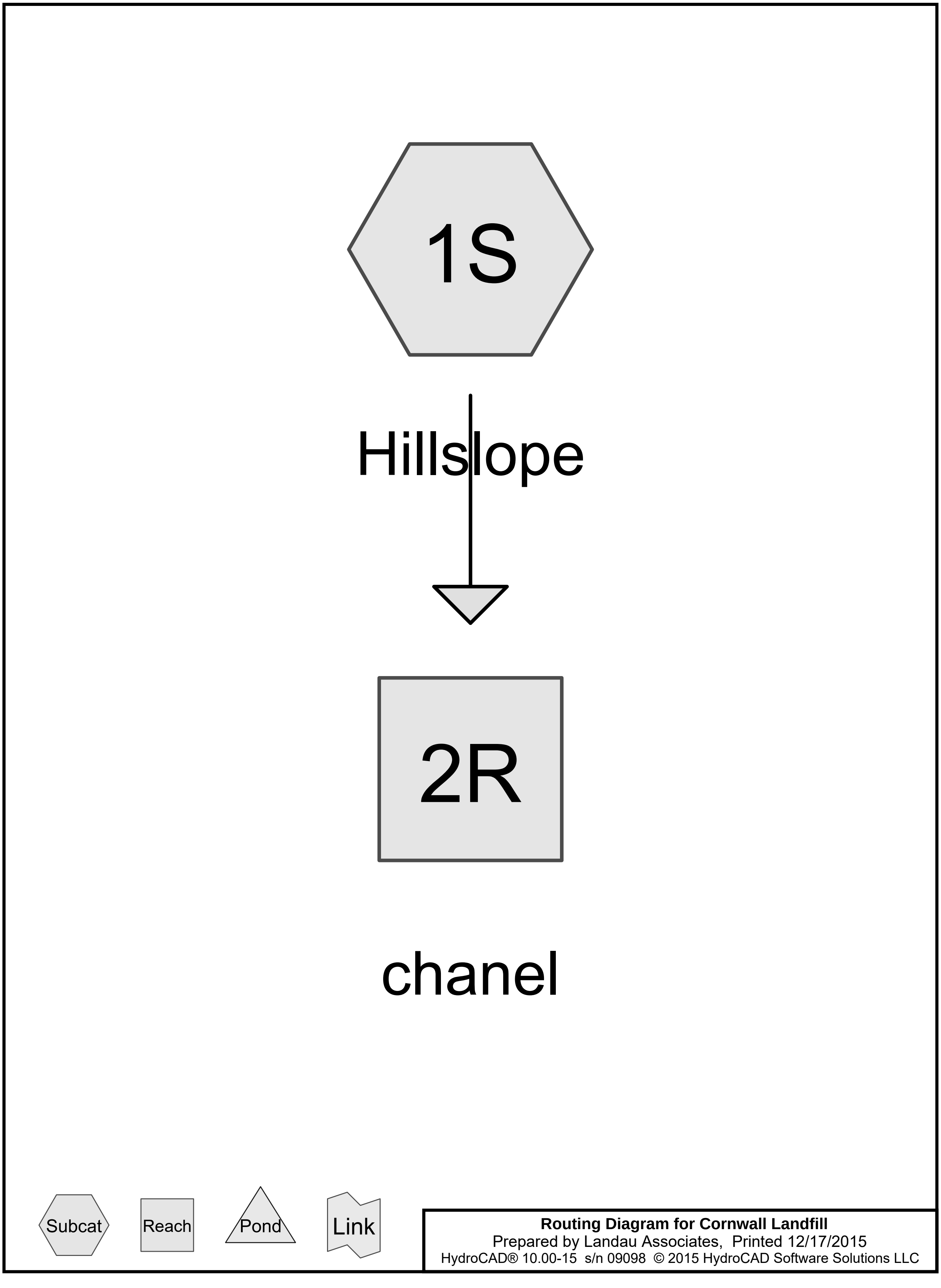
NORTHERN CATCHMENT

The northern catchment was modeled in HYDROCAD using the above assumptions
The maximum velocities of each of the three regimes as well as the runoff depth were calculated for the following events:

Return Event	Maximum Velocity 5% Slope (feet/sec)	Maximum Velocity 2% Slope (feet/sec)	Maximum Velocity Shoreline Area (feet/sec)	Maximum Runoff Depth (ft)	HYDROCAD Northern Catchment Page Reference
2-year	0.22	0.16	0.17	0.042	Page 2
10-year	0.22	0.16	0.17	0.1	Page 4
25-year	0.22	0.16	0.17	0.13	Page 6
100-year	0.22	0.16	0.17	0.16	Page 8

Summary

* Based on the assumed areas and slopes neither the southern or northern catchment exceed a maximum velocity of 5 feet/sec or a standing water depth of 2 feet in the 2, 10, 25, and 100 year 24 hour events



Routing Diagram for Cornwall Landfill
Prepared by Landau Associates, Printed 12/17/2015
HydroCAD® 10.00-15 s/n 09098 © 2015 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
2.800	79	<50% Grass cover, Poor, HSG B (1S)
2.800	**79**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
2.800	HSG B	1S
0.000	HSG C	
0.000	HSG D	
0.000	Other	
2.800		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	2.800	0.000	0.000	0.000	2.800	<50% Grass cover, Poor	1S
0.000	**2.800**	**0.000**	**0.000**	**0.000**	**2.800**	**TOTAL AREA**	

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Hillslope Runoff Area=2.800 ac 0.00% Impervious Runoff Depth=0.52"
Flow Length=60' Slope=0.2500 '/' Tc=3.0 min CN=79 Runoff=2.78 cfs 0.122 af

Reach 2R: chanel Avg. Flow Depth=0.18' Max Vel=1.15 fps Inflow=2.78 cfs 0.122 af
n=0.030 L=1,650.0' S=0.0061 '/' Capacity=86.91 cfs Outflow=0.96 cfs 0.122 af

Total Runoff Area = 2.800 ac Runoff Volume = 0.122 af Average Runoff Depth = 0.52"
100.00% Pervious = 2.800 ac 0.00% Impervious = 0.000 ac

Summary for Subcatchment 1S: Hillslope

[49] Hint: Tc<2dt may require smaller dt

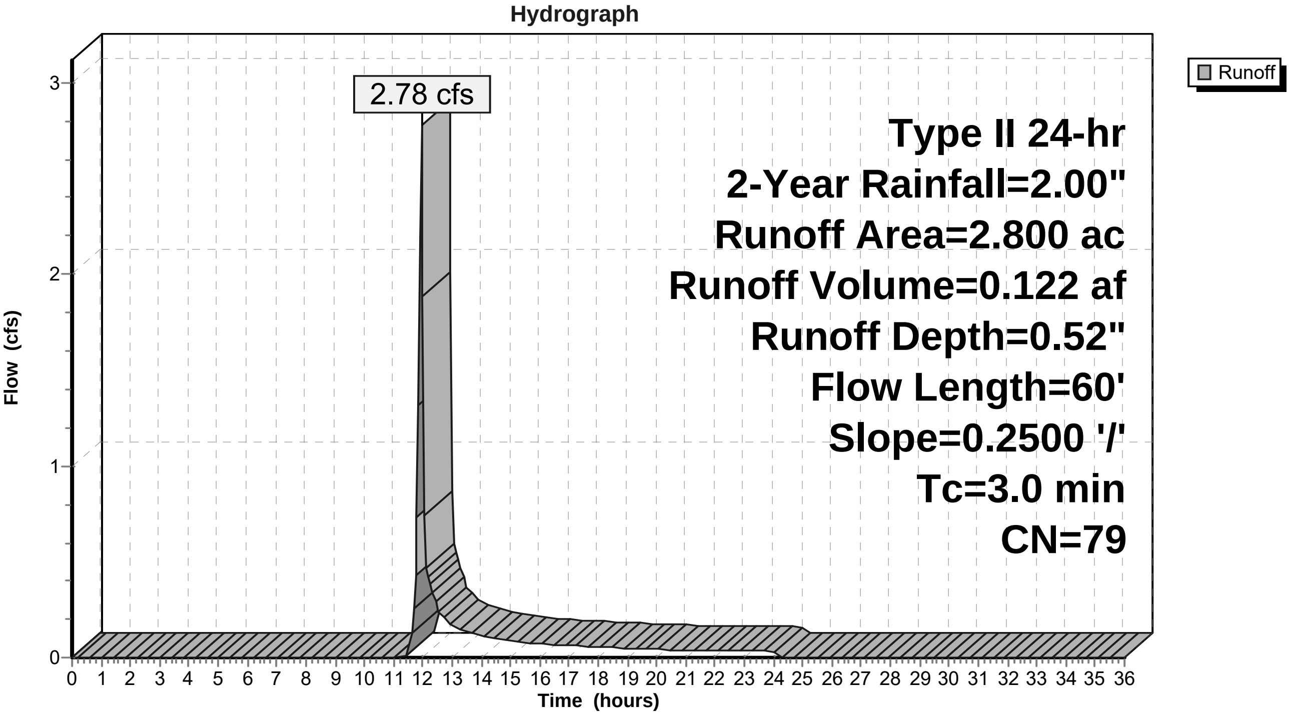
Runoff = 2.78 cfs @ 11.94 hrs, Volume= 0.122 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=2.00"

Area (ac)	CN	Description
2.800	79	<50% Grass cover, Poor, HSG B
2.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	60	0.2500	0.33		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.00"

Subcatchment 1S: Hillslope



Hydrograph for Subcatchment 1S: Hillslope

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	0.01	0.00	0.00
1.00	0.02	0.00	0.00
1.50	0.03	0.00	0.00
2.00	0.04	0.00	0.00
2.50	0.06	0.00	0.00
3.00	0.07	0.00	0.00
3.50	0.08	0.00	0.00
4.00	0.10	0.00	0.00
4.50	0.11	0.00	0.00
5.00	0.13	0.00	0.00
5.50	0.14	0.00	0.00
6.00	0.16	0.00	0.00
6.50	0.18	0.00	0.00
7.00	0.20	0.00	0.00
7.50	0.22	0.00	0.00
8.00	0.24	0.00	0.00
8.50	0.26	0.00	0.00
9.00	0.29	0.00	0.00
9.50	0.33	0.00	0.00
10.00	0.36	0.00	0.00
10.50	0.41	0.00	0.00
11.00	0.47	0.00	0.00
11.50	0.57	0.00	**0.01**
12.00	1.33	0.18	**1.88**
12.50	1.47	0.24	0.25
13.00	1.54	0.28	0.17
13.50	1.60	0.31	0.13
14.00	1.64	0.33	0.11
14.50	1.68	0.34	0.10
15.00	1.71	0.36	0.09
15.50	1.74	0.38	0.08
16.00	1.76	0.39	0.07
16.50	1.78	0.40	0.07
17.00	1.80	0.41	0.06
17.50	1.82	0.42	0.06
18.00	1.84	0.43	0.06
18.50	1.86	0.44	0.05
19.00	1.88	0.45	0.05
19.50	1.89	0.46	0.05
20.00	1.90	0.47	0.04
20.50	1.92	0.47	0.04
21.00	1.93	0.48	0.04
21.50	1.94	0.49	0.04
22.00	1.95	0.50	0.04
22.50	1.97	0.50	0.04
23.00	1.98	0.51	0.04
23.50	1.99	0.52	0.04
24.00	**2.00**	**0.52**	0.04
24.50	2.00	0.52	0.00
25.00	2.00	0.52	0.00
25.50	2.00	0.52	0.00
26.00	2.00	0.52	0.00
26.50	2.00	0.52	0.00
27.00	2.00	0.52	0.00
27.50	2.00	0.52	0.00
28.00	2.00	0.52	0.00
28.50	2.00	0.52	0.00
29.00	2.00	0.52	0.00
29.50	2.00	0.52	0.00
30.00	2.00	0.52	0.00
30.50	2.00	0.52	0.00
31.00	2.00	0.52	0.00
31.50	2.00	0.52	0.00
32.00	2.00	0.52	0.00
32.50	2.00	0.52	0.00
33.00	2.00	0.52	0.00
33.50	2.00	0.52	0.00
34.00	2.00	0.52	0.00
34.50	2.00	0.52	0.00
35.00	2.00	0.52	0.00
35.50	2.00	0.52	0.00
36.00	2.00	0.52	0.00

Summary for Reach 2R: chanel

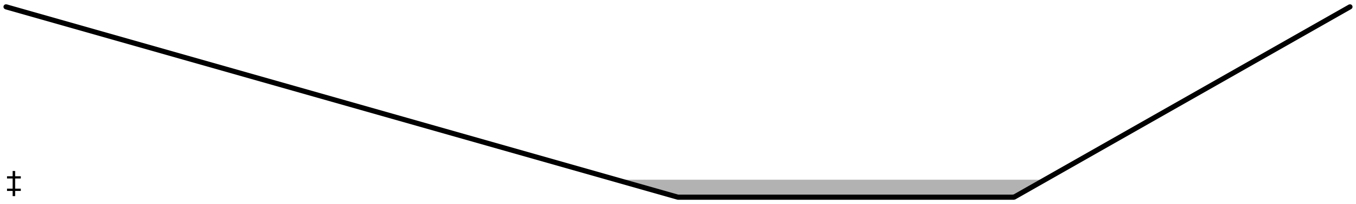
```
Inflow Area =          2.800 ac,    0.00% Impervious,  Inflow Depth =   0.52"    for  2-Year event
Inflow       =        2.78 cfs @   11.94 hrs,  Volume=             0.122 af
Outflow      =        0.96 cfs @   12.45 hrs,  Volume=             0.122 af,  Atten= 65%,  Lag= 30.4 min
```

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.15 fps, Min. Travel Time= 24.0 min
Avg. Velocity = 0.38 fps, Avg. Travel Time= 71.6 min

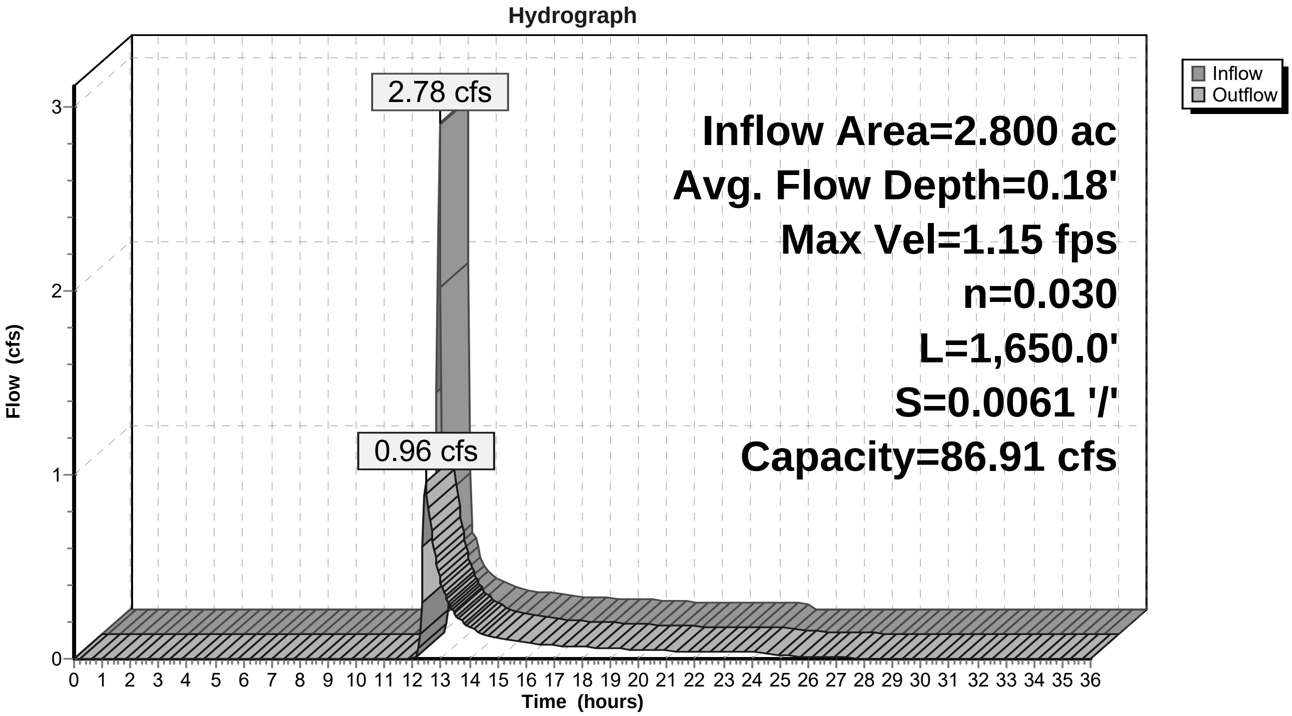
Peak Storage= 1,382 cf @ 12.05 hrs
Average Depth at Peak Storage= 0.18'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 86.91 cfs

4.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 2.0 '/' Top Width= 16.00'
Length= 1,650.0' Slope= 0.0061 '/'
Inlet Invert= 18.00', Outlet Invert= 8.00'

‡



Reach 2R: chanel



Hydrograph for Reach 2R: chanel

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)
0.00	0.00	0	18.00	0.00
1.00	0.00	0	18.00	0.00
2.00	0.00	0	18.00	0.00
3.00	0.00	0	18.00	0.00
4.00	0.00	0	18.00	0.00
5.00	0.00	0	18.00	0.00
6.00	0.00	0	18.00	0.00
7.00	0.00	0	18.00	0.00
8.00	0.00	0	18.00	0.00
9.00	0.00	0	18.00	0.00
10.00	0.00	0	18.00	0.00
11.00	**0.00**	0	18.00	0.00
12.00	**1.88**	**1,313**	**18.18**	**0.00**
13.00	0.17	**607**	**18.09**	**0.41**
14.00	0.11	408	18.06	0.17
15.00	0.09	332	18.05	0.11
16.00	0.07	289	18.04	0.09
17.00	0.06	261	18.04	0.07
18.00	0.06	242	18.04	0.06
19.00	0.05	222	18.03	0.06
20.00	0.04	202	18.03	0.05
21.00	0.04	189	18.03	0.04
22.00	0.04	183	18.03	0.04
23.00	0.04	178	18.03	0.04
24.00	0.04	174	18.03	0.04
25.00	0.00	94	18.01	0.02
26.00	0.00	51	18.01	0.01
27.00	0.00	28	18.00	0.01
28.00	0.00	15	18.00	0.00
29.00	0.00	8	18.00	0.00
30.00	0.00	4	18.00	0.00
31.00	0.00	2	18.00	0.00
32.00	0.00	1	18.00	0.00
33.00	0.00	1	18.00	0.00
34.00	0.00	0	18.00	0.00
35.00	0.00	0	18.00	0.00
36.00	0.00	0	18.00	0.00

```
                 Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
                Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
      Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment1S: Hillslope          Runoff Area=2.800 ac   0.00% Impervious   Runoff Depth=1.19"
                       Flow Length=60'   Slope=0.2500 '/'   Tc=3.0 min   CN=79   Runoff=6.48 cfs  0.277 af

Reach 2R: chanel                        Avg. Flow Depth=0.37'   Max Vel=1.71 fps   Inflow=6.48 cfs  0.277 af
                       n=0.030   L=1,650.0'   S=0.0061 '/'   Capacity=86.91 cfs   Outflow=3.17 cfs  0.277 af

          Total Runoff Area = 2.800 ac   Runoff Volume = 0.277 af   Average Runoff Depth = 1.19"
                                  100.00% Pervious = 2.800 ac     0.00% Impervious = 0.000 ac
```

Summary for Subcatchment 1S: Hillslope

[49] Hint: Tc<2dt may require smaller dt

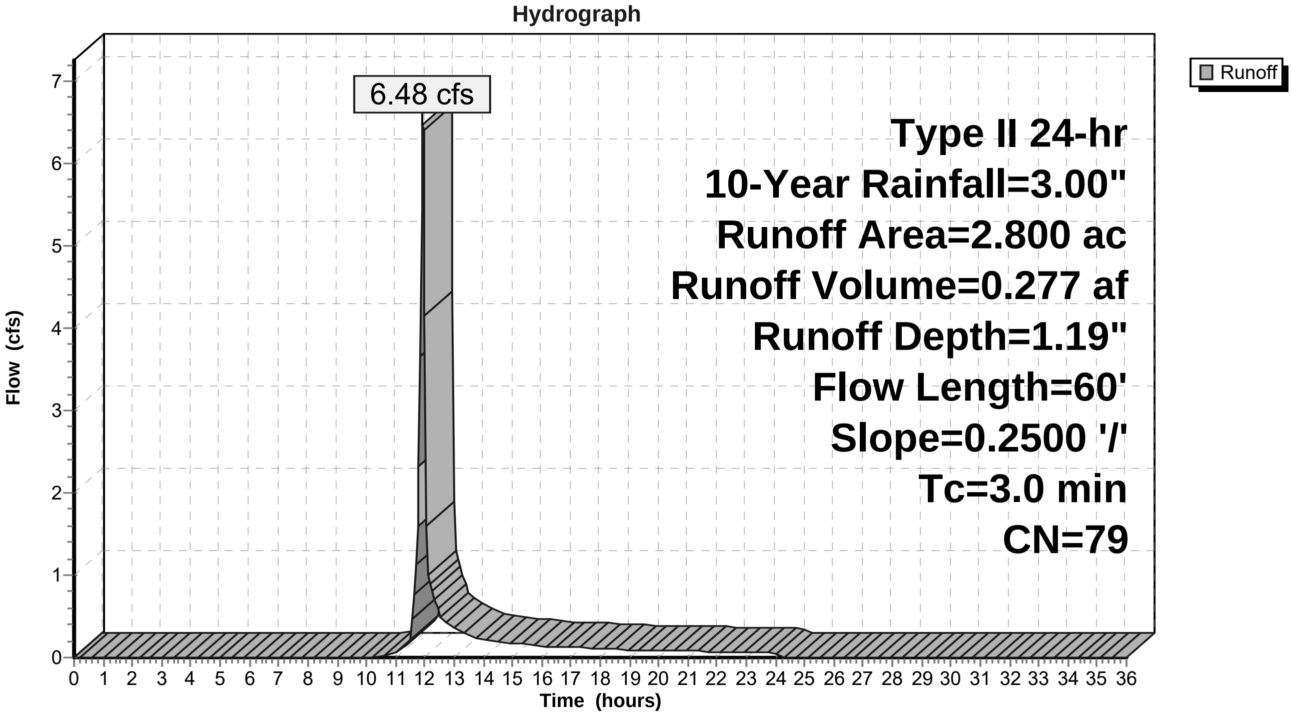
Runoff = 6.48 cfs @ 11.94 hrs, Volume= 0.277 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-Year Rainfall=3.00"

Area (ac)	CN	Description
2.800	79	<50% Grass cover, Poor, HSG B
2.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	60	0.2500	0.33		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.00"

Subcatchment 1S: Hillslope



Hydrograph for Subcatchment 1S: Hillslope

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	0.02	0.00	0.00
1.00	0.03	0.00	0.00
1.50	0.05	0.00	0.00
2.00	0.07	0.00	0.00
2.50	0.08	0.00	0.00
3.00	0.10	0.00	0.00
3.50	0.12	0.00	0.00
4.00	0.14	0.00	0.00
4.50	0.17	0.00	0.00
5.00	0.19	0.00	0.00
5.50	0.21	0.00	0.00
6.00	0.24	0.00	0.00
6.50	0.27	0.00	0.00
7.00	0.30	0.00	0.00
7.50	0.33	0.00	0.00
8.00	0.36	0.00	0.00
8.50	0.40	0.00	0.00
9.00	0.44	0.00	0.00
9.50	0.49	0.00	0.00
10.00	0.54	0.00	0.00
10.50	0.61	0.00	0.02
11.00	0.71	0.01	0.07
11.50	0.85	0.03	**0.19**
12.00	1.99	0.52	**4.16**
12.50	2.20	0.65	0.51
13.00	2.32	0.72	0.34
13.50	2.40	0.77	0.27
14.00	2.46	0.81	0.21
14.50	2.51	0.85	0.19
15.00	2.56	0.88	0.17
15.50	2.60	0.91	0.16
16.00	2.64	0.93	0.14
16.50	2.67	0.96	0.13
17.00	2.71	0.98	0.12
17.50	2.74	1.00	0.11
18.00	2.76	1.02	0.11
18.50	2.79	1.04	0.10
19.00	2.81	1.05	0.09
19.50	2.84	1.07	0.09
20.00	2.86	1.08	0.08
20.50	2.88	1.10	0.08
21.00	2.89	1.11	0.08
21.50	2.91	1.13	0.08
22.00	2.93	1.14	0.07
22.50	2.95	1.15	0.07
23.00	2.97	1.16	0.07
23.50	2.98	1.18	0.07
24.00	**3.00**	**1.19**	0.07
24.50	3.00	1.19	0.00
25.00	3.00	1.19	0.00
25.50	3.00	1.19	0.00
26.00	3.00	1.19	0.00
26.50	3.00	1.19	0.00
27.00	3.00	1.19	0.00
27.50	3.00	1.19	0.00
28.00	3.00	1.19	0.00
28.50	3.00	1.19	0.00
29.00	3.00	1.19	0.00
29.50	3.00	1.19	0.00
30.00	3.00	1.19	0.00
30.50	3.00	1.19	0.00
31.00	3.00	1.19	0.00
31.50	3.00	1.19	0.00
32.00	3.00	1.19	0.00
32.50	3.00	1.19	0.00
33.00	3.00	1.19	0.00
33.50	3.00	1.19	0.00
34.00	3.00	1.19	0.00
34.50	3.00	1.19	0.00
35.00	3.00	1.19	0.00
35.50	3.00	1.19	0.00
36.00	3.00	1.19	0.00

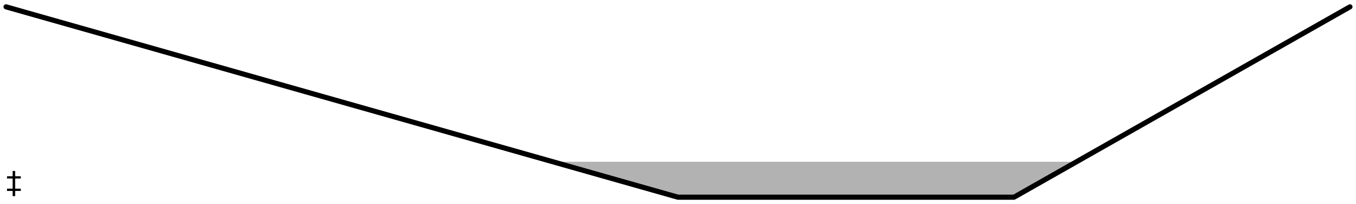
Summary for Reach 2R: chanel

```
Inflow Area =          2.800 ac,    0.00% Impervious,  Inflow Depth =   1.19"    for  10-Year event
Inflow      =         6.48 cfs @   11.94 hrs,  Volume=            0.277 af
Outflow     =         3.17 cfs @   12.29 hrs,  Volume=            0.277 af,  Atten= 51%,  Lag= 21.2 min
```

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.71 fps, Min. Travel Time= 16.0 min
Avg. Velocity = 0.45 fps, Avg. Travel Time= 61.5 min

Peak Storage= 3,136 cf @ 12.02 hrs
Average Depth at Peak Storage= 0.37'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 86.91 cfs

4.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 2.0 '/' Top Width= 16.00'
Length= 1,650.0' Slope= 0.0061 '/'
Inlet Invert= 18.00', Outlet Invert= 8.00'



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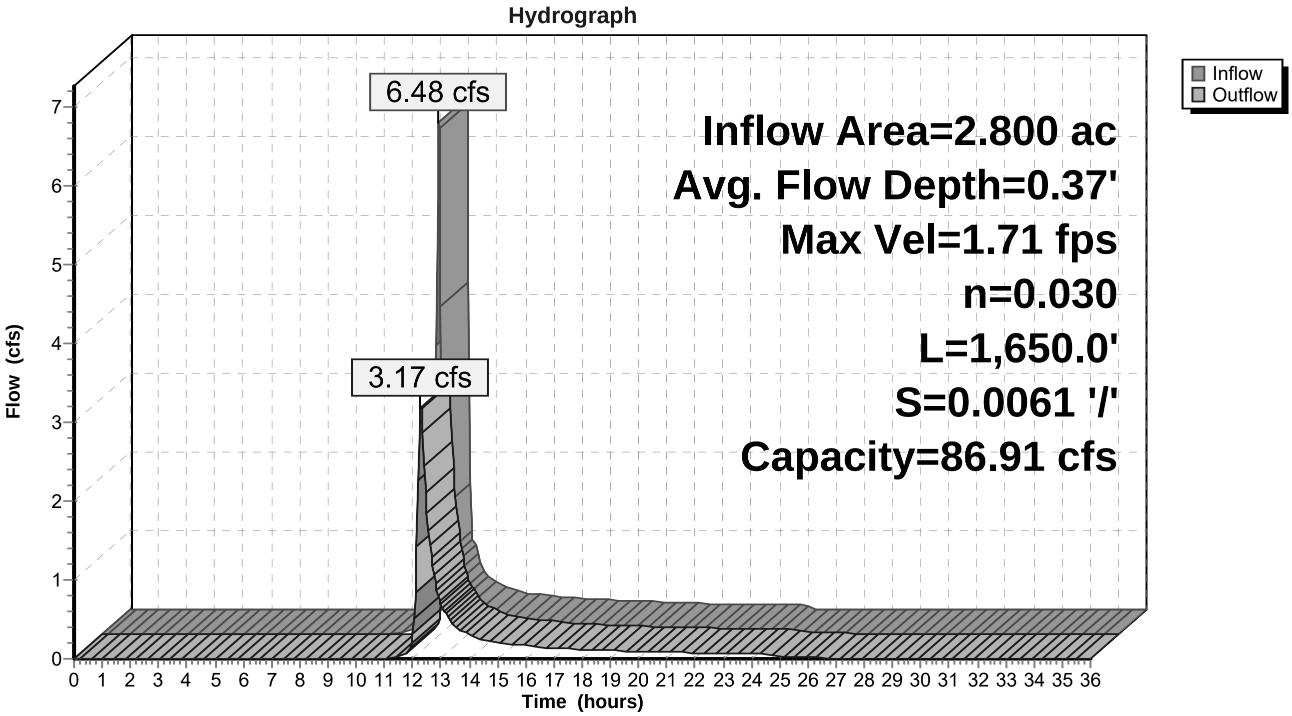
Reach 2R: chanel



Hydrograph for Reach 2R: chanel

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)
0.00	0.00	0	18.00	0.00
1.00	0.00	0	18.00	0.00
2.00	0.00	0	18.00	0.00
3.00	0.00	0	18.00	0.00
4.00	0.00	0	18.00	0.00
5.00	0.00	0	18.00	0.00
6.00	0.00	0	18.00	0.00
7.00	0.00	0	18.00	0.00
8.00	0.00	0	18.00	0.00
9.00	0.00	0	18.00	0.00
10.00	0.00	0	18.00	0.00
11.00	**0.07**	81	18.01	0.01
12.00	**4.16**	**3,100**	**18.37**	**0.31**
13.00	0.34	912	18.13	**0.69**
14.00	0.21	604	18.09	0.30
15.00	0.17	496	18.07	0.21
16.00	0.14	430	18.06	0.16
17.00	0.12	388	18.06	0.14
18.00	0.11	358	18.05	0.12
19.00	0.09	330	18.05	0.11
20.00	0.08	301	18.04	0.09
21.00	0.08	284	18.04	0.08
22.00	0.07	277	18.04	0.08
23.00	0.07	271	18.04	0.07
24.00	0.07	265	18.04	0.07
25.00	0.00	127	18.02	0.03
26.00	0.00	69	18.01	0.01
27.00	0.00	37	18.01	0.01
28.00	0.00	20	18.00	0.00
29.00	0.00	11	18.00	0.00
30.00	0.00	6	18.00	0.00
31.00	0.00	3	18.00	0.00
32.00	0.00	2	18.00	0.00
33.00	0.00	1	18.00	0.00
34.00	0.00	1	18.00	0.00
35.00	0.00	0	18.00	0.00
36.00	0.00	0	18.00	0.00

```
                    Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
                  Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
       Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment1S: Hillslope            Runoff Area=2.800 ac   0.00% Impervious   Runoff Depth=1.57"
                        Flow Length=60'   Slope=0.2500 '/'   Tc=3.0 min   CN=79   Runoff=8.51 cfs  0.365 af

Reach 2R: chanel                          Avg. Flow Depth=0.45'   Max Vel=1.92 fps   Inflow=8.51 cfs  0.365 af
                        n=0.030   L=1,650.0'   S=0.0061 '/'   Capacity=86.91 cfs   Outflow=4.58 cfs  0.365 af

       Total Runoff Area = 2.800 ac   Runoff Volume = 0.365 af   Average Runoff Depth = 1.57"
                                  100.00% Pervious = 2.800 ac     0.00% Impervious = 0.000 ac
```

Summary for Subcatchment 1S: Hillslope

[49] Hint: Tc<2dt may require smaller dt

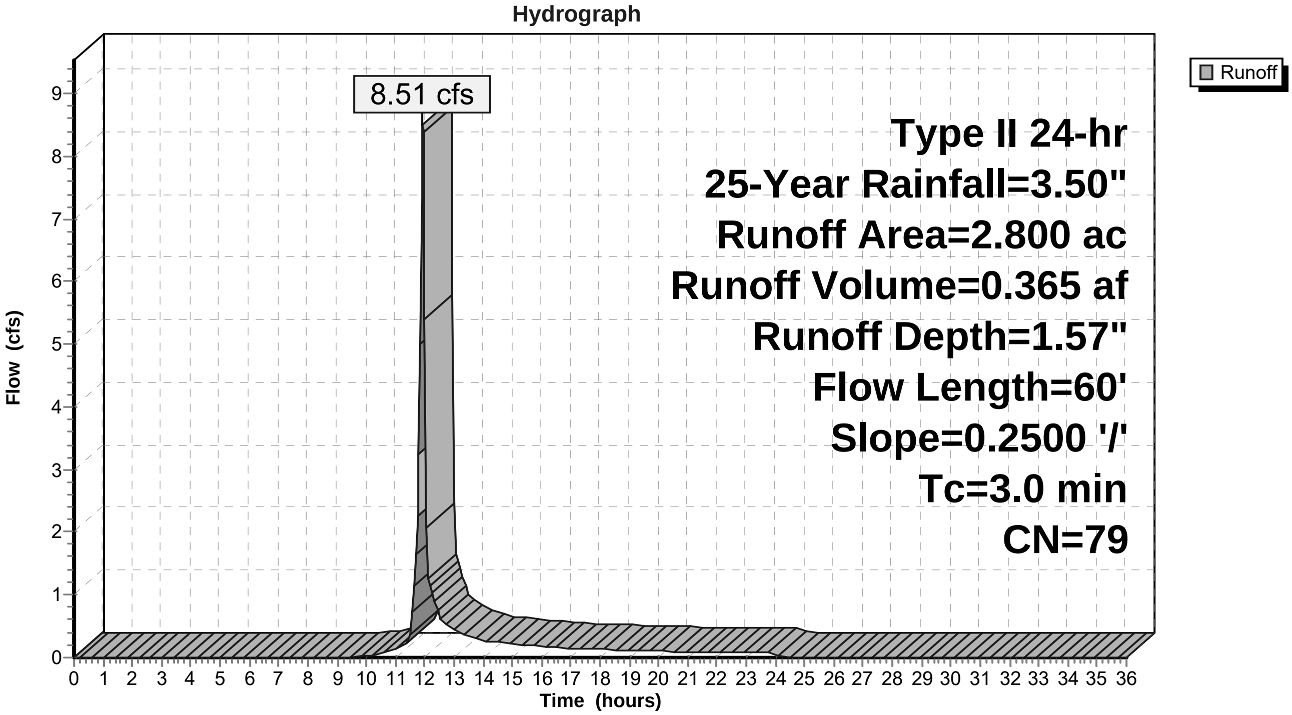
Runoff = 8.51 cfs @ 11.94 hrs, Volume= 0.365 af, Depth= 1.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=3.50"

Area (ac)	CN	Description
2.800	79	<50% Grass cover, Poor, HSG B
2.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	60	0.2500	0.33		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.00"

Subcatchment 1S: Hillslope



Hydrograph for Subcatchment 1S: Hillslope

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	0.02	0.00	0.00
1.00	0.04	0.00	0.00
1.50	0.06	0.00	0.00
2.00	0.08	0.00	0.00
2.50	0.10	0.00	0.00
3.00	0.12	0.00	0.00
3.50	0.14	0.00	0.00
4.00	0.17	0.00	0.00
4.50	0.19	0.00	0.00
5.00	0.22	0.00	0.00
5.50	0.25	0.00	0.00
6.00	0.28	0.00	0.00
6.50	0.31	0.00	0.00
7.00	0.35	0.00	0.00
7.50	0.38	0.00	0.00
8.00	0.42	0.00	0.00
8.50	0.46	0.00	0.00
9.00	0.51	0.00	0.00
9.50	0.57	0.00	0.01
10.00	0.63	0.00	0.03
10.50	0.71	0.01	0.06
11.00	0.82	0.03	0.13
11.50	0.99	0.07	**0.30**
12.00	2.32	0.72	**5.39**
12.50	2.57	0.89	0.65
13.00	2.70	0.98	0.44
13.50	2.80	1.04	0.34
14.00	2.87	1.09	0.27
14.50	2.93	1.14	0.24
15.00	2.99	1.18	0.22
15.50	3.04	1.22	0.19
16.00	3.08	1.25	0.17
16.50	3.12	1.28	0.16
17.00	3.16	1.30	0.15
17.50	3.19	1.33	0.14
18.00	3.22	1.35	0.13
18.50	3.25	1.38	0.13
19.00	3.28	1.40	0.12
19.50	3.31	1.42	0.11
20.00	3.33	1.44	0.10
20.50	3.35	1.45	0.10
21.00	3.38	1.47	0.09
21.50	3.40	1.49	0.09
22.00	3.42	1.50	0.09
22.50	3.44	1.52	0.09
23.00	3.46	1.54	0.09
23.50	3.48	1.55	0.09
24.00	**3.50**	**1.57**	0.08
24.50	3.50	1.57	0.00
25.00	3.50	1.57	0.00
25.50	3.50	1.57	0.00
26.00	3.50	1.57	0.00
26.50	3.50	1.57	0.00
27.00	3.50	1.57	0.00
27.50	3.50	1.57	0.00
28.00	3.50	1.57	0.00
28.50	3.50	1.57	0.00
29.00	3.50	1.57	0.00
29.50	3.50	1.57	0.00
30.00	3.50	1.57	0.00
30.50	3.50	1.57	0.00
31.00	3.50	1.57	0.00
31.50	3.50	1.57	0.00
32.00	3.50	1.57	0.00
32.50	3.50	1.57	0.00
33.00	3.50	1.57	0.00
33.50	3.50	1.57	0.00
34.00	3.50	1.57	0.00
34.50	3.50	1.57	0.00
35.00	3.50	1.57	0.00
35.50	3.50	1.57	0.00
36.00	3.50	1.57	0.00

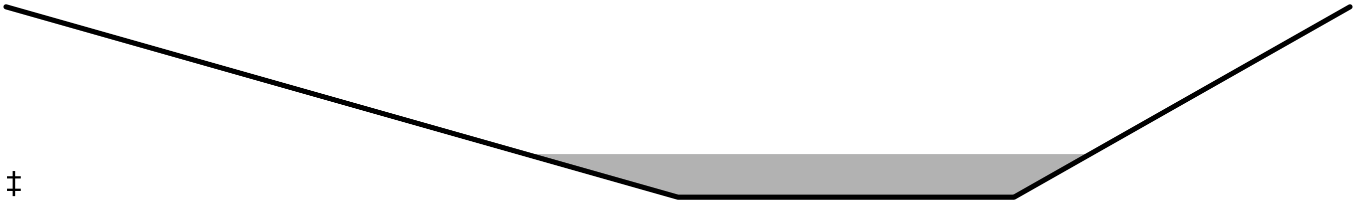
Summary for Reach 2R: chanel

Inflow Area = 2.800 ac, 0.00% Impervious, Inflow Depth = 1.57" for 25-Year event
Inflow = 8.51 cfs @ 11.94 hrs, Volume= 0.365 af
Outflow = 4.58 cfs @ 12.26 hrs, Volume= 0.365 af, Atten= 46%, Lag= 19.1 min

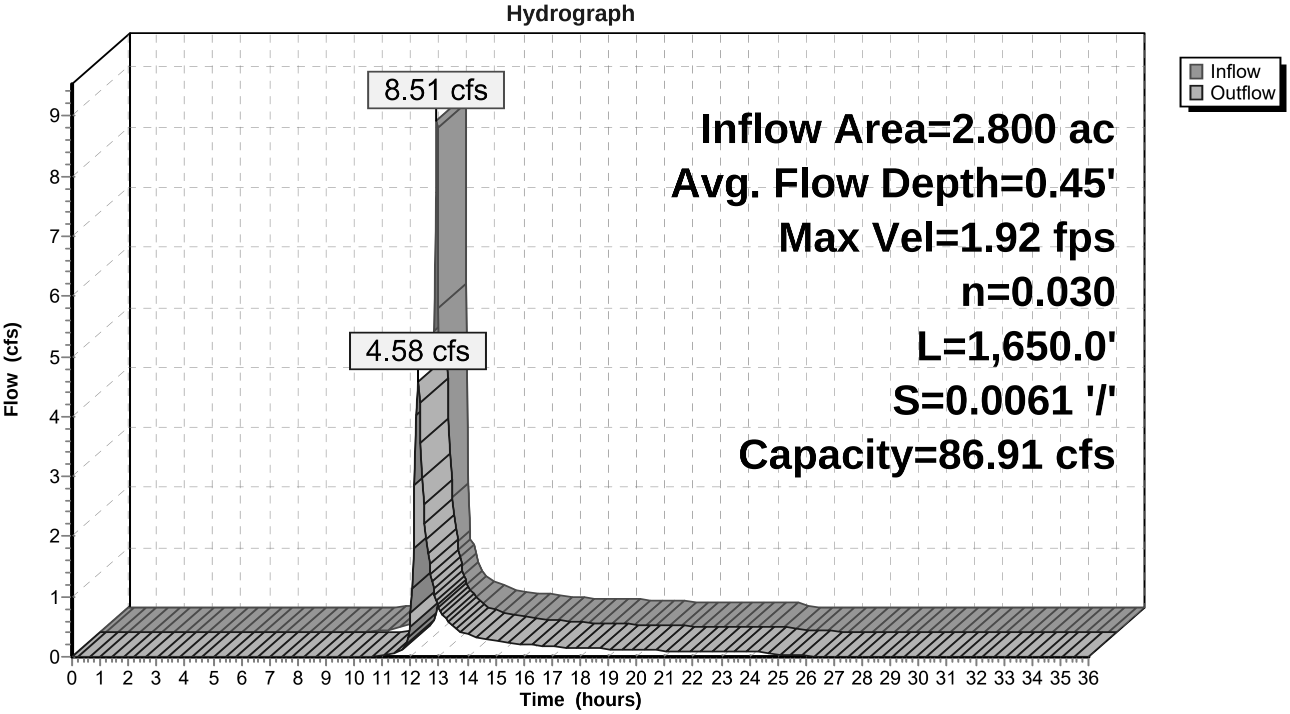
Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.92 fps, Min. Travel Time= 14.3 min
Avg. Velocity = 0.47 fps, Avg. Travel Time= 58.1 min

Peak Storage= 4,002 cf @ 12.01 hrs
Average Depth at Peak Storage= 0.45'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 86.91 cfs

4.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 2.0 '/' Top Width= 16.00'
Length= 1,650.0' Slope= 0.0061 '/'
Inlet Invert= 18.00', Outlet Invert= 8.00'



Reach 2R: chanel



Hydrograph for Reach 2R: chanel

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)
0.00	0.00	0	18.00	0.00
1.00	0.00	0	18.00	0.00
2.00	0.00	0	18.00	0.00
3.00	0.00	0	18.00	0.00
4.00	0.00	0	18.00	0.00
5.00	0.00	0	18.00	0.00
6.00	0.00	0	18.00	0.00
7.00	0.00	0	18.00	0.00
8.00	0.00	0	18.00	0.00
9.00	0.00	0	18.00	0.00
10.00	0.03	29	18.00	0.00
11.00	**0.13**	200	18.03	0.02
12.00	**5.39**	**3,979**	**18.45**	**0.74**
13.00	0.44	1,042	18.14	**0.82**
14.00	0.27	691	18.10	0.37
15.00	0.22	569	18.08	0.25
16.00	0.17	493	18.07	0.20
17.00	0.15	443	18.06	0.17
18.00	0.13	412	18.06	0.15
19.00	0.12	380	18.06	0.13
20.00	0.10	344	18.05	0.11
21.00	0.09	323	18.05	0.10
22.00	0.09	314	18.05	0.09
23.00	0.09	306	18.04	0.09
24.00	0.08	299	18.04	0.09
25.00	0.00	137	18.02	0.03
26.00	0.00	74	18.01	0.01
27.00	0.00	40	18.01	0.01
28.00	0.00	22	18.00	0.00
29.00	0.00	12	18.00	0.00
30.00	0.00	6	18.00	0.00
31.00	0.00	3	18.00	0.00
32.00	0.00	2	18.00	0.00
33.00	0.00	1	18.00	0.00
34.00	0.00	1	18.00	0.00
35.00	0.00	0	18.00	0.00
36.00	0.00	0	18.00	0.00

```
                 Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
                 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
     Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment 1S: Hillslope            Runoff Area=2.800 ac   0.00% Impervious   Runoff Depth=1.96"
                       Flow Length=60'   Slope=0.2500 '/'   Tc=3.0 min   CN=79   Runoff=10.62 cfs  0.458 af

Reach 2R: chanel                    Avg. Flow Depth=0.53'   Max Vel=2.09 fps   Inflow=10.62 cfs  0.458 af
                      n=0.030   L=1,650.0'   S=0.0061 '/'   Capacity=86.91 cfs   Outflow=5.94 cfs  0.458 af

          Total Runoff Area = 2.800 ac   Runoff Volume = 0.458 af   Average Runoff Depth = 1.96"
                                 100.00% Pervious = 2.800 ac     0.00% Impervious = 0.000 ac
```

Summary for Subcatchment 1S: Hillslope

[49] Hint: Tc<2dt may require smaller dt

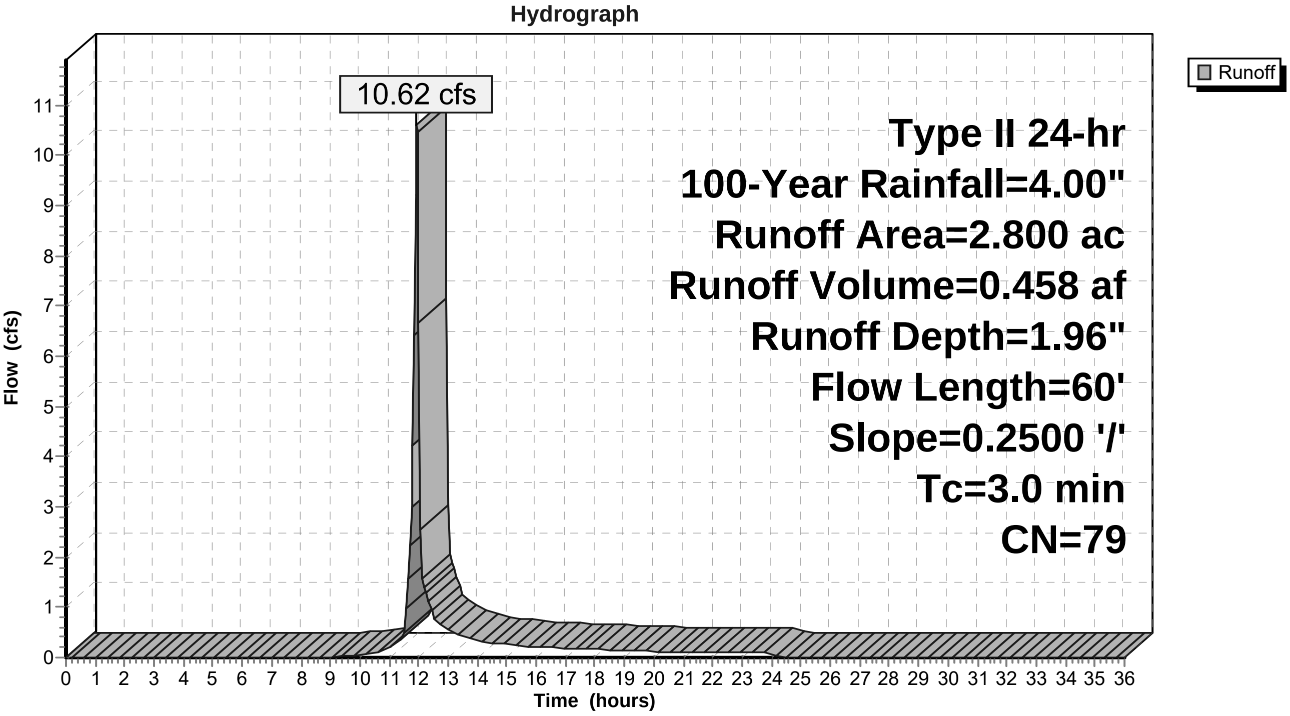
Runoff = 10.62 cfs @ 11.94 hrs, Volume= 0.458 af, Depth= 1.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=4.00"

Area (ac)	CN	Description
2.800	79	<50% Grass cover, Poor, HSG B
2.800		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.0	60	0.2500	0.33		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.00"

Subcatchment 1S: Hillslope



Hydrograph for Subcatchment 1S: Hillslope

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
0.00	0.00	0.00	0.00
0.50	0.02	0.00	0.00
1.00	0.04	0.00	0.00
1.50	0.06	0.00	0.00
2.00	0.09	0.00	0.00
2.50	0.11	0.00	0.00
3.00	0.14	0.00	0.00
3.50	0.16	0.00	0.00
4.00	0.19	0.00	0.00
4.50	0.22	0.00	0.00
5.00	0.25	0.00	0.00
5.50	0.28	0.00	0.00
6.00	0.32	0.00	0.00
6.50	0.36	0.00	0.00
7.00	0.40	0.00	0.00
7.50	0.44	0.00	0.00
8.00	0.48	0.00	0.00
8.50	0.53	0.00	0.00
9.00	0.59	0.00	0.01
9.50	0.65	0.01	0.03
10.00	0.72	0.01	0.06
10.50	0.82	0.03	0.10
11.00	0.94	0.05	0.19
11.50	1.13	0.11	**0.43**
12.00	2.65	0.94	**6.66**
12.50	2.94	1.14	0.80
13.00	3.09	1.25	0.53
13.50	3.20	1.33	0.41
14.00	3.28	1.40	0.32
14.50	3.35	1.45	0.29
15.00	3.41	1.50	0.26
15.50	3.47	1.54	0.23
16.00	3.52	1.58	0.20
16.50	3.56	1.62	0.19
17.00	3.61	1.65	0.18
17.50	3.65	1.68	0.17
18.00	3.68	1.71	0.16
18.50	3.72	1.74	0.15
19.00	3.75	1.76	0.14
19.50	3.78	1.79	0.13
20.00	3.81	1.81	0.12
20.50	3.83	1.83	0.12
21.00	3.86	1.85	0.11
21.50	3.88	1.87	0.11
22.00	3.91	1.89	0.11
22.50	3.93	1.91	0.11
23.00	3.95	1.93	0.11
23.50	3.98	1.95	0.10
24.00	**4.00**	**1.96**	0.10
24.50	4.00	1.96	0.00
25.00	4.00	1.96	0.00
25.50	4.00	1.96	0.00
26.00	4.00	1.96	0.00
26.50	4.00	1.96	0.00
27.00	4.00	1.96	0.00
27.50	4.00	1.96	0.00
28.00	4.00	1.96	0.00
28.50	4.00	1.96	0.00
29.00	4.00	1.96	0.00
29.50	4.00	1.96	0.00
30.00	4.00	1.96	0.00
30.50	4.00	1.96	0.00
31.00	4.00	1.96	0.00
31.50	4.00	1.96	0.00
32.00	4.00	1.96	0.00
32.50	4.00	1.96	0.00
33.00	4.00	1.96	0.00
33.50	4.00	1.96	0.00
34.00	4.00	1.96	0.00
34.50	4.00	1.96	0.00
35.00	4.00	1.96	0.00
35.50	4.00	1.96	0.00
36.00	4.00	1.96	0.00

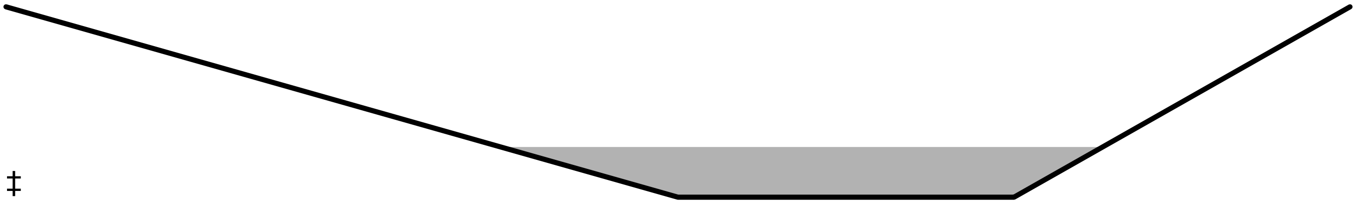
Summary for Reach 2R: chanel

```
Inflow Area =          2.800 ac,    0.00% Impervious,  Inflow Depth =   1.96"    for  100-Year event
Inflow       =        10.62 cfs @   11.94 hrs,  Volume=              0.458 af
Outflow      =         5.94 cfs @   12.23 hrs,  Volume=              0.458 af,  Atten= 44%,  Lag= 17.6 min
```

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.09 fps, Min. Travel Time= 13.1 min
Avg. Velocity = 0.50 fps, Avg. Travel Time= 55.4 min

Peak Storage= 4,851 cf @ 12.01 hrs
Average Depth at Peak Storage= 0.53'
Bank-Full Depth= 2.00' Flow Area= 20.0 sf, Capacity= 86.91 cfs

4.00' x 2.00' deep channel, n= 0.030 Earth, grassed & winding
Side Slope Z-value= 4.0 2.0 '/' Top Width= 16.00'
Length= 1,650.0' Slope= 0.0061 '/'
Inlet Invert= 18.00', Outlet Invert= 8.00'



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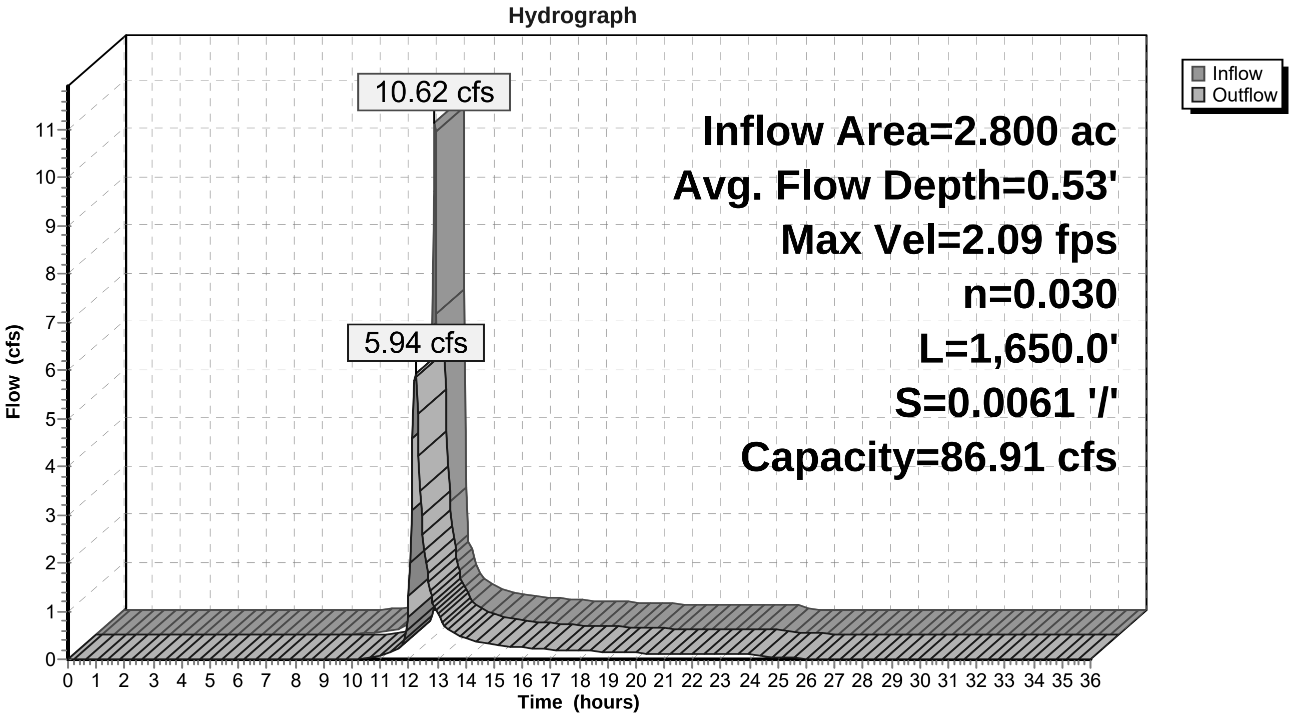
Reach 2R: chanel



Hydrograph for Reach 2R: chanel

Time (hours)	Inflow (cfs)	Storage (cubic-feet)	Elevation (feet)	Outflow (cfs)
0.00	0.00	0	18.00	0.00
1.00	0.00	0	18.00	0.00
2.00	0.00	0	18.00	0.00
3.00	0.00	0	18.00	0.00
4.00	0.00	0	18.00	0.00
5.00	0.00	0	18.00	0.00
6.00	0.00	0	18.00	0.00
7.00	0.00	0	18.00	0.00
8.00	0.00	0	18.00	0.00
9.00	0.01	9	18.00	0.00
10.00	0.06	95	18.01	0.01
11.00	**0.19**	326	18.05	0.07
12.00	**6.66**	**4,838**	**18.53**	**1.30**
13.00	0.53	1,162	18.16	**0.94**
14.00	0.32	773	18.11	0.43
15.00	0.26	638	18.09	0.30
16.00	0.20	553	18.08	0.24
17.00	0.18	496	18.07	0.20
18.00	0.16	459	18.07	0.18
19.00	0.14	424	18.06	0.15
20.00	0.12	386	18.06	0.13
21.00	0.11	361	18.05	0.12
22.00	0.11	350	18.05	0.11
23.00	0.11	342	18.05	0.11
24.00	0.10	333	18.05	0.10
25.00	0.00	146	18.02	0.04
26.00	0.00	79	18.01	0.02
27.00	0.00	43	18.01	0.01
28.00	0.00	23	18.00	0.00
29.00	0.00	12	18.00	0.00
30.00	0.00	7	18.00	0.00
31.00	0.00	4	18.00	0.00
32.00	0.00	2	18.00	0.00
33.00	0.00	1	18.00	0.00
34.00	0.00	1	18.00	0.00
35.00	0.00	0	18.00	0.00
36.00	0.00	0	18.00	0.00

Summary for Subcatchment 1S: Northern Catchment

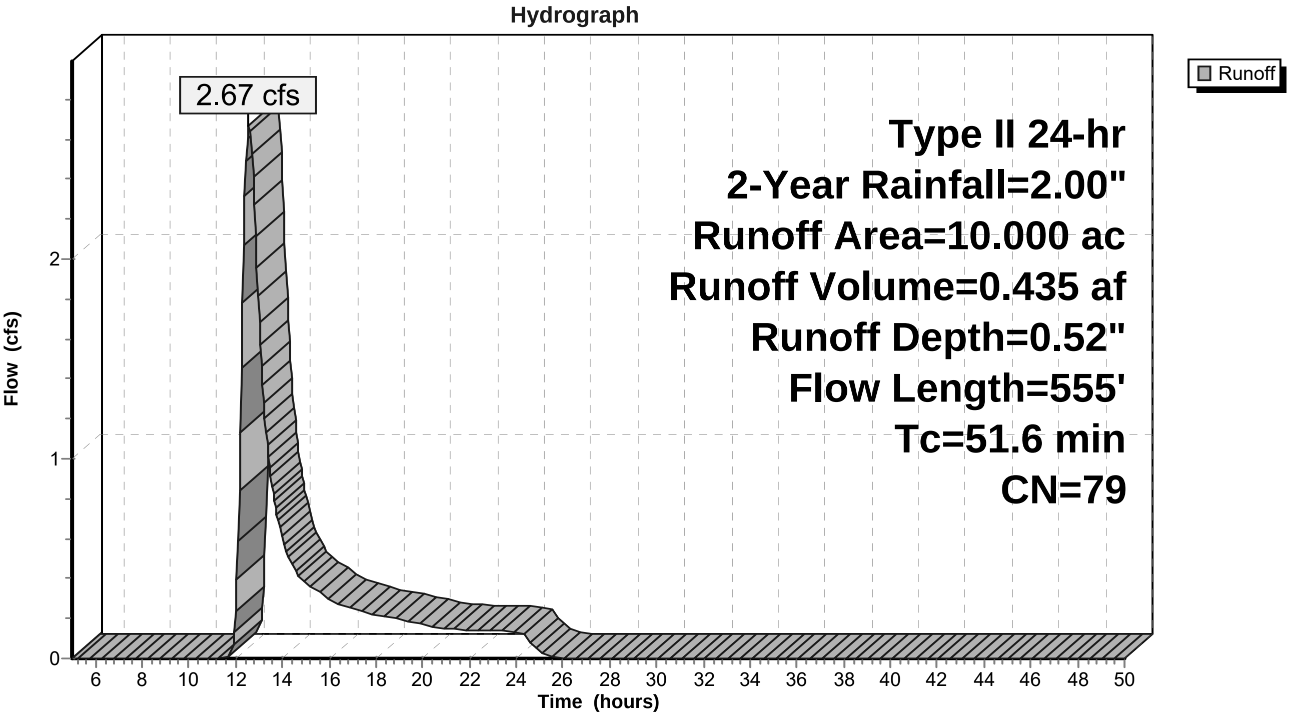
Runoff = 2.67 cfs @ 12.57 hrs, Volume= 0.435 af, Depth= 0.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-50.00 hrs, dt= 0.05 hrs
Type II 24-hr 2-Year Rainfall=2.00"

	Area (ac)	CN	Description
*	2.300	79	5% Slope
*	5.000	79	2% Slope
*	2.700	79	Shoreline
	10.000	79	Weighted Average
	10.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.1	185	0.0500	0.22		**Sheet Flow, 5 %** Grass: Short n= 0.150 P2= 2.00"
25.8	250	0.0200	0.16		**Sheet Flow, 2%** Grass: Short n= 0.150 P2= 2.00"
11.7	120	0.2500	0.17		**Sheet Flow, Shoreline** Grass: Bermuda n= 0.410 P2= 2.00"
51.6	555	Total			

Subcatchment 1S: Northern Catchment



Hydrograph for Subcatchment 1S: Northern Catchment

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.13	0.00	0.00
5.50	0.14	0.00	0.00
6.00	0.16	0.00	0.00
6.50	0.18	0.00	0.00
7.00	0.20	0.00	0.00
7.50	0.22	0.00	0.00
8.00	0.24	0.00	0.00
8.50	0.26	0.00	0.00
9.00	0.29	0.00	0.00
9.50	0.33	0.00	0.00
10.00	0.36	0.00	0.00
10.50	0.41	0.00	0.00
11.00	0.47	0.00	0.00
11.50	0.57	0.00	0.00
12.00	1.33	0.18	0.24
12.50	1.47	0.24	**2.61**
13.00	1.54	0.28	**1.68**
13.50	1.60	0.31	0.91
14.00	1.64	0.33	0.60
14.50	1.68	0.34	0.45
15.00	1.71	0.36	0.37
15.50	1.74	0.38	0.33
16.00	1.76	0.39	0.30
16.50	1.78	0.40	0.27
17.00	1.80	0.41	0.25
17.50	1.82	0.42	0.23
18.00	1.84	0.43	0.22
18.50	1.86	0.44	0.21
19.00	1.88	0.45	0.20
19.50	1.89	0.46	0.18
20.00	1.90	0.47	0.17
20.50	1.92	0.47	0.16
21.00	1.93	0.48	0.15
21.50	1.94	0.49	0.15
22.00	1.95	0.50	0.14
22.50	1.97	0.50	0.14
23.00	1.98	0.51	0.14
23.50	1.99	0.52	0.14
24.00	**2.00**	**0.52**	0.13
24.50	2.00	0.52	0.10
25.00	2.00	0.52	0.03
25.50	2.00	0.52	0.01
26.00	2.00	0.52	0.00
26.50	2.00	0.52	0.00
27.00	2.00	0.52	0.00
27.50	2.00	0.52	0.00
28.00	2.00	0.52	0.00
28.50	2.00	0.52	0.00
29.00	2.00	0.52	0.00
29.50	2.00	0.52	0.00
30.00	2.00	0.52	0.00
30.50	2.00	0.52	0.00
31.00	2.00	0.52	0.00
31.50	2.00	0.52	0.00
32.00	2.00	0.52	0.00
32.50	2.00	0.52	0.00
33.00	2.00	0.52	0.00
33.50	2.00	0.52	0.00
34.00	2.00	0.52	0.00
34.50	2.00	0.52	0.00
35.00	2.00	0.52	0.00
35.50	2.00	0.52	0.00
36.00	2.00	0.52	0.00
36.50	2.00	0.52	0.00
37.00	2.00	0.52	0.00
37.50	2.00	0.52	0.00
38.00	2.00	0.52	0.00
38.50	2.00	0.52	0.00
39.00	2.00	0.52	0.00
39.50	2.00	0.52	0.00
40.00	2.00	0.52	0.00
40.50	2.00	0.52	0.00
41.00	2.00	0.52	0.00
41.50	2.00	0.52	0.00
42.00	2.00	0.52	0.00
42.50	2.00	0.52	0.00
43.00	2.00	0.52	0.00
43.50	2.00	0.52	0.00
44.00	2.00	0.52	0.00
44.50	2.00	0.52	0.00
45.00	2.00	0.52	0.00
45.50	2.00	0.52	0.00
46.00	2.00	0.52	0.00
46.50	2.00	0.52	0.00
47.00	2.00	0.52	0.00
47.50	2.00	0.52	0.00
48.00	2.00	0.52	0.00
48.50	2.00	0.52	0.00
49.00	2.00	0.52	0.00
49.50	2.00	0.52	0.00
50.00	2.00	0.52	0.00

Summary for Subcatchment 1S: Northern Catchment

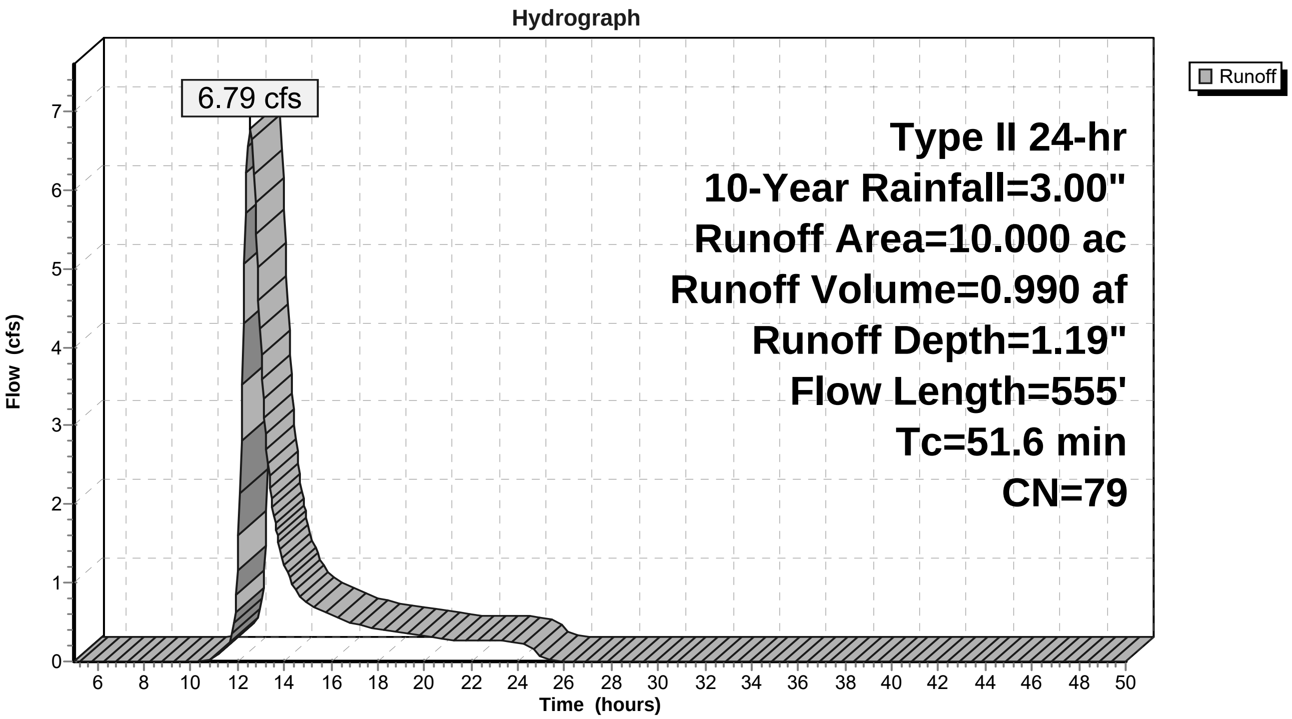
Runoff = 6.79 cfs @ 12.54 hrs, Volume= 0.990 af, Depth= 1.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-50.00 hrs, dt= 0.05 hrs
Type II 24-hr 10-Year Rainfall=3.00"

	Area (ac)	CN	Description
*	2.300	79	5% Slope
*	5.000	79	2% Slope
*	2.700	79	Shoreline
	10.000	79	Weighted Average
	10.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.1	185	0.0500	0.22		**Sheet Flow, 5 %** Grass: Short n= 0.150 P2= 2.00"
25.8	250	0.0200	0.16		**Sheet Flow, 2%** Grass: Short n= 0.150 P2= 2.00"
11.7	120	0.2500	0.17		**Sheet Flow, Shoreline** Grass: Bermuda n= 0.410 P2= 2.00"
51.6	555	Total			

Subcatchment 1S: Northern Catchment



Hydrograph for Subcatchment 1S: Northern Catchment

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.19	0.00	0.00
5.50	0.21	0.00	0.00
6.00	0.24	0.00	0.00
6.50	0.27	0.00	0.00
7.00	0.30	0.00	0.00
7.50	0.33	0.00	0.00
8.00	0.36	0.00	0.00
8.50	0.40	0.00	0.00
9.00	0.44	0.00	0.00
9.50	0.49	0.00	0.00
10.00	0.54	0.00	0.00
10.50	0.61	0.00	0.01
11.00	0.71	0.01	0.05
11.50	0.85	0.03	0.18
12.00	1.99	0.52	1.17
12.50	2.20	0.65	**6.73**
13.00	2.32	0.72	**3.90**
13.50	2.40	0.77	1.97
14.00	2.46	0.81	1.24
14.50	2.51	0.85	0.91
15.00	2.56	0.88	0.74
15.50	2.60	0.91	0.66
16.00	2.64	0.93	0.59
16.50	2.67	0.96	0.52
17.00	2.71	0.98	0.48
17.50	2.74	1.00	0.45
18.00	2.76	1.02	0.42
18.50	2.79	1.04	0.40
19.00	2.81	1.05	0.37
19.50	2.84	1.07	0.35
20.00	2.86	1.08	0.32
20.50	2.88	1.10	0.30
21.00	2.89	1.11	0.28
21.50	2.91	1.13	0.28
22.00	2.93	1.14	0.27
22.50	2.95	1.15	0.27
23.00	2.97	1.16	0.26
23.50	2.98	1.18	0.26
24.00	**3.00**	**1.19**	0.25
24.50	3.00	1.19	0.20
25.00	3.00	1.19	0.06
25.50	3.00	1.19	0.01
26.00	3.00	1.19	0.00
26.50	3.00	1.19	0.00
27.00	3.00	1.19	0.00
27.50	3.00	1.19	0.00
28.00	3.00	1.19	0.00
28.50	3.00	1.19	0.00
29.00	3.00	1.19	0.00
29.50	3.00	1.19	0.00
30.00	3.00	1.19	0.00
30.50	3.00	1.19	0.00
31.00	3.00	1.19	0.00
31.50	3.00	1.19	0.00
32.00	3.00	1.19	0.00
32.50	3.00	1.19	0.00
33.00	3.00	1.19	0.00
33.50	3.00	1.19	0.00
34.00	3.00	1.19	0.00
34.50	3.00	1.19	0.00
35.00	3.00	1.19	0.00
35.50	3.00	1.19	0.00
36.00	3.00	1.19	0.00
36.50	3.00	1.19	0.00
37.00	3.00	1.19	0.00
37.50	3.00	1.19	0.00
38.00	3.00	1.19	0.00
38.50	3.00	1.19	0.00
39.00	3.00	1.19	0.00
39.50	3.00	1.19	0.00
40.00	3.00	1.19	0.00
40.50	3.00	1.19	0.00
41.00	3.00	1.19	0.00
41.50	3.00	1.19	0.00
42.00	3.00	1.19	0.00
42.50	3.00	1.19	0.00
43.00	3.00	1.19	0.00
43.50	3.00	1.19	0.00
44.00	3.00	1.19	0.00
44.50	3.00	1.19	0.00
45.00	3.00	1.19	0.00
45.50	3.00	1.19	0.00
46.00	3.00	1.19	0.00
46.50	3.00	1.19	0.00
47.00	3.00	1.19	0.00
47.50	3.00	1.19	0.00
48.00	3.00	1.19	0.00
48.50	3.00	1.19	0.00
49.00	3.00	1.19	0.00
49.50	3.00	1.19	0.00
50.00	3.00	1.19	0.00

Summary for Subcatchment 1S: Northern Catchment

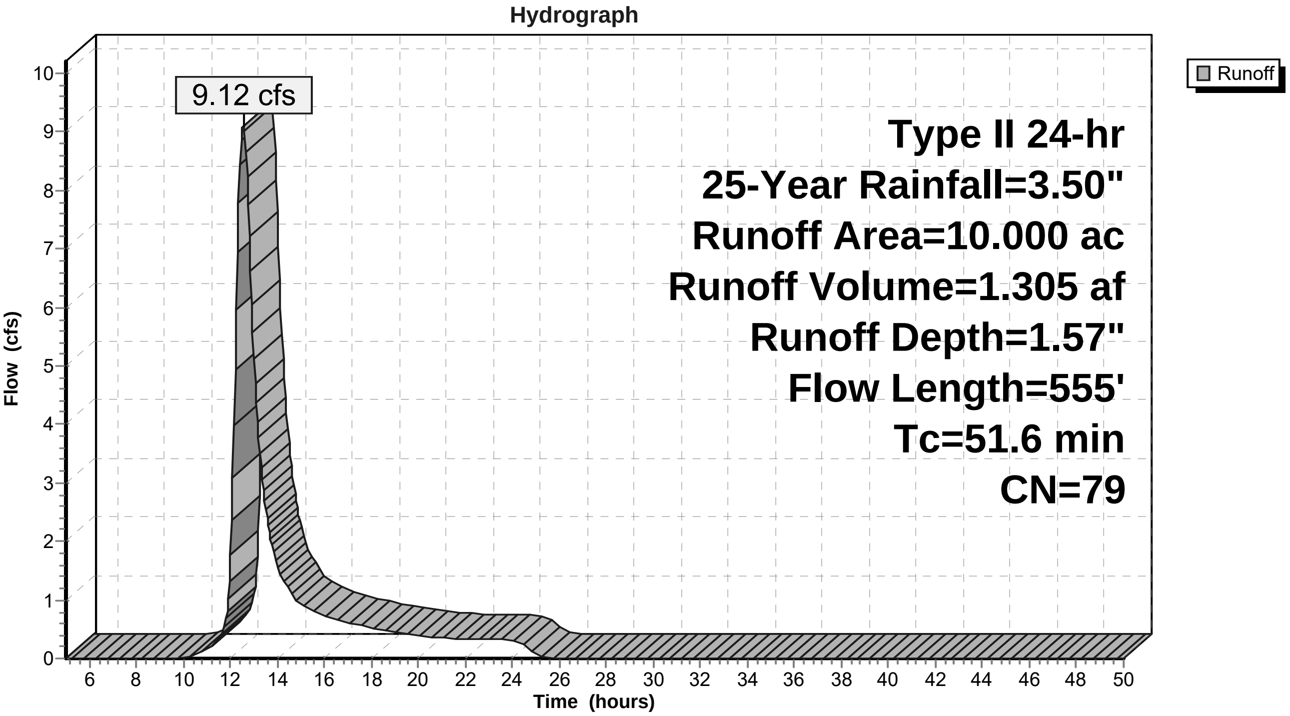
Runoff = 9.12 cfs @ 12.53 hrs, Volume= 1.305 af, Depth= 1.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-50.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-Year Rainfall=3.50"

	Area (ac)	CN	Description
*	2.300	79	5% Slope
*	5.000	79	2% Slope
*	2.700	79	Shoreline
	10.000	79	Weighted Average
	10.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.1	185	0.0500	0.22		**Sheet Flow, 5 %** Grass: Short n= 0.150 P2= 2.00"
25.8	250	0.0200	0.16		**Sheet Flow, 2%** Grass: Short n= 0.150 P2= 2.00"
11.7	120	0.2500	0.17		**Sheet Flow, Shoreline** Grass: Bermuda n= 0.410 P2= 2.00"
51.6	555	Total			

Subcatchment 1S: Northern Catchment



Hydrograph for Subcatchment 1S: Northern Catchment

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.22	0.00	0.00
5.50	0.25	0.00	0.00
6.00	0.28	0.00	0.00
6.50	0.31	0.00	0.00
7.00	0.35	0.00	0.00
7.50	0.38	0.00	0.00
8.00	0.42	0.00	0.00
8.50	0.46	0.00	0.00
9.00	0.51	0.00	0.00
9.50	0.57	0.00	0.00
10.00	0.63	0.00	0.02
10.50	0.71	0.01	0.07
11.00	0.82	0.03	0.16
11.50	0.99	0.07	0.36
12.00	2.32	0.72	1.76
12.50	2.57	0.89	**9.06**
13.00	2.70	0.98	**5.11**
13.50	2.80	1.04	2.53
14.00	2.87	1.09	1.58
14.50	2.93	1.14	1.15
15.00	2.99	1.18	0.94
15.50	3.04	1.22	0.83
16.00	3.08	1.25	0.74
16.50	3.12	1.28	0.65
17.00	3.16	1.30	0.60
17.50	3.19	1.33	0.56
18.00	3.22	1.35	0.53
18.50	3.25	1.38	0.50
19.00	3.28	1.40	0.47
19.50	3.31	1.42	0.43
20.00	3.33	1.44	0.40
20.50	3.35	1.45	0.37
21.00	3.38	1.47	0.35
21.50	3.40	1.49	0.34
22.00	3.42	1.50	0.34
22.50	3.44	1.52	0.33
23.00	3.46	1.54	0.32
23.50	3.48	1.55	0.32
24.00	**3.50**	**1.57**	0.31
24.50	3.50	1.57	0.24
25.00	3.50	1.57	0.07
25.50	3.50	1.57	0.02
26.00	3.50	1.57	0.00
26.50	3.50	1.57	0.00
27.00	3.50	1.57	0.00
27.50	3.50	1.57	0.00
28.00	3.50	1.57	0.00
28.50	3.50	1.57	0.00
29.00	3.50	1.57	0.00
29.50	3.50	1.57	0.00
30.00	3.50	1.57	0.00
30.50	3.50	1.57	0.00
31.00	3.50	1.57	0.00
31.50	3.50	1.57	0.00
32.00	3.50	1.57	0.00
32.50	3.50	1.57	0.00
33.00	3.50	1.57	0.00
33.50	3.50	1.57	0.00
34.00	3.50	1.57	0.00
34.50	3.50	1.57	0.00
35.00	3.50	1.57	0.00
35.50	3.50	1.57	0.00
36.00	3.50	1.57	0.00
36.50	3.50	1.57	0.00
37.00	3.50	1.57	0.00
37.50	3.50	1.57	0.00
38.00	3.50	1.57	0.00
38.50	3.50	1.57	0.00
39.00	3.50	1.57	0.00
39.50	3.50	1.57	0.00
40.00	3.50	1.57	0.00
40.50	3.50	1.57	0.00
41.00	3.50	1.57	0.00
41.50	3.50	1.57	0.00
42.00	3.50	1.57	0.00
42.50	3.50	1.57	0.00
43.00	3.50	1.57	0.00
43.50	3.50	1.57	0.00
44.00	3.50	1.57	0.00
44.50	3.50	1.57	0.00
45.00	3.50	1.57	0.00
45.50	3.50	1.57	0.00
46.00	3.50	1.57	0.00
46.50	3.50	1.57	0.00
47.00	3.50	1.57	0.00
47.50	3.50	1.57	0.00
48.00	3.50	1.57	0.00
48.50	3.50	1.57	0.00
49.00	3.50	1.57	0.00
49.50	3.50	1.57	0.00
50.00	3.50	1.57	0.00

Summary for Subcatchment 1S: Northern Catchment

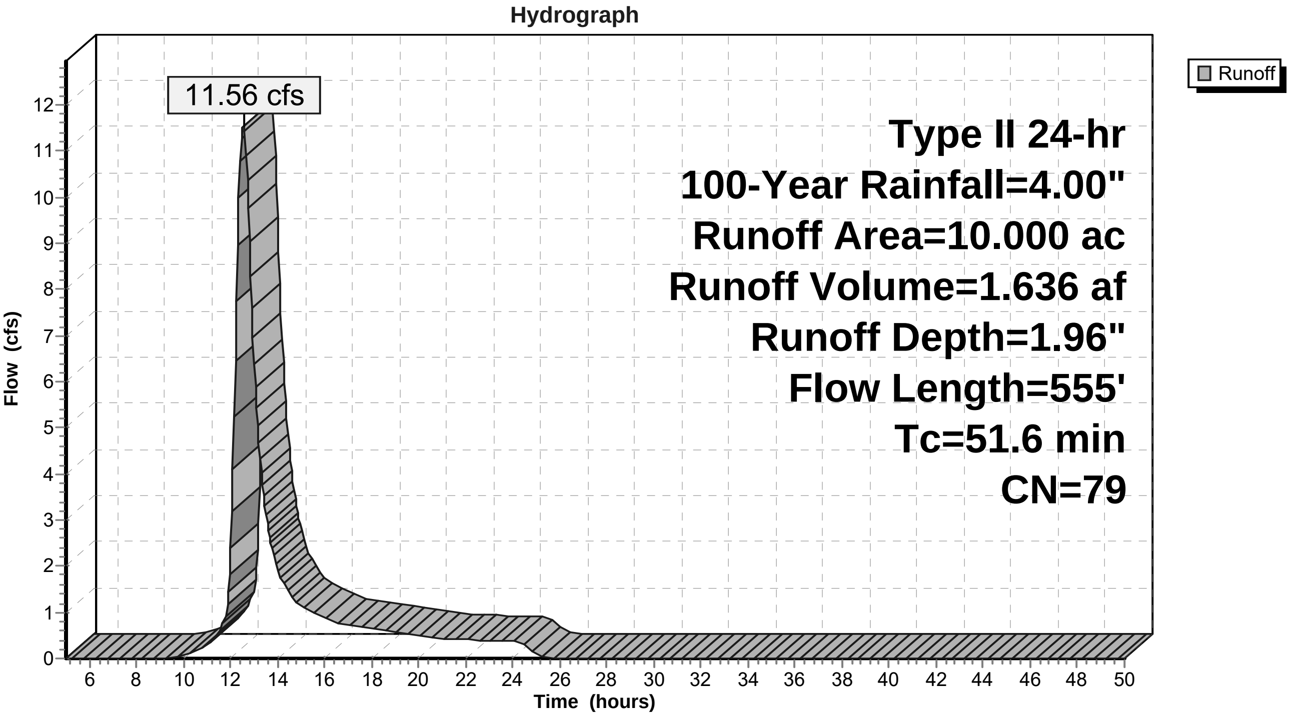
Runoff = 11.56 cfs @ 12.53 hrs, Volume= 1.636 af, Depth= 1.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-50.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-Year Rainfall=4.00"

	Area (ac)	CN	Description
*	2.300	79	5% Slope
*	5.000	79	2% Slope
*	2.700	79	Shoreline
	10.000	79	Weighted Average
	10.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.1	185	0.0500	0.22		**Sheet Flow, 5 %** Grass: Short n= 0.150 P2= 2.00"
25.8	250	0.0200	0.16		**Sheet Flow, 2%** Grass: Short n= 0.150 P2= 2.00"
11.7	120	0.2500	0.17		**Sheet Flow, Shoreline** Grass: Bermuda n= 0.410 P2= 2.00"
51.6	555	Total			

Subcatchment 1S: Northern Catchment



Hydrograph for Subcatchment 1S: Northern Catchment

Time (hours)	Precip. (inches)	Excess (inches)	Runoff (cfs)
5.00	0.25	0.00	0.00
5.50	0.29	0.00	0.00
6.00	0.32	0.00	0.00
6.50	0.36	0.00	0.00
7.00	0.40	0.00	0.00
7.50	0.44	0.00	0.00
8.00	0.48	0.00	0.00
8.50	0.53	0.00	0.00
9.00	0.59	0.00	0.00
9.50	0.65	0.01	0.03
10.00	0.72	0.01	0.08
10.50	0.82	0.03	0.16
11.00	0.94	0.05	0.30
11.50	1.13	0.11	0.57
12.00	2.65	0.94	2.41
12.50	2.94	1.14	**11.51**
13.00	3.09	1.25	**6.37**
13.50	3.20	1.33	3.12
14.00	3.28	1.40	1.93
14.50	3.35	1.45	1.40
15.00	3.41	1.50	1.13
15.50	3.47	1.54	1.00
16.00	3.52	1.58	0.89
16.50	3.56	1.62	0.79
17.00	3.61	1.65	0.72
17.50	3.65	1.68	0.67
18.00	3.68	1.71	0.63
18.50	3.72	1.74	0.60
19.00	3.75	1.76	0.56
19.50	3.78	1.79	0.52
20.00	3.81	1.81	0.48
20.50	3.83	1.83	0.44
21.00	3.86	1.85	0.42
21.50	3.88	1.87	0.41
22.00	3.91	1.89	0.40
22.50	3.93	1.91	0.39
23.00	3.95	1.93	0.39
23.50	3.98	1.95	0.38
24.00	**4.00**	**1.96**	0.37
24.50	4.00	1.96	0.29
25.00	4.00	1.96	0.09
25.50	4.00	1.96	0.02
26.00	4.00	1.96	0.00
26.50	4.00	1.96	0.00
27.00	4.00	1.96	0.00
27.50	4.00	1.96	0.00
28.00	4.00	1.96	0.00
28.50	4.00	1.96	0.00
29.00	4.00	1.96	0.00
29.50	4.00	1.96	0.00
30.00	4.00	1.96	0.00
30.50	4.00	1.96	0.00
31.00	4.00	1.96	0.00
31.50	4.00	1.96	0.00
32.00	4.00	1.96	0.00
32.50	4.00	1.96	0.00
33.00	4.00	1.96	0.00
33.50	4.00	1.96	0.00
34.00	4.00	1.96	0.00
34.50	4.00	1.96	0.00
35.00	4.00	1.96	0.00
35.50	4.00	1.96	0.00
36.00	4.00	1.96	0.00
36.50	4.00	1.96	0.00
37.00	4.00	1.96	0.00
37.50	4.00	1.96	0.00
38.00	4.00	1.96	0.00
38.50	4.00	1.96	0.00
39.00	4.00	1.96	0.00
39.50	4.00	1.96	0.00
40.00	4.00	1.96	0.00
40.50	4.00	1.96	0.00
41.00	4.00	1.96	0.00
41.50	4.00	1.96	0.00
42.00	4.00	1.96	0.00
42.50	4.00	1.96	0.00
43.00	4.00	1.96	0.00
43.50	4.00	1.96	0.00
44.00	4.00	1.96	0.00
44.50	4.00	1.96	0.00
45.00	4.00	1.96	0.00
45.50	4.00	1.96	0.00
46.00	4.00	1.96	0.00
46.50	4.00	1.96	0.00
47.00	4.00	1.96	0.00
47.50	4.00	1.96	0.00
48.00	4.00	1.96	0.00
48.50	4.00	1.96	0.00
49.00	4.00	1.96	0.00
49.50	4.00	1.96	0.00
50.00	4.00	1.96	0.00

ATTACHMENT B.4b

Hydraulics

LANDAU ASSOCIATES
130 2nd Avenue South
Edmonds, WA. 98020
Phone: (425) 778-0907 Fax: (425) 778-6409

JOB NO. 1037
JOB NAME Cornwall Ave Landfill
SUBJECT Sizing Storm drainage ditch Rational Method
CALC BY ALB DATE 10/13/2014
CHK BY KWW DATE 12/30/2015

Problem Statement:

Calculate the 10-year, 25-year and 100-year, 24-hour flows for the closed landfill discharging to the ditch on the southwest perimeter trench using the Rational Method

Requirements

* WAC 173-304-460(3)(iv) requires the runoff control system from active landfills to be able to collect and control at least the water volume resulting from a twenty-four hour, twenty-five year storm

* The stormwater collection trench on the southwest perimeter of the site receives water from south of the crest on the proposed cover and no offsite run-on.

* The trench is sized large enough to accommodate onsite flows from the 25-year, 24 hour storm with a maximum velocity of 5ft/sec and a maximum height of 2 feet

*Continuous simulation modelling of the site was not performed as there is not anticipated to be large amounts of changes to impervious surfaces, stormwater flow regimes. Additionally there is not any onsite storage of stormwater in ponds or other site specific BMPs that require design.

Assumptions:

* 2-Year 24 hour Isopluvial Storm 20 tenths of an inch
* 10-Year 24 hour Isopluvial Storm 30 tenths of an inch
* 25-Year 24 hour Isopluvial Storm 35 tenths of an inch
* 100-Year 24 hour Isopluvial storm 40 tenths of an inch
* Area of hillside (steep) 69,661 sq. ft (from CAD)
* Area of sloping into ditch south side 2,221 sq. ft (from CAD)
* Area of ditch 17,250 sq. ft (from CAD)
* Length of ditch 1228 ft (from CAD)
* Slope of ditch 0.5% (from CAD)
* Slope of hillside 33%
* Ditch and hillside will be covered with grass
* Use WSDOT Hydraulics Manual 1997 for guidance related to single event storm calculations

Drainage Basin Areas:	A (acres)
1. Drainage Area	2.1
Steep Sloped Grass	1.6
Shallow Sloped Grass	0.1
Grassy Swale	0.4

Per Figure 2-4.2 WSDOT Hydraulics Manual:

		C	
Runoff Coefficient (C)	10-year	25-year	100-year
Steep Sloped Grass (Lawns, Heavy Soil -Hilly)	0.35	0.39	0.48
Shallow Sloped Grass (Side Shoulders-Rolling)	0.25	0.28	0.31
Grassy Swale (grass shoulders-flat)	0.25	0.28	0.31

Note: According to the Manual, coefficients presented in Figure 2-4.2 are applicable for peak storms of 10-year or less frequency. To apply to a 25-year frequency, increase by 10 percent. To apply to a 100-year frequency, increase by 25 percent. The values above have been increased from the values presented in Table 4.7.1 accordingly. Values should not be increased above 0.90.

Per Figujre 2-4.4A of WSDOT Hydraulics Manual for Bellingham:

Rainfall Coefficient	m	n
10-Year	167	0.559
25-year	201	0.562
100-year	251	0.565

Per TableFigure 2-4.3 of the WSDOT Hydraulics Manual (English Units):

Ground Cover Coefficient

k =	420	Short Pasture grass or Lawn
	900	Small roadside ditch w/grass

Note: k values shown represent the ground cover types included in the longest flow path only.

Flow Path:		L	
1. Drainage Area		1288	ft
	Length of Slope	60	ft
	Length of ditch	1228	ft

Equations

Rational Method :

Q = CIA

where:

Q = runoff, in cubic feet per second (cfs)
C = runoff coefficient
I = rainfall intensity in inches per hour (in/hr)
A = contributing area, in acres (ac)

I = m / (Tc)^n

where:

I = rainfall intensity, in in/hr
Tc = time of concentration, in minutes (min)
m and n = rainfall intensity coefficients

Time of Concentration (Tc):

Tc = Tt1+Tt2+…+Ttn
Tt = L / [k * (S^0.5)] or Tt = (L^1.5) / [k * (dH^0.5)]

Where:

Tc = time of concentration, in min
Tt = travel time of flow segment, in min
L = length of segment, in feet (ft)
k = ground cover coefficient, in ft/min
S = slope of segment, in ft/ft
dH = change in elevation of segment, in ft

Note: The Tc value used should never be less than 5 minutes per the manual

Solution

Solve for Tc using Tt = (L^1.5) / [k * (dH^0.5)]:

		dH ft	L ft	Tt minutes	Tc minutes	Tc > 5?
1.	Hillside	17.0	60	0.151	--	
	ditch	5.0	1228	1.778	--	
				Total	1.93	**No; use 5**

Solve for I:		10-year	25-year	100-year
	I =	67.9	81.4	101.1

Conclusion

Calculate Flows:

1. Drainage to Ditch

	10-year	25-year	100-year		10-year	25-year	100-year
Q (cfs)	**47**	**61**	**94**	C*A =	0.7	0.8	0.9
Q (gpm)	20880	27511	42028				

LANDAU ASSOCIATES
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* Slope of ditch 0.5% (from CAD)
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Per Figure 2-4.2 WSDOT Hydraulics Manual:

		C	
Runoff Coefficient (C)	10-year	25-year	100-year
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Note: According to the Manual, coefficients presented in Figure 2-4.2 are applicable for peak storms of 10-year or less frequency. To apply to a 25-year frequency, increase by 10 percent. To apply to a 100-year frequency, increase by 25 percent. The values above have been increased from the values presented in Table 4.7.1 accordingly. Values should not be increased above 0.90.

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Rainfall Coefficient	m	n
10-Year	167	0.559
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Ground Cover Coefficient

k =	420	Short Pasture grass or Lawn
	900	Small roadside ditch w/grass

Note: k values shown represent the ground cover types included in the longest flow path only.

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1. Drainage Area		1288	ft
	Length of Slope	60	ft
	Length of ditch	1228	ft

Equations

Rational Method :

Q = CIA

where:

Q = runoff, in cubic feet per second (cfs)
C = runoff coefficient
I = rainfall intensity in inches per hour (in/hr)
A = contributing area, in acres (ac)

I = m / (Tc)^n

where:

I = rainfall intensity, in in/hr
Tc = time of concentration, in minutes (min)
m and n = rainfall intensity coefficients

Time of Concentration (Tc):

Tc = Tt1+Tt2+…+Ttn
Tt = L / [k * (S^0.5)] or Tt = (L^1.5) / [k * (dH^0.5)]

Where:

Tc = time of concentration, in min
Tt = travel time of flow segment, in min
L = length of segment, in feet (ft)
k = ground cover coefficient, in ft/min
S = slope of segment, in ft/ft
dH = change in elevation of segment, in ft

Note: The Tc value used should never be less than 5 minutes per the manual

Solution

Solve for Tc using Tt = (L^1.5) / [k * (dH^0.5)]:

		dH ft	L ft	Tt minutes	Tc minutes	Tc > 5?
1.	Hillside	17.0	60	0.151	--	
	ditch	5.0	1228	1.778	--	
				Total	1.93	**No; use 5**

Solve for I:		10-year	25-year	100-year
	I =	67.9	81.4	101.1

Conclusion

Calculate Flows:

1. Drainage to Ditch

	10-year	25-year	100-year		10-year	25-year	100-year
Q (cfs)	**47**	**61**	**94**	C*A =	0.7	0.8	0.9
Q (gpm)	20880	27511	42028				

ATTACHMENT B.5

HELP Model

```
_
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07 (1 November 1997)                 **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************



PRECIPITATION DATA FILE:    C:\WHI\VHELP22\data\P5110.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\VHELP22\data\P5110.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\VHELP22\data\P5110.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\VHELP22\data\P5110.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\VHELP22\data\P5110.VHP\I_390838.inp
OUTPUT DATA FILE:           C:\WHI\VHELP22\data\P5110.VHP\O_390838.prt


TIME:  14:54     DATE:  10/16/2015



******************************************************************************

    TITLE:  Cornwall Avenue Landfill Cover Two Percent

******************************************************************************



    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
           COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.



                             LAYER  1
                             --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   5
        THICKNESS                  =    60.96    CM
        POROSITY                   =     0.4570 VOL/VOL
        FIELD CAPACITY             =     0.1310 VOL/VOL
        WILTING POINT              =     0.0580 VOL/VOL
        INITIAL SOIL WATER CONTENT =     0.1443 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  0.100000224000E-02 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
             FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                             LAYER  2
                             --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER  20
        THICKNESS                  =     0.50    CM
        POROSITY                   =     0.8500 VOL/VOL
        FIELD CAPACITY             =     0.0100 VOL/VOL
        WILTING POINT              =     0.0050 VOL/VOL
```

```
            INITIAL SOIL WATER CONTENT  =      0.0139 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  10.0000000000      CM/SEC
            SLOPE                       =      2.00   PERCENT
            DRAINAGE LENGTH             =     21.3    METERS



                         LAYER  3
                         --------

                 TYPE 4 - FLEXIBLE MEMBRANE LINER
                  MATERIAL TEXTURE NUMBER  41
            THICKNESS                   =      0.10   CM
            POROSITY                    =      0.0000 VOL/VOL
            FIELD CAPACITY              =      0.0000 VOL/VOL
            WILTING POINT               =      0.0000 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.200000000000E-11 CM/SEC
            FML PINHOLE DENSITY         =      7.41   HOLES/HECTARE
            FML INSTALLATION DEFECTS    =      2.47   HOLES/HECTARE
            FML PLACEMENT QUALITY       =  3 - GOOD



                         LAYER  4
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER  23
            THICKNESS                   =     60.96   CM
            POROSITY                    =      0.4610 VOL/VOL
            FIELD CAPACITY              =      0.3600 VOL/VOL
            WILTING POINT               =      0.2030 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.4610 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-05 CM/SEC



                         LAYER  5
                         --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   9
            THICKNESS                   =     91.44   CM
            POROSITY                    =      0.5010 VOL/VOL
            FIELD CAPACITY              =      0.2840 VOL/VOL
            WILTING POINT               =      0.1350 VOL/VOL
            INITIAL SOIL WATER CONTENT  =      0.2838 VOL/VOL
            EFFECTIVE SAT. HYD. COND.   =  0.190000425600E-03 CM/SEC




               GENERAL DESIGN AND EVAPORATIVE ZONE DATA
               ----------------------------------------

           NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
                  SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
                  GOOD STAND OF GRASS, A SURFACE SLOPE OF  2.%
                  AND A SLOPE LENGTH OF   91. METERS.

           SCS RUNOFF CURVE NUMBER             =     55.07
           FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
           AREA PROJECTED ON HORIZONTAL PLANE  =      2.0234 HECTARES
           EVAPORATIVE ZONE DEPTH              =     61.0    CM
           INITIAL WATER IN EVAPORATIVE ZONE   =      8.794  CM
```

```
   UPPER LIMIT OF EVAPORATIVE STORAGE  =    27.859  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE  =     3.536  CM
   INITIAL SNOW WATER                  =     0.000  CM
   INITIAL WATER IN LAYER MATERIALS    =    62.857  CM
   TOTAL INITIAL WATER                 =    62.857  CM
   TOTAL SUBSURFACE INFLOW             =     0.00   MM/YR



             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           Bellingham           WA

       STATION LATITUDE                     =  48.74 DEGREES
       MAXIMUM LEAF AREA INDEX              =   2.00
       START OF GROWING SEASON (JULIAN DATE)  =    126
       END OF GROWING SEASON (JULIAN DATE)    =    287
       EVAPORATIVE ZONE DEPTH               =  24.0  INCHES
       AVERAGE ANNUAL WIND SPEED            =   9.10 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  75.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  69.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  70.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  79.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    Bellingham           WA

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    3.00        3.00        3.00        3.00        3.00        3.00
    3.00        3.00        3.00        3.00        3.00        3.00


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    Bellingham           WA

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   39.10       42.80       44.20       48.70       55.00       60.20
   64.80       64.10       60.00       52.50       44.80       41.00


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    Bellingham           WA
            AND STATION LATITUDE  =  48.74 DEGREES


*******************************************************************************

           MONTHLY TOTALS (IN INCHES) FOR YEAR   30
------------------------------------------------------------------------------

                      JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
                      ------- ------- ------- ------- ------- -------

PRECIPITATION            4.21    4.67    8.91    0.71    1.72    3.49
                         0.52    1.27    4.80    1.97    5.01    2.04
```

```
RUNOFF                    0.000   0.000   0.000   0.000   0.000   0.000
                          0.000   0.000   0.000   0.000   0.000   0.000

EVAPOTRANSPIRATION        0.398   0.630   2.045   1.670   1.615   2.573
                          1.692   0.424   2.043   1.218   0.597   0.673

LATERAL DRAINAGE COLLECTED  4.1921  4.1934  6.0724  1.6812  0.2280  1.3425
  FROM LAYER  2             0.4347  0.1450  0.8606  1.3827  2.8200  0.9872

PERCOLATION/LEAKAGE THROUGH  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  4                   0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

PERCOLATION/LEAKAGE THROUGH  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  5                   0.0000  0.0000  0.0000  0.0000  0.0000  0.0000


-------------------------------------------------------------------------------
          MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


AVERAGE DAILY HEAD ON       0.008   0.009   0.012   0.003   0.000   0.003
  TOP OF LAYER  3           0.001   0.000   0.002   0.003   0.006   0.002

STD. DEVIATION OF DAILY     0.006   0.013   0.015   0.005   0.000   0.003
  HEAD ON TOP OF LAYER  3   0.002   0.001   0.003   0.003   0.005   0.001

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                ANNUAL TOTALS FOR YEAR   30
-------------------------------------------------------------------------------
                                  INCHES      CU. FEET     PERCENT
                                 --------    ----------    -------
  PRECIPITATION                   39.32      713642.445    100.00

  RUNOFF                           0.000          0.000      0.00

  EVAPOTRANSPIRATION              15.581     282788.671     39.63

  DRAINAGE COLLECTED FROM LAYER  2    24.3399     441759.493     61.90

  PERC./LEAKAGE THROUGH LAYER  4    0.000041        0.751      0.00

  AVG. HEAD ON TOP OF LAYER  3      0.0042

  PERC./LEAKAGE THROUGH LAYER  5    0.000000        0.000      0.00

  CHANGE IN WATER STORAGE          -0.601     -10905.708     -1.53

  SOIL WATER AT START OF YEAR      27.216     493956.494

  SOIL WATER AT END OF YEAR        26.615     483050.786

  SNOW WATER AT START OF YEAR       0.000          0.000      0.00

  SNOW WATER AT END OF YEAR         0.000          0.000      0.00

  ANNUAL WATER BUDGET BALANCE       0.0000        -0.011      0.00

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      AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
------------------------------------------------------------------------------

                 JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                 -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS            2.83     2.23     2.75     2.93     2.38     3.16
                    3.90     2.74     3.44     3.05     2.93     2.13

  STD. DEVIATIONS   1.61     1.91     1.89     1.96     1.64     3.69
                    2.66     3.08     2.58     2.12     1.63     1.48

 RUNOFF
 ------
  TOTALS           0.001    0.001    0.000    0.002    0.000    0.055
                   0.011    0.008    0.013    0.006    0.000    0.000

  STD. DEVIATIONS  0.003    0.004    0.000    0.011    0.000    0.272
                   0.040    0.030    0.069    0.034    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
  TOTALS           0.678    0.896    1.576    1.924    1.958    2.662
                   3.430    2.060    1.390    0.944    0.577    0.526

  STD. DEVIATIONS  0.179    0.182    0.328    0.657    1.007    0.641
                   1.612    1.368    0.864    0.275    0.140    0.125

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
  TOTALS          1.6091   1.8545   1.4393   1.1977   0.6507   1.2849
                  1.2311   0.9186   0.8956   1.3275   1.5488   1.7394

  STD. DEVIATIONS 1.1918   1.5803   1.5253   1.2975   0.6314   1.9329
                  1.5443   1.1989   0.8614   1.4161   1.0222   1.4064

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
  TOTALS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
  TOTALS          0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS 0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                  0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


------------------------------------------------------------------------------
         AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
  AVERAGES        0.0040   0.0065   0.0029   0.0049   0.0013   0.0239
                  0.0063   0.0050   0.0043   0.0091   0.0032   0.0037

  STD. DEVIATIONS 0.0050   0.0125   0.0030   0.0150   0.0013   0.1030
                  0.0179   0.0145   0.0131   0.0375   0.0021   0.0036

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                  INCHES           CU. FEET       PERCENT
                              -------------------  -------------  ---------
 PRECIPITATION                 34.48    (   7.624)     625756.0     100.00

 RUNOFF                         0.096   (  0.2924)       1743.31      0.279

 EVAPOTRANSPIRATION            18.622   (  3.0290)     337983.15     54.012

 LATERAL DRAINAGE COLLECTED    15.69727 (  5.39770)    284899.268   45.52881
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH     0.00005 (  0.00004)         0.841     0.00013
   LAYER  4

 AVERAGE HEAD ON TOP             0.006 (    0.010)
   OF LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)         0.000     0.00000
   LAYER  5

 CHANGE IN WATER STORAGE          0.062   (  0.9617)       1130.29      0.181

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           PEAK DAILY VALUES FOR YEARS    1 THROUGH   30       and their dates (DDDYYYY)
  ----------------------------------------------------------------------------
                                          (INCHES)      (CU. FT.)
                                         ----------   -------------
    PRECIPITATION                           8.41       152638.17304   1660023

    RUNOFF                                  1.489      27017.77067   1660023

    DRAINAGE COLLECTED FROM LAYER  2          3.84424      69771.46049   1670023

    PERCOLATION/LEAKAGE THROUGH LAYER  4      0.000088        1.59204   1670023

    AVERAGE HEAD ON TOP OF LAYER  3           9.760

    MAXIMUM HEAD ON TOP OF LAYER  3          11.694

    LOCATION OF MAXIMUM HEAD IN LAYER  2
         (DISTANCE FROM DRAIN)               35.1 FEET

    PERCOLATION/LEAKAGE THROUGH LAYER  5      0.000000        0.00000        0

    SNOW WATER                              3.33       60442.8075    210028


    MAXIMUM VEG. SOIL WATER (VOL/VOL)                0.4168

    MINIMUM VEG. SOIL WATER (VOL/VOL)                0.0580


     ***  Maximum heads are computed using McEnroe's equations.  ***

          Reference:  Maximum Saturated Depth over Landfill Liner
                      by Bruce M. McEnroe, University of Kansas
                      ASCE Journal of Environmental Engineering
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                 Vol. 119, No. 2, March 1993, pp. 262-270.

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            FINAL WATER STORAGE AT END OF YEAR   30
   ----------------------------------------------------------------------
             LAYER        (INCHES)       (VOL/VOL)
             -----        --------       ---------
               1           5.3248         0.2219

               2           0.0071         0.0360

               3           0.0000         0.0000

               4          11.0640         0.4610

               5          10.2191         0.2839

            SNOW WATER       0.000

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.07 (1 November 1997)               **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                  USAE WATERWAYS EXPERIMENT STATION                       **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:    C:\WHI\VHELP22\data\P5110.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\VHELP22\data\P5110.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\VHELP22\data\P5110.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\VHELP22\data\P5110.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\VHELP22\data\P5110.VHP\I_390838.inp
OUTPUT DATA FILE:           C:\WHI\VHELP22\data\P5110.VHP\O_390838.prt


TIME:  15: 3     DATE:  10/16/2015


******************************************************************************

   TITLE:  Cornwall Avenue Landfill Cover Five Percent

******************************************************************************


   NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
          COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                          LAYER  1
                          --------

                TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER   5
        THICKNESS                  =     60.96   CM
        POROSITY                   =      0.4570 VOL/VOL
        FIELD CAPACITY             =      0.1310 VOL/VOL
        WILTING POINT              =      0.0580 VOL/VOL
        INITIAL SOIL WATER CONTENT  =      0.1441 VOL/VOL
        EFFECTIVE SAT. HYD. COND.   =  0.100000224000E-02 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
             FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                          LAYER  2
                          --------

                 TYPE 2 - LATERAL DRAINAGE LAYER
                   MATERIAL TEXTURE NUMBER  20
        THICKNESS                  =      0.50   CM
        POROSITY                   =      0.8500 VOL/VOL
        FIELD CAPACITY             =      0.0100 VOL/VOL
        WILTING POINT              =      0.0050 VOL/VOL
```

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      INITIAL SOIL WATER CONTENT  =      0.0132 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
      SLOPE                       =      5.00   PERCENT
      DRAINAGE LENGTH             =     42.7    METERS



                        LAYER  3
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  41
      THICKNESS                   =      0.10   CM
      POROSITY                    =      0.0000 VOL/VOL
      FIELD CAPACITY              =      0.0000 VOL/VOL
      WILTING POINT               =      0.0000 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.200000000000E-11 CM/SEC
      FML PINHOLE DENSITY         =      7.41   HOLES/HECTARE
      FML INSTALLATION DEFECTS    =      2.47   HOLES/HECTARE
      FML PLACEMENT QUALITY       =  3 - GOOD



                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  23
      THICKNESS                   =     60.96   CM
      POROSITY                    =      0.4610 VOL/VOL
      FIELD CAPACITY              =      0.3600 VOL/VOL
      WILTING POINT               =      0.2030 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.4610 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-05 CM/SEC



                        LAYER  5
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   9
      THICKNESS                   =     91.44   CM
      POROSITY                    =      0.5010 VOL/VOL
      FIELD CAPACITY              =      0.2840 VOL/VOL
      WILTING POINT               =      0.1350 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.2838 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.190000425600E-03 CM/SEC




          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
            GOOD STAND OF GRASS, A SURFACE SLOPE OF  5.%
            AND A SLOPE LENGTH OF   91. METERS.

    SCS RUNOFF CURVE NUMBER            =    56.66
    FRACTION OF AREA ALLOWING RUNOFF   =   100.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =      2.0234 HECTARES
    EVAPORATIVE ZONE DEPTH             =    61.0    CM
    INITIAL WATER IN EVAPORATIVE ZONE  =      8.784  CM
```

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   UPPER LIMIT OF EVAPORATIVE STORAGE  =     27.859  CM
   LOWER LIMIT OF EVAPORATIVE STORAGE  =      3.536  CM
   INITIAL SNOW WATER                  =      0.000  CM
   INITIAL WATER IN LAYER MATERIALS    =     62.846  CM
   TOTAL INITIAL WATER                 =     62.846  CM
   TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR



             EVAPOTRANSPIRATION AND WEATHER DATA
             ----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
           Bellingham          WA

       STATION LATITUDE                    =  48.74 DEGREES
       MAXIMUM LEAF AREA INDEX             =   2.00
       START OF GROWING SEASON (JULIAN DATE)  =    126
       END OF GROWING SEASON (JULIAN DATE)    =    287
       EVAPORATIVE ZONE DEPTH              =  24.0  INCHES
       AVERAGE ANNUAL WIND SPEED           =   9.10 MPH
       AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  75.00 %
       AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  69.00 %
       AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  70.00 %
       AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  79.00 %


    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    Bellingham          WA

           NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    3.00        3.00        3.00        3.00        3.00        3.00
    3.00        3.00        3.00        3.00        3.00        3.00


    NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    Bellingham          WA

       NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
   39.10       42.80       44.20       48.70       55.00       60.20
   64.80       64.10       60.00       52.50       44.80       41.00


    NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
           COEFFICIENTS FOR    Bellingham          WA
             AND STATION LATITUDE  =  48.74 DEGREES


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           MONTHLY TOTALS (IN INCHES) FOR YEAR   30
-------------------------------------------------------------------------------

                          JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
                          ------- ------- ------- ------- ------- -------

PRECIPITATION                  4.21    4.67    8.91    0.71    1.72    3.49
                          0.52    1.27    4.80    1.97    5.01    2.04

RUNOFF                     0.000   0.000   0.000   0.000   0.000   0.000
```

```
                 0.000   0.000   0.000   0.000   0.000   0.000

EVAPOTRANSPIRATION           0.404   0.635   2.052   1.674   1.616   2.563
                 1.666   0.389   2.023   1.224   0.600   0.677

LATERAL DRAINAGE COLLECTED       4.1801  4.1910  6.0529  1.6954  0.2278  1.3493
  FROM LAYER  2               0.4623  0.2070  0.8494  1.3859  2.8091  0.9843

PERCOLATION/LEAKAGE THROUGH      0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  4                  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

PERCOLATION/LEAKAGE THROUGH      0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  5                  0.0000  0.0000  0.0000  0.0000  0.0000  0.0000


-------------------------------------------------------------------------------
                MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


AVERAGE DAILY HEAD ON            0.007   0.007   0.010   0.003   0.000   0.002
  TOP OF LAYER  3             0.001   0.000   0.001   0.002   0.005   0.002

STD. DEVIATION OF DAILY         0.005   0.010   0.012   0.004   0.000   0.003
  HEAD ON TOP OF LAYER  3       0.002   0.001   0.002   0.003   0.003   0.001

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                      ANNUAL TOTALS FOR YEAR   30
-------------------------------------------------------------------------------
                                  INCHES         CU. FEET     PERCENT
                                 --------       ----------    -------
  PRECIPITATION                        39.32         713642.445    100.00

  RUNOFF                            0.000           0.000      0.00

  EVAPOTRANSPIRATION                   15.522       281724.435     39.48

  DRAINAGE COLLECTED FROM LAYER  2       24.3946       442752.516     62.04

  PERC./LEAKAGE THROUGH LAYER  4         0.000037         0.679      0.00

  AVG. HEAD ON TOP OF LAYER  3           0.0033

  PERC./LEAKAGE THROUGH LAYER  5         0.000000         0.000      0.00

  CHANGE IN WATER STORAGE               -0.597       -10834.495     -1.52

  SOIL WATER AT START OF YEAR           27.215       493944.308

  SOIL WATER AT END OF YEAR             26.618       483109.813

  SNOW WATER AT START OF YEAR            0.000           0.000      0.00

  SNOW WATER AT END OF YEAR              0.000           0.000      0.00

  ANNUAL WATER BUDGET BALANCE            0.0000          -0.011      0.00

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        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                    JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                    -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
  TOTALS              2.83     2.23     2.75     2.93     2.38     3.16
                      3.90     2.74     3.44     3.05     2.93     2.13

  STD. DEVIATIONS     1.61     1.91     1.89     1.96     1.64     3.69
                      2.66     3.08     2.58     2.12     1.63     1.48

 RUNOFF
 ------
  TOTALS             0.002    0.002    0.000    0.003    0.000    0.065
                     0.016    0.012    0.016    0.008    0.000    0.000

  STD. DEVIATIONS    0.006    0.011    0.000    0.018    0.000    0.307
                     0.054    0.042    0.087    0.045    0.000    0.000

 EVAPOTRANSPIRATION
 ------------------
  TOTALS             0.657    0.863    1.564    1.931    1.956    2.647
                     3.377    1.968    1.360    0.924    0.560    0.503

  STD. DEVIATIONS    0.173    0.199    0.318    0.616    0.996    0.657
                     1.607    1.354    0.871    0.283    0.148    0.139

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
  TOTALS            1.5835   1.8643   1.4306   1.2208   0.6605   1.2216
                    1.3175   0.9869   1.0340   1.3802   1.6076   1.6751

  STD. DEVIATIONS   1.1099   1.5884   1.5440   1.2959   0.6317   1.7847
                    1.4929   1.1739   0.8697   1.4345   1.0559   1.2684

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
  TOTALS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
  TOTALS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

  STD. DEVIATIONS   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                    0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
  AVERAGES          0.0025   0.0045   0.0023   0.0032   0.0011   0.0191
                    0.0029   0.0027   0.0030   0.0063   0.0027   0.0027

  STD. DEVIATIONS   0.0018   0.0067   0.0025   0.0079   0.0010   0.0917
                    0.0056   0.0072   0.0081   0.0242   0.0017   0.0020

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                                 INCHES          CU. FEET      PERCENT
                            -------------------  -------------  ---------
 PRECIPITATION                 34.48    (   7.624)    625756.0     100.00

 RUNOFF                         0.123   (  0.3387)      2234.33      0.357

 EVAPOTRANSPIRATION            18.310   (  3.0149)    332310.95     53.106

 LATERAL DRAINAGE COLLECTED    15.98250 (  5.28862)    290076.059   46.35610
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH    0.00004 (  0.00003)        0.716     0.00011
   LAYER  4

 AVERAGE HEAD ON TOP            0.004 (    0.008)
   OF LAYER  3

 PERCOLATION/LEAKAGE THROUGH    0.00000 (  0.00000)        0.000     0.00000
   LAYER  5

 CHANGE IN WATER STORAGE        0.063   (  0.8704)      1134.68      0.181

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          PEAK DAILY VALUES FOR YEARS    1 THROUGH   30      and their dates (DDDYYYY)
  ------------------------------------------------------------------------
                                       (INCHES)     (CU. FT.)
                                      ----------   -------------
     PRECIPITATION                         8.41       152638.17304   1660023

     RUNOFF                               1.682       30518.89474   1660023

     DRAINAGE COLLECTED FROM LAYER  2          3.59013      65159.37752   1670023

     PERCOLATION/LEAKAGE THROUGH LAYER  4      0.000077        1.39656   1670023

     AVERAGE HEAD ON TOP OF LAYER  3           8.543

     MAXIMUM HEAD ON TOP OF LAYER  3          11.886

     LOCATION OF MAXIMUM HEAD IN LAYER  2
          (DISTANCE FROM DRAIN)             31.6 FEET

     PERCOLATION/LEAKAGE THROUGH LAYER  5      0.000000        0.00000        0

     SNOW WATER                            3.33       60442.8075    210028


     MAXIMUM VEG. SOIL WATER (VOL/VOL)              0.4055

     MINIMUM VEG. SOIL WATER (VOL/VOL)              0.0580


   ***  Maximum heads are computed using McEnroe's equations.  ***

        Reference:  Maximum Saturated Depth over Landfill Liner
                    by Bruce M. McEnroe, University of Kansas
                    ASCE Journal of Environmental Engineering
                    Vol. 119, No. 2, March 1993, pp. 262-270.
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               FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
                LAYER        (INCHES)       (VOL/VOL)
                -----        --------       ---------
                  1           5.3292         0.2221

                  2           0.0061         0.0308

                  3           0.0000         0.0000

                  4          11.0640         0.4610

                  5          10.2189         0.2839

               SNOW WATER       0.000

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07 (1 November 1997)                 **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************



PRECIPITATION DATA FILE:    C:\WHI\VHELP22\data\P5110.VHP\_weather1.dat
TEMPERATURE DATA FILE:      C:\WHI\VHELP22\data\P5110.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:  C:\WHI\VHELP22\data\P5110.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:    C:\WHI\VHELP22\data\P5110.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:  C:\WHI\VHELP22\data\P5110.VHP\I_390838.inp
OUTPUT DATA FILE:           C:\WHI\VHELP22\data\P5110.VHP\O_390838.prt


TIME:  15: 8     DATE:  10/16/2015



******************************************************************************

    TITLE:  Cornwall Avenue Landfill Cover Twenty-Five Percent

******************************************************************************



    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
           COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                            LAYER  1
                            --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   5
         THICKNESS                 =    60.96   CM
         POROSITY                  =     0.4570 VOL/VOL
         FIELD CAPACITY            =     0.1310 VOL/VOL
         WILTING POINT             =     0.0580 VOL/VOL
         INITIAL SOIL WATER CONTENT  =     0.1441 VOL/VOL
         EFFECTIVE SAT. HYD. COND.   =  0.100000224000E-02 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.



                            LAYER  2
                            --------

                  TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER  20
         THICKNESS                 =     0.50   CM
         POROSITY                  =     0.8500 VOL/VOL
         FIELD CAPACITY            =     0.0100 VOL/VOL
         WILTING POINT             =     0.0050 VOL/VOL
```

```
      INITIAL SOIL WATER CONTENT  =      0.0132 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
      SLOPE                       =     25.00   PERCENT
      DRAINAGE LENGTH             =    202.7    METERS


                        LAYER  3
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  41
      THICKNESS                   =      0.10   CM
      POROSITY                    =      0.0000 VOL/VOL
      FIELD CAPACITY              =      0.0000 VOL/VOL
      WILTING POINT               =      0.0000 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.0000 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.200000000000E-11 CM/SEC
      FML PINHOLE DENSITY         =      7.41   HOLES/HECTARE
      FML INSTALLATION DEFECTS    =      2.47   HOLES/HECTARE
      FML PLACEMENT QUALITY       =  3 - GOOD


                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER  23
      THICKNESS                   =     60.96   CM
      POROSITY                    =      0.4610 VOL/VOL
      FIELD CAPACITY              =      0.3600 VOL/VOL
      WILTING POINT               =      0.2030 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.4610 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.100000000000E-05 CM/SEC


                        LAYER  5
                        --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   9
      THICKNESS                   =     91.44   CM
      POROSITY                    =      0.5010 VOL/VOL
      FIELD CAPACITY              =      0.2840 VOL/VOL
      WILTING POINT               =      0.1350 VOL/VOL
      INITIAL SOIL WATER CONTENT  =      0.2838 VOL/VOL
      EFFECTIVE SAT. HYD. COND.   =  0.190000425600E-03 CM/SEC


          GENERAL DESIGN AND EVAPORATIVE ZONE DATA
          ----------------------------------------

     NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
            SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
            GOOD STAND OF GRASS, A SURFACE SLOPE OF 25.%
            AND A SLOPE LENGTH OF   91. METERS.

    SCS RUNOFF CURVE NUMBER            =    59.31
    FRACTION OF AREA ALLOWING RUNOFF   =   100.0    PERCENT
    AREA PROJECTED ON HORIZONTAL PLANE =     2.0234 HECTARES
    EVAPORATIVE ZONE DEPTH             =    61.0    CM
    INITIAL WATER IN EVAPORATIVE ZONE  =     8.784  CM
```

```
     UPPER LIMIT OF EVAPORATIVE STORAGE  =     27.859  CM
     LOWER LIMIT OF EVAPORATIVE STORAGE  =      3.536  CM
     INITIAL SNOW WATER                  =      0.000  CM
     INITIAL WATER IN LAYER MATERIALS    =     62.846  CM
     TOTAL INITIAL WATER                 =     62.846  CM
     TOTAL SUBSURFACE INFLOW             =      0.00   MM/YR



           EVAPOTRANSPIRATION AND WEATHER DATA
           ----------------------------------

      NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             Bellingham          WA

         STATION LATITUDE                     =  48.74 DEGREES
         MAXIMUM LEAF AREA INDEX              =   2.00
         START OF GROWING SEASON (JULIAN DATE)  =    126
         END OF GROWING SEASON (JULIAN DATE)    =    287
         EVAPORATIVE ZONE DEPTH               =  24.0  INCHES
         AVERAGE ANNUAL WIND SPEED            =   9.10 MPH
         AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  75.00 %
         AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  69.00 %
         AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  70.00 %
         AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  79.00 %


      NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    Bellingham          WA

             NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

   JAN/JUL    FEB/AUG    MAR/SEP    APR/OCT    MAY/NOV    JUN/DEC
   -------    -------    -------    -------    -------    -------
     3.00       3.00       3.00       3.00       3.00       3.00
     3.00       3.00       3.00       3.00       3.00       3.00


      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    Bellingham          WA

         NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

   JAN/JUL    FEB/AUG    MAR/SEP    APR/OCT    MAY/NOV    JUN/DEC
   -------    -------    -------    -------    -------    -------
    39.10      42.80      44.20      48.70      55.00      60.20
    64.80      64.10      60.00      52.50      44.80      41.00


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    Bellingham          WA
              AND STATION LATITUDE  =  48.74 DEGREES


*******************************************************************************

             MONTHLY TOTALS (IN INCHES) FOR YEAR   30
-------------------------------------------------------------------------------

                          JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC
                          ------- ------- ------- ------- ------- -------

PRECIPITATION                4.21    4.67    8.91    0.71    1.72    3.49
                           0.52    1.27    4.80    1.97    5.01    2.04
```

```
RUNOFF                    0.000   0.000   0.000   0.000   0.000   0.000
                 0.000   0.000   0.000   0.000   0.000   0.000

EVAPOTRANSPIRATION           0.406   0.637   2.054   1.675   1.616   2.572
                 1.657   0.407   2.028   1.224   0.600   0.676

LATERAL DRAINAGE COLLECTED      4.1769  4.1892  6.0502  1.6954  0.2277  1.3267
  FROM LAYER  2              0.4835  0.1593  0.8741  1.3864  2.8098  0.9846

PERCOLATION/LEAKAGE THROUGH     0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  4                0.0000  0.0000  0.0000  0.0000  0.0000  0.0000

PERCOLATION/LEAKAGE THROUGH     0.0000  0.0000  0.0000  0.0000  0.0000  0.0000
  LAYER  5                0.0000  0.0000  0.0000  0.0000  0.0000  0.0000


-------------------------------------------------------------------------------
          MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


AVERAGE DAILY HEAD ON          0.007   0.007   0.010   0.003   0.000   0.002
  TOP OF LAYER  3            0.001   0.000   0.001   0.002   0.005   0.002

STD. DEVIATION OF DAILY        0.005   0.010   0.012   0.004   0.000   0.003
  HEAD ON TOP OF LAYER  3      0.002   0.001   0.002   0.003   0.003   0.001

*******************************************************************************



*******************************************************************************

             ANNUAL TOTALS FOR YEAR   30
-------------------------------------------------------------------------------
                          INCHES       CU. FEET     PERCENT
                         --------      ----------   -------
  PRECIPITATION                  39.32        713642.445    100.00

  RUNOFF                       0.000          0.000      0.00

  EVAPOTRANSPIRATION                15.551       282252.159     39.55

  DRAINAGE COLLECTED FROM LAYER  2       24.3639       442195.207     61.96

  PERC./LEAKAGE THROUGH LAYER  4         0.000038         0.682      0.00

  AVG. HEAD ON TOP OF LAYER  3           0.0034

  PERC./LEAKAGE THROUGH LAYER  5         0.000000         0.000      0.00

  CHANGE IN WATER STORAGE              -0.595       -10804.910     -1.51

  SOIL WATER AT START OF YEAR           27.214       493915.569

  SOIL WATER AT END OF YEAR            26.618       483110.658

  SNOW WATER AT START OF YEAR            0.000          0.000      0.00

  SNOW WATER AT END OF YEAR             0.000          0.000      0.00

  ANNUAL WATER BUDGET BALANCE            0.0000         -0.011      0.00

*******************************************************************************
```

```
*******************************************************************************

        AVERAGE MONTHLY VALUES IN INCHES FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------

                     JAN/JUL  FEB/AUG  MAR/SEP  APR/OCT  MAY/NOV  JUN/DEC
                     -------  -------  -------  -------  -------  -------
 PRECIPITATION
 -------------
   TOTALS              2.83     2.23     2.75     2.93     2.38     3.16
                       3.90     2.74     3.44     3.05     2.93     2.13

   STD. DEVIATIONS     1.61     1.91     1.89     1.96     1.64     3.69
                       2.66     3.08     2.58     2.12     1.63     1.48

 RUNOFF
 ------
   TOTALS             0.005    0.004    0.000    0.006    0.000    0.084
                      0.026    0.019    0.021    0.012    0.000    0.000

   STD. DEVIATIONS    0.017    0.022    0.000    0.031    0.000    0.362
                      0.084    0.066    0.111    0.066    0.001    0.000

 EVAPOTRANSPIRATION
 ------------------
   TOTALS             0.636    0.847    1.549    1.931    1.957    2.644
                      3.392    1.980    1.363    0.911    0.549    0.486

   STD. DEVIATIONS    0.188    0.205    0.313    0.620    0.990    0.662
                      1.636    1.365    0.859    0.286    0.153    0.150

 LATERAL DRAINAGE COLLECTED FROM LAYER  2
 ----------------------------------------
   TOTALS            1.6109   1.8791   1.4415   1.2235   0.6607   1.2097
                     1.2896   0.9704   1.0319   1.3870   1.6090   1.6800

   STD. DEVIATIONS   1.1371   1.6220   1.5535   1.2884   0.6404   1.7396
                     1.4595   1.1500   0.8687   1.4168   1.0323   1.3351

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
   TOTALS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS            0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000

   STD. DEVIATIONS   0.0000   0.0000   0.0000   0.0000   0.0000   0.0000
                     0.0000   0.0000   0.0000   0.0000   0.0000   0.0000


-------------------------------------------------------------------------------
            AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


 DAILY AVERAGE HEAD ON TOP OF LAYER  3
 -------------------------------------
   AVERAGES          0.0026   0.0044   0.0023   0.0032   0.0011   0.0167
                     0.0026   0.0024   0.0028   0.0052   0.0027   0.0027

   STD. DEVIATIONS   0.0018   0.0063   0.0025   0.0079   0.0010   0.0788
                     0.0049   0.0056   0.0066   0.0179   0.0017   0.0021
```

```
*******************************************************************************


*******************************************************************************

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH   30
-------------------------------------------------------------------------------
                              INCHES          CU. FEET       PERCENT
                          -------------------   -------------   ---------
 PRECIPITATION               34.48    (   7.624)    625756.0     100.00

 RUNOFF                     0.177   (  0.4188)      3213.87      0.514

 EVAPOTRANSPIRATION           18.245   (  3.0213)    331136.58     52.918

 LATERAL DRAINAGE COLLECTED     15.99323 (  5.24106)    290270.862   46.38723
   FROM LAYER  2

 PERCOLATION/LEAKAGE THROUGH     0.00004 (  0.00002)        0.696     0.00011
   LAYER  4

 AVERAGE HEAD ON TOP            0.004 (    0.007)
   OF LAYER  3

 PERCOLATION/LEAKAGE THROUGH     0.00000 (  0.00000)        0.000     0.00000
   LAYER  5

 CHANGE IN WATER STORAGE        0.063   (  0.7877)      1134.70      0.181

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              PEAK DAILY VALUES FOR YEARS    1 THROUGH   30       and their dates (DDDYYYY)
   -------------------------------------------------------------------------
                                          (INCHES)      (CU. FT.)
                                         ----------   -------------
     PRECIPITATION                          8.41        152638.17304   1660023

     RUNOFF                              1.971        35771.96338   1660023

     DRAINAGE COLLECTED FROM LAYER  2          3.34046       60627.95770   1670023

     PERCOLATION/LEAKAGE THROUGH LAYER  4       0.000066         1.19434   1670023

     AVERAGE HEAD ON TOP OF LAYER  3           7.277

     MAXIMUM HEAD ON TOP OF LAYER  3          11.975

     LOCATION OF MAXIMUM HEAD IN LAYER  2
          (DISTANCE FROM DRAIN)              0.0 FEET

     PERCOLATION/LEAKAGE THROUGH LAYER  5       0.000000         0.00000         0

     SNOW WATER                            3.33        60442.8075    210028


     MAXIMUM VEG. SOIL WATER (VOL/VOL)               0.3943

     MINIMUM VEG. SOIL WATER (VOL/VOL)               0.0580


      ***  Maximum heads are computed using McEnroe's equations.  ***

          Reference:  Maximum Saturated Depth over Landfill Liner
                    by Bruce M. McEnroe, University of Kansas
```

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              ASCE Journal of Environmental Engineering
              Vol. 119, No. 2, March 1993, pp. 262-270.

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_
*******************************************************************************

           FINAL WATER STORAGE AT END OF YEAR   30
    ----------------------------------------------------------------------
            LAYER        (INCHES)       (VOL/VOL)
            -----        --------       ---------
              1           5.3293         0.2221

              2           0.0061         0.0310

              3           0.0000         0.0000

              4          11.0640         0.4610

              5          10.2189         0.2839

           SNOW WATER       0.000

*******************************************************************************
*******************************************************************************
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APPENDIX C

Aquatic Cover Design

DRAFT Basis of Design Report
Cornwall Cleanup Site

COAST & HARBOR
ENGINEERING
A Division of Hatch Mott MacDonald

Draft Basis of Design Report
CORNWALL CLEANUP SITE

Prepared for:

Port of Bellingham

This document summarizes the basis of design for preliminary level design of the Cornwall Avenue Landfill Cleanup Project and is being released for the purpose of review, under the authority of Vladimir Shepsis, Ph.D., P.E. This document is not to be used for purposes of permitting, final engineering design, or for construction documents.

Prepared by:

Vladimir Shepsis, PhD, PE
Principal Coastal Engineer

COAST & HARBOR
ENGINEERING
A Division of Hatch Mott MacDonald

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Edmonds, WA 98020
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FIGURES

COAST & HARBOR
ENGINEERING
A Division of Hatch Mott MacDonald

DRAFT Basis of Design Report
Cornwall Cleanup Site

1. Introduction

This technical report summarizes the engineering basis of design that was used by Coast & Harbor Engineering (CHE), a Division of Hatch Mott McDonald for the preliminary level of design of the Cornwall Avenue Landfill Cleanup Project. Prior to the preliminary design, CHE developed and coordinated with the Project Team comprised of the Port of Bellingham (Port), Landau Associates (Landau), and CHE, a technical memorandum (CHE 2015) to establish the environmental data and assumptions utilized to develop design criteria for the preliminary design. Refer to (CHE 2015) for details regarding the input data, assumptions, as well as design criteria that was used in the preliminary design (see Attachment A).

As requested by the Project Team, CHE developed two shoreline protection measure alternatives: (a) Alt 1 (hereafter referred to as *baseline alternative*); and (b) Alt 2 (hereafter referred to as *rock groin alternative*). A site plan and cross-sections were developed for both alternatives and were presented to the Port and the Project Team. Two sets of drawings for these alternatives are presented in Attachments B and C, respectively.

Upon presentation of the two alternatives, the *rock groin alternative* was selected as the preferred alternative by the Port. This technical report focuses on engineering aspects of the preliminary design of the coastal engineering elements for the *rock groin alternative*. Figure 1 is a plan view of the preliminary design that shows the locations and extension of the coastal elements of the project. These elements include: (a) rock groin; (b) south gravel cobble beach with revetment; (c) sandy gravel beach; (d) north gravel cobble beach with revetment; and (e) sediment cap. Each of these elements were selected and designed to provide adequate project performance functions (see Section 3) and meet the design criteria defined and established in CHE 2015. Please note that wave conditions at the project site were the major controlling factor for the design of the coastal engineering elements; the tidal currents were found to be negligible. Therefore, detailed wave analysis and numerical modeling was performed to establish the wave conditions prior to the project (existing conditions) and upon construction of the proposed coastal elements (post-project conditions). Descriptions of the wave modeling as well as the basis of design for each individual coastal element are presented in Sections 2 and 3.

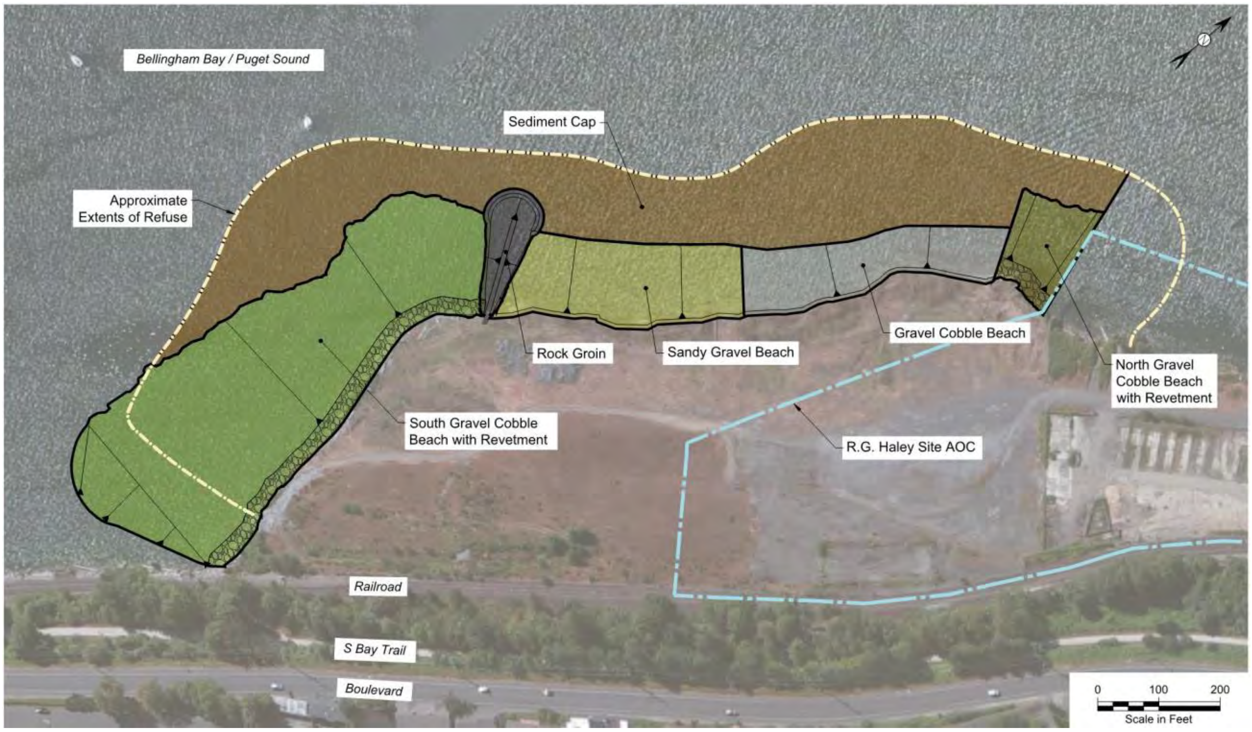


Figure 1. Plan view of preliminary design of project coastal engineering elements: (a) rock groin; (b) south cobble gravel beach with revetment; (c) sandy gravel beach; (d) north cobble gravel beach with revetment; and (e) sediment cap

2. Wave Analysis

2.1. Methodology

Wave conditions at the project site were developed based on numerical modeling of wind-wave generation for the design wind speeds from south to west. Wave modeling was conducted using the two-dimensional (2-D) Simulating Waves Nearshore Model (SWAN 40.72, Delft Technical University, 2008) in steady state mode. SWAN simulates growth of waves by wind and accounts for shoaling, refraction, diffraction, and bottom damping of waves as they approach the shoreline. The numerical model SWAN was applied to a regional (large) as well as a local (nested) domain to simulate wind-wave growth and propagation for the design wind from the directions 180° through 330° TN for water levels ranging from MLLW to MHHW + 2.4 ft.

The SWAN modeling results for the critical wind direction cases were extracted near the project site and applied as a boundary condition for a nearshore model of the immediate project vicinity. Two nearshore models of HWAVE (Zheleznyak *et al.* 2009) and SWASH (Delft 2010) were utilized to simulate the interaction of waves with the bottom and groin structure for existing and proposed project features.

The SWAN wave modeling numerical grid was built using the bathymetry data from various sources and provided project topography data (CHE 2015). Figure 2 shows the model bathymetry for the large and nested modeling grids.

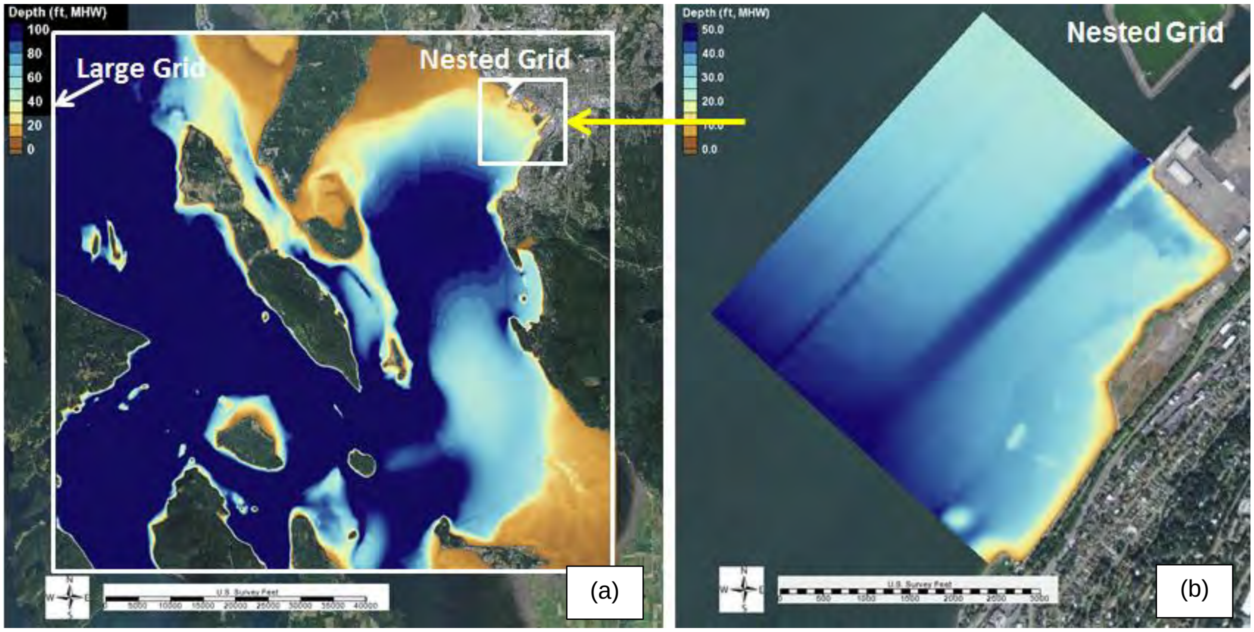


Figure 2. SWAN Wave modeling bathymetry grids: (a) large and (b) nested

2.2. Results

Modeling was conducted for the design storm event (100-year return period storm) approaching from all wave generation directions in the sector between 180 and 300 degrees following established design criteria (see CHE 2015). A few example modeling results for existing conditions for Bellingham Bay and a zoomed-in view at the project site are shown in Figures 3 and 4, respectively.

The figure shows a distribution (field) of significant wave heights during the design storm for various wind directions over the nested modeling domain in color format. The wave modeling outputs in terms of significant wave heights were used as the basis for comparison and optimization of various project element components.

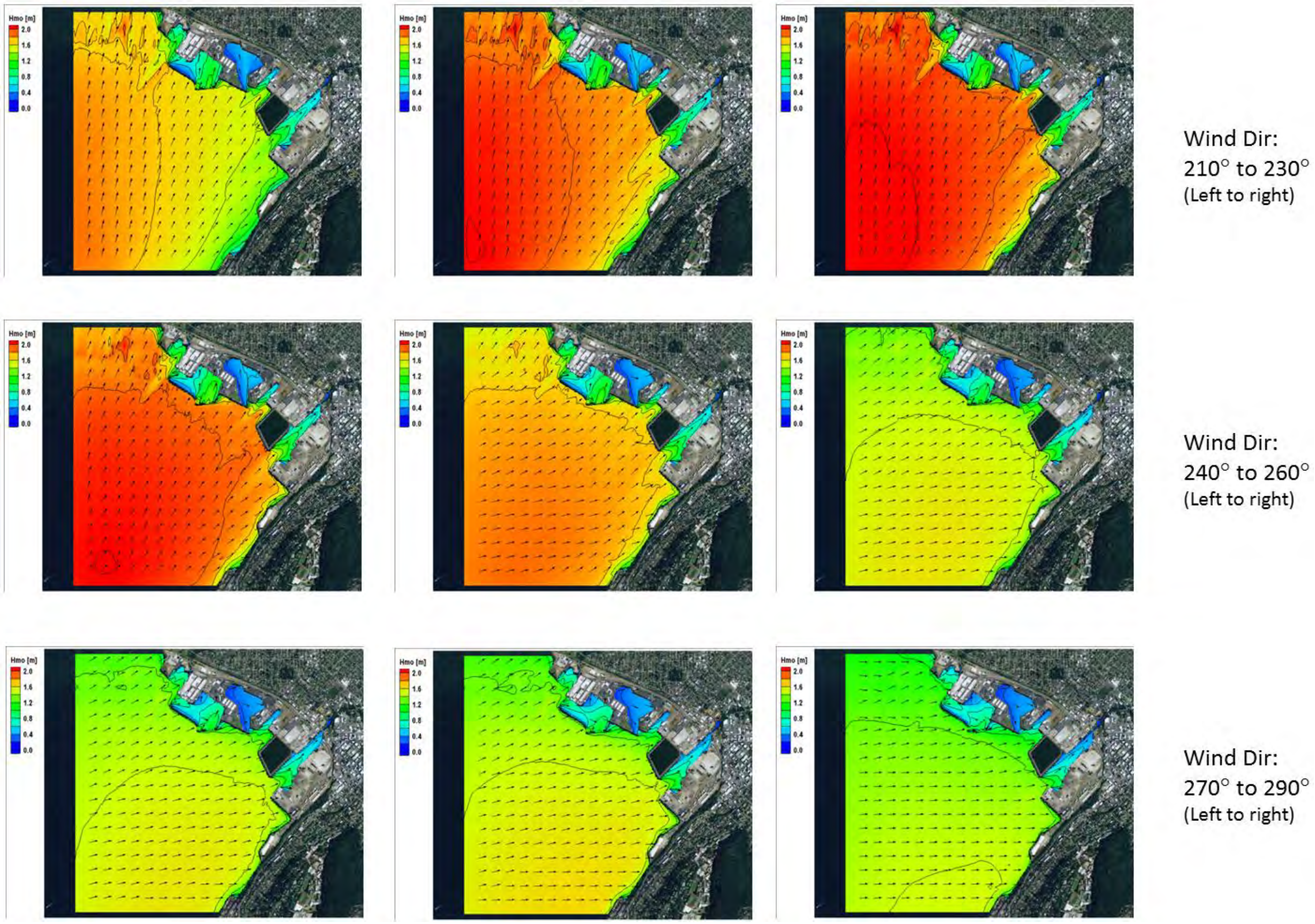


Figure 3. Example wave modeling outputs in Bellingham Bay; wave heights over modeling domain during design storms from different directions

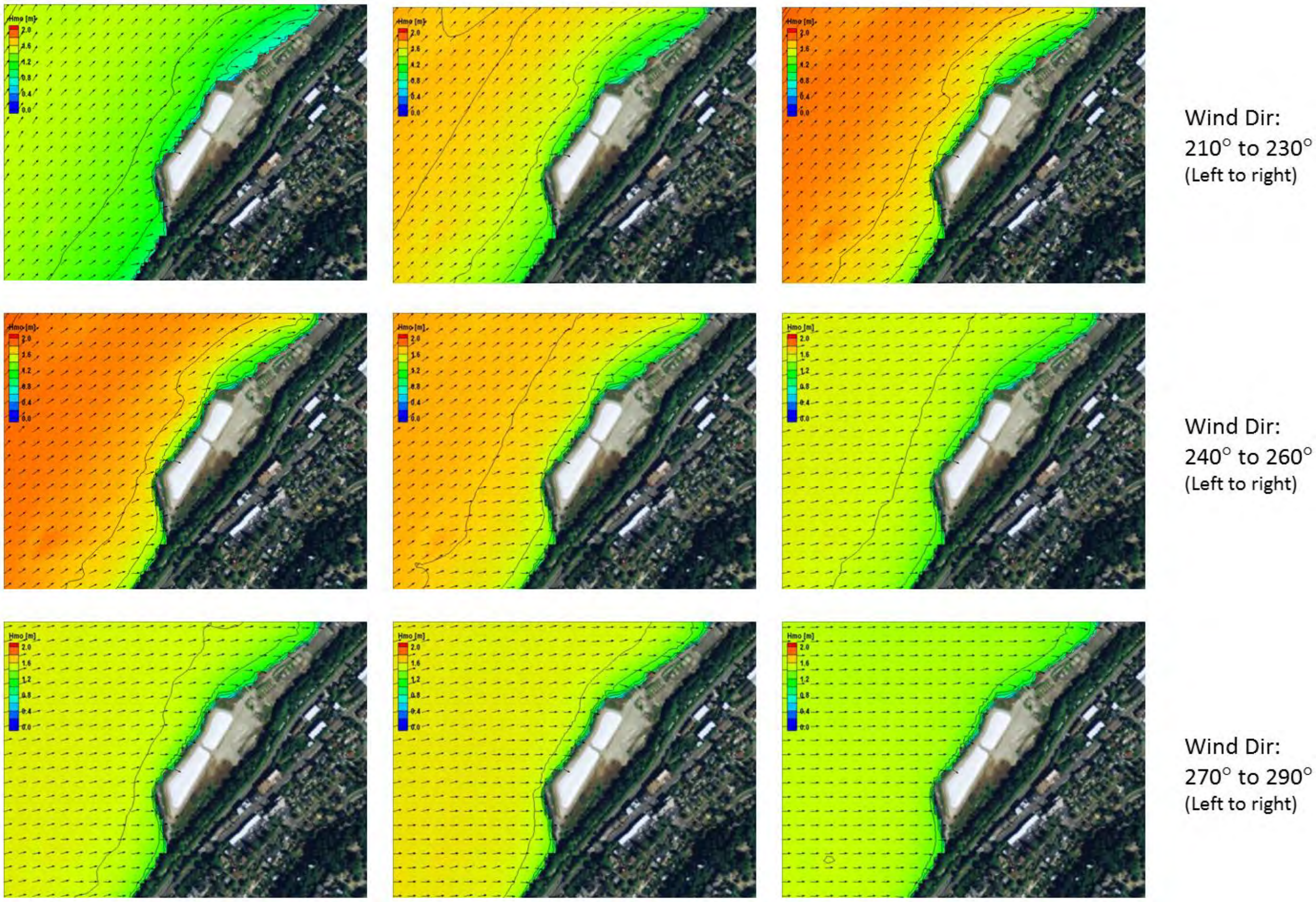


Figure 4. Example wave modeling outputs at project site; wave heights over modeling domain during design storms from different directions

3. Design

3.1. Rock Groin

The rock groin was designed to provide the following functions:

- Wave sheltering for the northern shoreline.
- Minimize size of material for shoreline protection north of the groin.
- Minimize down-drift (northward) loss of the beach material from the south gravel beach.

To meet these functions, the rock groin alignment and cross-sectional dimensions were determined using numerical wave modeling.

Upon completion of modeling of existing conditions, the featured rock groin was built into the modeling grid and modeling was conducted for various locations and configurations of the rock groin to identify the optimal location and configuration to meet the desired functions. Figure 5 shows example wave modeling results for testing a groin for the project conditions (one of the groin alterations), and shows a field of wave heights in the project domain.

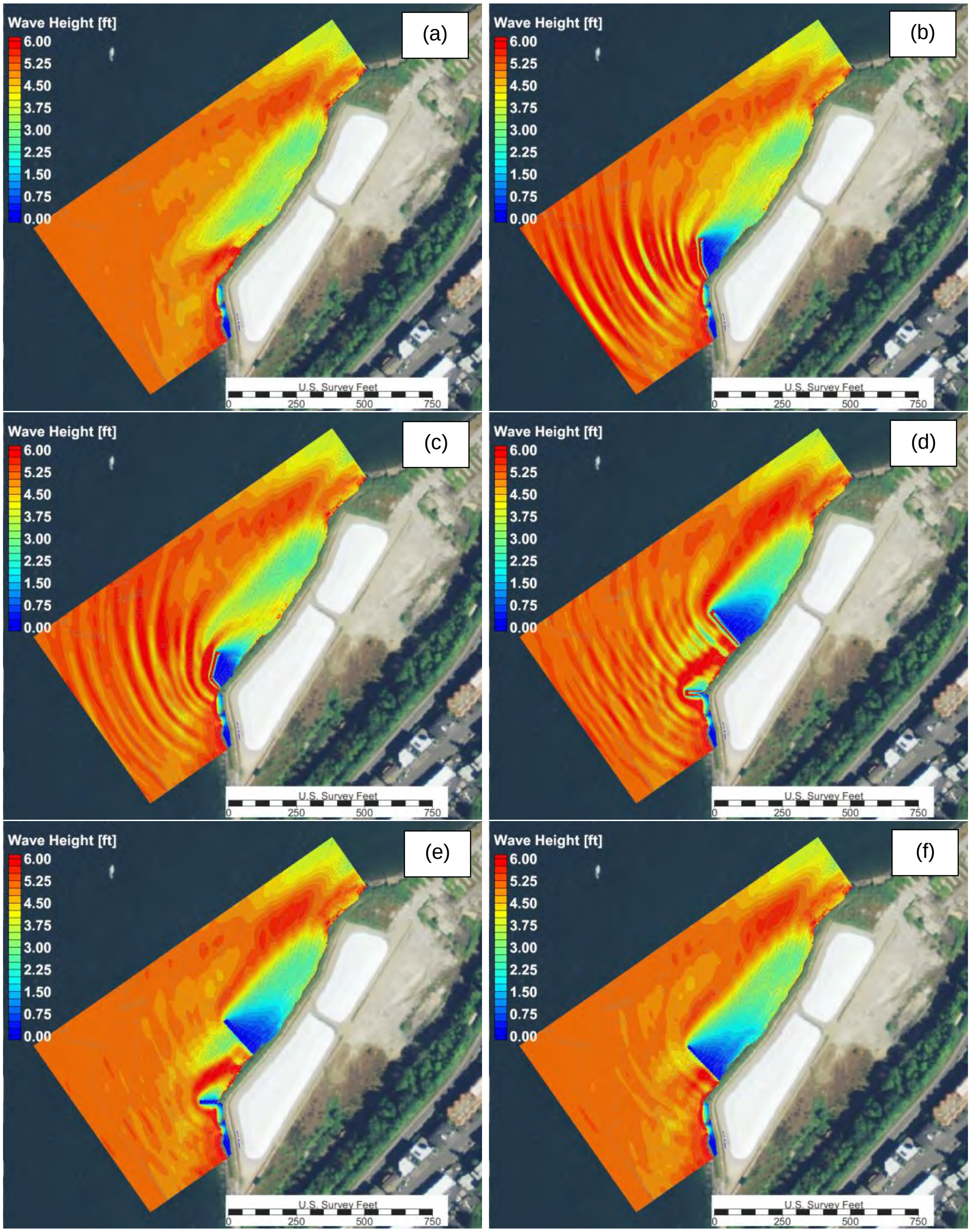


Figure 5. Results of nearshore wave modeling for (a) existing conditions and (b to f) various layouts of groin(s)

Figure 5 shows that for this particular groin location and configuration, the sheltered wave area extends approximately 600 ft north of the groin. Upon completion of the wave modeling, the optimal location and configuration of the groin was selected, as shown in plan view in Figure 1 and in a longitudinal cross-section in Figure 6.

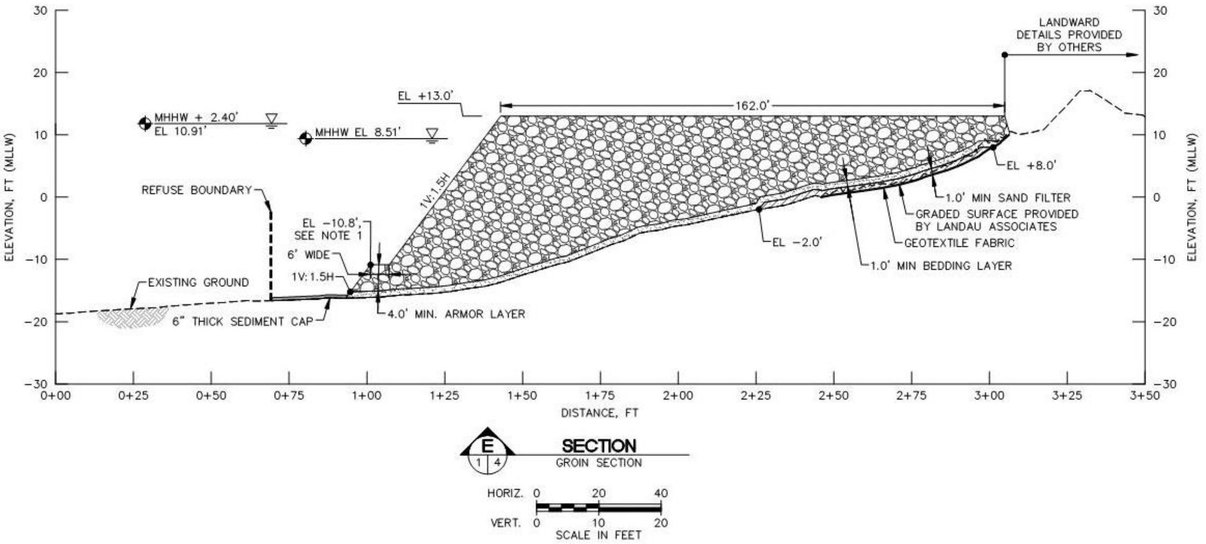


Figure 6. Longitudinal cross-section of rock groin

The figure shows that the groin extends to a water depth of approximately -15 ft MLLW with a total length of approximately 162 ft. Crest elevation of the groin was designed at an elevation of +13 ft MLLW. The groin was built on top of the bedding layer with a minimum thickness of 1 ft. This bedding layer is underlain by filter fabric to inhibit scouring and washing away fine particles of sediment from the bottom by upwelling forces.

The groin was designed with a launch-type of toe protection. Crest elevation of the toe is at elevation of -10.8 ft MLLW. The side slope of the groin and toe protection was designed at 1V:1.5H. The design width of the groin crest is at +6 ft. Special geotechnical analysis will be required at the next phase of the design to estimate possible long-term and short-term subsidence of the groin and to incorporate this subsidence into the final design (if required).

Armor rock for the groin was sized using standard methods for stability against the 100-year design wave occurring at the design high tide elevation. This rock size was determined as a median weight (W_{50}) of 1,138 pounds with corresponding median diameter (D_{50}) of approximately 1.9 ft.

3.2. South Gravel Cobble Beach with Revetment

The south gravel cobble beach with revetment was designed to provide the following functions:

- Protect the southern reach of shoreline and bottom slope from erosion and exposure to direct wave impact.
- Develop a stable beach of dynamic equilibrium with substrate potential for habitat enhancement.

The south gravel cobble beach would be formed in a setting similar to a pocket beach located between two hard points: the southernmost boundary of the project and the groin. This area is subjected to direct impact from the largest waves approaching the project site from the southwest. Currently, the capacity for sediment containment in the area is minimal due to the narrow width of the beach and the pattern of wave diffraction at the southern corner of the landfill. Upon construction of the groin and placement of a sufficient thickness of gravel cobble beach material, the pattern of wave diffraction will change and increase the sediment containment capacity in the area.

The upper part of the south gravel cobble beach is designed to be protected by armor revetment. This revetment was designed to account for possible uncertainties in performance of the gravel cobble beach and to ensure that even during the most extreme event the landfill shoreline will not erode. Figure 7 shows a typical cross-section of the south gravel cobble beach with revetment.

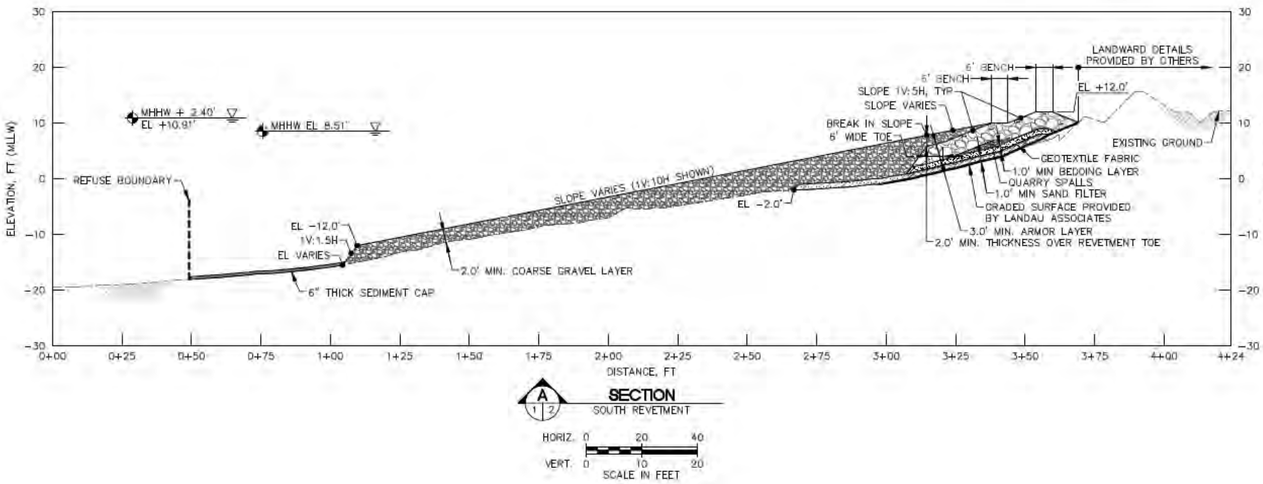


Figure 7. Typical cross-section of south gravel cobble beach with revetment

The figure shows that the beach is designed with a slope of 1V:10H, which is slightly flatter than typical coarse gravel beaches in the Puget Sound area. The flatter beach was designed considering significant exposure of this reach of shoreline to wave impact in order to provide more flexibility to possible adjustments in the profile. It is expected that parts of the profile, specifically in the wave-breaking zone, would armor itself by steepening and accumulating a larger size of cobbles. Lower elevations in the profile, typically below the elevation of breaking waves, would form a finer beach with a flatter slope. In designing this beach with a flat slope, we also accounted for the fact that there is no universal engineering methodology for coarse gravel beach design. There is always certain risk that design beach parameters (based on available engineering methodology) would differ from that occurring in reality. A flatter beach mitigates this risk by allowing more natural adjustment without exposure of the native bottom.

The type and size of beach material was selected to maintain a stable beach in dynamic equilibrium; preclude direct wave impact on the bottom; and enhance habitat capacity. Upon analysis of stability and using data from other similar projects in the

Puget Sound area, gravel cobble beach material with a diameter of $D_{50} = 2.5''$ is recommended. Figure 8 shows a photograph with representative type of material that may be used for construction of the south gravel cobble beach.

Figure 8. Representative type of material that may be used for construction of south gravel cobble beach

The revetment at this part of the shoreline was designed at the upper part of the beach from elevation +12 ft, MLLW to approximately 2 ft, MLLW. The revetment will protect the upper shoreline from wave overtopping and runup. At the southernmost part of the project, the revetment will be keyed into the existing upper part of the shoreline. The extension and details of key revetment elements will be developed during the next phase of the design.

The revetment was designed to follow the existing configuration of the slope and to minimize volumes of cut and fill. However, a minimal volume of quarry spalls is still required and was used for design to develop the appropriate grades (slopes) for placement of armor rock. Similar to the groin structure, the revetment is sitting on the bedding layer underlain by filter fabric. Armor rock for the revetment was preliminary sized using standard methods for stability against the 100-year design wave occurring at the design high tide elevation. This rock size was determined as a median weight (W_{50}) of 563 pounds with corresponding median diameter (D_{50}) of approximately 1.5 ft.

3.3. Sandy Gravel Beach

The sandy gravel beach was designed to provide the following functions:

- Protect the shoreline and bottom slope on the north side of the groin from erosion and exposure to direct wave impact.
- Develop a stable beach of dynamic equilibrium with substrate potential for habitat enhancement.

The sandy gravel beach was designed in the area sheltered by the groin from waves approaching from the southwest direction and extends approximately 600 ft to the north (from the groin). Figure 9 shows a typical design cross-section for this beach.

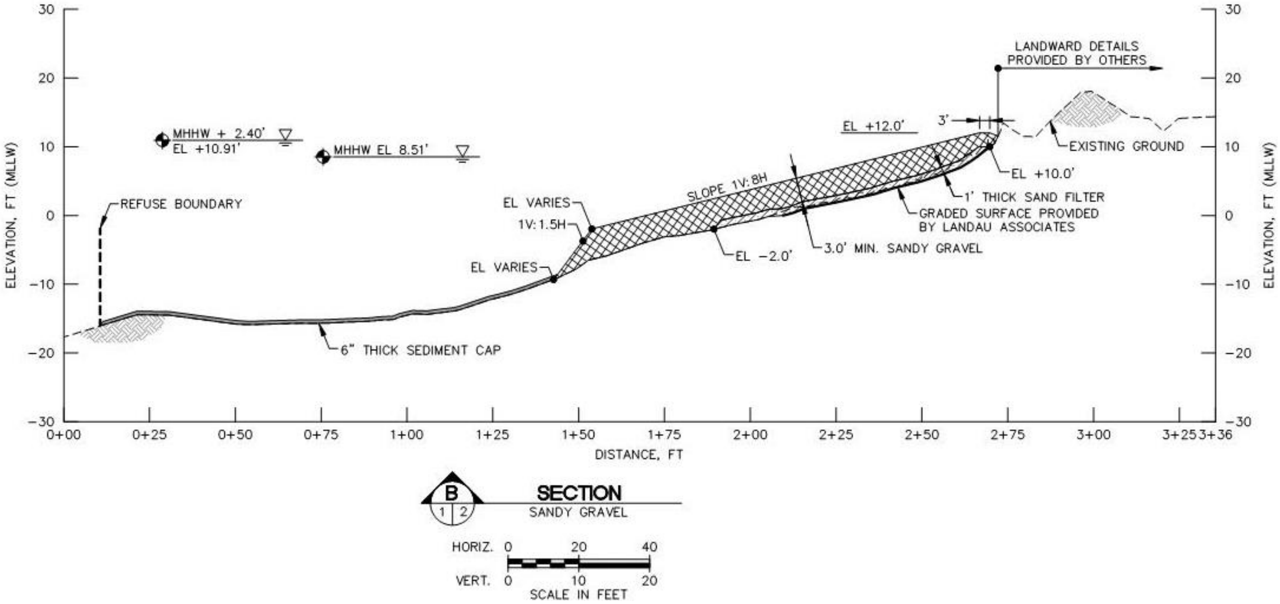


Figure 9. Typical cross-section of sandy-gravel beach

The figure shows that the beach is designed at a slope of 1V:8 H that corresponds to typical mixed sand and gravel (MSG) beaches observed in Puget Sound. Beach placement would occur from an elevation of +12 ft MLLW to a variable elevation (-10 ft MLLW or higher, depending on bottom slope configuration). It is expected that some redistribution of beach material up/down the slope and along the shoreline would occur during the first couple of storms to achieve conditions of dynamic equilibrium. The thickness of the beach material layer was designed at 3 ft thick to allow for such an adjustment with no risk of exposing the native bottom to wave impact.

Material for the sand-gravel beach was selected to meet the performance functions and to address variability of wave hydrodynamic conditions along the north (north of the groin) stretch of shoreline. Based on the results of wave modeling (See Figure 1), wave impact is significantly reduced in the area adjacent to the groin from the north due to a sheltering effect. Further to the north, the sheltering effect gradually diminishes, and eventually beach material along this northern stretch of shoreline would diversify in accordance with wave hydrodynamic conditions. A fine sediment beach (mostly fine to medium sand) will most likely form on the north side of the groin. This beach would extend further to the north to the coarser sandy-gravel beach, and finally at the transition to the next element of the project, the cobble gravel beach, it would be mostly gravel material. In order to meet this diversity, material for the sandy gravel beach was designed from a relatively wide range of fine-grained and gravelly sediment of $D_{50} = 0.08''$. Figure 10 shows a photograph demonstrating the representative type of material that may be used for construction of the sandy gravel beach at this part of the shoreline.

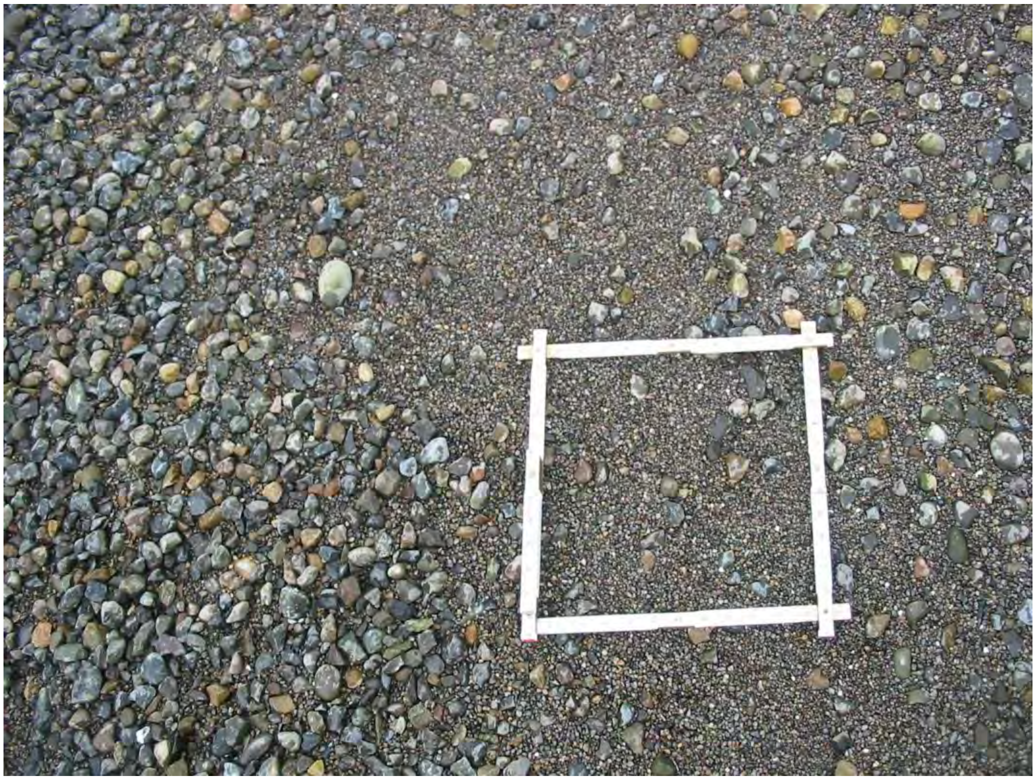


Figure 10. Representative type of material that may be used for construction of sandy gravel beach at this part of shoreline

3.4. North Gravel Cobble Beach with Revetment

The north gravel cobble beach with revetment was designed to provide the following functions:

- Protect the northern reach of shoreline and bottom slope from erosion and exposure to direct wave impact.
- Develop potential for future habitat enhancement.

As shown by the results of numerical modeling, the proposed groin is capable of sheltering wave conditions along a significant stretch of the project shoreline (approximately 600 ft) in the lee side (north side of the groin) for most extreme waves coming from the southwest. However, the model also shows that the most northern stretch of the project shoreline (approximately 100 ft) would still be subjected to direct (not attenuated) wave impact and would need to be protected against possible wave erosion.

The extensive revetment structure was designed along this northern area of the project to ensure there is no erosion of this portion of the vulnerable shoreline. Similar to the south cobble-gravel beach with revetment, this stretch of shoreline was designed to protect the upper slope of the shoreline from elevation +12 ft, MLLW to approximately 2 ft, MLLW. The revetment was designed to follow the existing configuration of the slope and to minimize volumes of cut and fill. However, a minimal volume of quarry spalls is still required and was used for design to develop the appropriate grades (slopes) for placement of armor rock.

It should be noted that due to a change in alignment at this most northern part of the project area the shoreline extends slightly seaward, forming a landform feature similar to a headland. The revetment structure and north gravel cobble beach were designed to account for and enhance this headland effect, and use this effect to form a more stable beach on the north side of the revetment. For this purpose, the toe of the revetment was designed with a minimum width of 6 ft. During detailed design, the width of the toe should be revised to maximize the headland effect and provide more stability for the shoreline stretch adjacent to the north beach. Also, thickness of materials will be revised to minimize seaward relocation of the MHHW line.

As specified by the design criteria (CHE 2015), the revetment structure is sitting on the bedding layer underlain by filter fabric. Armor stone for the revetment was preliminary sized using standard methods for stability against the 100-year design wave occurring at the design high tide elevation. This rock size was determined as a median weight (W_{50}) of 563 pounds with corresponding median diameter (D_{50}) of approximately 1.5 ft.

The gravel cobble beach was designed to cover the toe of the revetment and extends to elevation of -15 ft, MLLW. Figure 11 shows a typical cross-section of the north gravel cobble beach with revetment.

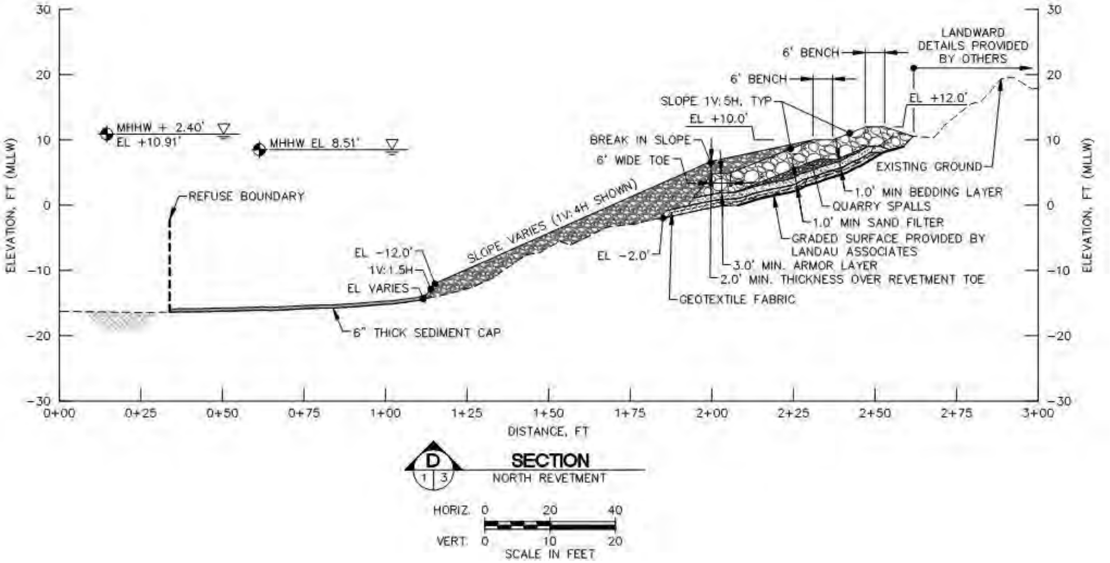


Figure 11. Typical cross-section of north gravel cobble beach with revetment

The figure shows that the beach is designed at a variable slope of 1V:4H to 1V:6H, which is slightly steeper than typical coarse gravel beaches in the Puget Sound area. The beach was designed with the understanding that a stretch of this gravel-cobble material would be sacrificed to provide sorting and natural forming of a cobble armor layer at the toe of the revetment. Some of this sacrificial material would migrate further to the north to form a transition between the Cornwall and R.G. Haley Site. Some of that material would migrate to deeper water and provide protection to sand cap material. It is also likely that some of the sacrificial material would settle at the south, forming a transition between the sandy-gravel beach and revetment. Due to the complexity of the littoral and morphologic processes at this area, it is difficult to accurately predict the behavior of the gravel-cobble material to be placed at this part of shoreline. However, based on observation from other projects in Puget Sound, it is expected that eventually a dynamically stable shoreline would be developed at the toe of the revetment and at transitions to the north and south from this revetment.

The type and size of beach material was selected to meet the above-discussed performance functions: maintain a stable beach in dynamic equilibrium; preclude direct wave impact on the bottom; and enhance habitat capacity. The selected type of material is similar to that designed for the north gravel cobble beach. The diameter of this material is $D_{50} = 2.5''$. The representative material is shown in Figure 10 above.

3.5. Thin Sediment Cap Layer

A non-engineered thin (minimum 6-inch thick) sediment cap layer has been designed on the bottom slope of the shoreline seaward from the shoreline erosion protection measures to the approximate extent of refuse material. The thin layer sediment cap will consist of a fine-grained sand layer placed on the existing sediment to enhance natural recovery of the sea bottom over the seaward extent of the landfill. The grain-size was selected based on resistance to the tractive forces of the tidal currents and the ability to enhance the growth of the natural biota in this area.

One of the project design criteria was placement of a thin (minimum 6-inch thick) sediment cap layer on the bottom slope seaward from the shoreline erosion protection measures. The thin sediment cap layer’s seaward boundary was defined by the approximate extent of refuse material and was provided by the Project Team (see CHE 2015).

The sediment cap layer does not function as an erosion protection measure and in general was not required to be designed to withstand the eroding forces of currents and wave impact during a 100-year design storm event. The material for sand cap is recommended at $D_{50} = 0.5$ mm. More specific recommendations for sand cap material placement will be developed during the next phase of design.

4. Construction

The shoreline protection construction work will be conducted with regard to Best Management Practice (BMP) to comply with all permit requirements and water quality standards. The boundaries of the in-water construction zone will be defined by warning buoys or markers to preclude any risk to mariners. Information on the construction zone boundaries and warning to mariners may also be posted by the Coast Guard. If needed, gander booms or silt curtains will be installed prior to or during construction to minimize escape of debris, turbid water, and plume from the construction sites.

4.1. Construction sequencing for shoreline and in-water work

Work for construction of shoreline protection will be conducted during a time window allowed by the permit for in-water work. The shoreline protection work will commence with construction of the groin and revetment. Once the groin and revetment are constructed, placement of gravel-cobble and gavel sand beaches will occur. Placement of a sand cap will occur after construction of all other coastal elements of the project and completion of a pre-sand cap survey.

4.2. Construction quality assurance monitoring

Construction quality control (likely to be required) will be provided by supervision of work by an experienced Coastal Engineer and upon conducting regular conditional and progress bathymetric and topographic surveys. The quality control will ensure compliance of construction materials to that specified by the design, verification of excavation grades (where appropriate), elevations of the bedding layers, and grades of constructed shoreline protection. Monitoring of the constructed grades and adjacent shoreline will be conducted with regard to the permit requirements and if required by the Project Owner. If required, a detailed monitoring program will be developed and coordinated with the Project Team and controlling agencies. Long-term monitoring of rock settlement along the groin and revetment may be conducted to ensure clearance of the rock settlement is designed properly.

5. References

CHE. 2015. Cornwall Site Cleanup Input Data and Assumptions. Document No: 349297.01 Rev: C. Draft Technical Memorandum.

Delft University. 2008. Simulating Waves Nearshore Model, SWAN 40.72, Delft Technical University.

Delft. 2010. “SWASH USER MANUAL.” User’s Manual. Delft University of Technology Faculty of Civil Engineering and Geosciences Environmental Fluid Mechanics Section.

Maynord, S. 1998. “Appendix A: Armor Layer Design for the Guidance for In-Situ Subaqueous Capping of Contaminated Sediment.” EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

Vanoni, V.A. 1975. Sedimentation Engineering. ASCE Manuals and Reports on Engineering Practice – No. 54, 730 pp.

Zheleznyak, M., Demchenko, R. and Kolomiets, P. 2009. “Spectral Hyperbolic Wave Transformation Model, Version 1.0.” User’s Manual.

ATTACHMENT A

Cornwall Site Cleanup Input Data and Assumptions Draft Technical Memorandum

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald

Draft Technical Memorandum
Cornwall Cleanup Site Input Data and Assumptions

This document was developed to coordinate with the Port of Bellingham and Project Team on the data and assumptions to be used by Coast & Harbor Engineering, a Division of Hatch Mott MacDonald (CHE) for coastal engineering and preliminary design of the Cornwall Cleanup Site. CHE established the project design criteria, presented in Section 2, based on requirements and constraints provided by the Project Team as well as standard engineering practice.

1. Project Data

1.1. Wind Data

Hourly wind data measured at the Bellingham Airport meteorological station were used for the analysis. The wind data measured at the Bellingham Airport station was compiled and processed for the period from 1948 to 2014. Wind statistical analysis and determination of wind design parameters were conducted based on long-term wind data from Bellingham Airport. The location of the wind measuring station relative to the project site is shown in Figure 1. Wind measurements representing one-minute duration were compiled and statistically processed for a period of 41 years (from 1973 to 2014). A 100-year return period wind speed from sector 190˚-240˚ T.N. was selected for wave modeling and analysis, as discussed further in Section 2.1. Wind speeds during this storm from different directions are depicted in Table 1.

1.2. Bathymetry and Topography

The following datasets of bathymetry and topography data are available and have been used for analysis and engineering:

- Port Townsend Digital Elevation Model (DEM) developed by NOAA, 2011-02-07. The spatial resolution of the DEM is 1/3 arc-second (approximately 10 meters). The DEM dataset was used further to develop a large wave modeling domain to simulate wave generation and propagation to the project site.
- Nearshore bathymetry and upland topography surveys conducted by Wilson Engineering in February and March of 2015. The nearshore bathymetry data were further used for construction of a nested modeling domain to simulate detailed wave transformation at the nearshore areas and to investigate interaction of waves with the existing and proposed project features.

Figure 1. Project site location and Bellingham International Airport wind station

Table 1. Design Wind Speed by Direction

Return Period (Year)	Sector Wind Speed (mph)					
	190	200	210	220	230	240
100	54.2	55.7	49.9	55.5	58.1	57.8

2. Project Design Criteria

2.1. Design Wind-wave Storm Event

A 100-year return period storm event was selected for analysis and numerical modeling of stability of the shoreline erosion protection features. Please note that there are not any generally acceptable standards (engineering or regulatory) identified to select the design storm event criteria for nearshore cleanup projects. Typically, shoreline erosion protection projects have been designed to withstand wind-wave storm events with a 25- or 50-year return period. Based on previous experience with the Whatcom Waterway (Port of Bellingham) and R.G. Haley (City of Bellingham) projects and to maintain methodologic consistency, CHE selected a 100-year storm event as the design wave storm criteria for the Cornwall Cleanup project.

2.2. Sea Level Rise

Future climate change predictions have required the design to consider potential sea-level rise (SLR) over time. The SLR assumption for this site is 2.4 ft, consistent with the SLR cited in the RI/FS. This value is consistent with the SLR assumed for other cleanup sites in Bellingham Bay, and was the SLR value used in the Waterfront District EIS. It should be noted that an assumed SLR value of 2.4 ft is significantly greater than values being assumed for major marine infrastructure projects in Puget

Sound. For example, the Mukilteo multimodal project uses a SLR design criteria = 1.08 ft and the Elliot Bay (Seattle Waterfront) Seawall Replacement Project has used a medium estimate of SLR of 1.65 ft. It is acknowledged that predicting SLR is a developing topic and that estimates will likely be refined over time. The design has been performed in a way to allow modifications due to additional SLR.

2.3. Tidal Data and Tide Elevation Design Criteria

Standard tide elevations (1981-2001 Epoch) in Bellingham Bay relative to MLLW and NAVD88 datums are depicted in Table 2. MLLW is assumed to be the project datum.

Two tide levels were used for engineering analysis and design: Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW). MHHW tide elevation will be used for design of stability of the upper part of the shoreline, while MLLW tide elevation will be used to ensure stability of the project elements at the lower part of the profile. MHHW tide elevation will be used in combination with the sea level rise increment (+ 2.4 ft).

Table 2. Bellingham Bay Tidal Elevations

Description	Datum	MLLW [ft]	NAVD88 [ft]
Highest Observed Tide	H.O.T.	10.42	9.94
Mean Higher-High Water	MHHW	8.51	8.03
Mean High Water	MHW	7.79	7.31
Mean Tide Level	MTL	5.07	4.59
Mean Sea Level	MSL	4.95	4.47
Mean Low Water	MLW	2.35	1.87
North American Vertical Datum	NAVD	0.48	0
Mean Lower-Low Water	MLLW	0	-0.48

2.4. Tsunami

Tsunami waves occur in water bodies due to earthquakes or landslides. Per the Critical Areas Report for the interim action at the Cornwall site (Landau Associates, 2011), a tsunami could be generated by a large earthquake in the Pacific Ocean basin. The Department of Natural Resources (DNR) Division of Geology and Earth Resources and the National Oceanic and Atmospheric Administration (NOAA) have published estimates of tsunami inundation in the Bellingham Bay area based on modeling of ground deformations and waves that may be generated by a major Cascadia Subduction Zone (CSZ) earthquake. The results of the DNR and NOAA modeling study (Walsh *et al.* 2004) entitled “Tsunami Hazard Map of the Bellingham Area, Washington: Modeled Tsunami Inundation from a Cascadia Subduction Zone Earthquake” indicate that a magnitude 9.1 Cascadia Subduction Zone earthquake may result in a tsunami wave arriving approximately 2 ½ hours after the earthquake at a tide stage near mean high water (MHW) which might be expected to result in a depth of inundation in the “knee-high or less” range (depending, of course, on the specific location/elevation along the shoreline).

Additionally, upland and submarine landslides flowing into northern Puget Sound or Bellingham Bay, as well as certain types of movements on crustal faults that might extend under Puget Sound and adjacent areas, could potentially create tsunami waves in Bellingham Bay that would arrive earlier than one from a Cascadia Subduction Zone earthquake. However, these types of features and events and associated risks are not yet well studied.

Based on knowledge of tsunami wave hydrodynamics, it appears that damage from an extreme tsunami event at the project site may occur at the upland part (above ordinary high water elevations) due to overtopping, and/or at the lower elevation of the project due to bottom shear stresses. It is concluded that if a tsunami event occurs at the Site and if damage to the cap or erosion protection material ensues, then repair of this damage would be equivalent to the maintenance repair work. No tsunami criteria were assumed for design of the Cornwall Cleanup project.

2.5. Project Boundary

The project boundary was provided by the Project Team and is defined by the approximate extents of refuse as well as the R.G. Haley Site AOC, as shown in Figure 2.

Figure 2. Project site boundary defined by approximate extents of refuse and R.G. Haley Site AOC

2.6. Design Criteria for Erosion Protection and Cap Material

Major assumptions used as design criteria for erosion protection and cap material are presented below:

- Excavation of the upland or bottom slope of the landfill is only allowed under the condition that the bottom of the excavation is above the “graded surface” provided by Landau Associates. No other excavation is considered as part of designing shoreline protection and capping elements for the project. This implies that post-project ground and bottom slope elevations will be modified (increased) relative to existing conditions) to accommodate shoreline protection and cap material features. Details of erosion protection measures (material thickness and elevations) will be revised at the detailed design phase to minimize impact to aquatic habitat and to seaward relocation of MHHW line.
- A one-foot thick sand filter layer is required for the entire shoreline at the site between an upper elevation of +8 ft to a lower elevation of -2 ft, MLLW, as shown schematically in Figure 3.

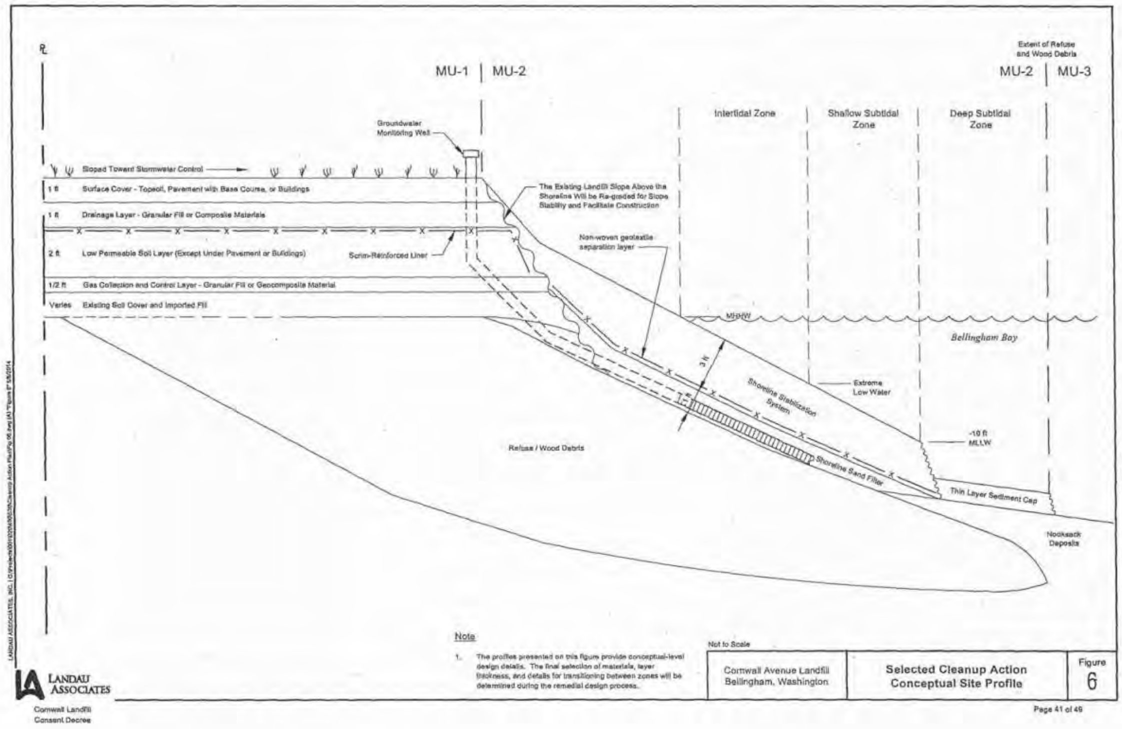


Figure 3. Selected Cleanup Action Conceptual Site Profile (Landau Associates 2015)

- A non-engineered minimum six-inch thick “thin layer sediment cap” is required to be placed on top of the existing shoreline in areas where no shoreline protection measure is proposed (see Figure 3). This thin layer sediment cap should extend seaward to the refuse extent, as provided by Landau Associates.
- Stability of the bottom sediment and erosion protection measure material will be analyzed to meet the wave design criteria (see Section 2.1) and tidal current

velocities (where needed). Based on the data and knowledge from the previous Whatcom Waterway Cleanup project study, tidal current velocities at the project site are small. However, additional investigation will be conducted to determine if bottom shear stress from the tidal current velocities is critical for the design of the thin cap layer design.

- The rock size for the cap material and shoreline erosion protection measures will be determined using a static stability (no movement) assumption. This assumption means that the capping material (rock material) will be designed to be immobile during the design storm event.
- Dynamic stability criteria will be applied for a cap that is designed from material other than rock (gravel, cobble, sand). Dynamic stability criteria assumes some natural movement and sorting of sediment under wave impact until a natural armoring layer is developed from the coarser fraction of sediment. This criteria also assumes that during natural movement and sorting of the capping layer no exposure of native bottom material can occur.

2.7. Transitions

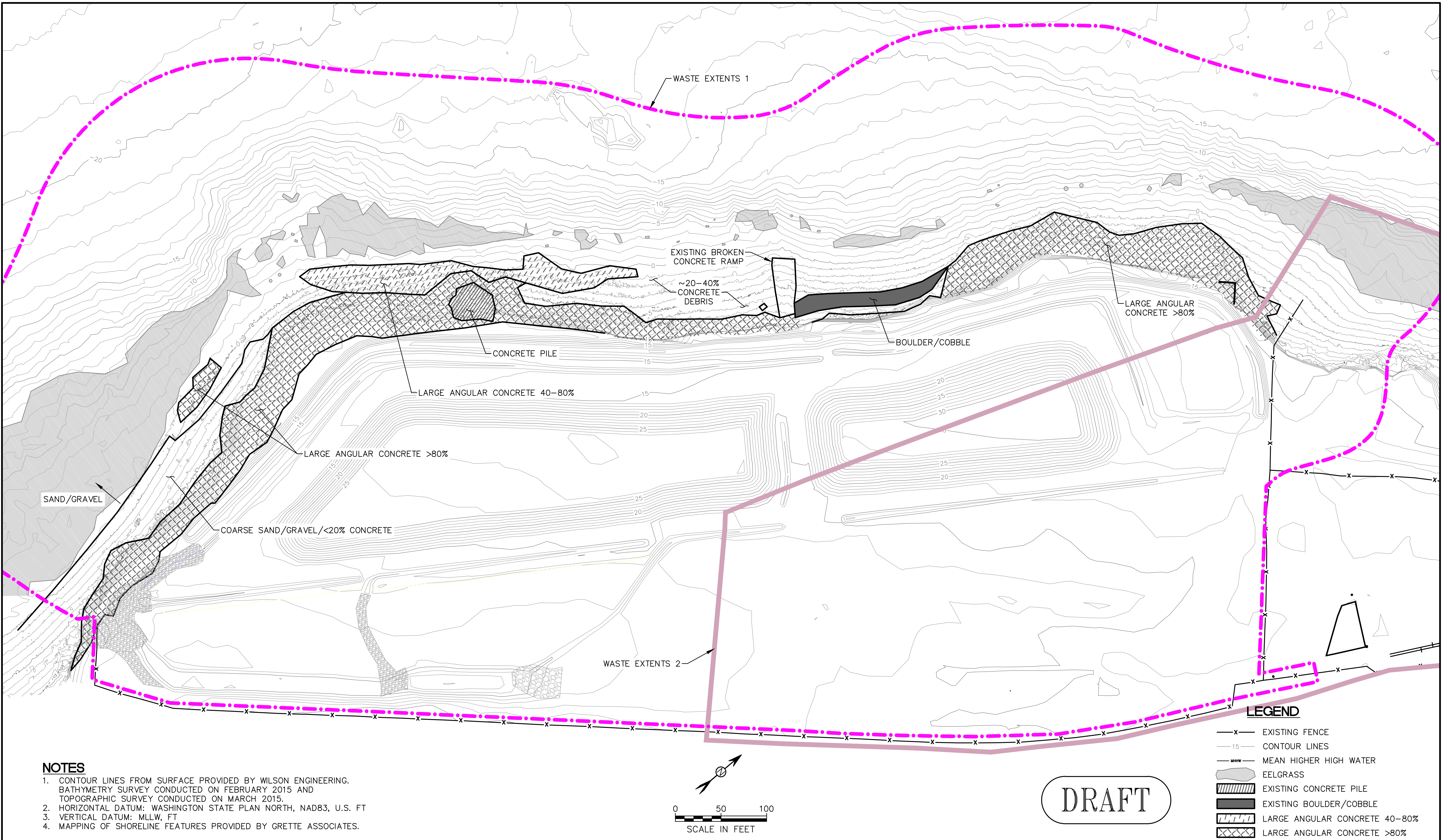
Details of the transitions (between the coastal engineering elements and transitions to the existing shoreline) were presented only at the preliminary level of design and will need to be refined during the next phases of design.

3. Reference

Landau Associates. 2015. Cornwall Avenue Landfill Cleanup Action Conceptual Site Profile.

ATTACHMENT B

Baseline Alternative Design Drawings



NOTES

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2. HORIZONTAL DATUM: WASHINGTON STATE PLAN NORTH, NAD83, U.S. FT
3. VERTICAL DATUM: MLLW, FT
4. MAPPING OF SHORELINE FEATURES PROVIDED BY GRETTE ASSOCIATES.

DRAFT

LEGEND

—x—	EXISTING FENCE
—15—	CONTOUR LINES
—MHHW—	MEAN HIGHER HIGH WATER
⬭	EELGRASS
▥	EXISTING CONCRETE PILE
■	EXISTING BOULDER/COBBLE
▨	LARGE ANGULAR CONCRETE 40–80%
▩	LARGE ANGULAR CONCRETE >80%

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CHECKED BY	VS			
PROJECT ENGINEER	YN			
PROJECT MANAGER	VS			
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PORT OF BELLINGHAM
CORNWALL CLEANUP

EXISTING SITE PLAN

REFERENCE SHEET NUMBER

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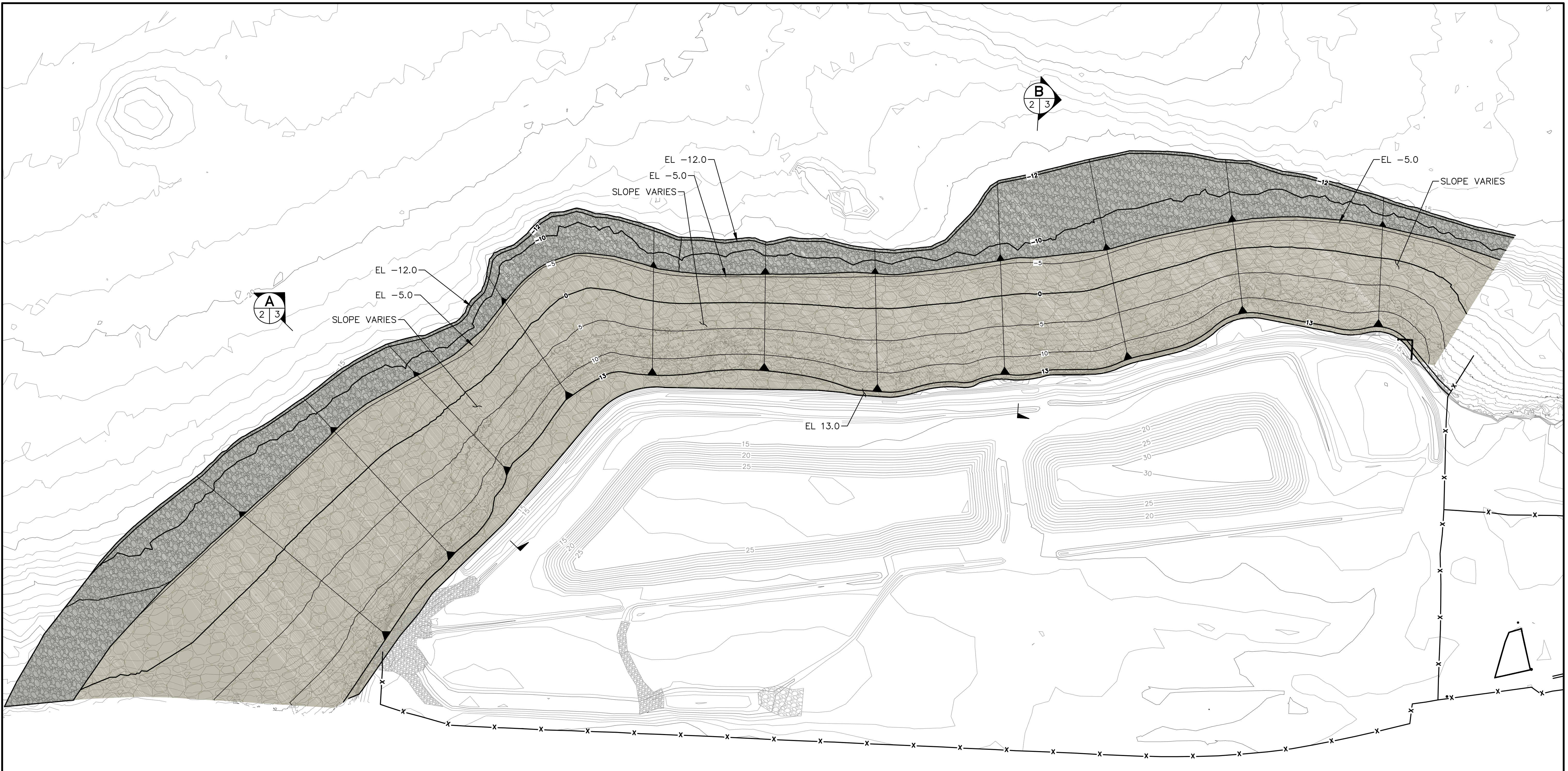
FILE: Z:\349297 – Port of Bellingham Cornwall Cleanup\7 – Design\349297 – Cornwall Site.dwg PLOT DATE: 2015-09-14



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2. HORIZONTAL DATUM: WASHINGTON STATE PLAN NORTH, NAD83, U.S. FT
3. VERTICAL DATUM: MLLW, FT
4. MAPPING OF SHORELINE FEATURES PROVIDED BY GRETTE ASSOCIATES.

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LEGEND

—x—	EXISTING FENCE
—15—	PROPOSED CONTOUR LINES
—15—	EXISTING CONTOUR LINES
—MHHW—	MEAN HIGHER HIGH WATER
▨	ARMOR
▩	COARSE GRAVEL

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PORT OF BELLINGHAM
CORNWALL CLEANUP

PROPOSED SITE PLAN

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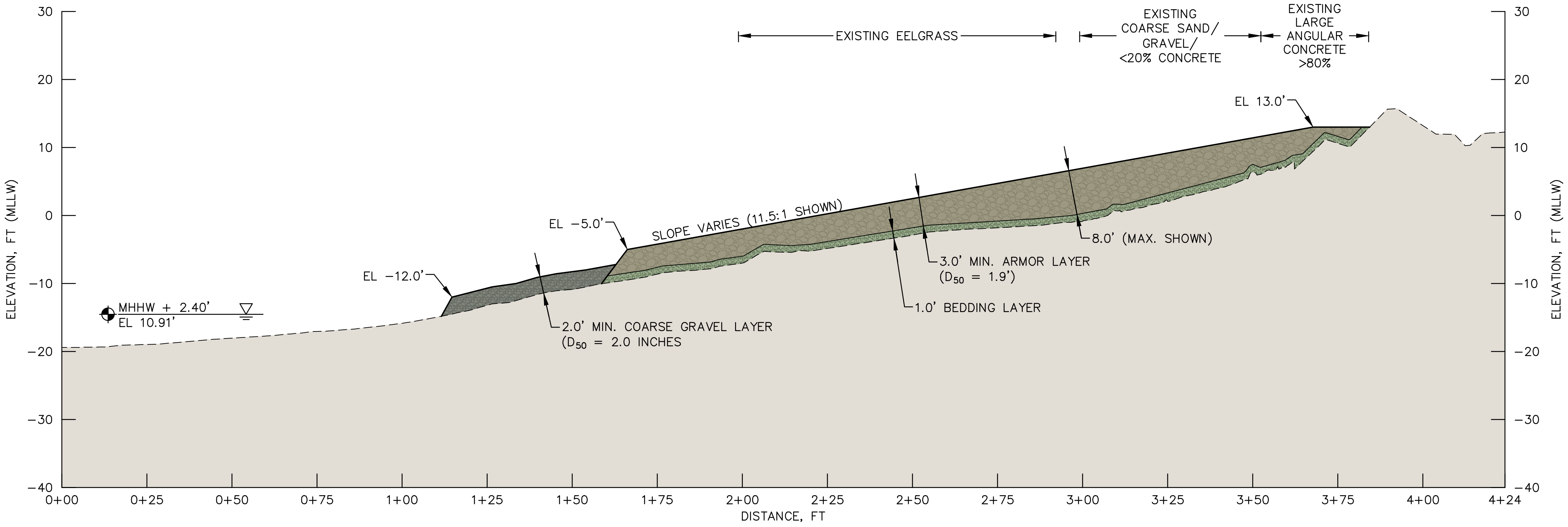

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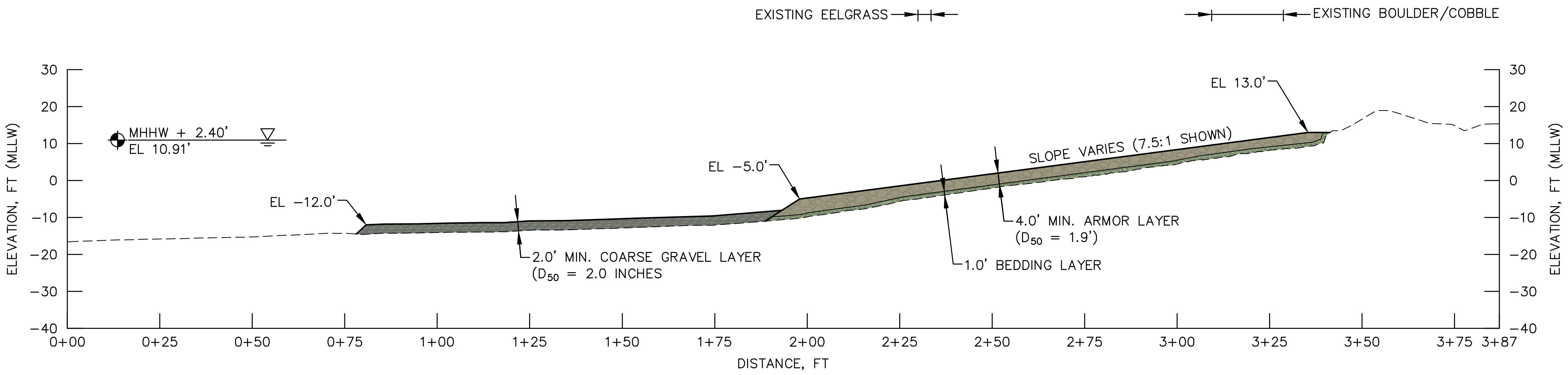

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PORT OF BELLINGHAM
CORNWALL CLEANUP

SECTIONS 1

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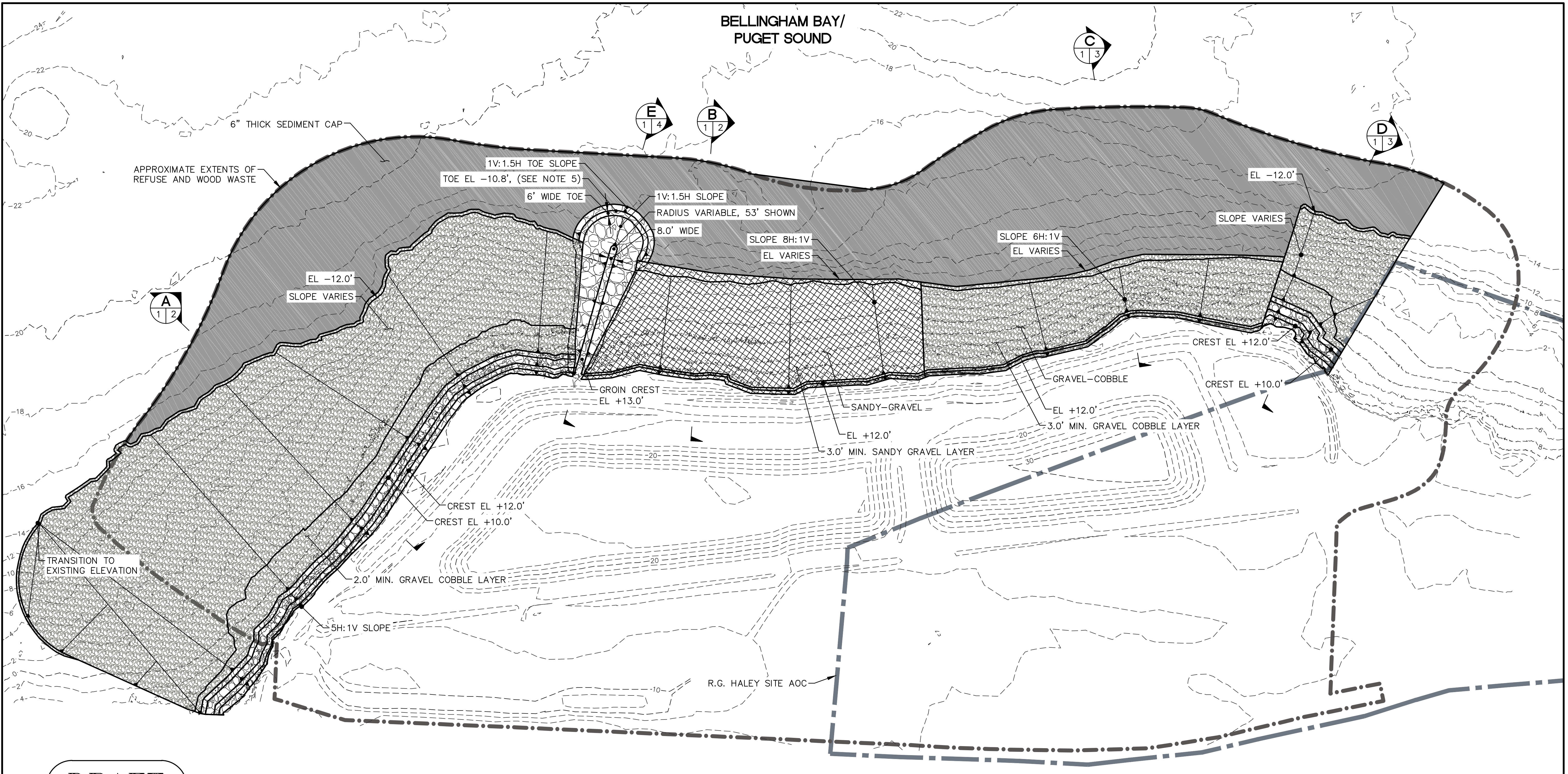
ATTACHMENT C

Rock Groin Alternative (Preferred Alternative) Design Drawings



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NOTES

1. CONTOUR LINES FROM SURFACE PROVIDED BY WILSON ENGINEERING. BATHYMETRY SURVEY CONDUCTED ON FEBRUARY 2015 AND TOPOGRAPHIC SURVEY CONDUCTED ON MARCH 2015.
2. HORIZONTAL DATUM: WASHINGTON STATE PLAN NORTH, NAD83, U.S. FT
3. VERTICAL DATUM: MLLW, FT
4. MAPPING OF SHORELINE FEATURES PROVIDED BY GRETTE ASSOCIATES.
5. GROIN TOE PROTECTION DETAILS ARE CONCEPTUAL AND SHALL BE DESIGNED IN THE NEXT PROJECT PHASE.

0 60 120
SCALE IN FEET

TIDAL WATER LEVELS (MLLW)

MEAN HIGHER HIGH WATER + SRL	+10.91'
MEAN HIGHER HIGH WATER (MHHW)	+8.51'
MEAN LOWER LOW WATER (MLLW)	0.00'

LEGEND

—x—	EXISTING FENCE	▨	ARMOR STONE
—15—	EXISTING CONTOUR LINES	▨	SANDY GRAVEL
—MHHW—	MEAN HIGHER HIGH WATER	▨	GRAVEL COBBLE
— ▪ —	R.G. HALEY SITE AOC	▨	SEDIMENT CAP
—•—•—	LANDFILL BOUNDARY		

DESIGNED BY	YN			
ENTERED BY	BT			
CHECKED BY	VS			JOB NUMBER
PROJECT ENGINEER	YN			349297
PROJECT MANAGER	VS			CONTRACT NO.
	DATE	REVISION	BY	

SCALE
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VERT.: AS NOTED

VERIFY SCALE
BAR IS ONE INCH ON 22x36 DRAWINGS AND HALF INCH ON 11x17 DRAWINGS, IF NOT, ADJUST SCALES ACCORDINGLY
0 1"

COAST & HARBOR ENGINEERING
A Division of Hatch Mott MacDonald
110 JAMES ST, STE 101 EDMONDS, WA 98020
PH 425−778−2542 • FAX 425−778−6883

PORT OF BELLINGHAM
Washington State

PORT OF BELLINGHAM
CORNWALL CLEANUP

ALT 1 − PROPOSED SITE PLAN

REFERENCE SHEET NUMBER

SHEET
1
OF
4
SHEETS

FILE: \\10.225.1.2\w\349297 − Port of Bellingham Cornwall Cleanup\7 − Design\CAD\E − Preliminary\2 − Working\349297 − REDESIGN sheets.dwg PLOT DATE: 2015−12−07

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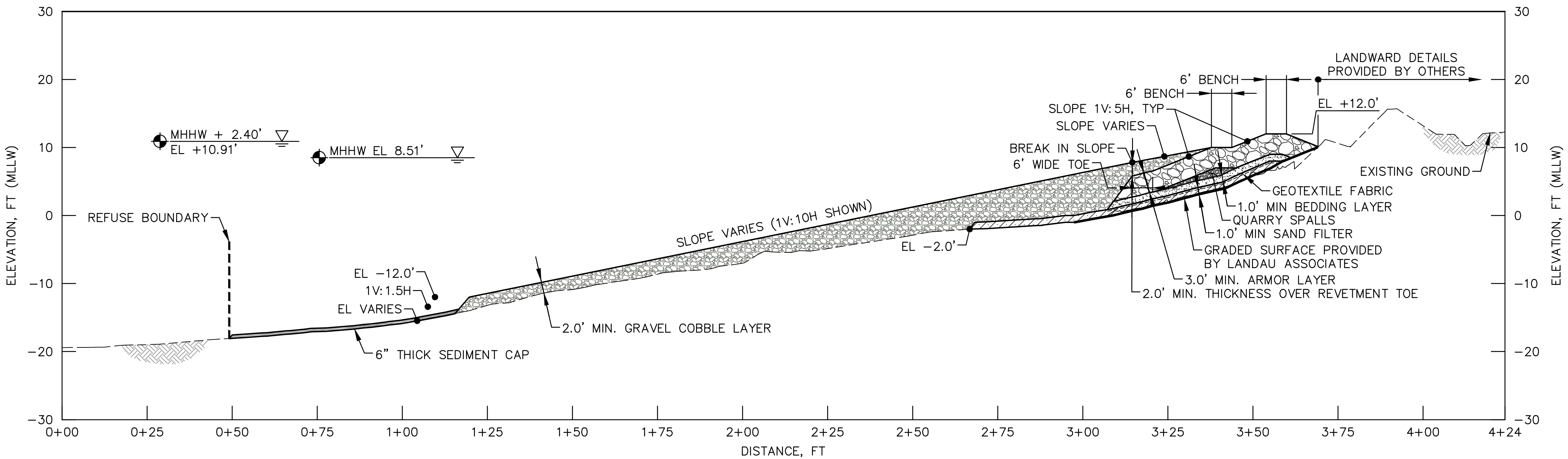

SECTION A
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SOUTH REVETMENT

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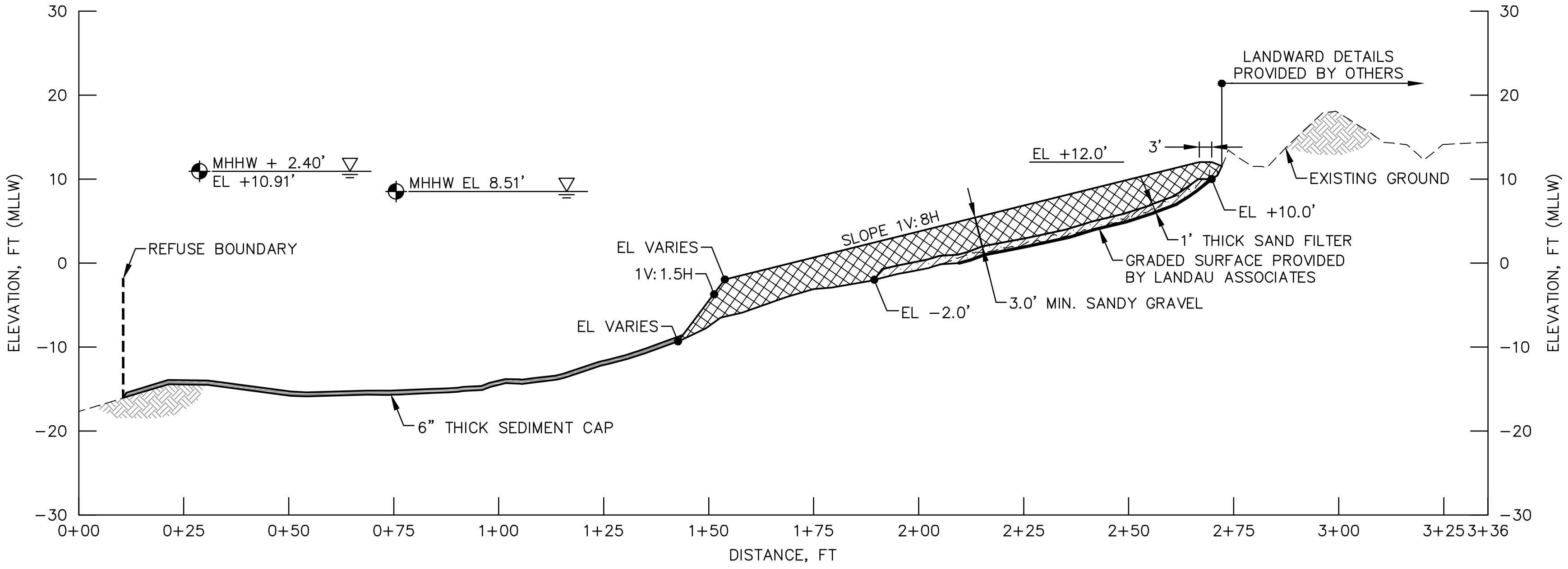

SECTION B
1 | 2
SANDY GRAVEL

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VERT. 0 10 20
SCALE IN FEET

LEGEND

▨ ARMOR STONE
▨ QUARRY SPALLS
▨ GRAVEL COBBLE
▨ BEDDING
▨ SANDY GRAVEL
▨ SEDIMENT CAP
▨ SAND FILTER

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SOUTH REVETMENT & SANDY-GRAVEL

REFERENCE SHEET NUMBER

SHEET 2 OF 4 SHEETS

FILE: C:\Users\tad69807\Desktop\349297 – REDESIGN sheets.dwg PLOT DATE: 2015-12-04

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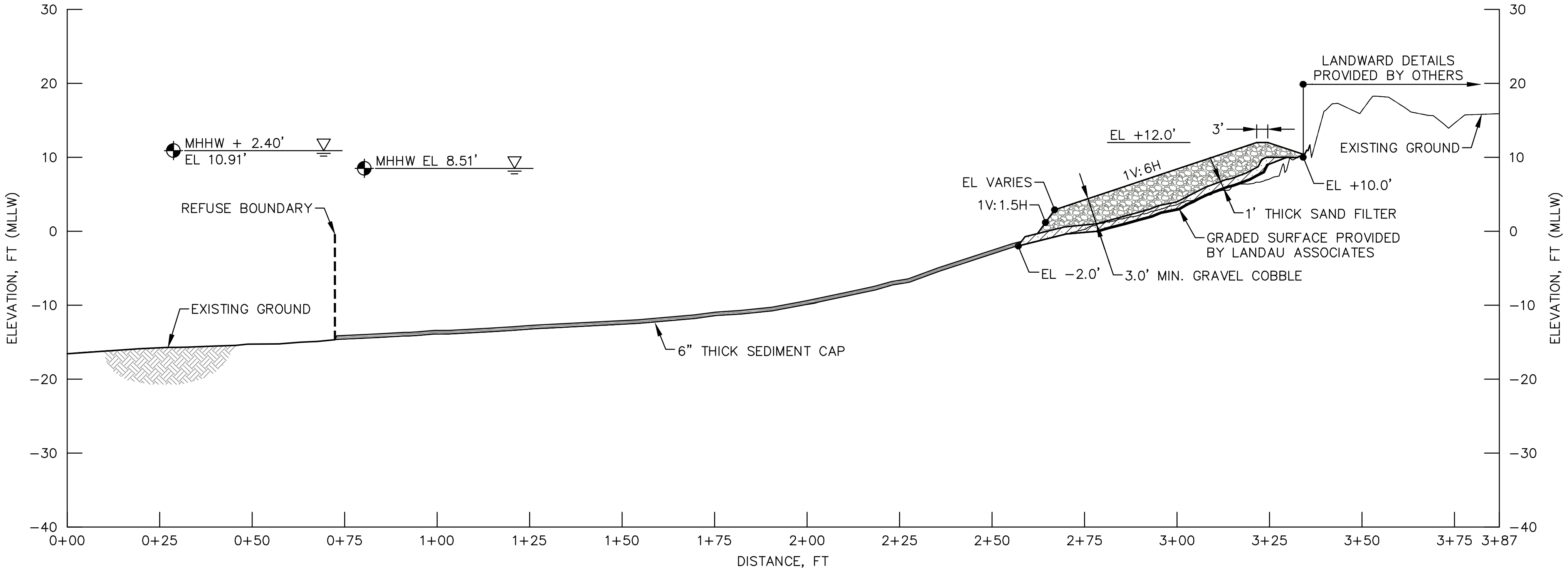

C 1 | 3

SECTION

GRAVEL COBBLE

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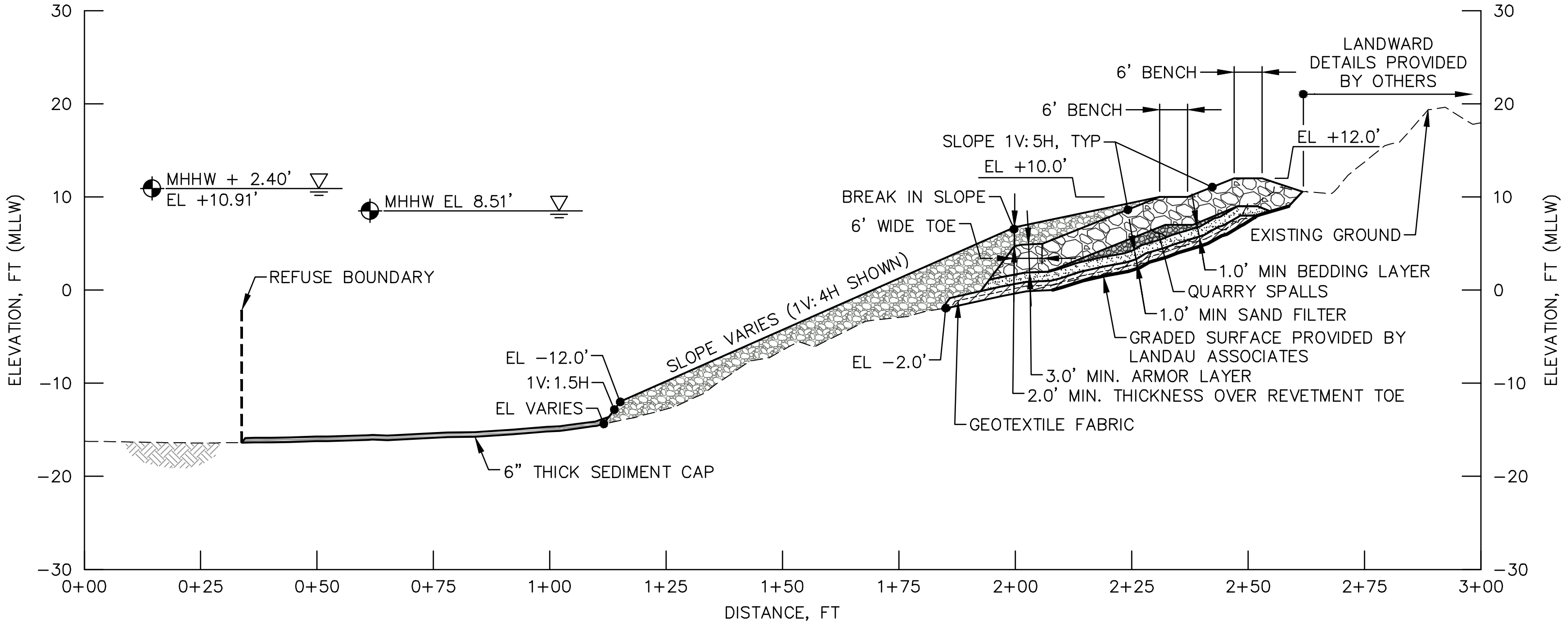
VERT. 0 10 20
SCALE IN FEET



D 1 | 3

SECTION

NORTH REVETMENT

HORIZ. 0 20 40
VERT. 0 10 20
SCALE IN FEET

LEGEND

▨	ARMOR STONE
▨	QUARRY SPALLS
▨	GRAVEL COBBLE
▨	BEDDING
▨	SEDIMENT CAP
▨	SAND FILTER

FILE: C:\Users\tod69807\Desktop\349297 - REDESIGN sheets.dwg PLOT DATE: 2015-12-04

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CORNWALL CLEANUP

GRAVEL COBBLE & NORTH REVETMENT

REFERENCE SHEET NUMBER

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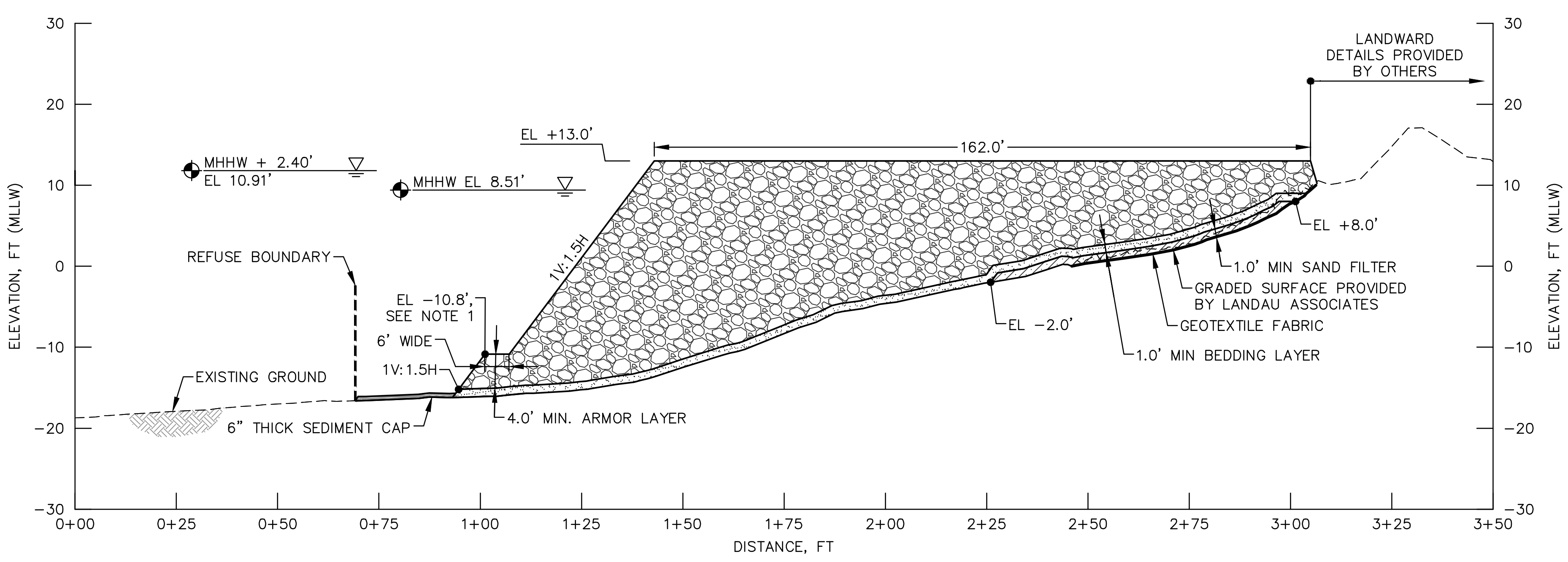

E
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SECTION
GROIN SECTION

HORIZ. 0 20 40
VERT. 0 10 20
SCALE IN FEET

LEGEND

▨	ARMOR STONE
▩	QUARRY SPALLS
▨	GRAVEL COBBLE
░	BEDDING
▒	SEDIMENT CAP
▧	SAND FILTER

NOTES

1. GROIN TOE PROTECTION DETAILS ARE CONCEPTUAL AND SHALL BE DESIGNED IN THE NEXT PROJECT PHASE.

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PROJECT ENGINEER	YN				349297
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GROIN

REFERENCE SHEET NUMBER

SHEET 4 OF 4 SHEETS

FILE: \\10.225.1.2\w\349297 – Port of Bellingham Cornwall Cleanup\7 – Design\CAD\E – Preliminary\2 – Working\349297 – REDESIGN sheets.dwg PLOT DATE: 2015-12-04

APPENDIX D

Bioassay Testing Results

APPENDIX D

SEDIMENT BIOASSAY RESULTS

TABLE OF CONTENTS

FIGURE

ATTACHMENT

SUMMARY OF BIOASSAY RESULTS

Five surface sediment samples were collected at the Cornwall Avenue Landfill cleanup site (Site) for bioassay testing. The samples were collected at the locations indicated on Figure D-1. These sample locations were selected to evaluate sediment conditions where at least 1 foot (ft) of sediment has been deposited by natural recovery over top of landfill refuse. The samples were collected and processed on June 10, 2015 in accordance with the Pre-Design Investigation Work Plan (Landau Associates 2015), and submitted under chain of custody to Ramboll-Environ in Port Angeles, Washington, for evaluation.

The testing consisted of introducing marine biota to the sediment samples under closely controlled and monitored conditions, and evaluating whether observed impacts were within acceptable ranges as compared to the biota subjected to uncontaminated control (reference) samples. Three tests were conducted on the samples, following Puget Sound Estuary Protocols (PSEP), Sediment Management Standard (SMS) criteria, and the Sediment Cleanup User's Manual II (SCUM II) guidance from the Washington State Department of Ecology. The three tests included a 10-day amphipod test using *E. estuaries*, a 20-day juvenile polychaete survival and growth test using *N. arenaceodentata*, and a larval development test using *M. galloprovincialis*.

The reference samples were collected from two stations in Carr Inlet on June 19, 2015. These sample locations were selected based on providing uncontaminated sediment for test control. Two samples were required instead of one in order to provide a range of grain-sizes similar to those observed in the samples collected at the Site.

Sediment cleanup objectives (SCO) and cleanup screening levels (CSLs) are established by the Washington State Department of Ecology for each of the three tests. Each of the five Site samples passed all three tests at the SCO, the more conservative of the two established criteria. Additional details of the tests and results are provided in the attached laboratory report from Ramboll Environ.

Data Quality Verification

The reported laboratory procedures were reviewed for compliance with applicable guidance or critiera from PSEP, SCUM II, and updates from the Sediment Management Annual Review Meetings (SMARM). The following bullets summarize the results of the data quality verification.

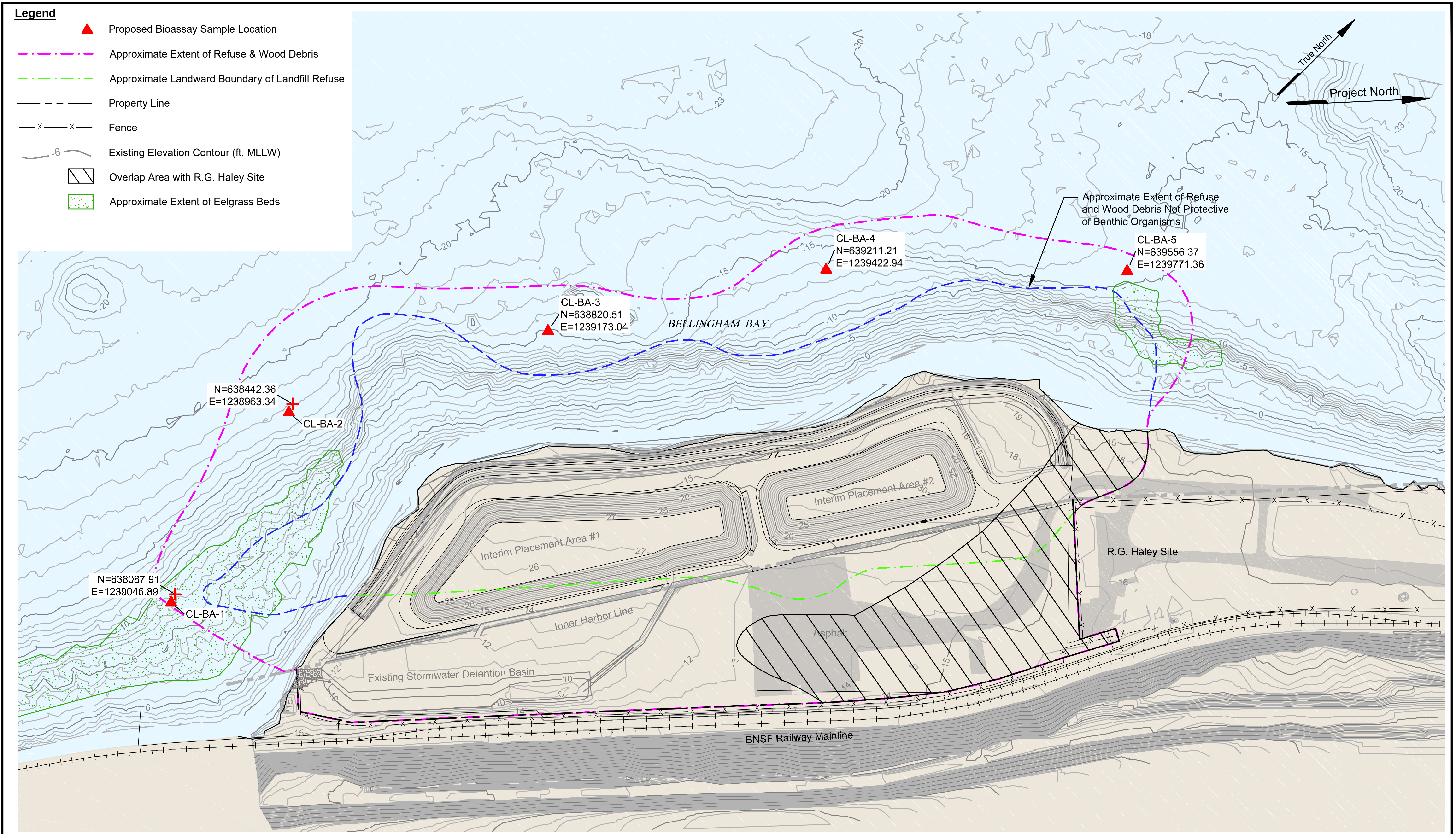
- Appropriate laboratory procedures followed the applicable guidance.
- All tests were conducted within the required 8-week holding time.
- All hand entered data was reviewed for data entry errors and corrected if necessary. A minimum of 10 percent of all calculations and data sorting were reviewed for errors.
- Review counts were performed on any apparent outliers.

- All water quality parameters were maintianed within acceptable limits through the duration of the 10-day ampphipod test, with minor deviations in temperature and salinity. These deviations are not anticipated to affect the results.
- All water quality parameters were withing acceptable limits through the duration of the 20-day juvenile polychaete bioassay test with the exception of salinity. Salinity was recorded slightly above the target range but well within tolerance limits for the test organism. This deviation is not anticipated to affect results.

Bioassay results appear to be usable as reported, without modification or additional qualification.

References

Landau Associates. 2015. *Work Plan, Pre-Design Characterization, Cornwall Avenue Landfill Site, Bellingham, Washington*. Prepared for Port of Bellingham. April 30.



Basemap source: Port of Bellingham 1996, Anchor Environmental 2008, Wilson Engineering LLC 2015

0 150 200
Scale in Feet

Landau Associates, Inc. | G:\Projects\001\037\040\041\F01 BioassaySamplingLocations.dwg (A) "Figure F-1" 9/18/2015

LANDAU ASSOCIATES

Engineering Design Report
Cornwall Avenue Landfill
Bellingham, Washington

Bioassay Sampling Locations

Figure
D-1

ATTACHMENT D.1

Biological Testing Results, Cornwall Avenue Landfill Site, Bellingham, WA. Ramboll Environ Report ID 081815.01. August 18, 2015

RAMBOLL ENVIRON

ENVIRONMENT
& HEALTH

BIOLOGICAL TESTING RESULTS

CORNWALL AVENUE LANDFILL SITE

BELLINGHAM, WA

Prepared for:
Landau Associates
Edmonds, WA

On behalf of:
Port of Bellingham
Bellingham, WA

Prepared by:
Ramboll Environ US Corporation
4770 NE View Dr.
PO Box 216
Port Gamble, Washington 98364

Client Contract Reference: Project Number 0001037.030.036

Ramboll Environ Report ID: 081815.01

Submittal Date: August 18, 2015

Contents

Tables

ACRONYMS AND ABBREVIATIONS

AFDW:	Ash-free dry weight
ARI:	Analytical Resources, Inc., Tukwila, WA
cm:	Centimeter
CSL:	Cleanup Screening Level
°C:	Degrees Celsius
EC_{50}:	Effective Concentration that results in a 50% reduction in a sub-lethal endpoint
g:	Grams
LC_{50}:	Lethal Concentration that results in a 50% reduction in survival
L:	Liter
µm:	Micrometer
mg:	Milligram
mg/L:	Milligrams per liter
mL:	Milliliter
mm:	Millimeter
NELAP:	National Environmental Laboratory Accreditation Program
NOEC:	No Observed Effect Concentration
ppt:	parts per thousand
PSEP:	Puget Sound Estuary Protocols (PSEP 1995)
SCO:	Sediment Cleanup Objective
SMS:	Sediment Management Standards
SOP:	Standard operation procedure
SSAPA:	Sediment Sampling and Analysis Plan Appendix (SSAPA; Ecology 2008)
SMARM:	Sediment Management Annual Review Meeting
UIA:	Un-ionized ammonia
USACE:	United States Army Corps of Engineers
USEPA:	United States Environmental Protection Agency
WA:	Washington State
WAC:	Washington Administrative Code
WDOE:	Washington (State) Department of Ecology

All testing reported herein was performed consistent with our laboratory's quality assurance program. All results are intended to be considered in their entirety, and Ramboll Environ is not responsible for use of less than the complete report. The test results summarized in this report apply only to the sample(s) evaluated.

Brian Hester

Brian Hester

Laboratory Director

1 INTRODUCTION

Ramboll Environ conducted biological toxicity testing with sediment samples collected by Landau Associates, Inc. as part of a pre-design investigation being performed at the Cornwall Avenue Landfill Site in Bellingham, Washington. Sediments were evaluated for biological effects following guidance provided by the Washington State Department of Ecology (WDOE) Sediment Management Standards (SMS) under the Washington Administrative Code (WAC) 173-204-315. This report presents the results of the toxicity testing portion of the Cornwall Avenue sediment investigation. .

2 METHODS

This section summarizes the test methods followed for this biological characterization. Test methods followed guidance provided by the Puget Sound Estuary Program (PSEP 1995), the Sediment Cleanup User's Manual II (SCUM II; Ecology 2015), and the various updates presented during the Annual Sediment Management Review meetings (SMARM). Sediment toxicity was evaluated using three standard PSEP bioassays; the 10-day amphipod test, the juvenile polychaete survival and growth test, and the benthic larval development test.

2.1 Sample Collection Sample and Animal Receipt

Five test sediments were collected on June 10, 2015 and were received at Ramboll Environ on June 11, 2015. Reference sediments from two stations within Carr Inlet, WA were collected by Ramboll Environ on June 19, 2015 and received on the same day. Sediment samples were stored in a walk-in cold room at 4 ± 2°C in the dark. The test sediment was not sieved prior to testing. All tests were conducted within the eight week holding time.

Amphipods (*Eohaustorius estuarius*) were supplied by Northwestern Aquatic Sciences in Newport, Oregon. Animals were held in native sediment at 15°C prior to test initiation. Juvenile polychaete worms (*Neanthes arenaceodentata*) were obtained from Aquatic Toxicology Support in Bremerton, Washington. Juvenile polychaetes were held in seawater at 20°C (Neanthes were cultured in water-only and were not held in sediment prior to testing). *Mytilus galloprovincialis* (mussel) broodstock were provided by Dave Gutoff in San Diego, CA. Broodstock were held in unfiltered seawater at 16°C prior to spawning.

Native *Eohaustorius* sediment from Yaquina Bay, Oregon was also provided by Northwest Aquatic Sciences for use as control sediment treatments for the amphipod and juvenile polychaete tests.

2.2 Sample Grain Size and Reference Comparison

Sediment grain size is one of the characteristics used in selecting the appropriate reference sediment(s) to compare the chemical and biological responses of project sediments. The percent fines value is defined as the amount of sediment that passes through a 62.5-µm sieve, expressed as a percentage of the total sample analyzed. This is also the sum of the silt and clay fraction of sediment. Wet-sieve grain size results for the reference sample was conducted in the field (at the time of collection) by Ramboll Environ. The percent-fines determination of the project sediments are summarized in Table 2-1.

Table 2-1. Sample and Reference Grain Size Comparison.

Treatment	Percent Fines[1]	Treatment Compared To:
CR1 (Reference)	48%	
CARR02(Reference)	82%	
CL-BA-1	48%	CR1
CL-BA-2	74%	CARR02
CL-BA-3	76%	CARR02
CL-BA-4	72%	CARR02
CL-BA-5	75%	CARR02

[1] Wet sieve results

Project sample CL-BA-1 was compared to the reference "CR1" (48% fines) for the purposes of evaluating the sediment under the sediment management standards. All remaining project samples were compared to the reference "CARR02" (82% fines).

2.3 Ultra-Violet Light Exposure

Test sediment samples were exposed to ultra-violet (UV) light during the entire test exposure. The UV light regime followed guidance provided by Appendix C of SCUM II (Ecology 2015). UV light was provided by fluorescent light ballast containing one Duro-Test Vita-Lite® (40W, 5500°K, 91 CRI) fluorescent bulb and one standard fluorescent bulb (Phillips F40CW). The UV bulbs were placed within 12" above the sediment surface. All test chambers in the UV exposures were left uncovered to prevent any UV loss. Tests were conducted on water-tables to ensure that the additional lighting did not alter water temperatures in the test chambers. In all other respects, the methods followed the standard testing protocols are summarized below.

2.4 10-day Amphipod Bioassay

The 10-day acute toxicity test with *E. estuarius* was initiated on June 26, 2015. To prepare the test exposures, approximately 175 mL of sediment was placed in clean, acid and solvent-rinsed 1-L glass jars, which were then filled with 775 mL of 0.45-µm filtered seawater at 28 ppt. The control and reference sediment were tested concurrently with the test treatment. Five replicates were used to evaluate sediment toxicity while the remaining two replicates were designated as sacrificial surrogate chambers. One surrogate chamber was sacrificed at test initiation to measure porewater and overlying ammonia and sulfides. The remaining surrogate chamber was used for measuring daily water quality throughout the test, as well as porewater and overlying ammonia and sulfides at test termination. Total ammonia as nitrogen was monitored using an Orion meter fitted with an ammonia ion-specific probe. Total sulfides as S^{2-} were monitored using a HACH DR/2800 Spectrophotometer.

Test chambers were placed in randomly assigned positions in a 15°C water bath and allowed to equilibrate overnight. Trickle-flow aeration was provided to prevent dissolved oxygen concentrations from dropping below acceptable levels.

Immediately prior to test initiation, water quality parameters were measured in the surrogate chamber for each treatment. Dissolved oxygen (DO), temperature, pH, and salinity were then monitored in the surrogate chambers daily until test termination. Target test parameters were:

Dissolved Oxygen:	≥5.1 mg/L
pH:	7 - 9 units
Temperature:	15 ± 1°C
Salinity:	28 ± 1ppt

The tests were initiated by randomly allocating 20 *E. estuarius* into each test chamber, ensuring that each of the amphipods successfully buried into the sediment. Amphipods that did not bury within approximately one hour were replaced with healthy amphipods. The 10-day amphipod bioassay was conducted as a static test with no feeding during the exposure period. At test termination, sediment from each test chamber was sieved through a 0.5-mm screen and all recovered amphipods transferred into a Petri dish. The number of surviving and dead amphipods was then determined under a dissecting microscope.

A water-only, 4-day reference-toxicant test was conducted concurrently with the sediment tests using ammonium chloride. The ammonium chloride reference-toxicant test was used to ensure animals used in the test were healthy and of similar sensitivity to prior tests. This test also provided information on the sensitivity to any ammonia concentrations that might be present in the sediments.

2.5 20-day Juvenile Polychaete Bioassay

The 20-day chronic toxicity test with *N. arenaceodentata* was initiated on July 2, 2015. Test exposures were prepared with approximately 175 mL of sediment placed in clean, acid and solvent-rinsed 1-L glass jars, which were then filled with 775 mL of 0.45-µm filtered seawater at 28 ppt. The control and reference sediment were tested concurrently with the test treatment. Five replicates were used to evaluate sediment toxicity while the remaining two replicates were designated as sacrificial surrogate chambers. One surrogate chamber was sacrificed at test initiation to measure overlying and interstitial ammonia and sulfides. The remaining surrogate chamber was used for measuring daily water quality throughout the test, as well as overlying and interstitial ammonia and sulfides at test termination. Total ammonia as nitrogen was monitored using an Orion meter fitted with an ammonia ion-specific probe. Total sulfides as S^{2-} were monitored using a HACH DR/2800 Spectrophotometer.

Test chambers were placed in randomly assigned positions in a water bath at 20°C and allowed to equilibrate overnight. Trickle-flow aeration was provided to prevent dissolved oxygen concentrations from dropping below acceptable levels.

Immediately prior to test initiation, water quality parameters were measured. Dissolved oxygen, temperature, pH, and salinity were then monitored in the surrogates daily until test termination. Target test parameters were:

Dissolved Oxygen:	≥4.6 mg/L
pH:	7 - 9 units
Temperature:	20 ± 1°C
Salinity:	28 ± 2 ppt

The juvenile polychaete test was initiated by randomly allocating five *N. arenaceodentata* into each test chamber, and observing whether each of the worms successfully buried into the sediment. Worms that did not bury within approximately one hour were replaced with healthy worms. The 20-day test was conducted as a static-renewal test, with exchanges of 300 mL of water occurring every third day. *N. arenaceodentata* were fed every other day with 40 mg of TetraMarin® (approximately 8 mg dry weight per worm). At test termination, sediment from each test chamber was sieved through a 0.5-mm screen and all recovered worms transferred into a Petri dish. The number of surviving and dead worms was determined. All surviving worms were then transferred to pre-weighed, aluminum foil weigh-boats, and dried in a drying oven at 60°C for approximately 24 hours. Each weigh-boat was removed, cooled in a dessicator, and then weighed on a microbalance to 0.01 mg. Each of the weigh boats was then heated to 550°C for 2 hours in order to determine the ashed weight. Ash-free dry weights (AFDW) were calculated to correct for the influence of sediment grain size differences between treatments. The ashed boats were weighed to 0.01 mg and the ashed weight was subtracted from the dry weight to calculate the AFDW. Both dry weight and AFDW were used to determine individual worm weight and growth rates.

A water-only, 4-day reference-toxicant test was conducted concurrently with the sediment tests using ammonium chloride. The ammonium chloride reference-toxicant test was used to ensure animals used in the test were healthy and of similar sensitivity to prior tests. This test also provided information on the sensitivity to any ammonia concentrations that might be present in the sediments.

2.6 Larval Developmental Bioassay

Test sediment was evaluated using the larval benthic toxicity test with the mussel, *M. galloprovincialis*. The mussel larval test was initiated on July 15, 2015. The control and reference sediment were tested with the test treatments. To prepare the test exposures, 18 g (±1 g) of test sediment was placed in clean, acid and solvent-rinsed 1-L glass jars, which were then filled to 900 mL with 0.45-µm filtered seawater. Six replicate chambers were prepared for the test treatment, reference sediment, and the native sediment control treatment. Five of the replicates were used to evaluate the test; the sixth replicate was used as a water quality surrogate. Each chamber was shaken for 10 seconds and then placed in predetermined randomly-assigned positions in a water bath at 16°C.

To collect gametes for each test, mussels were placed in clean seawater and acclimated at 16°C for approximately 20 minutes. The water bath temperature was then increased over a period of 15 minutes to 20°C. Mussels were held at 20°C and monitored for spawning individuals. Spawning females and males were removed from the water bath and placed in individual containers with seawater. These individuals were allowed to spawn until sufficient gametes were available to initiate the test. After the spawning period, eggs are transferred to fresh seawater and filtered through a 0.5 mm Nitex® mesh screen to remove large debris, feces, and excess gonadal matter. A composite was made of the sperm and diluted with fresh seawater. The fertilization process was initiated by adding sperm to the isolated egg containers. Egg-sperm solutions were periodically homogenized with a perforated plunger during the fertilization process and sub-samples observed under the microscope for egg and sperm viability. Approximately one to one and a half hours after fertilization, embryo solutions were checked for fertilization rate. Only those embryo stocks with >90% fertilization were used to initiate the tests. Embryo solutions were rinsed free of excess sperm and then combined to create one embryo stock solution. Density of the embryo stock solution was determined by counting the number of embryos in a subsample of homogenized stock solution. This was used to determine the volume of embryo stock solution to deliver approximately 27,000 embryos to each test chamber.

Dissolved oxygen, temperature, pH, and salinity were monitored in water quality surrogates to prevent loss or transfer of larvae by adhesion to water-quality probes. Ammonia and sulfides in the overlying water were measured on Day 0 and Day 2 (test termination). Total ammonia as nitrogen was monitored using an Orion meter fitted with an ammonia ion-specific probe. Total sulfides as S^{-2} were monitored using a HACH DR/2800V Spectrophotometer. Target test parameters were as follows:

Dissolved Oxygen:	≥5.0 mg/L
pH:	7 - 9 units
Temperature:	16 ± 1°C
Salinity:	28 ± 1ppt

The development test was conducted as a static test without aeration. The protocol calls for test termination when 95% of the embryos in the control have reached the prodissoconch I stage (approximately 48-60 hours). At termination, the overlying seawater was decanted into a clean 1-L jar and mixed with a perforated plunger. From this container, a 10 mL subsample was transferred to a scintillation vial and preserved in 5% buffered formalin. Larvae were subsequently stained with a dilute solution of Rose Bengal in 70% alcohol to help visualization of larvae. The number of normal and abnormal larvae was enumerated on an inverted microscope. Normal larvae included all D-shaped prodissoconch I stage larvae. Abnormal larvae included abnormally shaped prodissoconch I larvae and all early stage larvae.

A water-only reference-toxicant test was conducted concurrently with the sediment tests using ammonium chloride. The ammonium chloride reference-toxicant test was used to ensure animals used in the test were healthy and of similar sensitivity to prior tests. This test also provided information on the sensitivity to ammonia concentrations that would possibly be present in the sediments.

2.7 Data Analysis and QA/QC

All water quality and endpoint data were entered into Excel spreadsheets. Water quality parameters were summarized by calculating the mean, minimum, and maximum values for each test treatment. Endpoint data were calculated for each replicate and the mean values and standard deviations were determined for each test treatment.

All hand-entered data was reviewed for data entry errors, which were corrected prior to summary calculations. A minimum of 10% of all calculations and data sorting were reviewed for errors. Review counts were conducted on any apparent outliers.

For the larval test, the normalized combined mortality and abnormality endpoint was used to evaluate the test sediment. This was based on the number of normal larvae in each treatment and reference sample divided by the mean number of normal larvae in the control replicates, as defined in the SCUM II guidance document (Ecology 2015).

For SMS suitability determinations, comparisons were made according SCUM II (Ecology 2015) and Fox et al. (1998). For DMMP suitability determinations, comparisons were made according to the USACE User's Manual (USACE 2013). Data reported as percent mortality or survival were transformed using an arcsine square root transformation prior to statistical analysis. All data were tested for normality using the Wilk-Shapiro test and equality of variance using Levene's test. Determinations of statistical significance were based on one-tailed Student's t-tests with an alpha of 0.05. A comparison of the larval endpoint relative to the reference was made using an alpha level of 0.10. For samples failing to meet assumptions of normality, a Mann-Whitney test was conducted to determine significance. For those samples failing to meet the assumptions of normality and equality of variance, a t-test on rankits was used.

3 RESULTS

The results of the sediment testing, including a summary of test results and water quality observations are presented in this section. Data for each of the replicates, as well as laboratory bench sheets are provided Appendix A and statistical analyses are provided in Appendix B.

3.1 10-day Amphipod Bioassay

The bioassay test with *E. estuarius* was validated with 3% mortality in the native sediment control, which met the performance criterion of ≤10% mortality. This result indicates that the test conditions were suitable for adequate amphipod survival. Mean mortality in the reference treatments CR1 and CARR02 were 2% and 1%, respectively, which met the performance criteria (<25% mortality) and indicated that the reference sediment was acceptable for suitability determination. Mean mortality in the project samples ranged from 2% to 19%. All endpoint results are summarized in Table 3-1.

Summaries of water quality measurements, ammonia and sulfide concentrations, and test conditions are presented in Table 3-2, Table 3-3, Table 3-4, and Table 3-5.

All water quality parameters were within the acceptable limits throughout the duration of the test, with the exception of minor deviations in temperature and salinity. Temperature was recorded slightly above the targeted range of 15±1°C on Day 5 (Max value 17.4°C). The temperature control system was adjusted upon discovery and temperatures returned to the targeted range for the duration of the test. Salinity was recorded slightly above the recommended range of 28 ± 1 ppt (Max: 30 ppt), this salinity was still well within the tolerance range for this species. These deviations would not be expected to affect the significance of the test results.

A reference-toxicant test (positive control) was performed on the batch of test organisms utilized for this study. The LC_{50} value was well within control chart limits (±2 standard deviations from the laboratory historical mean). This result indicates that the test organisms used in this study were of similar sensitivity to those previously tested at Ramboll Environ.

Ammonia concentrations observed in the *E. estuarius* test were below the No Observed Effect Concentration (NOEC) value derived from the concurrent ammonia reference-toxicant test (Table 3-3; compare to NOEC of 132 mg/L). Values were also below the published threshold concentration of 15 mg/L total ammonia (Barton 2002). Therefore ammonia concentrations within the sediment samples should not have been a contributor to any adverse biological effects observed in the test treatments. Initial sulfide concentrations in interstitial water were below 0.3 mg/L and would not be expected to contribute to toxicity.

Table 3-2. Test Results for *Eohaustorius estuarius*.

Treatment	Replicate	Number Initiated	Number Surviving	Percentage Survival	Mean Percentage		Standard Deviation
					Survival	Mortality	
Control	1	20	19	95	97	3	2.7
	2	20	20	100			
	3	20	19	95			
	4	20	20	100			
	5	20	19	95			
CR1 (Reference)	1	20	20	100	98	2	2.7
	2	20	20	100			
	3	20	20	100			
	4	20	19	95			
	5	20	19	95			
CARR02 (Reference)	1	20	19	95	99	1	2.2
	2	20	20	100			
	3	20	20	100			
	4	20	20	100			
	5	20	20	100			
CL-BA-1	1	20	19	95	98	2	2.7
	2	20	20	100			
	3	20	20	100			
	4	20	19	95			
	5	20	20	100			
CL-BA-2	1	20	18	90	85	15	5.0
	2	20	16	80			
	3	20	17	85			
	4	20	16	80			
	5	20	18	90			
CL-BA-3	1	20	15	75	81	19	8.2
	2	20	18	90			
	3	20	15	75			
	4	20	15	75			
	5	20	18	90			
CL-BA-4	1	20	19	95	93	7	5.7
	2	20	17	85			
	3	20	19	95			
	4	20	18	90			
	5	20	20	100			
CL-BA-5	1	20	18	90	86	14	8.2
	2	20	18	90			
	3	20	19	95			
	4	20	15	75			
	5	20	16	80			

Table 3-3. Water Quality Summary for Eohaustorius estuarius.

Treatment	Dissolved Oxygen (mg/L)			Temperature (°C)			Salinity (ppt)			pH (units)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Control	8.3	7.8	9.7	15.6	14.6	17.3	28	28	29	8.0	7.9	8.1
CR1 (Reference)	8.2	7.8	8.5	15.6	14.6	17.4	29	28	30	8.1	7.9	8.4
CARR02 (Reference)	8.1	7.8	8.4	15.7	14.7	17.3	29	28	30	8.0	7.9	8.2
CL-BA-1	8.3	7.9	8.5	15.6	14.8	17.2	28	28	30	8.2	8.0	9.0
CL-BA-2	8.2	7.9	8.6	15.6	14.8	17.3	29	28	30	8.2	8.0	8.8
CL-BA-3	8.2	7.9	8.4	15.6	14.8	17.4	29	28	30	8.3	8.0	8.8
CL-BA-4	8.2	7.9	8.6	15.6	14.7	17.2	28	28	29	8.3	7.9	8.9
CL-BA-5	8.2	7.6	8.6	15.6	14.6	17.2	28	28	29	8.3	7.9	9.1

Table 3-4. Ammonia Summary for *Eohaustorius estuarius.*

Treatment	Overlying Ammonia (mg/L Total)		Interstitial Ammonia (mg/L Total)	
	Day 0	Day 10	Day 0	Day 10
Control	0.203	0.528	0.0977	0.0765
CR1 (Reference)	0.159	0.00	2.16	0.317
CARR02 (Reference)	0.126	0.0116	1.35	0.474
CL-BA-1	0.112	0.0022	1.27	0.107
CL-BA-2	0.778	0.0140	6.48	0.811
CL-BA-3	0.757	0.00	4.16	0.771
CL-BA-4	0.512	0.356	2.26	1.71
CL-BA-5	0.279	0.127	4.57	1.01

NOEC (concurrent reference-toxicant test derived) = 132 mg/L

Table 3-5. Sulfide Summary for Eohaustorius estuarius.

Treatment	Overlying Sulfides (mg/L)		Interstitial Sulfides (mg/L)	
	Day 0	Day 10	Day 0	Day 10
Control	0.000	0.016	ND	ND
CR1 (Reference)	0.000	0.016	0.000	0.074
CARR02 (Reference)	0.000	0.028	0.000	0.150
CL-BA-1	0.000	0.016	0.050	0.049
CL-BA-2	0.000	0.043	0.047	0.077
CL-BA-3	0.001	0.018	0.000	0.058
CL-BA-4	0.019	0.060	0.028	0.091
CL-BA-5	0.035	0.034	0.049	0.050

ND – no data; insufficient volume for analysis.

Table 3-6.Test Condition Summary for Eohaustorius estuarius.

Test Conditions: PSEP E. estuarius		
Sample Identification	Control, CR1, CARR02, CL-BA-1, CL-BA-2, CL-BA-3, CL-BA-4, CL-BA-5	
Date sampled	June 10, 2015	
Date received	June 11, 2015	
Test dates	June 26 – July 6, 2015	
Sample storage conditions	4°C, dark	
Days of holding Recommended: ≤8 weeks (56 days)	16 Days	
Source of control sediment	Yaquina Bay, OR	
Test Species	E. estuarius	
Supplier	Northwestern Aquatic Sciences, Newport, OR	
Date acquired	June 25, 2015	
Age class	Subadult, 3-5 mm	
Test Procedures	PSEP 1995 with SMARM revisions	
Test location	Ramboll Environ Port Gamble Laboratory	
Test type/duration	10-Day static	
Control water	North Hood Canal seawater, 0.45μm filtered	
Test dissolved oxygen	Recommended: > 5.1 mg/L	Achieved: 7.8 – 9.7 mg/L
Test temperature	Recommended: 15 ± 1 °C	Achieved: 14.6 – 17.4 °C
Test Salinity	Recommended: 28 ± 1 ppt	Achieved: 28 - 30 ppt
Test pH	Recommended: 7 - 9	Achieved: 7.9 – 9.1
Control Performance Standard SMS, DMMP	Recommended: Control ≤ 10% mortality	Achieved: 3%; Pass
Reference Performance Standard SMS DMMP	Recommended: Reference ≤ 25% mortality Reference ≤ 20% mortality (relative to Control)	Achieved: 2%, 1%; Pass Achieved: -1%;-2% Pass
Reference Toxicant LC50 (total ammonia)	LC50 = 197.1 mg/L	
Mean; Acceptable Range (total ammonia)	133.0; 38.9 – 227.1 mg/L	
NOEC (total ammonia)	132 mg/L	
NOEC (unionized ammonia)	1.578 mg /L	
Test Lighting	Continuous with full spectrum lighting per SCUM II Appendix C	
Test chamber	1-Liter Glass Chamber	
Replicates/treatment	5 + 2 surrogates (one used for WQ measurements throughout the test)	
Organisms/replicate	20	
Exposure volume	175 mL sediment/ 775 mL water	
Feeding	None	
Water renewal	None	
Deviations from Test Protocol	Temperature and salinity	

3.2 20-day Juvenile Polychaete Bioassay

No mortality was observed in the *N. arenaceodentata* control sediment and mean individual growth (MIG) in the control sediment was 0.731 mg/ind/day (dry weight) and 0.436 mg/ind/day (AFDW). These values fall within the test acceptability criteria of ≤10% mean mortality and ≥0.38 mg/ind/day mean individual growth (Kendall 1996), indicating that the test conditions were suitable for adequate polychaete survival and growth. A summary of the test results for all samples is shown in Table 3-6. Summaries of water quality measurements, ammonia and sulfide concentrations, and test conditions are presented in Table 3-7, Table 3-8, Table 3-9, and Table 3-10

Mean mortality in the two reference treatments were 0% and 4%, meeting the reference performance standard of ≤10% (Ecology 2015; USACE 2015). Mean individual growth for the reference treatments (CR1 and CARR02) were 0.677 and 0.650 mg/ind/day (dry weight) and 0.472 and 0.463 mg/ind/day (AFDW). When compared to the control, MIG expressed as dry weight met the reference performance standard of ≥80%.

Mortality in all project sediments was 0%. Mean individual growth (as dry weight) in the test treatments ranged from 0.618 to 0.758 mg/ind/day. Mean individual growth in the AFDW assessment, which removes variability caused by gut contents, ranged from 0.476 to 0.586 mg/ind/day as AFDW. The observed mean growth in the project sediments was greater than or similar to the respective endpoints for the reference treatments in all cases.

A reference-toxicant test (positive control) was performed on the batch of test organisms utilized for this study. The LC_{50} value was well within control chart limits (±2 standard deviations from the laboratory historical mean). This result indicates that the test organisms used in this study were of similar sensitivity to those previously tested at Ramboll Environ.

All water quality parameters were within the acceptable limits throughout the duration of the test with the exception of salinity. Salinity was recorded slightly above the targeted range, but remained well within the tolerance range for this test organism.

Ammonia concentrations observed in the *N. arenaceodentata* test were below the No Observed Effect Concentration (NOEC) value derived from the concurrent ammonia reference-toxicant test (Table 3-8; compare to NOEC of 140 mg/L). Initial sulfide concentrations in interstitial water were below the NOEC (3.47 mg/L; Kendall and Barton 2004) for all samples.

Table 3-7. Test Results for *Neanthes arenaceodentata*.

Treatment	Rep	Number Initiated	Survivors	Mean Mortality (%)	Individual Growth (mg/ind/day)					
					Dry Weight	Mean	Std Dev	AFDW	Mean	Std Dev
Control	1	5	5	0	0.668	0.731	0.126	0.438	0.436	0.054
	2	5	5		0.683			0.371		
	3	5	5		0.585			0.412		
	4	5	5		0.820			0.445		
	5	5	5		0.899			0.517		
CR1 (Reference)	1	5	5	0	0.573	0.677	0.091	0.394	0.472	0.067
	2	5	5		0.655			0.463		
	3	5	5		0.824			0.578		
	4	5	5		0.654			0.446		
	5	5	5		0.680			0.479		
CARR02 (Reference)	1	5	5	4	0.635	0.650	0.126	0.437	0.463	0.080
	2	5	4		0.864			0.576		
	3	5	5		0.615			0.482		
	4	5	5		0.530			0.354		
	5	5	5		0.604			0.466		
CL-BA-1	1	5	5	0	0.642	0.618	0.080	0.503	0.502	0.058
	2	5	5		0.545			0.435		
	3	5	5		0.603			0.515		
	4	5	5		0.556			0.469		
	5	5	5		0.743			0.589		
CL-BA-2	1	5	5	0	0.587	0.655	0.097	0.458	0.515	0.068
	2	5	5		0.732			0.565		
	3	5	5		0.705			0.539		
	4	5	5		0.731			0.585		
	5	5	5		0.518			0.430		
CL-BA-3	1	5	5	0	0.803	0.758	0.074	0.617	0.586	0.040
	2	5	5		0.788			0.596		
	3	5	5		0.831			0.604		
	4	5	5		0.647			0.515		
	5	5	5		0.720			0.598		
CL-BA-4	1	5	5	0	0.655	0.642	0.146	0.510	0.476	0.105
	2	5	5		0.810			0.610		
	3	5	5		0.704			0.522		
	4	5	5		0.485			0.368		
	5	5	5		0.468			0.371		
CL-BA-5	1	5	5	0	0.760	0.679	0.087	0.586	0.531	0.055
	2	5	5		0.535			0.442		
	3	5	5		0.727			0.544		
	4	5	5		0.700			0.563		
	5	5	5		0.672			0.521		

Table 3-8. Water Quality Summary for *Neanthes arenaceodentata*.

Treatment	Dissolved Oxygen (mg/L)			Temperature (°C)			Salinity (ppt)			pH (units)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Control	7.3	5.6	7.8	20.4	19.2	21.0	29	28	30	7.9	7.6	8.0
CR1 (Reference)	7.4	6.6	8.0	20.5	19.3	21.0	29	28	30	8.0	7.6	8.3
CARR02 (Reference)	7.4	6.8	8.0	20.4	19.0	21.0	29	28	30	8.1	7.8	8.3
CL-BA-1	7.5	7.3	7.7	20.1	19.0	20.7	30	28	31	8.3	7.9	8.5
CL-BA-2	7.5	6.2	8.8	20.5	19.1	21.2	29	28	30	8.3	7.7	8.6
CL-BA-3	7.5	6.8	8.0	20.5	19.1	21.0	29	28	30	8.2	7.6	8.4
CL-BA-4	7.3	6.8	7.6	20.5	19.2	21.0	29	28	30	8.2	7.8	8.5
CL-BA-5	7.3	6.9	7.6	20.5	19.2	21.0	29	28	30	8.2	7.8	8.4

Table 3-9. Ammonia Summary for *Neanthes arenaceodentata*.

Treatment	Overlying Ammonia (mg/L Total)		Interstitial Ammonia (mg/L Total)	
	Day 0	Day 20	Day 0	Day 20
Control	0.210	0.844	0.367	0.767
CR1 (Reference)	0.247	0.408	2.94	0.557
CARR02 (Reference)	0.392	0.254	ND	0.307
CL-BA-1	0.409	0.231	1.85	0.280
CL-BA-2	1.32	0.183	3.89	0.262
CL-BA-3	1.53	0.142	3.52	0.215
CL-BA-4	1.11	0.551	1.22	1.02
CL-BA-5	0.972	0.386	3.98	0.220

ND – no data; insufficient volume for analysis.
BOLD= Exceeds NOEC (concurrent reference-toxicant test derived) of 140 mg/L

Table 3-10. Sulfide Summary for *Neanthes arenaceodentata*.

Treatment	Overlying Sulfides (mg/L Total)		Interstitial Sulfides (mg/L Total)	
	Day 0	Day 20	Day 0	Day 20
Control	0.015	0.000	ND	ND
CR1 (Reference)	0.018	0.013	0.038	0.028
CARR02 (Reference)	0.013	0.015	0.038	0.039
CL-BA-1	0.009	0.025	0.059	0.021
CL-BA-2	0.000	0.084	0.103	0.015
CL-BA-3	0.023	0.072	0.060	0.026
CL-BA-4	0.000	0.034	0.095	0.026
CL-BA-5	0.000	0.052	0.088	0.021

ND – no data; insufficient volume for analysis.

Table 3-11. Test Condition Summary for *Neanthes arenaceodentata*.

Test Conditions: PSEP *N. arenaceodentata*		
Sample Identification	Control, CR1, CARR02, CL-BA-1, CL-BA-2, CL-BA-3, CL-BA-4, CL-BA-5	
Date sampled	June 10, 2015	
Date received	June 11, 2015	
Test dates	July 2 – 22, 2015	
Sample storage conditions	4°C, dark	
Days of holding Recommended: ≤8 weeks (56 days)	22 Days	
Source of control sediment	Yaquina Bay, OR	
Test Species	*N. arenaceodentata*	
Supplier	Aquatic Toxicology Support	
Date acquired	July 1, 2015	
Age class	Juvenile; 17 – 19 Days post emergence	
Test Procedures	PSEP 1995 with SMARM revisions	
Test location	Ramboll Environ Port Gamble Laboratory	
Test type/duration	20-Day static renewal	
Control water	North Hood Canal seawater, 0.45µm filtered	
Test dissolved oxygen	Recommended: > 4.6 mg/L	Achieved: 5.6 – 8.8 mg/L
Test temperature	Recommended: 20 ± 1 °C	Achieved: 19.0 – 21.2 °C
Test Salinity	Recommended: 28 ± 2 ppt	Achieved: 28 - 31 ppt
Test pH	Recommended: 7 - 9	Achieved: 7.6 – 8.6
Initial biomass	Recommended: 0.5 - 1.0 mg Minimum: 0.25 mg	0.786 mg; Acceptable
Control Performance Standard	Recommended: Control ≤ 10% mortality	Achieved: 0% Pass
	Recommended: ≥ 0.72 mg/ind/day Minimum: ≥ 0.38 mg/ind/day (as Dry Weight)	Achieved: 0.731 mg/ind/day; Pass
Reference performance standard	Recommended: Mortality ≤20%	CR1: 0%; Pass CARR02: 4%; Pass
	$MIG_{Reference}/MIG_{Control} \geq 80\%$	CR1: 92.6%; Pass CARR02: 88.9%; Pass
Reference Toxicant LC$_{50}$ (total ammonia)	LC$_{50}$ = 185.6 mg/L	
Mean; Acceptable Range (total ammonia)	142.0; 50.5 – 233.5 mg/L	
NOEC (total ammonia)	140 mg/L	
NOEC (unionized ammonia)	1.402 mg /L	
Test Lighting	Continuous with full spectrum lighting per SCUM II Appendix C	
Test chamber	1-Liter Glass Chamber	
Replicates/treatment	5 + 2 surrogates (one used for WQ measurements throughout the test)	
Organisms/replicate	5	
Exposure volume	175 mL sediment/ 775 mL water	
Feeding	40 mg/jar every other day (8mg/ind every other day)	
Water renewal	Water renewed every third day (1/3 volume of exposure chamber)	
Deviations from Test Protocol	Salinity	

3.3 Larval Development Bioassay

The larval development test with *M. galloprovincialis* was validated by 94.8% normalized combined normal survivorship, defined as the mean number of normal larvae within the control divided by the stocking density. This value was within the SMS acceptability criteria of ≥70%. A summary of the test results for all samples is shown in Table 3-11. Summaries of water quality measurements, ammonia and sulfide concentrations, and test conditions are presented in Table 3-12, Table 3-13, and Table 3-14.

Mean control-normalized normal survival of the reference sediments were 77.0% (CR1) and 67.6% (CARR02, which met the reference acceptability criteria of 65% mean control-normalized normal survival (relative). Mean control-normalized survival in the test treatments ranged from 56.4% to 80.1%. The test mean chamber stocking density (measured at test initiation) was 26.8 embryos/mL.

A reference-toxicant test (positive control) was performed on the batch of test organisms utilized for this study. The LC_{50} value was well within control chart limits (±2 standard deviations from the laboratory historical mean). Therefore the test organisms used in this study were of similar sensitivity to those previously tested at Ramboll Environ.

All water quality parameters were within the acceptable limits throughout the duration of the test.

Ammonia concentrations observed in the *M. galloprovincialis* test were below the No Observed Effect Concentration (NOEC) value derived from the concurrent ammonia reference-toxicant test (Table 3-13; compare to NOEC of 2.77 mg/L). This indicates that ammonia concentrations within the sediment samples should not have been a contributor to any adverse biological effects observed in the test treatments.

Table 3-12. Test Results for *Mytilus galloprovincialis*.

Treatment	Rep	Number Normal	Number Abnormal	Mean # Normal	Normalized Combined Normal Survivorship (%)[1, 2]	Mean Combined Normal Survivorship (%)	Std. Dev.
Control	1	256	14	255.6	95.5	94.8	5.5
	2	269	12		100.0		
	3	243	12		90.7		
	4	235	15		87.7		
	5	275	21		100.0		
CR1 (Reference)	1	209	7	208.2	81.8	77.0	14.3
	2	313	19		100.0		
	3	175	11		68.5		
	4	177	11		69.2		
	5	167	15		65.3		
CARR02 (Reference)	1	173	13	172.8	67.7	67.6	5.7
	2	198	9		77.5		
	3	165	7		64.6		
	4	163	10		63.8		
	5	165	9		64.6		
CL-BA-1	1	209	11	190.0	81.8	74.3	6.1
	2	185	26		72.4		
	3	171	12		66.9		
	4	203	17		79.4		
	5	182	17		71.2		
CL-BA-2	1	215	8	218.6	84.1	80.1	13.2
	2	166	8		64.9		
	3	200	12		78.2		
	4	325	18		100.0		
	5	187	19		73.2		
CL-BA-3	1	163	23	144.2	63.8	56.4	8.8
	2	113	41		44.2		
	3	133	28		52.0		
	4	144	30		56.3		
	5	168	32		65.7		
CL-BA-4	1	253	21	176.8	99.0	69.2	17.5
	2	172	12		67.3		
	3	150	14		58.7		
	4	140	17		54.8		
	5	169	16		66.1		
CL-BA-5	1	156	26	155.0	61.0	60.6	9.1
	2	154	39		60.3		
	3	180	34		70.4		
	4	118	36		46.2		
	5	167	24		65.3		

[1] Control normality normalized to stocking density (268).

[2] Reference and treatment normal survivorship are normalized to the mean Control normality (255.6).

Table 3-13. Water Quality Summary for *Mytilus galloprovincialis*.

Treatment	Dissolved Oxygen (mg/L)			Temperature (°C)			Salinity (ppt)			pH (units)		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Control	7.4	6.8	7.8	16.2	15.5	17.0	28	28	28	7.6	7.2	7.9
CR1 (Reference)	6.7	6.4	7.1	16.9	16.7	17.0	28	27	28	7.8	7.7	7.8
CARR02 (Reference)	6.7	6.4	6.9	16.9	16.7	17.0	28	27	28	7.8	7.8	7.9
CL-BA-1	6.4	6.2	6.6	16.8	16.7	16.9	28	27	28	7.8	7.8	7.8
CL-BA-2	6.7	6.4	7.1	16.7	16.2	17.0	27	27	28	7.7	7.7	7.8
CL-BA-3	6.7	6.5	6.9	16.8	16.6	16.9	28	27	28	7.7	7.7	7.8
CL-BA-4	6.2	5.7	7.0	16.7	16.6	16.9	28	28	28	7.7	7.7	7.8
CL-BA-5	6.1	5.5	6.4	16.6	15.9	17.0	28	27	28	7.7	7.7	7.8

Table 3-14. Ammonia and Sulfide Summary for *Mytilus galloprovincialis*.

Treatment	Overlying Ammonia (mg/L Total)		Overlying Sulfides (mg/L Total)	
	Day 0	Final (Day 2)	Day 0	Final (Day 2)
Control	0.128	0.00	0.006	0.001
CR1 (Reference)	0.0397	0.00	0.099	0.042
CARR02 (Reference)	0.0385	0.00	0.099	0.014
CL-BA-1	0.0337	0.0202	0.082	0.015
CL-BA-2	0.0578	0.141	0.072	0.010
CL-BA-3	0.0661	0.0936	0.054	0.022
CL-BA-4	0.0866	0.237	0.062	0.069
CL-BA-5	0.0906	0.0702	0.004	0.032

NOEC (concurrent reference-toxicant test derived) = 2.77 mg/L

Table 3-15. Test Condition Summary for *Mytilus galloprovincialis*.

Test Conditions: PSEP *M. galloprovincialis*		
Sample Identification	Control, CR1, CARR02, CL-BA-1, CL-BA-2, CL-BA-3, CL-BA-4, CL-BA-5	
Date sampled	June 10, 2015	
Date received	June 11, 2015	
Test dates	July 15 – 17, 2015	
Sample storage conditions	4°C, dark	
Holding time Recommended: < 8 weeks (56 days)	35 Days	
Test Species	*M. galloprovincialis*	
Supplier	Dave Gutoff, San Diego, CA	
Date acquired	July14, 2015	
Age class	<2-h old embryos	
Test Procedures	PSEP 1995 with SMARM revisions	
Test location	Ramboll Environ Port Gamble Laboratory	
Test type/duration	48-60 Hour static test (Actual: 48 hours)	
Control water	North Hood Canal sea water, 0.45µm filtered	
Test dissolved oxygen	Recommended: > 5.0 mg/L	Achieved: 5.5 – 7.8 mg/L
Test temperature	Recommended: 16 ± 1 °C	Achieved: 15.5 – 17.0 °C
Test Salinity	Recommended: 28 ± 1 ppt	Achieved: 27 – 28 ppt
Test pH	Recommended: 7 - 9	Achieved: 7.2 – 7.9
Stocking Density	Recommended: 20 – 40 embryos/mL	Achieved: 26.8 embryos/mL
Control performance standard	Recommended: Control normal survival $\geq$ 70%	Achieved: 94.8%, Pass
Reference performance standard	Recommended: Reference normal survival relative to control $\geq$ 65%	Achieved: 81.2% (CR1); 71.3% (CARR02)
Reference Toxicant LC_{50} (total ammonia)	LC_{50} = 3.9 mg/L	
Mean; Acceptable Range (total ammonia)	5.5; 0.5 – 10.5 mg/L	
NOEC (total ammonia)	2.77 mg/L	
NOEC (unionized ammonia)	0.063 mg /L	
Test Lighting	14hr Light / 10hr Dark; with full spectrum lighting per SCUM II Appendix C	
Test chamber	1-Liter Glass Chamber	
Replicates/treatment	5 + 1 surrogate (used for WQ measurements throughout the test)	
Exposure volume	18 g sediment/ 900 mL water	
Feeding	none	
Water renewal	none	
Deviations from Test Protocol	Salinity	

4 DISCUSSION

Sediments were evaluated based on Sediment Management Standards (SMS) criteria. The biological criteria are based on both statistical significance (a statistical comparison) and the degree of biological response (a numerical comparison). The SMS criteria are derived from the Washington Department of Ecology's Sediment Cleanup User's Manual II (SCUM II; Ecology 2015). Comparisons were made for each treatment against the reference sample. Two numerical comparisons were made under SMS, the Sediment Cleanup Objective (SCO) and the Cleanup Screening Level (CSL).

Additional data is included below summarizing the test results evaluated under the Dredged Material Management Program (DMMP) criteria. As with SMS, the biological criteria are based on both statistical significance (a statistical comparison) and the degree of biological response (a numerical comparison); however some differences exist between the two programs. The DMMP criteria are taken from the Dredged Material Evaluation and Disposal Procedures for nondispersive disposal sites (USACE 2015). Suitability was determined using a combination of test results, with 2-hit failures requiring a sample to fail 2-hit criteria in more than one bioassay. If a sample fails the 1-hit criteria for any bioassay, it is not considered suitable for disposal at a proposed disposal site.

4.1 Amphipod Test Suitability Determination

Under the SMS program, a treatment will fail SCO if mean mortality in the test sediment is >25% and the difference is statistically significant ($p \leq 0.05$). Treatments fail the CSL if mean mortality in the test treatment >30% relative to the reference sediment and the difference is statistically significant.

Project sediments from the Cornwall Avenue Site do not fail the SCO and CSL criteria for the amphipod test as shown in Table 4-1.

Table 4-16. SMS Comparison for *Eohaustorius estuarius*.

Treatment	Mean Mortality (%)	Compared To:	Statistically More than Reference?	Mortality Comparison to Reference M_T-M_R (%)	Fails SCO?[1] > 25 %	Fails CSL?[2] > 30 %
Control	3					
CR1	2					
CARR02	1					
CL-BA-1	2	CR1	No	0	No	No
CL-BA-2	15	CARR02	**Yes**	14	No	No
CL-BA-3	19	CARR02	**Yes**	18	No	No
CL-BA-4	7	CARR02	**Yes**	6	No	No
CL-BA-5	14	CARR02	**Yes**	13	No	No

[1] SCO: Statistical Significance and MT >25%
[2] CSL: Statistical Significance and MT-MR >30%
M_T = Treatment Mortality
M_R = Reference Mortality
TBD = To be determined

Under the DMMP program, a test treatment will fail the 2-Hit criteria if mean mortality in the test treatment is >20% relative to the control sediment and the difference is statistically significant. Treatments will fail the 1-Hit criteria when the 2-Hit conditions are met and if the mean mortality in the test treatment is >30% the mean mortality in the appropriate reference sediment.

Project sediments from the Cornwall Avenue Site do not exceed the 1-Hit and 2-Hit criteria for *E. estuarius* (Table 4-2).

Table 4-17. DMMP Comparison for *Eohaustorius estuarius*.

Treatment	Mean Mortality (%)	Compared To:	Statistically More than Associated Reference?	Mortality Comparison to Reference M_T-M_R (%)	Mortality Comparison to Control M_T-M_C (%)	Fails 2-Hit Rule?[1]	Fails 1-Hit Rule?[2]
Control	3						
CR1	2						
CARR02	1						
CL-BA-1	2	CR1	No	0	-1	No	No
CL-BA-2	15	CARR02	**Yes**	14	12	No	No
CL-BA-3	19	CARR02	**Yes**	18	16	No	No
CL-BA-4	7	CARR02	**Yes**	6	4	No	No
CL-BA-5	14	CARR02	**Yes**	13	11	No	No

[1] 2-Hit Criteria: M_T-M_C >20% and Statistical Significance

[2] 1-Hit Criteria: M_T-M_C >20% and Statistical Significance (M_T vs M_R) and M_T-M_R >30%

M_T = Treatment Mortality
M_C = Control Mortality
M_R = Reference Mortality
TBD = To be determined

4.2 Juvenile Polychaete Test Suitability Determination

Suitability determinations for the juvenile polychaete test were based on mean individual growth (MIG). A test treatment fails SCO criteria if MIG is statistically lower in the test treatment, relative to the reference, and MIG in the test treatment is <70% that of the reference. The treatments will fail CSL criteria if MIG is significantly lower than the reference treatment and is <50% that of the treatment.

Project sediments from the Cornwall Avenue Site do not fail the SCO and CSL criteria when evaluated on the dry weight and AFDW basis (Table 4-3).

Table 4-18. SMS Comparison for *Neanthes arenaceodentata*.

Treatment	MIG (mg/ind/day)	Comparison To:	Statistically Less than Reference?	MIG Relative to Reference MIG_T/MIG_R (%)	Fails SCO?[1] < 70%	Fails CSL?[2] < 50%
			Dry Weight			
Control	0.731					
CR1	0.677					
CARR02	0.650					
CL-BA-1	0.618	CR1	No	91	No	No
CL-BA-2	0.655	CARR02	No	101	No	No
CL-BA-3	0.758	CARR02	No	117	No	No
CL-BA-4	0.624	CARR02	No	96	No	No
CL-BA-5	0.679	CARR02	No	105	No	No
			Ash-Free Dry Weight			
Control	0.436					
CR1	0.472					
CARR02	0.463					
CL-BA-1	0.502	CR1	No	106	No	No
CL-BA-2	0.515	CARR02	No	111	No	No
CL-BA-3	0.586	CARR02	No	127	No	No
CL-BA-4	0.476	CARR02	No	103	No	No
CL-BA-5	0.531	CARR02	No	115	No	No

[1] SCO: Statistical Significance and MIG_T/MIG_R <70%

[2] CSL: Statistical Significance and MIG_T/MIG_R <50%

MIG_T = Treatment Mean Individual Growth

MIG_R = Reference Mean Individual Growth

Under DMMP guidelines, juvenile polychaete test treatments fail to meet the 2-Hit criteria when the mean individual growth rate (MIG) in the test sediment is less than 80% of the MIG in the control, is less than 70% of the MIG in the reference sediment, and the comparison to reference sediment is statistically significant. Test treatments fail to meet 1-Hit criteria when the mean individual growth rate (MIG) in the test sediment is less than 80% of MIG in the control, is less than 50% of the MIG in the reference sediment, and the comparison to reference sediment is statistically significant ($p \leq 0.05$).

Project sediments from the Cornwall Avenue Site passed the 1-Hit and 2-Hit criteria when compared to the reference and control sediments in both dry weight and ash free dry weight comparisons (Table 4-4).

Table 4-19. DMMP Comparison for *Neanthes arenaceodentata*.

Treatment	MIG (mg/ind/day)	Statistically Less than Reference?	MIG Relative to Control MIG_T/MIG_C (%)	MIG Relative to Reference MIG_T/MIG_R (%)	Fails 2-Hit Rule?[1]	Fails 1-Hit Rule?[2]
Dry Weight						
Control	0.731					
CR1	0.677					
CARR02	0.650					
CL-BA-1	0.618	CR1; No	85	91	No	No
CL-BA-2	0.655	CARR02;No	90	101	No	No
CL-BA-3	0.758	CARR02;No	104	117	No	No
CL-BA-4	0.624	CARR02;No	85	96	No	No
CL-BA-5	0.679	CARR02;No	105	105	No	No
Ash-Free Dry Weight						
Control	0.436					
CR1	0.472					
CARR02	0.463					
CL-BA-1	0.502	CR1; No	106	106	No	No
CL-BA-2	0.515	CARR02;No	109	111	No	No
CL-BA-3	0.586	CARR02;No	124	127	No	No
CL-BA-4	0.476	CARR02;No	101	103	No	No
CL-BA-5	0.531	CARR02;No	113	115	No	No

[1] 2-Hit Criteria: MIG_T/MIG_C <80% and Statistical Significance (MIG_T vs MIG_R) and MIG_T/MIG_R <70%

[2] 1-Hit Criteria: MIG_T/MIG_C <80% and Statistical Significance (MIG_T vs MIG_R) and MIG_T/MIG_R <50%

MIG_T = Treatment Mean Individual Growth
MIG_R = Reference Mean Individual Growth
MIG_C = Control Mean Individual Growth

4.3 Larval Test Suitability Determination

Larval test treatments fail SCO criteria if the percentage of normal larvae in the test treatment is significantly lower than that of the reference and if the normal larval development in the test treatment is less than 85% of the normal development in the reference after normalizing to the control. Treatments fail CSL criteria if the percentage of normal larvae in the test treatment is significantly lower than that of the reference and if the normal larval development in the test treatment is less than 70% of the normal development in the reference after normalizing to the control.

Project sediments from the Cornwall Avenue Site do not fail the SCO and CSL criteria for larval development (Table 4-5).

Table 4-20. SMS Comparison for *Mytilus galloprovincialis*.

Treatment	Mean Normal Survival (%)[1]	Mean Number Normal	Compared To:	Statistically Less than Reference? (CARR-REF)	Normal Survival Comparison to Reference $(N_R-N_T)/N_C$[%]	Fails SCO?[2] > 15%	Fails CSL?[3] > 30%
Control	94.8	256					
CR1	77.0	208					
CARR02	67.6	173					
CL-BA-1	74.3	190	CR1	No	7	No	No
CL-BA-2	80.1	219	CARR02	No	-18	No	No
CL-BA-3	56.4	144	CARR02	Yes	11	No	No
CL-BA-4	69.2	177	CARR02	No	-2	No	No
CL-BA-5	60.6	155	CARR02	Yes	7	No	No

[1] Control data is normalized to the stocking density; reference and project treatments are normalized to the control

[2] SCO: Statistical Significance and $(N_R-N_T)/N_C > 0.15$

[3] CSL: Statistical Significance and $(N_R-N_T)/N_C > 0.30$

N_T =Treatment Mean Number Normal

N_R =Reference Mean Number Normal

Larval test treatments fail the DMMP 2-Hit criteria if the percentage of normal larvae (normalized to control) in the test treatment is less than 80% and is significantly lower ($p \leq 0.1$) than that of the reference. Treatments fail the 1-Hit criteria when the 2-Hit criteria are met and the normalized larval development in the reference minus the normalized larval development in the test treatment is greater than 30%.

Samples CL-BA-3 and CL-BA-5 fail the 2-Hit criteria for larval development (Table 4-6).

Table 4-21. DMMP Comparison for *Mytilus galloprovincialis*.

Treatment	Mean Normal Survival (%)[1]	Mean Number Normal	N_T/N_C <80%?	Statistically Less than Reference?	Normal Survival Comparison to Reference ($N_R/N_C - N_T/N_C$ [%])	Fails 2-Hit Rule?[2]	Fails 1-Hit Rule?[3]
Control	94.8	256					
CR1	77.0	208					
CARR02	67.6	173					
CL-BA-1	74.3	190	74.3%;Yes	CR1; No	7.1	No	No
CL-BA-2	80.1	219	85.5%;No	CARR02;No	-17.9	No	No
CL-BA-3	56.4	144	56.4%;Yes	CARR02;Yes	11.2	**Yes**	No
CL-BA-4	69.2	177	69.2%;Yes	CARR02;No	-1.6	No	No
CL-BA-5	60.6	155	60.6%Yes	CARR02;Yes	6.7	**Yes**	No

[1] Control data is normalized to the stocking density; reference and project treatments are normalized to the control

[2] 2-Hit Criteria: N_T/N_C <80% and Statistical Significance (N_T vs N_R)

[3] 1-Hit Criteria: N_T/N_C <80% and Statistical Significance (N_T vs N_R) and $N_R/N_C - N_T/N_C$ >30%

N_T = Treatment Mean Number Normal

N_R = Reference Mean Number Normal

5 SUMMARY

A summary of the biological tests conducted on the Cornwal Avenue Site sediments evaluated under both the SMS sediment quality criteria (Table 5-1) and DMMP suitability (Table 5-2) are provided below.

All project samples pass the SCO and CSL performance criteria for all tests performed on the Cornwall Avenue Site sediments (Table 5-1).

Two samples exceeded the 2-Hit criteria for larval test performance under the DMMP program; however, the lack of additional 2-Hit failures for the other two PSEP bioassays suggest that the samples pass the DDMP criteria for acceptable disposal.

Table 5-22. Summary of SMS Evaluation.

Treatment	Sediment Cleanup Objectives			Cleanup Screening Levels		
	Amphipod	Polychaete	Larval	Amphipod	Polychaete	Larval
CL-BA-1	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-2	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-3	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-4	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-5	Pass	Pass	Pass	Pass	Pass	Pass

Table 5-23. Summary of DMMP Evaluation.

Treatment	2-Hit			1-Hit			Overall Determination
	Amphipod	Polychaete	Larval	Amphipod	Polychaete	Larval	
CL-BA-1	Pass	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-2	Pass	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-3	Pass	Pass	**Fail**	Pass	Pass	Pass	Pass
CL-BA-4	Pass	Pass	Pass	Pass	Pass	Pass	Pass
CL-BA-5	Pass	Pass	**Fail**	Pass	Pass	Pass	Pass

6 REFERENCES

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APPENDIX E

Eelgrass and Habitat Report

PORT OF BELLINGHAM

CORNWALL AVENUE LANDFILL SITE: EELGRASS AND SHORELINE HABITAT SURVEY

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1 INTRODUCTION

The Cornwall Avenue Landfill Site (Site) is located along the waterfront of the City of Bellingham between Boulevard Park and the former Georgia Pacific pulp mill (Figure 1). The Site is approximately 16.5 acres (13 acres upland and 3.5 acres aquatic) and was historically utilized for sawmill operations, log storage, warehousing, and as a municipal solid waste landfill. The current configuration of the Site (uplands and aquatic acreage) was significantly modified between 1950-1965, when approximately 10 acres of aquatic habitat was filled during the Sites use for a municipal waste disposal. The landfill was covered with a non-engineered soil cover and over the years the refuse has impacted site soils, groundwater, and sediments with hazardous substances.

In 2014, the Washington Department of Ecology (Ecology) entered into a Consent Decree with the Port of Bellingham (Port), the City of Bellingham (City), and the Washington State Department of Natural Resources (DNR) for the Site final cleanup action. The final cleanup action addresses the upland and shoreline/aquatic portions of the Site in order to protect human health and the environment from hazardous substances on the Site. Cleanup activities will include the placement of an low permeability cap on the upland portion of the Site to prevent rain and other water from passing through the landfill waste and leaching chemicals into Bellingham Bay, installing a shoreline protection system in the aquatic portion of the Site to prevent further erosion of solid waste from eroding into Bellingham Bay, and a thin layer cap in the deeper subtidal portion of the Site to accelerate natural recovery of sediment quality. Following the cleanup, a waterfront park will be developed on the Site that will offer recreation, waterfront access, and enhanced wildlife habitat.

In support of this cleanup action, Grette Associates was contracted by Landau Associates to conduct a habitat survey of the Site to assess the existing aquatic and shoreline habitat conditions. The aquatic survey was focused on surveying for the presence of eelgrass (*Zostera marina*), macroalgae, substrates, and debris. The shoreline survey focused on the existing habitat conditions (primarily vegetation, slopes, and substrates) present between the aquatic and upland portions of the site. The existing habitat conditions will provide baseline environmental conditions and will be utilized to assist with the design and permitting of the cleanup action.

This Report has been prepared to describe the monitoring activities and the results of the habitat survey conducted at the Cornwall Avenue Landfill Site as part of the pre-design for the Cornwall Avenue Landfill Cleanup. The information within this report will update and expand on previously collected information and will provide the level of detail required to support remedial design and permitting.

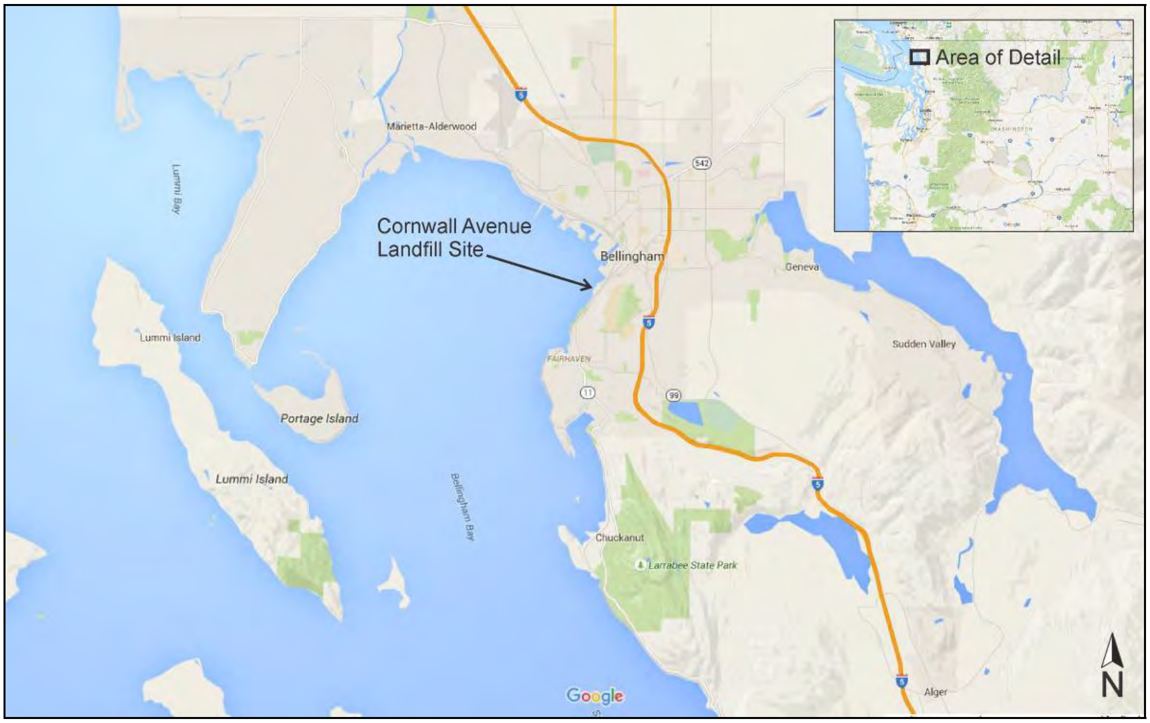

Figure 1. Vicinity map (images © Google 2015)

2 EELGRASS AND MACROALGAE SURVEY

2.1 INTRODUCTION

Due to the fact that this project will occur within the intertidal and shallow sub-tidal environments and in an area where eelgrass is known to occur, an eelgrass survey was required. The survey will assist in the design of the proposed project and will help minimize and estimate the potential impacts of the project on the eelgrass habitat. The eelgrass survey was designed to assess the areal coverage of eelgrass, estimate the total number of turions present on the site, delineate the edges of eelgrass habitat, and collect information on macroalgae, debris, and substrates.

2.2 METHODS

Since eelgrass was known to occur on the Site, the survey methodology was based on the WDFW Preliminary/Intermediate Eelgrass/Macroalgae Habitat Survey Guidelines. The proposed eelgrass survey applied a combination of the two guidelines and was consistent with modifications previously approved by WDFW. As part of the survey the entire approximately 1,750 lineal feet of the Site shoreline was surveyed. Prior to the field effort, approximately 44 transects were established extending roughly perpendicular to the mean higher high water (MHHW) elevation at the shoreline. The transects were spaced about 40 ft apart (except four transects that were located at a shared origin; 31a-d) and extended from the MHHW out to a depth greater than -15 ft MHHW (Figure 2). Based on previous eelgrass delineations at the Site and adjacent to the Site, eelgrass is not expected to occur below -15 ft MHHW and as a result the transects were each approximately 300 ft in length. Each transect was defined by anchoring a 300-ft fiberglass tape measure at the MHHW and extending it out 300 ft perpendicular to shore. Transect start points were marked using a differential global positioning system (dGPS); individual sampling points and transect end points were not marked. Along each transect, the presence of eelgrass was recorded and flagged for later surveying. The edge was either flagged by diver deploying a buoy for the tender boat to survey in using dGPS or was surveyed in by walking the eelgrass boundary during low tide. For all eelgrass encountered along the transects, the entire edge of the eelgrass bed was completely surveyed. The delineation mapped the entire extent of eelgrass on the Site.

Along each transect, sampling occurred at the MHHW (0 ft) and at 20-ft increments out to 300 ft (for a total of 16 sampling locations per transect). At each sampling point, three plots were sampled every 20 ft for eelgrass presence and density. When low tide allowed, a portion of the sampling was conducted on foot; all inundated portions of the transects were surveyed by divers. Relative to the transect line, turion density were measured by placing a 0.25 m^2 quadrat at the 2, 6 and 10 o'clock position relative to north. The number of turions within the quadrat while in each of the three positions was recorded, noting the general condition, approximate blade length and presence of reproductive turions. Each measurement represented the total eelgrass turion counts within the quadrat. These samples were then converted to turion density per m^2 by multiplying each count by four. An average density for each sampling location was calculated by adding the three densities and dividing by three. Total turion count was determined by multiplying average density (within the eelgrass beds) by total area (acres) of eelgrass.

In addition to the presence of eelgrass, the survey also collected information on the existing substrates, debris, and macroalgae presence and coverage. This information was collected in detail within the sample plots (20 ft spacing along transects) as well as general notes were collected along the entire transects.

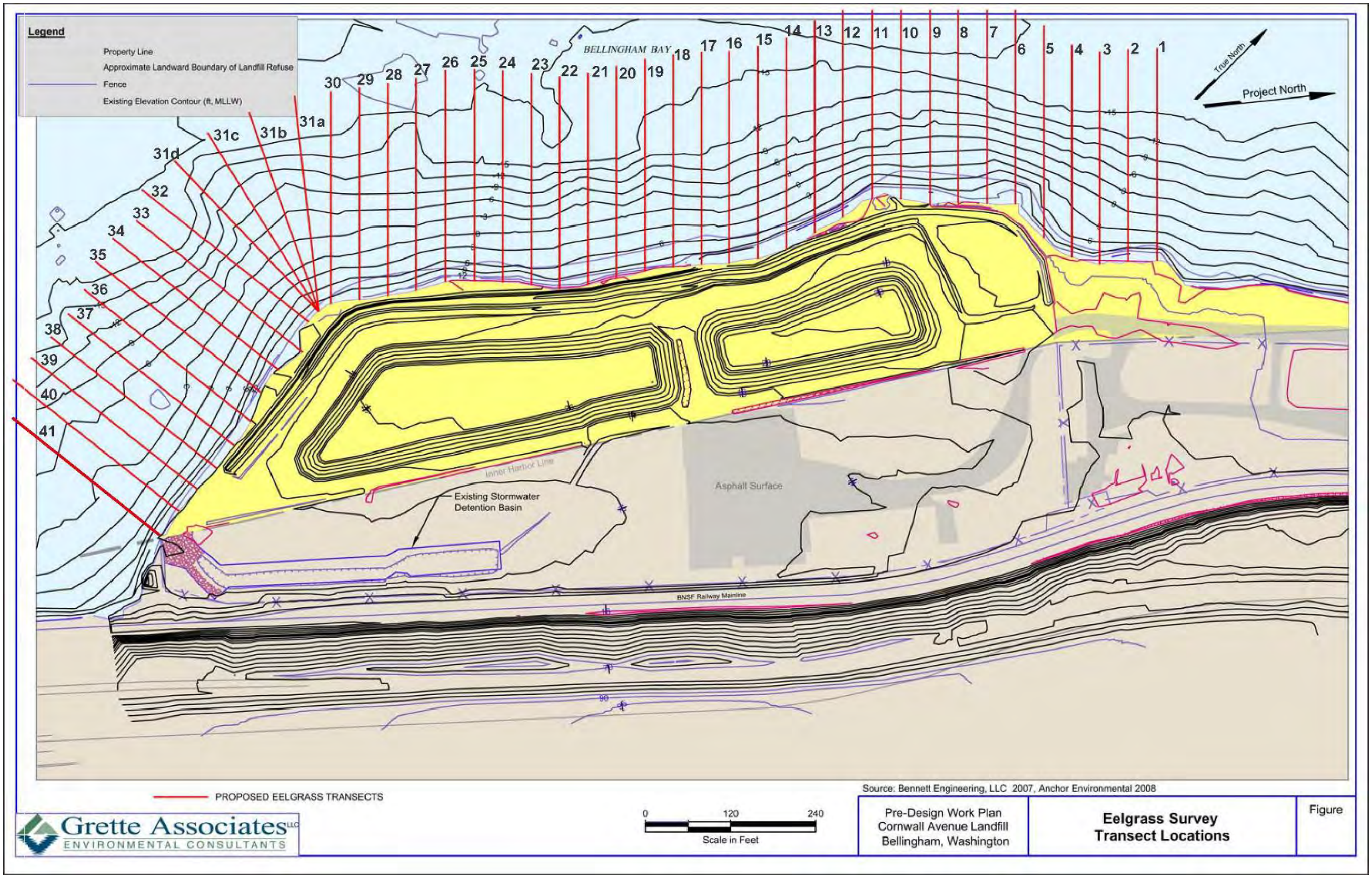

Figure 2. Eelgrass survey transect locations

2.3 RESULTS

The eelgrass survey was conducted between June 29 and July 1, 2015, which was within the WDFW recommended survey window. Based on sampling, eelgrass presence along the shoreline was extremely variable and limited to a narrow strip of elevations (approximately -1 ft and -9 ft MHHW). Eelgrass was observed along 29 of the 44 transects (Table 1) and was separated into four (4) distinct areas based on substrates, densities, areal coverage, and habitat conditions (Figure 3). The delineation resulted in a total of approximately 59,850 sq ft (1.4 acres) of eelgrass habitat within the proposed limits of the study area shown on Figure 3. Average eelgrass densities along the transects ranged from 15 to 176 turions per m^2, with an overall average density of 52 turions per m^2 for the Site. In general, sea lettuce and rockweed were the dominant species present in the nearshore zone, with coverage ranging between 5 and 25 percent. In deeper waters Turkish towel, sea lettuce, gracilaria, sargassum, and laminaria spp., were common, with coverage generally less than 20 percent. A complete list of macroalgae species encountered during the Site survey is included in Table 3. Field data sheets are provided in Appendix A.

As stated above, the eelgrass habitat on the Site was divided up into four (4) distinct areas (A, B, C, and D) based on eelgrass coverage and habitat conditions. Area A is located at the northern portion of the Site and encompasses approximately 250 linear feet of shoreline. Eelgrass is present within a narrow band from approximately -2 ft to -8 ft MHHW. This eelgrass is connected to a larger bed that continues to the north of the Site (outside of the project footprint). Within Area A there is approximately 9,750 sq ft of eelgrass habitat. Average turion densities along the transects ranged from 24 to 60 turions per m^2 with an average density of 44 turions per m^2. Overall, the estimated number of turions within Area A is approximately 39,820. Eelgrass within this area was in good condition and turion lengths ranged from 4 to 6 ft tall. Few reproductive shoots were observed within this area.

Substrates from approximately 0 ft MHHW to the landward edge of the eelgrass bed within Area A consists of bricks, cobble, and gravel, while substrates within the eelgrass bed were dominated by silt and coarse sand. The majority of the eelgrass was devoid of debris (woody, glass, or concrete); less than 10 percent. Substrates above 0 ft MHHW is discussed in Section 3. Waterward of the eelgrass beds the substrates were dominated by silt; however, towards the waterward edge of the eelgrass wood debris was observed. Woody debris observed included old pile, cut logs (large and small), and bark (large and small pieces). The larger woody debris was located at the surface while the small bark was present up to 6 inches below the surface. Overall the wood debris was observed to a distance of approximately 180 to 220 ft waterward of the MHHW. Debris coverage within this area was less 40 percent. Beyond that distance substrates were dominated by silt with little if any debris or vegetation (likely due to the soft substrates and extremely high turbidity; less than 2 ft visibility).

Macroalgae presence and coverage varied significantly within the eelgrass bed in Area A. The majority of the eelgrass bed was devoid of macroalgae, which is likely due to the lack of hard surfaces. Macroalgae present within the eelgrass beds was dominated sargassum (*Sargassum spp*), seagrass laver (*Smithora naiadum*), and sea lettuce (*Ulva lactuca*) and coverage was less than 25 percent in all areas, with many areas less than 10 percent. No macroalgae was observed waterward of the eelgrass beds. Landward of the eelgrass bed sea lettuce and rockweed (*Fucus gardneri)* were the only macrolagae present. Macroalgae coverage landward of the eelgrass beds was sparse and the maximum coverage was 25 percent from the edge of the eelgrass bed to MHWW.

Area B is located at the south of Area A and encompasses approximately 730 linear feet of shoreline. The majority of the area consists of sparse eelgrass patches between -2 and -6 ft MHHW. A total of 22 eelgrass patches were observed within this area and the distance between patches is too far for the beds to be functioning as a single larger bed. Of the 22 patches only 5 of them were located along the survey transects. However, due to low tides and excellent visibility the eelgrass patches between the transects were easily observed and delineated. Within Area B there is approximately 2,520 sq ft of eelgrass habitat. Average turion densities along the transects ranged from 21 to 176 turions per m^2 with an average density of 61 turions per m^2. This average density is somewhat misrepresentative of the eelgrass within this area due to the fact that the average density is driven by the one sample plot with a high turion count (176 turions per m^2). Densities were also recorded for each of the eelgrass patches located between the patches along the transects. Densities within these patches were similar to the densities along the transects (except for the 176 turions) and ranged between 18 to 65 turions per $m^{2.}$ Overall, the conservative estimate for the number of turions within Area B is approximately 14,274 (based on the conservative 61 turions per m^2). Eelgrass within this area was in good condition and turion lengths ranged from 4-6 ft tall. Few reproductive shoots were observed within this area.

Substrates from approximately 0 ft MHHW to the landward edge of the eelgrass bed within Area B consists of bricks, concrete rubble (large and small) cobble, and gravel (up to 0 ft MHHW) while substrates within the eelgrass bed was dominated by coarse sand, silt, and cobble. The majority of the eelgrass patches were devoid of debris (woody, glass, or concrete); however towards the waterward edge of the eelgrass wood debris became more prevalent (between 100-140 ft from the MHHW). Substrates above 0 ft MHHW will be discussed in Section 3. Waterward of the eelgrass beds the substrates were dominated by silt and debris (wood, glass, and porcelain). Wood debris waterward of the eelgrass consisted of both cut logs (large and small) and bark (large and small pieces). As with Area A, the larger woody debris was located at the surface while the small bark was present up to 6 inches below the surface. Woody debris extended out to 300 ft on some of the transects (low coverage ~5%); however, the heavier wood debris (15-20 percent coverage) terminated between 220 to 260 ft waterward of the MHHW. In addition to the woody debris, there was a high coverage of other debris (metal, glass, and porcelain) between 80 to 160 ft waterward of the MHHW in the majority of the area. The presence of debris waterward of the eelgrass patches has no impact on the presence of eelgrass due to the soft substrates and poor visibility.

Macroalgae presence and coverage varied significantly within the eelgrass bed. The majority of the eelgrass bed was devoid of macroalgae (average coverage less than 35 percent); however, within some of the patches macroalgae coverage was approximately

75 percent. Macroalgae within the eelgrass patches was dominated by sea lettuce. Other species present consisted of sargassum, laminaria, Turkish towel (*Chondracanthus exasperates)* and Gracilaria (*Gracilaria* spp). Macroalgae was observed to approximately 80 to 140 ft waterward of the MHHW. In areas devoid of eelgrass, macroalgae covered approximately 40-50 percent of the area between approximately -2 ft to approximately -8 ft below the MHHW, with the dominant species being ulva. Macrolagae landward of approximately -2 ft MHHW (all the way to the MHHW) was dominated by ulva and fucus and coverage was between 20-25 percent.

Area C is located south of Area B and encompasses approximately 330 linear feet of shoreline. Eelgrass is present within a band from approximately -2 ft to -8 ft MHHW. Eelgrass within this area consists of a large bed and several smaller patches in the southern portion of the area. The eelgrass bed is approximately 65 feet wide at the southern end and gradually tapers down to 0 ft wide at the northern end of the area. Additionally, there are several smaller patches to the south of this large bed. Within Area C there is approximately 8,800 sq ft of eelgrass habitat. Average turion densities along the transects ranged from 15 to 105 turions per m^2 with an average density of 46 turions per m^2. Overall, the estimated number of turions within Area C is approximately 37,582. Eelgrass within this area was in good conditions and turion lengths ranged from 4 to 6 ft tall. Few reproductive shoots were observed within this area.

Substrates from approximately 0 ft MHHW to the landward edge of the eelgrass bed within Area C consists of concrete debris (large), cobble, and boulder (up to -1 to 0 ft MHHW) while substrates within the eelgrass bed was dominated by coarse sand and cobble. The majority of the eelgrass was devoid of debris (woody, glass, or concrete). Substrates above 0 ft MHHW will be discussed in Section 3. Waterward of the eelgrass beds the substrates were dominated by silt. However, towards the waterward edge of the eelgrass wood and glass debris was observed. Woody debris observed included old piles, cut logs (large and small), and bark (large and small pieces) and glass debris consists of bottles. Overall debris was observed from between 140 to 300 ft waterward of the MHHW with coverage ranging from 0-15 percent cover for woody debris to up to 75 percent cover by glass debris. The coverage by debris varied significantly within the area and overall coverage was less than 35 percent for the entire area.

Macroalgae presence and coverage varied significantly within the eelgrass bed. The majority of the eelgrass bed was devoid of macroalgae, which is likely due to the lack of hard surfaces. Macroalgae present within the eelgrass bed was dominated sargassum, seagrass laver, and sea lettuce with an areal coverage less than 25 percent in the majority of the areas. Macroalgae on average extended approximately 120-160 ft from the MHHW; however, in a few areas the macroalgae extended to approximately 200 ft waterward of the MHWW. In these areas the macroalgae in the deeper waters was dominated by laminaria. Macroalgae observed landward of the eelgrass bed was dominated by sea lettuce and rockweed with an average coverage less than 30 percent.

Area D is located at the southern portion of the Site and encompasses approximately 430 linear feet of shoreline. A large eelgrass bed was present along the entire shoreline. The eelgrass bed was approximately 165 ft wide at the southern edge of the property and the bed tapers to a width of 10 ft wide at the northern end of Area D. The eelgrass bed is approximately located between elevations -1 ft to -9 ft MHHW. The eelgrass narrows at the northern portion of this area due to increased slopes, substrates, and increased energy. There is a small gap between the eelgrass bed in Areas D and C, which is large enough to consider the beds separate. Within Area D there is approximately 38,790 sq ft of eelgrass habitat. Average turion densities along the transects ranged from 45 to 75 turions per m^2 with an average density of 58 turions per m^2. Overall, the estimated number of turions within Area D is approximately 208,974. Eelgrass within this area was in good conditions and turion lengths ranged from 4 to 6 ft tall. Numerous reproductive shoots were observed within this area.

Substrates from approximately 0 ft MHHW to the landward edge of the eelgrass bed within Area D consists of coarse sand and gravel that gradually transition into boulders and angular concrete (landward of 0 ft MHHW). Within the eelgrass bed the substrates transition from coarse sand and silt to silt with coarse sand at approximately -5 ft MHHW. The majority of the eelgrass was devoid of debris (woody, glass, or concrete); however, woody debris (logs) that was present appeared to be random and not associated with the historic use of the property. Within this area only sparse woody debris was observed. The level of concrete debris within the eelgrass elevations increased towards the northern portion of this area, along with the presence of glass and porcelain. Immediately waterward of 0 ft MHHW, substrates are dominated by coarse sand with some gravel and cobble and the substrates above 0 ft MHHW will be discussed in Section 3. Waterward of the eelgrass beds the substrates were dominated by silt.

Macroalgae presence and coverage varied significantly within the eelgrass bed. In the entire southern portion of the area, macroalgae was absent from the eelgrass bed and waterward of the eelgrass bed. Macroalgae was present landward of the eelgrass bed, but it was primarily limited to below ~+4 ft MHHW. Macroalgae landward of the eelgrass bed was dominated by sea lettuce and rockweed with coverages that ranged from 10 to 75 percent. Macroalgae presence increased at the upper elevations where rockweed was the dominant species (maximum of 20 percent coverage). Along the most northern transect of this area the coverage by macroalgae species increased significantly. This appeared to be in response to an increase in substrate size. The majority of the macroalgae was anchored to the existing concrete debris. Macroalgae present within this area (from ~+4 ft to -9 ft MHHW was dominated by sea lettuce, gracilaria, and sargassum. Macroalgae coverage ranged between 10-50 percent.

Overall, the survey indicated that approximately 59,850 sq ft of eelgrass was present within the Site. Based on an average turion density of 52 turions per m^2, it is estimated that the Site contains approximately 300,650 turions. Sampling documented a mix of man-made debris and natural substrates across the Site. Within the nearshore environment (0 to 100 feet from the MHHW), concrete rubble and debris were present on top of sand, gravel, and cobble. Pile stubs, wood waste, glass, metal, ceramic, and other debris were also common throughout this area. From 100 to 140 feet from the MHHW, substrates were predominated by sand and gravel with reduced amounts of rubble and debris. Beyond 140 feet from the MHHW, substrates were nearly 100 percent silt across the Site.

Table 1. Average Density of Eelgrass (turions/m^2) Along Survey Transects

Transect	Approximate Distance from MHHW (ft)																
	0	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	Average
1				29	137	81	36	17									60
2						59	57	39	31								46
3								68	25								47
4							43	39	15								32
5							27	21									24
6					59	53											56
7																	
8						24											24
9																	
10																	
11																	
12																	
13																	
14																	
15					176												176
16																	
17																	
18																	
19							21										21
20																	
21																	
22																	
23																	
24						32											32
25						52											52
26																	
27					19	97											58
28						52											52
29					104	105	1	3									105
30					76	85	32										24
31a								43									43
31b						9	20										15
31c						3	37		19								15

Transect	**Approximate Distance from MHHW (ft)**																
	0	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**	**240**	**260**	**280**	**300**	**Average**
31d					9	120	55	41									56
32						80	37										59
33						1	77	45									61
34						88	85	61	64	4							75
35					1	60	43	7									51
36					92	79	39	17									57
37				4	59	81	63	47	55	25							55
38						69	43	87	27	27	16	5					45
39				4	49	80	100	31	28	37	37						52
40				112	93	93	13	56	57	55	8						69
41				61	144	56	39	17	67	32	28						56
Average Turion Density for the Site																	**52**

Note: blank cells indicate that no eelgrass was present

Table 2. Common Macroalgae Encountered at the Cornwall Avenue Landfill Site

Species	**Common Name**
Chondracanthus exasperatus	Turkish Towel
Fucus gardneri	Rockweed
Gracilaria spp.	Gracilaria
Laminaria spp.	Laminaria
Sargassum spp.	Sargassum
Smithora naiadum	Seagrass Laver
Cladophora sericea	Filamentous Green Algae
Ulva lactuca	Sea Lettuce
Ceramium spp.	Ceramium
Mazzaella splendens	Iridescent seaweed

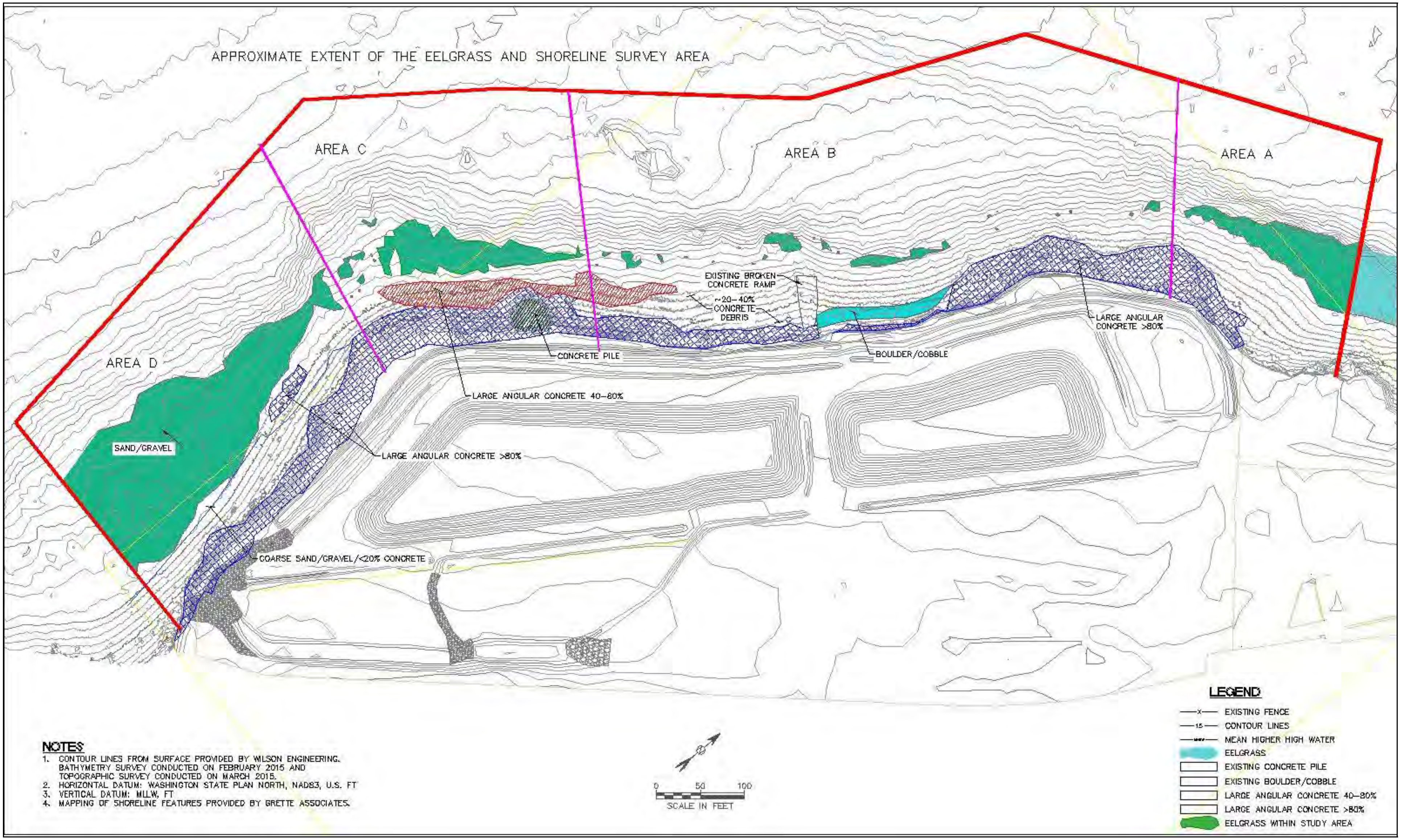

Figure 3. Delineated eelgrass habitat and shoreline features (eelgrass areas are labeled for purposes of discussion); Grette Associates 2015.

3 SHORELINE HABITAT SURVEY

3.1 METHODS

Grette Associates also conducted a shoreline survey to assess the existing habitat conditions the functions along the entire Cornwall shoreline. The survey focused on the existing substrates, debris, vegetation, and slopes. This survey consisted of biologists walking the shoreline, noting habitat structures, substrate and vegetation. For the purpose of recording and reporting, the shoreline was separated into sections with similar habitat attributes. Biologists collected qualitative data documenting the distribution of vegetation along each section of shoreline. Substrate characteristics, along with any other significant habitat features, were also qualitatively documented. The existing substrates and debris along the shoreline was delineated and mapped. This effort was coordinated with the eelgrass survey in order to ensure that the entire Site was surveyed.

3.2 RESULTS

The shoreline survey was conducted on May 19, 2015. Shoreline features are shown in Figure 3 above. The topography of the Site is generally consistent throughout, with a flat upland terrace that transitions abruptly to a steeply-sloped embankment leading down to the MHHW. A berm and a storm water ditch are present surrounding the edge of the upland terrace. The area landward of the MHHW is vegetated primarily by weedy grasses and forbs, and includes dense stands of Himalayan blackberry. Below the MHHW, the shoreline slopes moderately waterward. This area is covered with man-made materials, generally large, angular concrete that transition to more natural substrates around +2 ft MHHW (large angular concrete to boulders, cobble, gravel, and sand). Substantial amounts of debris, including glass, brick, metal, and wood waste are also present within this zone.

The upland and shoreline habitats present on the Site are extremely similar and provide little variability. The upland portions of the Site have been significantly altered as part of the historic use and the initial cleanup actions on the Site. The majority of the upland is flat with little vegetation. There are two large stockpiles of material covered with plastic liner over them. The Site has been graded and stormwater ditches have been constructed to control storm water runoff from the Site. The majority of the upland is unvegetated. The entire upland portion of the Site is surrounded by an earthen berm with a 2H:1V slope on the landward side and a storm water ditch. The entire berm (landward, top and waterward sides) is vegetated by upland grasses and weedy species (dominated by blackberry and thistle). There are no native trees or shrubs on the Site. The slope of the waterward side of the berm is variable. Along the majority of the northern portion of the Site the vegetated berm extends to a nearly vertical slope located at approximately +10 ft MHHW. The vertical slope is a result of the presence of larger boulder and concrete debris. Along the majority of the southern portion of the Site there is a narrow flat area located immediately waterward of the berm. Waterward of this flat the shoreline is steeply sloped and consists of concrete debris (large angular concrete, concrete pile, etc.).

Overall, the shoreline waterward of the berm is characterized by a heavily armored shoreline, which is present above the MHHW and extends waterward below the MHHW. Armoring consists of large concrete debris (primarily angular and variable in size) or boulders. These larger substrates extend from above the MHHW down to between +6 ft to +2 ft MHHW. The exceptions to this are an approximately 175-ft long swath north of the existing concrete ramp and the northern 125 ft on the survey area. Within these areas there is a steep shoreline bank (consists of either fine substrates or boulder/concrete); however, these substrates only extend to approximately 10 ft MHHW. These are the only areas where large concrete debris and of boulders/cobbles don't dominate the shoreline.

As stated above the majority of the upper portion of the shoreline is very consistent (large substrates) and is providing little if any habitat variability. The main habitat variability on the Site occurs below these larger substrates (below approximately +6 and +2 ft MHHW) and is separated into four distinct sections. This habitat area extends down to approximately 0 ft MHHW (below this elevation habitat/substrates were described in the eelgrass section).

The first area is located in the northern portion of the survey area, which is one of the areas that do not have a heavily armored shoreline slope. This area covers approximately 140 ft of the shoreline. From the uplands, there is a nearly vertical slope to just below approximately +12 ft MHHW that consists of finer substrates. The remainder of the shoreline between approximately +12 ft and 0 ft MHHW is very uniform in slope and substrates. Substrates within this area are dominated by debris (smaller angular concrete, bricks, and glass) with small areas of gravel and cobble. Average coverage by debris is greater than 65% with some areas completely (100%) covered. Slopes within this area are gradual and range from 5-15H:1V. The coverage of the shoreline by debris starts to decrease at approximately +2 ft MHHW and then eventually tapers off to less than 5 percent around 0 ft MHHW. Macroalgae coverage within this area is sparse covering less than 20 percent of the entire area. Macroalgae is dominated by ulva and rockweed, with rockweed dominating the upper elevations.

The second area is located directly south of the first area and encompasses approximately 715 linear feet of shoreline. Again this area is located waterward of the heavily armored portion of the shoreline, which is steeply sloped and is located between approximately +8 ft and 0ft MHHW. This area is gradually sloped (between 5-15H-1V) with moderate sized substrates in the upper elevations tapering down to coarse sand and gravel at 0 ft MHHW. Substrates in the upper elevations are dominated by rounded boulder and cobble, angular concrete debris, gravel, and coarse sand. Overall coverage by debris (angular concrete, bricks, glass, metal, etc) is between 20-40 percent, with some areas nearly 100 percent). Substrates within this area are pretty uniformly distributed; however, there are smaller patches where a specific substrate type dominates nearly 100 percent of the shoreline. One example is the area dominated by rounded boulder and cobble. There are also areas dominated by debris, like the existing concrete ramp. Other features along the shoreline include large concrete boxes, cut piles, and rounded logs. Macroalgae within this area is dominated by ulva and rockweed, with rockweed dominating the upper elevations. The larger substrates provide a large number of attachment sites; however, macroalgae covers ranges between 25-50 percent, with some areas ranging up to 85 percent. Other macroalgae species present includes laminaria, iridescent seaweed, filamentous green algae, seagrass laver, sargassum, gracilaria, and turkish towel.

The third area is located directly south of the second area and encompasses approximately 400 linear feet of shoreline. Again this area is located waterward of the heavily armored portion of the shoreline, which in this area extends down to +4 ft to +2 ft MHHW. This area is the heaviest armored portion of the shoreline. Below the heavily armored portion of the shoreline, which consists of large angular concrete (slabs) and even long concrete piles, the substrates are dominated by smaller angular concrete. Concrete debris in this portion of the area extends to below 0 ft MHHW and is dominated by smaller concrete slabs. Substrates within this area are pretty uniformly distributed. Concrete debris is covering between 40-80 percent of the shoreline. The reminder of the area consists of smaller debris (brick, glass, smaller concrete), gravel and cobble. Slopes within the area below the heavily armored portion of the shoreline are approximately 5H:1V. Macroalgae within this area averages between 10 and 40 percent with an overall coverage of approximately 20 percent. As with the remainder of the shoreline the upper elevations are dominated by rockweed and ulva dominates the lower elevations. Other macroalgae species present includes laminaria, filamentous green algae, sargassum, and gracilaria.

The final area is located in the southern portion of the site and encompasses approximately 415 lineal feet of shoreline. Above approximately +6 ft MHHW, the shoreline consists of large angular concrete. Below approximately + 6 ft MHHW, down to approximately -1 ft to -2 ft MHHW, the shoreline is gradually sloped and the substrates are dominated by coarse sand, shell hash, and cobble. The slopes of the shoreline below the large steeply sloped angular concrete are approximately 8H:1V. There are sparse pieces of concrete debris and boulders; however, for the most part the substrates are dominated by smaller material. There is also a small patch of concrete debris just below 0 ft MHHW. Within this area the size of substrates and the presence of angular concrete increases from the south to the north. Macroalgae is located both within the larger substrates and within the areas with coarse sand and gravel and in both areas the species are dominated by sea lettuce and rockweed. Average macroalgae coverage within each of these areas is less than 25 percent.

PORT OF BELLINGHAM
CORNWALL AVENUE LANDFILL SITE: EELGRASS AND SHORELINE HABITAT SURVEY

PHOTOGRAPHS

Photograph 3. Flat upland terrace with weedy grasses and forbs growing along shoreline berm with a stormwater ditch immediately landward. Consistent along entire shoreline.

Photograph 2. Flat upland terrace with weedy grasses and forbs growing along shoreline berm with a stormwater ditch immediately landward. Consistent along entire shoreline.

Photograph 3. Vegetated berm immediately landward of the MHHW dominated by upland weedy species. Vegetated berm transitions quickly into the shoreline dominated by concrete debris.

Photograph 4. Weedy grasses and forbs and extensive coverage of angular concrete between the upland and the MHHW in the southern portion of the Site.

Photograph 5. Steep transition from upland to MHHW, with dense stand of Himalayan blackberry within the middle of the Site.

Photograph 6. Weedy grasses and forbs and extensive coverage of angular concrete between the upland and the MHHW along the southern extent of the Site.

Photograph 7. Steep transition from the upland to the MHHW, with dense stands of Himalayan blackberry and extensive coverage of angular concrete

Photograph 8. Extensive coverage of angular concrete below the MHHW within the middle of the Site.

Photograph 9. Extensive coverage of angular concrete below the MHHW within the middle of the Site.

Photograph 10. Increasing amounts of cobble and gravel in the substrates along the nearshore margin in the southern portion of the Site.

Photograph 11. Increasing amounts of cobble and gravel in the substrates along the nearshore margin in the northern portion of the Site.

Photograph 12. Glass and debris amongst cobble and gravel along the nearshore margin in the northern portion of the Site.

PORT OF BELLINGHAM
CORNWALL AVENUE LANDFILL SITE: EELGRASS AND SHORELINE HABITAT SURVEY

APPENDIX A: EELGRASS SURVEY DATA SHEETS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15____ Time:__Variable_ Transect:_1_____________

Observer:_MI_____ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6, 4	glass, pile stubs
20	-	0	0	0	Ulva: 20%	6, 4, 2	glass
40	-	0	0	0	Ulva: 25%	4, 2	glass
60	Starts @ 60 ft	12	6	4	Ulva: 10%	2, 4	-
80		42	26	35	Cer: 10%, Smith: 10%	2, 4	-
100		18	24	19	Sarg: 5%, Smith: 10%	2, 4, 6, 8	-
120		13	9	5	Smith: 30%	0, 2, 4, 6	-
140	Ends @ 145 ft	6	0	7	Smith: 20%	0, 4, 8	-
160		0	0	0	-	0, 4, 8	sea star
180	-	0	0	0	-	0, 8	-
200	-	0	0	0	-	0, 8	-
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15 Time: Variable Transect: 2

Observer: MI Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6, 4, 2	pile stubs, glass
20	-	0	0	0	Ulva: 5%	6, 4, 2	pile stubs, glass
40	-	0	0	0	Ulva: 5%	6, 4, 2	glass
60	-	0	0	0	Ulva: 10%	6, 4, 2	glass
80	Starts @ 86 ft	0	0	0	Ulva: 10%	4, 6, 2	-
100		15	7	22	Cer: 10%	0, 2, 4	-
120		13	19	11	Smith: 20%	0, 2, 4	-
140		7	12	10	Smith: 20%	0, 2	-
160		7	11	5	Lam: 5%, Smith: 20%	0, 2	-
180	Ends @ 164 ft	0	0	0	-	0, 8	wood debris, large concrete anchor block @181 ft
200	-	0	0	0	-	0, 8	wood debris on surface
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15
Time: Variable
Transect: 3

Observer: LL
Tide: Variable
Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6, 3	rusty metal (25%)
20	-	0	0	0	-	pile, 5, 4, 3	-
40	-	0	0	0	-	7, 4, 3	-
60	-	0	0	0	-	3 , 7, 6, 4	-
80	-	0	0	0	Ulva: 5%	7, 4, 3	glass (10%)
100	-	0	0	0	Ulva: 10%	7, 4, 3	glass (5 %)
120	Start @ 109 ft	0	0	0	-	4, 0, 7, 8 (cut pile), 1	-
140	-	18	20	13	-	0, 8 (cut pile), 1	-
160	End @ 156 ft	9	4	6	-	0, 8 (cut pile), 1	-
180	-	0	0	0	-	1, 0, 8	wood debris (bark) present within 1 - 2 inches of surface
200	-	0	0	0	-	1, 0, 8	wood debris (bark) present within 1 - 2 inches of surface
220	-	0	0	0	-	0	~206 ft = end of wood debris (bark)
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15____ Time:__Variable_ Transect:_4_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	2, 3	-
20	-	0	0	0	-	3, 7	glass (10%)
40	-	0	0	0	-	7, 3	glass (20%)
60	-	0	0	0	Ulva: 5%	7, 3	glass (5%)
80	-	0	0	0	Ulva: 10%	4, 3, 7	-
100	-	0	0	0	Ulva: 15%	4, 3, 7	-
120	Start @ 107 ft	7	14	11	Ulva: 5%	0, 4, 8	wood debris at surface
140		9	16	4	-	0, 4, 8	wood debris at surface
160	End @ 155 ft	6	7	4	-	0, 4, 8	wood debris at surface
180	-	0	0	0	-	0, 8	large wood on surface and wood debris just below surface
200	-	0	0	0	-	0, 8	wood debris [bark] (10%) mostly below inch of silt
220	-	0	0	0	-	0, 8	wood debris on surface; ends ~226 ft
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15____ Time:__Variable_ Transect:_5_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6, 3, 2, 4	-
20	-	0	0	0	Fucus: 10%	3, 6, 8	-
40	-	0	0	0	Fucus: 25%	3, 6, 7	-
60	-	0	0	0	-	3, 7	-
80	-	0	0	0	Ulva: 25%	4, 3, 7	-
100	-	0	0	0	Ulva: 25%	4, 3, 7, 6	-
120	Start @ 103 ft	6	12	8	-	0, 8	wood debris (bark) at surface
140	End @ 126 ft	9	14	2	-	0, 7, 8	wood debris (bark) at surface
160	-	0	0	0	-	0, 8	wood debris (bark) at surface
180	-	0	0	0	-	0, 8	wood debris (bark) at surface
200	-	0	0	0	-	0, 8	wood debris (bark) at surface
220	-	0	0	0	-	0, 8	wood debris (bark) at surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15 Time: Variable Transect: 6

Observer: JS Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Chond 15%	6	old wood pile
40	-	0	0	0	Ulva: 5%	3, 4, 1	-
60	-	0	0	0	Ulva: 10%	2, 4	barnacles
80	Start @ 80 ft	32	0	12	-	2, 4	barnacles
100	End @ 99 ft	40	0	0	-	2, 0	-
120	-	0	0	0	-	0	-
140	-	0	0	0	-	0	sea star
160	-	0	0	0	-	0	-
180	-	0	0	0	-	0	-
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Began survey at 300 ft; swam towards shore; Transect 6 runs across the tip of eelgrass bed which extends approximately 6 ft towards Transect. Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15____ Time:__Variable_ Transect:_7_____________

Observer:_JS_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6, 7	-
20	-	0	0	0	-	6, 7	-
40	-	0	0	0	Ulva: 1% Chond 5%	6, 5, 3	mussels, barnacles
60	-	0	0	0	Ulva: 10%	3, 4	barnacles
80	-	0	0	0	Ulva: 1%	4	barnacles
100	-	0	0	0	Ulva: 1%	0, 2, 4	-
120	-	0	0	0	-	0, 8	Wood debris on surface
140	-	0	0	0	-	0,8	Wood debris on surface
160	-	0	0	0	-	0,8	Wood debris on surface
180	-	0	0	0	-	0	-
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Began survey at 300 ft; swam towards shore. Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 7/1/15 Time: Variable Transect: 8

Observer: LL Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6, 7	-
20	-	0	0	0	-	6, 7	-
40	-	0	0	0	Fucus: 10%	6, 7	-
60	-	0	0	0	Ulva: 2%	2, 3	-
80	Patch @ 97 ft	0	0	0	Ulva: 25%	3, 4	-
100	Patch @ 107-110 ft	16	2	0	Ulva: 50%	0, 2, 4	-
120	-	0	0	0	-	0, 2, 4	-
140	-	0	0	0	-	0, 2, 4, 8	Wood debris on surface
160	-	0	0	0	-	0, 8	Wood debris on surface
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_9_____________

Observer:_MI______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	
20	-	0	0	0	Fucus: 10%	6, 3	
40	-	0	0	0	Ulva: 25%, Fucus: 10%	4, 3, 2	
60	-	0	0	0	Ulva: 25%, Fil. Green: 10%	4, 3, 2	
80	-	0	0	0	Ulva: 25%	2, 4	
100	-	0	0	0	Lam: 10%, Ulva: 20%	2, 4, 8	Wood debris on surface
120	-	0	0	0	Ulva: 20%	0, 8	Wood debris on surface
140	-	0	0	0	-	0, 8	Wood debris on surface
160	-	0	0	0	-	0, 8	Wood debris on surface
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0	
220	-	0	0	0	-	0	
240	-	0	0	0	-	0	
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_10_____________

Observer:_LL______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 5%	6, 3	mussels
40	-	0	0	0	Ulva: 15%, Fucus: 10%	2, 3, 4	barnacles
60	-	0	0	0	Ulva: 25%, Fil. Green: 5%	2 (20%), 3 (40%), 4 (40%)	-
80	-	0	0	0	Ulva: 10%	2 (50%), 4 (50%)	-
100	-	0	0	0	Lam: 5%, Ulva: 10%	2, 4 (40%)	-
120	-	0	0	0	-	0, 8, 7	117 ft begin wood debris on surface and brick debris
140	-	0	0	0	-	0, 8, 7	135ft end brick debris
160	-	0	0	0	-	0, 8, 7	Wood debris on surface
180	-	0	0	0	-	0, 8, 7	Wood debris on surface
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Date: 6/29/15____ Time:__Variable_ Transect:_11_____________

Observer:_MI_____ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	2, 3, 6	-
20	-	0	0	0	-	6	-
40	-	0	0	0	Ulva: 40%, Fucus: 30%	6	mussels, barnacles
60	-	0	0	0	Ulva: 30%, Cer: 10%	6, 7, 4, 2	glass, barnacles
80	-	0	0	0	Lam: 5%, Sarg: 30%, Ulva: 10%	6, 4, 1, 2	Dungeness Crab
100	-	0	0	0	Ulva:5%, Lam 5%	4, 2, 0, 1, 6, 7	Concrete and brick debris
120	-	0	0	0	-	0, 2, 1, 4, 6, 7	Concrete and brick debris
140	-	0	0	0	-	0, 2, 6, 7	Concrete and brick debris
160	-	0	0	0	-	0, 2, 8	wood waste on surface
180	-	0	0	0	-	0, 8	wood waste on surface
200	-	0	0	0	-	0, 8	wood waste on surface
220	-	0	0	0	-	0, 8	wood waste on surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_12____________

Observer:_LL____ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 50%	3, 6	
40	-	0	0	0	Fucus: 40%, Ulva: 10%	5	
60	-	0	0	0	Ulva: 15%, Irid: 5%	4, 3, 2, 6	
80	-	0	0	0	Ulva: 20%, Sarg: 15%	2, 4, 6	
100	-	0	0	0	-	2, 4, 6	
120	-	0	0	0	-	2, 4, 6	concrete and brick rubble
140	-	0	0	0	-	0, 8	wood waste (bark) on surface and within 3 inches of surface
160	-	0	0	0	-	0, 8	wood waste (bark) on surface and within 3 inches of surface
180	-	0	0	0	-	0, 8	wood waste (bark) on surface and within 3 inches of surface
200	-	0	0	0	-	0	
220	-	0	0	0	-	0, 8	wood waste (bark) on surface and within 3 inches of surface
240	-	0	0	0	-	0, 8	wood waste (bark) on surface and within 3 inches of surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0, 8	wood waste (bark) on surface
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_13_____________

Observer:_MI______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6, 4	
20	-	0	0	0	Fucus: 30%	6, 4, 7	
40	-	0	0	0	Fucus: 25%	5, 7	
60	-	0	0	0	Ulva: 50%, Fucus: 10%	4, 1, 6	high level of surface glass
80	-	0	0	0	Ulva: 40%, Cer: 5%	4, 2, 1, 6	bay pipefish, barnacles, surf perch
100	-	0	0	0	Ulva: 10%, Grac: 2%, Lam: 5%	4, 1, 2, 7, 8	Wood waste on surface. Dungeness and Red rock crab.
120	-	0	0	0	Lam: 40%, Ulva: 5%	4, 2, 0, 8	Wood waste on surface. Red rock crab
140	-	0	0	0	-	0, 2, 8	Wood waste on surface.
160	-	0	0	0	-	0, 2	-
180	-	0	0	0	-	0, 2, 8	Wood waste on surface.
200	-	0	0	0	-	0, 2, 8	Wood waste on surface.
220	-	0	0	0	-	0, 2	-
240	-	0	0	0	-	0, 2, 8	Wood waste on surface.
260	-	0	0	0	-	0, 2	-
280	-	0	0	0	-	0, 2	-
300	-	0	0	0	-	0, 2	-

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_14_____________

Observer:_LL______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 40%	6, 3	-
40	-	0	0	0	Fucus: 20%	6, 3	-
60	-	0	0	0	Ulva: 20%	7 (10%), 4 (75%), 3 (5%), 2 (10%)	-
80	-	0	0	0	Cer: 25%, Ulva: 35%	4 (60%), 2	-
100	-	0	0	0	Ulva: 10%, Sarg: 10%, Lam: 20%	2, 4 (25%)	-
120	-	0	0	0	Sarg: 15%	0, 4 (25%)	-
140	-	0	0	0	macro ends @ 136 ft	0	woody debris (bark) ~5 -10% at surface within top 2 inches
160	-	0	0	0	-	0	-
180	-	0	0	0	-	0	-
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0	230 ft: large log
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: eelgrass: 8-89 ft southside ~1 ft to 6 ft (3x6), 3-4 ft tall, epiphytes 30%, 14/12/9 per 1/4 m2; N 81-84 ft (3x3) 2-4 ft tall, 0-3 ft, epi 30%, 64 turions; 81 ft S 2x6 ft, 17 per 1/4 m2, 15 per 1/4 m2.

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_15_____________

Observer:_MI______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6, 3	
20	-	0	0	0	Fucus: 30%	6, 3	
40	-	0	0	0	Fucus: 20%, Ulva: 10%	6, 4, 1	glass, metal stake, surf perch
60	-	0	0	0	Ulva: 10%	4, 1, 2, 7	barnacles, dung. Crab
80	Patch at 79 and 96 ft	45	25	62	Smith: 75%, Sarg: 10%	4, 1, 2	band of eelgrass ~15 ft wide extends south. Sea star, gunnels, surf perch
100	-	0	0	0	Lam: 10%, Ulva: 5%	4, 1, 2	-
120	-	0	0	0	Ulva: 5%	4, 1, 2, 8	wood waste on surface
140	-	0	0	0	-	0, 2, 8	wood waste on surface
160	-	0	0	0	-	0, 8	wood waste on surface
180	-	0	0	0	-	0	
200	-	0	0	0	-	0, 8	wood waste on surface
220	-	0	0	0	-	0, 8	wood waste on surface
240	-	0	0	0	-	0, 8	wood waste on surface
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7)

Macroalgae Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_16_____________

Observer:_LL______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	
20	-	0	0	0	Fucus: 30%	6	
40	-	0	0	0	Fucus: 5%	4, 6, 3, 5	
60	-	0	0	0	Ulva: 5%	4, 3, 2, 6	glass (5%)
80	82 - 93 ft	0	0	0	Ulva: 60%	4, 6, 2	
100	-	0	0	0	-	0, 2, 4, 8	wood waste on surface
120	-	0	0	0	-	0, 4, 7, 8	wood waste on surface
140	-	0	0	0	-	0, 8	wood waste on surface
160	-	0	0	0	-	0, 8	wood waste on surface
180	-	0	0	0	-	0, 8	wood waste on surface
200	-	0	0	0	-	0, 8	wood waste on surface
220	-	0	0	0	-	0, 8	wood waste on surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0, 8	wood waste on surface
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	-

NOTES: eelgrass both sides of tape from 82-93 ft: band extends to Transect 17; North side: 2/6/10, 21/18/20; South side: 26/28/14; eelgrass ~5 ft tall, <5% silt, coarse sand, 30-40% cobble. Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_17_____________

Observer:_MI______ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	1, 6	
20	-	0	0	0	Fucus: 10%	5, 6, 4	
40	-	0	0	0	Fucus: 20%	5, 6, 7, 4	broken glass, barnacles
60	-	0	0	0	Ulva: 5%	6, 7, 4, 1	glass, barnacles. 14 turion patch 5 ft North @ 75 ft
80	82 (3 ft S)	0	0	0	Ulva: 75%, Cer: 10%	4, 2, 1	barnacles
100	93 ft	0	0	0	Lam: 5%, Ulva: 5%	0, 2	red rock crab
120	-	0	0	0	-	0, 1, 8	shell (<5%), glass and wood waste on surface
140	-	0	0	0	-	0, 2, 8	very large log, partially buried @ 132 ft
160	-	0	0	0	-	0, 8	wood waste on surface
180	-	0	0	0	-	0, 8	wood waste on surface
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0, 8	wood waste on surface
240	-	0	0	0	-	0, 8	wood waste on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus);
Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Date: 6/29/15____ Time:__Variable_ Transect:_18_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	1, 6, 4	
20	-	0	0	0	-	3, 5	
40	-	0	0	0	Fucus: 15%	6 (80%), 3 (15%)	glass (5%)
60	-	0	0	0	-	3 (30%), 2 (10%), 4 (40%)	glass (50%)
80	-	0	0	0	Ulva: 15%, Cer: 70%	4 (75%), 3 (10%), 2	
100	-	0	0	0	Ulva: 10%	0, 2	
120	Patch at 106-118 ft	see below			-	0, 8	Wood debris [bark] on surface to ~2 in. depth
140	-	0	0	0	-	0, 8	Wood debris [bark] on surface to ~2 in. depth
160	-	0	0	0	-	0, 8	Wood debris [bark] on surface to ~2 in. depth
180	-	0	0	0	-	0, 8	Wood debris [bark] on surface to ~2 in. depth
200	-	0	0	0	-	0, 8	Wood debris [bark] on surface to ~2 in. depth
220	-	0	0	0	-	0, 8	Wood debris [bark] on surface to ~2 in. depth
240	-	0	0	0	-	0	
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: eelgrass 106-118 ft: ~2-25 ft South (R) 4x6- 30 turions; (R) 6x12- 12/13/8 per 1/4 m2; (R) 1x2- 4 turions. Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_19_____________

Observer:_MI_______ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6/asphalt, 1	-
20	-	0	0	0	-	3, 4	-
40	-	0	0	0	Fucus: 25%	4, 1, 5, 7, 6	glass
60	-	0	0	0	Ulva: 25%, Fucus: 25%	5, 4, 6	glass, mussels, barnacles
80	-	0	0	0	Ulva: 65%	4, 5	barnacles, starry flounder,
100	Start @ 103 ft	0	0	0	Ulva: 30%, Lam: 20%, Cer: 25%	0, 2	dense eelgrass band btwen 103-113 ft. Surf perch. Sparse eelgrass btwn 113-
120	End @ 122 ft	6	10	0	Lam: 25%, Sarg: 40%	0, 2, 6	large concrete chunk @ 123 ft
140	-	0	0	0	-	0	4, 1 end @ 156 ft
160	-	0	0	0	-	0, 8	Wood debris on surface
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette AssociatesLLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/29/15____ Time:__Variable_ Transect:_20_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6, asphalt	-
20	-	0	0	0	-	6, asphalt	-
40	-	0	0	0	-	3, 6, 4	-
60	-	0	0	0	-	4, 3	-
80	-	0	0	0	Ulva: 60%	4, 6, 3	metal debris (10%)
100	-	0	0	0	Sarg: 25%, Ulva: 100%	0, 2	-
120	-	0	0	0	-	0, 2, 8	woody debris (logs and planks)
140	-	0	0	0	-	0, 2	-
160	-	0	0	0	-	0, 8	Wood debris on surface (bark)
180	-	0	0	0	-	0, 8	Wood debris on surface (bark)
200	-	0	0	0	-	0, 8	Wood debris on surface (bark)
220	-	0	0	0	-	0	
240	-	0	0	0	-	0	
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 21

Observer: LL Tide: Variable Datasheet: 1 of 1

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6/asphalt, 3	-
20	-	0	0	0	-	3, 6/asphalt	-
40	-	0	0	0	Fucus: 20%	3, 6/asphalt	-
60	-	0	0	0	Fucus: 10%, Ulva: 10%	6 (10%), 3 (40%), 4 (50%)	-
80	-	0	0	0	-	6/7 (30%), 4 (30%), 3 (30%), 2	-
100	-	0	0	0	Ulva: 30%, Cer: 10%	0, 2	-
120	-	0	0	0	Sarg: 40%, Ulva: 10%	0, 2	-
140	-	0	0	0	-	0	-
160	-	0	0	0	-	0, 8	wood waste (bark) on surface
180	-	0	0	0	-	0, 8	wood waste (bark) on surface
200	-	0	0	0	-	0, 8	wood waste (bark) on surface
220	-	0	0	0	-	0, 8	wood waste (bark) on surface
240	-	0	0	0	-	0	
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: Eelgrass 115 N 18 ft (3x3) 61 turions; 100 S (1x3) 10 turions. Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_22_____________

Observer:_MI_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	1, 6	-
20	-	0	0	0	-	1, 6, 3	-
40	-	0	0	0	Fucus: 10%	3, 4, 6	barnacles, mussels
60	-	0	0	0	Fucus: 5%, Ulva: 1%	3, 4, 6	barnacles, mussels, wood waste
80	-	0	0	0	Fucus: 5%, Ulva: 40%	6, 4, 1, 7	glass, ceramic
100	-	0	0	0	Ulva: 50%, Cer: 30%	0, 2	glass
120	-	0	0	0	Sarg: 10%, Ulva: 20%	0, 2	pisaster
140	-	0	0	0	Lam: 10%, Sarg: 10%	0, 2	starry flounder, dung. Crab, metal ladder
160	-	0	0	0	-	0, 1, 2, glass	dung. Crab, sea star
180	-	0	0	0	-	0, 1, glass	4, 1 end @ 177 ft; old bottles @ 175 ft
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0, 8	Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 23

Observer: LL Tide: Variable Datasheet: 1 of 1

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	4, 3, 2	-
20	-	0	0	0	-	6, 3	barnacles
40	-	0	0	0	Fucus: 5%	3, 6	wood waste on surface
60	-	0	0	0	Fucus: 5%, Ulva: 10%	3, 6	barnacles, mussels
80	-	0	0	0	Ulva: 10%, Fucus: 15%	2, 6, 7	-
100	-	0	0	0	Ulva: 10%	0, 2, glass	-
120	-	0	0	0	Ulva: 10%, Sarg: 15%, Cer: 10%	0, 2	-
140	-	0	0	0	-	0, 2	-
160	-	0	0	0	-	0, 8	wood waste on surface
180	-	0	0	0	-	0, 8	Wood debris on surface and within ~2 inches
200	-	0	0	0	-	0, 8	Wood debris on surface and within ~2 inches
220	-	0	0	0	-	0, 8	Wood debris on surface and within ~2 inches
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: eelgrass @ 117, 6 ft N (1x1) 7 turions; patches to N 107-117; 2 ft N @ 109 ft 3 turion; patches to S 100-110 ft (~20 ft S). Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_24_____________

Observer:_MI_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6	-
20	-	0	0	0	-	6, 3	-
40	-	0	0	0	Fucus	4, 3, 1	barnacles, mussels
60	-	0	0	0	Ulva: 30%, Fucus: 10%	5, 3	barnacles, mussels
80	Start @ 88 ft (~10 ft S)	0	0	0	Cer: 20%, Ulva: 30%	4, 1, 2	-
100	End @ 100 ft	7	5	12	Sarg: 10%, Smith: 30%, Ulva: 10%, Lam: 5%, Cer:	0, 2, glass, ceramic	High level of glass and ceramic debris (coffee cup, plates, etc)
120	-	0	0	0	Lam: 20%, Sarg: 10%, Ulva: 5%	0	gunnels; small eelgrass patch btwn 105-110 ft: 22 turions total
140	-	0	0	0	Lam: 2%	0	1 turion @136 ft, sea stars
160	-	0	0	0	-	0, 8, metal, glass	High level of metal, glass debris. Visibility <1 ft at ~160 ft
180	-	0	0	0	-	0, 8, metal, glass	High level of metal, glass debris. Visibility <1 ft at ~160 ft
200	-	0	0	0	-	0, 8	Wood debris on surface. Visibility <1 ft at ~160 ft
220	-	0	0	0	-	0, 8	Wood debris on surface. Visibility <1 ft at ~160 ft
240	-	0	0	0	-	0, 8	Wood debris on surface. Visibility <1 ft at ~160 ft
260	-	0	0	0	-	0	Visibility <1 ft at ~160 ft
280	-	0	0	0	-	0	Visibility <1 ft at ~160 ft
300	-	0	0	0	-	0	Visibility <1 ft at ~160 ft

NOTES: eelgrass 121-131 ft N 4-26 ft more patches to N. 8/12/9 per 1/4 m2 4 - 5 ft tall w/ 30% epi and Repro; 113 ft 5-6 ft 10/16/4 3-4 ft tal; 1 patch further S ~30 ft; 103-112 ft N 2 ft - 10ft 30% epi 4-5 ft tall, Repro 211/17/20. Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 25

Observer: LL Tide: Variable Datasheet: 1 of 1

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	-	6, 4, 1	barnacles
40	-	0	0	0	-	3, 1, 4	barnacles
60	-	0	0	0	Ulva: 30%, Fucus: 1%	3, 1, 4	barnacles
80	-	0	0	0	Ulva: 70%	6	barnacles
100	Start @ 98 ft	14	9	16	Lam: 5%, Ulva: 10%	0, 2	-
120	End @ 112 ft	0	0	0	-	0, 2	-
140	-	0	0	0	-	0, 2	-
160	-	0	0	0	-	0, 2, glass	glass on surface and within 2 inches of surface
180	-	0	0	0	-	0, 8, glass	wood waste (5%), glass
200	-	0	0	0	-	0, 8	wood waste on surface and within 2 inches of surface
220	-	0	0	0	-	0, 8	wood waste on surface and within 2 inches of surface
240	-	0	0	0	-	0, 8	wood waste on surface and within 2 inches of surface
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_26_____________

Observer:_MI_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6	-
20	-	0	0	0	-	6, 4	barnacles
40	-	0	0	0	Fucus: 5%	3, 1, 5	mussels, barnacles
60	-	0	0	0	Ulva: 25%	6, 5, 1, 3	mussels, barnacles
80	-	0	0	0	Cer: 20%, Ulva: 30%	4, 6, 1, 2	Patch betwen 92 and 96 ft (44 turions)
100	-	0	0	0	Ulva: 20%, Lam: 10%	0, 2	Small patches between 86-90 ft, 6-10 ft S of transect
120	-	0	0	0	Sarg: 10%, Lam: 5%, Grac: 5%	0, 2	Patch @ 105 ft (14 turions)
140	-	0	0	0	-	0, glass	Heavy glass
160	-	0	0	0	-	0, 8	Heavy glass. <1 ft visibility after 154 ft. Wood debris on surface
180	-	0	0	0	-	0, 8	<1 ft visibility after 154 ft. Wood debris on surface
200	-	0	0	0	-	0, 8	<1 ft visibility after 154 ft. Wood debris on surface
220	-	0	0	0	-	0, 8	<1 ft visibility after 154 ft. Wood debris on surface
240	-	0	0	0	-	0, 8	<1 ft visibility after 154 ft. Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 27

Observer: MI Tide: Variable Datasheet: 1 of 1

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Chond: 5%	6, 3, 4	barnacles, mussels
40	-	0	0	0	Ulva: 5%, Fucus: 5%	6, 1, 3	-
60	-	0	0	0	Ulva: 20%	6, 4	-
80	Starts @ 80 ft	0	0	14	Sarg: 20%, Lam: 5%, Cer: 10%	4, 2, 1	Patch @ 80 ft (14 turions)
100	Ends @ 104 ft	8	38	27	Sarg: 20%, Lam: 10%, Ulva: 5%	0, 2	-
120	-	0	0	0	Sarg: 5%	0, 2, 8, glass	Wood waste and glass on surface starts at 107 ft
140	-	0	0	0	-	0, 2, glass, metal, ceramic	metal, ceramic, and glass debris
160	-	0	0	0	-	0, 8, glass	wood waste, cans, glass
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0	Wood debris on surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0, 8	Wood debris on surface
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Date: 6/30/15____ Time:__Variable_ Transect:_28_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 10%	6, 3	barnacles
40	-	0	0	0	Fucus: 10%, Ulva: 5%	6, 3	barnacles, mussels
60	-	0	0	0	Ulva: 10%, Fucus: 20%	6, 4, 3	-
80	Start @ 84 ft	0	0	0	Ulva: 15%	6, 4, 4	-
100	-	14	25	0	-	0, 2	-
120	End @ 104 ft	0	0	0	-	0, 2	
140	-	0	0	0	-	0, 2, glass	heavy glass
160	-	0	0	0	-	0, glass	Wood debris on surface
180	-	0	0	0	-	0, 8, glass	Wood debris on surface. Heavy glass.
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_29_____________

Observer:_MI_______ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	-	6, 4	barnacles
40	-	0	0	0	Ulva: 5%, Fucus: 5%	3, 6	barnacles, mussels
60	-	0	0	0	Ulva: 30%	6, 4, 2, glass	sparse glass
80	Start @ 76 ft	32	27	19	Smith: 30%	4, 2, 6	dense eelgrass
100		38	19	22	Smith: 30%, Lam: 5%	4, 2, 1	reprod.
120	End @ 115 ft	1	0	0	-	4, 2, 1, 0	-
140	-	2	0	0	-	0, glass	heavy glass
160	-	0	0	0	-	0, 8, glass	Wood debris on surface. Heavy glass.
180	-	0	0	0	-	0, 8, glass	Wood debris on surface. Heavy glass.
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0, 8	Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_30_____________

Observer:_MI_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Chond: 5%, Fucus: 5%	6	barnacles
40	-	0	0	0	Ulva: 10%, Fucus: 10%	6, 3, 4	barnacles, mussels
60	-	0	0	0	Ulva: 40%	6, 4, 3	-
80	Start @ 78 ft	19	24	14	Ulva: 10%	4, 1, 2	poor visibility
100	End @ 117 ft	12	30	22	Lam: 10%, Ulva: 5%, Sarg: 5%	4, 2, 1	surf perch
120	Band @ 120-124 ft	9	10	5	Sarg: 20%, Ulva: 5%	2, 4, 1, glass	Manmade debirs and glass starts @ 114 ft
140	-	0	0	0	Cer: 5%	2, 1, 4, glass	Manmade debirs and glass starts @ 114 ft
160	-	0	0	0	-	0, glass	Manmade debirs and glass
180	-	0	0	0	-	0, glass	Manmade debirs and glass
200	-	0	0	0	-	0, 8	Manmade debirs and glass
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0, 9	Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 10 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 31a

Observer: MI Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	-	6, 4	-
40	-	0	0	0	Fucus: 20%, Ulva: 5%	6	mussels, barnacles
60	-	0	0	0	Fucus: 10%, Ulva: 10%	6, 1, 5, 2, glass	glass shards, plastic debris
80	-	0	0	0	-	5, 4, 1, 8, glass	glass, plastic, wood waste
100	-	0	0	0	Ulva: 80%	0, 2, glass	forks, glass
120	-	0	0	0	Ulva: 80%, Cer 5%	0, 2	large overlapping concrete slabs btwn 110 and 118 ft
140	Start @ 131 ft	10	15	7	Ulva: 10%, Sarg: 10%	0, 2	-
160	End @ 153 ft	0	0	0	-	0, 2, cermaic plates, wood	Broken plates and wood debris
180	-	0	0	0	-	0, 1	red rock crab, dung. Crab, shells
200	-	0	0	0	-	0, 8, glass	Bottles and wood debris on surface
220	-	0	0	0	-	0, glass	bottles
240	-	0	0	0	-	0, glass	bottles
260	-	0	0	0	-	0, 8, glass	Bottles and wood debris on surface
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0, glass	bottles

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 31b

Observer: MI Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 10%	6, 5	barnacles
40	-	0	0	0	Fucus: 25%, Ulva: 5%	6, 1, 4, glass	glass shards
60	-	0	0	0	Ulva: 30%	4, 1, 8, glass	glass shards, wood debris. Shiner surfperch
80	-	0	0	0	Ulva: 60%, Cer: 15%	4, 1, 2, 7	plastic bags, debris
100	Start @ 100 ft	7	0	0	Ulva: 40%, Lam: 5%, Cer: 20%, Sarg: 5%	0, 2	Patch @ 90 ft (4 turions) and Patch @ 100 ft (7 turions)
120	End @ 115 ft	10	0	5	Ulva: 25%, Cer: 10%	0, 2, glass	25 sq ft patch @ 114 (~150 turions). Small patches between 100 -129 ft.
140	-	0	0	0	Grac: 10%, Sarg: 20%, Lam: 20%	0, 2, glass	Sparse patches between 125-129 ft.
160	-	0	0	0	Sarg: 20%	0, 2, 8, glass	Bottles and wood debris on surface.
180	-	0	0	0	-	0, 8, ceramic	Wood and ceramic debris on surface.
200	-	0	0	0	-	0, 8, 6, ceramic	Ceramic, concrete and wood debris on surface.
220	-	0	0	0	-	0, 8, 6, ceramic	Ceramic, concrete and wood debris on surface.
240	-	0	0	0	-	0, 8, 6, ceramic	Ceramic, concrete and wood debris on surface.
260	-	0	0	0	-	0, 8, 6, ceramic	Ceramic, concrete and wood debris on surface.
280	-	0	0	0	-	3	-
300	-	0	0	0	-	0, 8, 6, ceramic	Ceramic, concrete and wood debris on surface.

NOTES: Eelgrass 4 to 6 ft tall; 20 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 31c

Observer: JS Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 15%	6	-
40		0	0	0	Fucus: 15%	6, 3, 1	-
60	-	0	0	0	Ulva: 70%, Lam: 10%	4, 1, 6	-
80	-	0	0	0	Ulva: 70%, Lam: 10%	4, 1, 6	-
100	Sparse patch @ 84-97 ft	0	2	0	Ulva: 15%, Sarg: 5%, Lam: 5%	0, 2	-
120	Start @ 122 ft	6	14	8	Ulva: 10%	0, 2	dung. Crab
140		0	0	0	Sarg: 5%, Ulva: 10%	0, 2	Sparse eelgrass bed
160	End @ 160 ft	0	0	14	-	0, 2	-
180	-	0	0	0	-	0	-
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0, 6, 8	Wood and concrete debris on surface
240	-	0	0	0	-	0, 6, 9	Wood and concrete debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0, 6, 9	Wood and concrete debris on surface
300	-	0	0	0	-	0	-

NOTES: Began survey @ 300 ft, swam towards shore. Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Date: 6/30/15 Time: Variable Transect: 31d Bearing 290

Observer: JS Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 30%	6	-
40	-	0	0	0	Fucus: 10%	6, 3	mussels, barnacles
60	-	0	0	0	Ulva: 30%	6, 7, 4, 1	-
80	Start @ 74 ft	6	0	1	Ulva: 30%, Sarg: 5%	0, 2, 1, 4	-
100		28	30	32	-	0, 2	-
120		25	14	2	Ulva: 10%	0, 2	-
140		12	1	18	Grac: 10%, Lam: 10%, Ulva: 5%	0, 2	-
160	End @ 145 ft	0	0	0	Lam: 5%	0	-
180	-	0	0	0	Lam: 5%	0, 8	Wood debris on surface
200	-	0	0	0	Lam: 5%	0	-
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0, 8	Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Began survey @ 300 ft, swam towards shore, Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus);
Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 32

Observer: MI Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6	-
20	-	0	0	0	Fucus: 35%	6, 5	glass shards
40	-	0	0	0	Fucus: 25%	5, 6, 1	-
60	-	0	0	0	Ulva: 40%	4, 1, 6, glass	glass shards
80	-	0	0	0	Ulva: 30%, Cer 20%	5, 4, 1, 2, glass, metal	Glass and metal debris
100	Start @ 94 ft	34	12	14	Sarg 30%, Ulva: 10%	0, 2	Patch @ 90 ft (6 turions). Large concrete block in eelgrass
120	End @ 117 ft	12	7	9	Grac 5%, Ulva: 10%	0, 2	surf perch, small boulders, gunnels, sea star, red rock crab
140	-	0	0	0	Ulva: 5%, Sarg 5%	0, 2	flounder
160	-	0	0	0	Ulva: 2%	0, 8, glass	Glass and wood debris on surface
180	-	0	0	0	-	0, 8, glass	Glass and wood debris on surface
200	-	0	0	0	-	0, 8, glass	Sparse glass and wood debris on surface
220	-	0	0	0	-	0, 8, glass	Sparse glass and wood debris on surface
240	-	0	0	0	-	0, 8, glass	Sparse glass and wood debris on surface
260	-	0	0	0	-	0, glass	Sparse glass on surface
280	-	0	0	0	-	0, glass	Sparse glass on surface
300	-	0	0	0	-	0, glass	Sparse glass on surface

NOTES: Eelgrass 4 to 6 ft tall; 15 % epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 33

Observer: JS Tide: Variable Datasheet: 1 of 1

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	-	6, 5	-
20	-	0	0	0	Fucus: 25%	6, 1, 4	glass shards
40	-	0	0	0	Fucus: 5%	3, 1	-
60	-	0	0	0	Ulva: 10%	4, 3, 5	mussels, barnacles
80	-	0	0	0	Ulva: 75%	4, 1, 6	-
100	Start @ 101 ft	1	0	0	Ulva: 5%, Laminaria: 5%	0, 2, 5	purple sea star
120		24	16	18	-	0, 2	-
140	End @ 148 ft	12	12	10	-	0, 2	-
160	-	0	0	0	-	0	-
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0	
240	-	0	0	0	-	0, 8	Wood debris on surface
260	-	0	0	0	-	0	
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: Began survey at 300 ft; swam towards shore. eelgrass 4-6 ft tall, ~10-15% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 34

Observer: JS Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	6, 8	pile stubs
20	-	0	0	0	Fucus: 20%, Ulva: 5%	1, 5, glass	glass shards, rubber hose
40	-	0	0	0	Fucus: 5%, Ulva: 10%	3, 1	mussels, oysters
60	-	0	0	0	Ulva: 60%	6	barnacles, mussels
80	-	0	0	0	Ulva: 70%	2, 4	-
100	Start @ 87 ft	22	24	20	-	0, 2	-
120		18	26	20	-	0, 2	-
140		16	14	16	-	0, 2	-
160	End @ 153 ft	16	18	14	-	0, 2	-
180	-	1	1	1	-	0	-
200	-	0	0	0	-	0	-
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0	-
260	-	0	0	0	-	0,8	Wood debris on surface
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Began survey at 300 ft; swam towards shore. eelgrass 4-6 ft tall, ~10-15% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_35_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	Fucus: 20%	6, 8	pile stubs
20	-	0	0	0	Fucus: 30%	6, 1, 4, glass	glass shards, pile stubs
40	-	0	0	0	Ulva: 20%	3, 4, 6	
60	Start @ 77 ft	0	0	0	Ulva: 80%	6, 3	
80		0	1	0	Ulva: 10%	4, 3, 6, 1, 2	
100		17	16	12	-	0, 2	Reproductives
120		8	17	7	-	0, 2	
140	End @ 155 ft	4	0	1	-	0, 2	
160		0	0	0	-	0	
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0	
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0, 8	Wood debris on surface
260	-	0	0	0	-	0, 8	Wood debris on surface
280	-	0	0	0	-	0	
300	-	0	0	0	-	0	

NOTES: Eelgrass 4 to 5 ft tall; ~10% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates^LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 36

Observer: LL Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	-	5, 6, 8	pile stub, sparse barnacles
20	-	0	0	0	Ulva: 5%	2, 4, 6, 1	-
40	-	0	0	0	Ulva: 15%	3, 6, 1, 2	-
60	-	0	0	0	Ulva: 25%	4, 6, 3, 1	-
80	Start @ 77 ft	19	28	22	-	2, 1	-
100	-	26	19	14	-	0, 2	Reproductives
120	-	8	12	9	-	0, 2	Reproductives
140	End @ 144 ft	5	6	2	-	0, 2	-
160	-	0	0	0	-	0	-
180	-	0	0	0	-	0, 8	Wood debris on surface
200	-	0	0	0	-	0, 8	Wood debris on surface
220	-	0	0	0	-	0	-
240	-	0	0	0	-	0, 8	Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 5 to 10% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15____ Time:__Variable_ Transect:_37_____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	Fucus: 25%	5, 6, 7, glass	glass shards
20	-	0	0	0	Ulva: 10%, Fucus: 5%	4, 1, 6, 5	-
40	-	0	0	0	Ulva: 10%	6, 4, 1	-
60	Start @ 57 ft	2	1	0	Ulva: 15%	2, 0, 1, 4	-
80		17	21	6	-	2, 0, 1	-
100		18	27	16	Ulva: 10%	0, 2	-
120		6	19	22	-	0, 2	Repro
140		14	17	4	-	0, 2	-
160		21	14	6	-	0, 2	-
180	End @ 187 ft	10	7	2	-	0	-
200		0	0	0	-	0	-
220		0	0	0	-	0, 8	Wood debris on surface
240		0	0	0	-	0, 8	Wood debris on surface
260		0	0	0	-	0	-
280		0	0	0	-	0, 8	Wood debris on surface
300		0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; 5 to 10% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 38

Observer: JS Tide: Variable Datasheet: 1 of 1

Distance	Eelgrass Begin/End	Turion Counts 2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	Fucus: 15%	6, 5	-
20	-	0	0	0	Fucus: 5%	6, 4, 2, 1	-
40	-	0	0	0	-	2, 3	-
60	-	0	0	0	-	2, 3	-
80	Start @ 65 ft	0	0	0	-	2	-
100		25	27	0	-	0, 2	-
120		10	12	10	-	0, 2	-
140		20	22	23	-	0, 2	-
160		7	8	5	-	0, 2	-
180		10	6	4	-	0, 2	-
200	End @ 217 ft	12	0	0	-	0, 2	-
220		12	0	0		0	-
240		12	0	0		0	-
260		12	0	0		0	-
280		12	0	0		0	-
300		12	0	0		0	-

NOTES: eelgrass 4-6 ft tall, ~10-15% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Date: 6/30/15____ Time:__Variable_ Transect:_39_____________

Observer:_JS_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	Fucus: 30%	6, 5	barnacles, shells
20	-	0	0	0	-	4, 2, 1, glass	glass
40	-	0	0	0	-	4, 1, 2	
60	-	2	0	1	-	0, 2	-
80	Start @ 74 ft	12	10	15	-	0, 2	-
100		20	20	20	-	0, 2	-
120		30	20	25	-	0, 2	-
140		7	10	6	-	0, 2	-
160		8	7	6	-	0, 2	-
180		10	8	10	-	2, 0, 8	Wood debris on surface
200		10	8	10	-	0, 2	Less than 1 ft visibility
220		10	8	10		0, 2	-
240		10	8	10		0, 2, 8	Wood debris on surface. Less than 1 ft visibility
260		10	8	10		0, 2, 8	Wood debris on surface. Less than 1 ft visibility
280		10	8	10		0, 2	-
300		10	8	10		0, 2	-

NOTES: eelgrass 4-6 ft tall, ~10-15% epiphytes

Substrate Key:

Silt (0); Shell Hash (1); Sand (2); Gravel (3); Cobble (4); Boulder (5); Concrete Rubble/Debris (6); Bricks (7); Wood waste (8)

Macroalgae Key:

Ulva lactuca (Ulva); Smithora naiadum (Smith); Sargassum spp (Sarg); Laminaria (Lam); Gracilaria (Grac); Fucus gardneri (Fucus); Ceramium (Cer); Chondracanthus exasperatus (Chond); Mazzaella splendens (Mazz); Cladophora sericea (Clad)

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Date: 6/30/15____ Time:__Variable_ Transect:_40____________

Observer:_LL_______ Tide:_Variable_ Datasheet:__1__ of __1__

		Turion Counts					
Distance	Eelgrass Begin/End	2	6	10	Macroalgae	Substrate	Other
0	-	0	0	0	Fucus: 30%	5, 6	barnacles
20	-	0	0	0	Fucus: 10%	4, 1, 6	-
40	-	0	0	0	-	4 (50%), 2, SF (30%)	-
60	Start @ 54 ft	32	27	25	-	firm silty sand, SF (5%)	Reproductives
80		29	17	24	-	firm silty sand, SF (5%)	Reproductives
100		24	27	19	-	0, 2	-
120		4	2	4	-	0, 2, 8	Wood debris on surface (large bark)
140		11	19	12	-	0, 2	Reproductives
160		12	17	14	Ulva: 10%	0, 2	-
180		14	8	19	-	0, 2	-
200	End @ 214 ft	2	3	1	-	0, 2	Wood debris on surface (large bark)
220	-	0	0	0	-	0, 2	-
240	-	0	0	0	-	0, 8	Wood debris on surface (large bark)
260	-	0	0	0	-	0, 8	Wood debris on surface (large bark)
280	-	0	0	0	-	0	-
300	#VALUE!	0	0	0	-	0	-

NOTES: Eelgrass 4 to 6 ft tall; ~10% epiphytes.

Grette Associates LLC
ENVIRONMENTAL CONSULTANTS

Location: Cornwall Avenue Landfill

Eelgrass and Macroalgae Survey

Date: 6/30/15 Time: Variable Transect: 41

Observer: LL Tide: Variable Datasheet: 1 of 1

		Turion Counts					
Distance	**Eelgrass Begin/End**	**2**	**6**	**10**	**Macroalgae**	**Substrate**	**Other**
0	-	0	0	0	Fucus: 20%	5, 6	barnacles
20	-	0	0	0	Ulva: 10%	5, 6, 4, 1, 2	-
40	-	0	0	0	Ulva: 10%	0, 2, 1	-
60	Start @ 52 ft	18	14	14	-	0, 2, 1	-
80	-	42	29	37	-	0, 2, 1	-
100	-	19	11	12	-	0, 2	-
120	-	9	11	9	-	0, 2	-
140	-	4	6	3	-	0, 2, 8	Wood debris on surface
160	-	17	14	19	-	0, 2	-
180	-	6	4	14	-	0, 2, 8	Wood debris on surface
200	End @ 218 ft	4	6	11	-	0	-
220	-	0	0	0	-	0, 8	Wood debris on surface
240	-	0	0	0	-	0, 9	Wood debris on surface
260	-	0	0	0	-	0	-
280	-	0	0	0	-	0	-
300	-	0	0	0	-	0, 8	Wood debris on surface

NOTES: eelgrass 4-6 ft tall, ~10-15% epiphytes

APPENDIX F

Hilton Avenue Soil Borrow Source

APPENDIX F

HILTON AVENUE SOIL BORROW SOURCE

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Introduction

The Cornwall Avenue Landfill Site (Site) is relatively flat in its current condition. An engineered landfill cover system is being designed for the Site, as described in the Engineering Design Report. Per the Minimum Functional Standards (MFS) for solid waste handling (Chapter 173-304 WAC), a landfill cover must have sufficient slope to promote drainage off the cover system. The MFS requires that a minimum 2 percent slope be established and maintained throughout post-closure operation and maintenance of the landfill. This typically requires that steeper slopes be established at the time of landfill closure in anticipation of post-closure settlement that occurs due to decomposition of the waste and settlement due to consolidation from the weight of the closure cap.

As discussed in the EDR, up to 46,000 in-place cubic yards of fill will be required to establish Site design grades and maintain at least a minimum 2 percent slope over the upland portion of the Site. This is a significant volume of fill which is not available on Site and must be imported. Placing the additional soil at the Site months or years in advance of the landfill cover construction would provide beneficial preloading, which would minimize the long-term settlement potential and aid in preventing depressions that could form over time in the landfill cover.

The Port identified an offsite borrow source to provide general fill at the Site. The source of soil was located on property owned by the Port, along Hilton Avenue in Bellingham, Washington. The following sections provide an evaluation of the geotechnical and environmental suitability of this source of fill.

Hilton Avenue Soil

The subject soil was originally intertidal sediment that was dredged from the Bellingham waterfront to create the Port's Squalicum Inner Harbor in the early 1980s. The material was used to create the uplands where the Hotel Bellwether and restaurants are currently located. Then, in the late 1990s and early 2000s, the soil was relocated to its current Hilton Avenue location during construction of the Hotel Bellwether subgrade parking garage and the Bellwether office buildings. Figure F.2-1 shows the current location of the soil stockpile, and presents surveyed elevation contours that were used to assess the volume of soil available. Based on the elevation survey, conducted in October 2015 by Wilson Engineering, there appears to be sufficient soil available to approximately meet the fill requirements to establish the subgrade elevations required in advance of placing the final cover system for the Site cleanup action.

Geotechnical Testing

On October 26, 2015, Landau Associates conducted a test pit investigation to collect samples for geotechnical testing. The location of the test pits (with prefix HATP) are shown on Figure F.1-1. The soil was evaluated based on the following criteria:

- Manual classification (Unified Soil Classification System and ASTM 2487 and 2488)
  - See Figures F.1-2 to F.1-5
- Plasticity (Atterberg limit test by ASTM 4318)
  - See Figure F.1-6
- Grain size evaluation by sieve analysis
  - See Figure F.1-7

- Moisture-density relationship by ASTM D 1557C and ASTM D 4718
    - See Figures F.1-8 and F.1-9.

The results of these geotechnical tests are provided as Attachment F.1. In summary, the visual classification and laboratory testing indicate the soil in the stockpile is of variable composition, ranging from gravelly sand with silt to sandy clay with gravel. Although clay is present, based on the plasticity and moisture-density testing, the soil is considered appropriate for use as general fill to establish Site grades.

Chemical Analysis

The soil has been characterized by laboratory analysis on three occasions. The latest of these characterizations was conducted by Landau Associates in 2015. The material was previously evaluated by GeoEngineers in 1998 during an environmental site assessment.

On December 10, 2015, Landau Associates collected five vertically composited samples from the material for analytical testing from the locations shown on Figure F.2-1. The samples were retrieved using direct-push sampling equipment, with exploration oversight and sample collection by a Landau Associates environmental professional. A single composite sample representing the full thickness of the fill material was collected from each location. Soil characterization boring logs were prepared during the investigation, which are provided in Figures F.2-2 to F.2-6.

The chemical testing parameters were developed in cooperation with the Washington State Department of Ecology (Ecology), to determine if the soil has been contaminated based on its location in a waterfront area that was historically used for industrial purposes. All samples were analyzed for total petroleum hydrocarbons (TPH) using method NWTPH-HCID, with follow up analysis for any TPH ranges that were detected. Samples were also tested for heavy metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc), semivolatile organic compounds (SVOCs), total organic carbon, and dioxins/furans.

Highly conservative exposure and migration pathways were used to develop the screening levels used to assess whether the soil is suitable for use on the Site. As shown in Table F.2-1, the potential exposure pathways considered in screening the data included direct contact (ingestion), protection of terrestrial species, protection of marine sediment quality, and protection of groundwater in both unsaturated and saturated soil conditions. The most protective of these values was used as the screening level for evaluation of soil quality. It should be noted that these screening levels consider exposure pathways that may not be applicable for the development of soil cleanup levels, but meeting these extremely conservative screening levels clearly demonstrates that the use of this soil for general fill at the Site does not pose a threat to human health of the environment.

The analytical results for the composite samples are presented in Table F.2-2. As shown in the table, all detected constituents were below the screening levels, with only one exception. Copper was detected in one sample at a 40.7 milligrams per kilogram (mg/kg), a concentration slightly greater than the preliminary screening level of 36 mg/kg. However, because the highest copper concentration is less than 2 times the screening level, less than 10 percent of the copper data exceed the screening level, and the 95 percent upper confidence limit on the mean for the copper data is approximately 25 mg/kg, (well below the screening level), the soil is considered to meet the copper screening level.

As noted above, the soil quality was also evaluated in 1998. Analytical data from the 1998 evaluation is provided in Table F.2-3, and the two associated reports are provided as attachment F.2.b for reference. As shown in Table F.2-3, no volatile organic compounds (VOCs), SVOCs, or polychlorinated biphenyls (PCBs) were detected. One sample out of the 5 analyzed in 1998 for mercury had a detectable concentration of mercury (0.105 mg/kg), which is greater than the screening level of 0.07 mg/kg. Mercury was below the screening level in each of the 5 samples analyzed in 2015. Because the single detection of mercury in 1998 is less than 2 times the screening level, less than 10 percent of the mercury data exceed the screening level, and the 95 percent upper confidence limit on the mean for mercury including all 16 analytical results available is approximately 0.05 mg/kg (well below the screening level), the soil is considered to meet the mercury screening level.

Sediment data from a US Army Corps of Engineers study in 1976 was also reviewed and is attached. We considered these data as background information indicative of the generally good soil/sediment quality, but not directly representative of Hilton Avenue soil because it was associated with a much larger dredge area than the area from which the Hilton soil originated. The 1976 data should be considered as no longer representative of the mixed fill (because they represent the upper surface of the sediment prior to dredging and mixing), and subject to the provisions of WAC 273-340-360(2)(g), which allows mixing under certain circumstances.

Conclusion

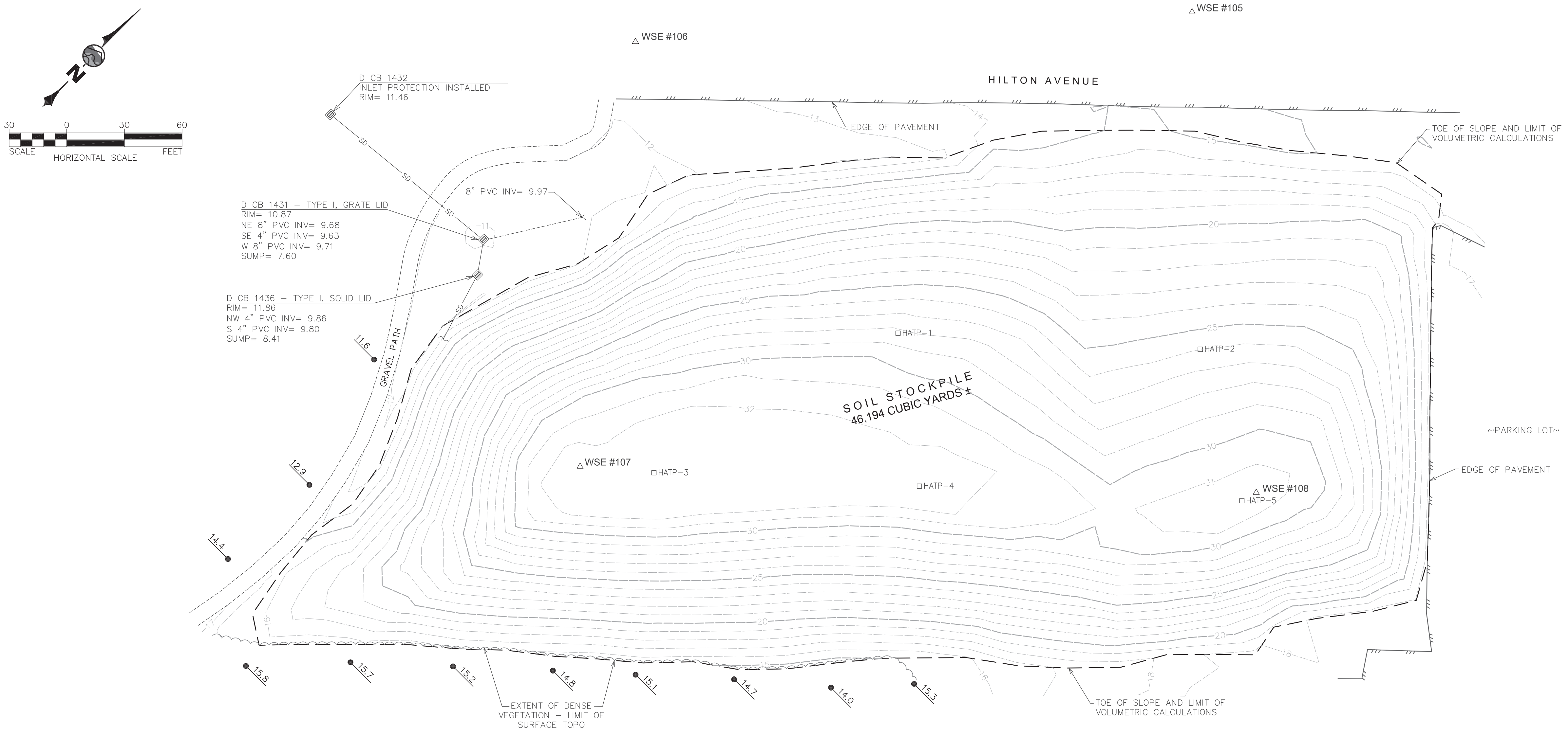
Based on the laboratory analyses attached and the considerations discussed above, the use of the Hilton Avenue soil at the Site was approved as an early action by Ecology on March 2, 2016 for reuse as fill material at the Site to establish grades beneath the impermeable cover system. The fill was transferred and placed on the Cornwall Avenue Landfill Site from June 1 through June 28, 2016. The early action completion report for importing and placing the fil on the Cornwall Landfill Site is provided as Appendix F.3.

APPENDIX F.1

Hilton Avenue Soil Borrow Source Evaluation

ATTACHMENT F.1a

Geotechnical Testing



SURVEY NOTES

1. THIS VOLUMETRIC SURVEY WAS PERFORMED FOR LANDAU ASSOCIATES, INC. IN OCTOBER OF 2015. THE PURPOSE OF THE SURVEY IS FOR CALCULATING VOLUMES. THIS MAP IS NOT INTENDED TO BE A COMPLETE TOPOGRAPHIC REPRESENTATION OF THE SITE.

2. MONUMENTATION SHOWN HEREON WAS RECOVERED OR ESTABLISHED DURING THE COURSE OF THIS SURVEY.

3. ANGULAR AND LINEAR MEASUREMENTS WERE COLLECTED USING A COMBINATION OF GPS AND CONVENTIONAL METHODOLOGIES. PRIMARY CONTROL WAS COLLECTED USING TRIMBLE R7 SURVEY-GRADE GPS RECEIVERS OPERATING IN NETWORKED RTK MODE. FROM GPS CONTROL, A TRIMBLE S-6 ROBOTIC TOTAL STATION WAS USED TO COLLECT TOPOGRAPHIC DATA.

4. STORM DRAINAGE STRUCTURES SHOWN HEREON MAY NOT REPRESENT ALL SUCH FACILITIES ON SITE. AN EXHAUSTIVE SEARCH WAS NOT CONDUCTED TO LOCATE OTHER POSSIBLE STRUCTURES.

CONTROL NOTES

1. BASIS OF COORDINATES: FOUND CITY OF BELLINGHAM BRASS SURFACE MONUMENT AT THE CENTERLINE POINT OF INTERSECTION OF THE BELLWETHER WAY LOOP. WSE CONTROL POINT #904, C.O.B. DESIGNATION #4457. THE FOLLOWING PUBLISHED NAD83/98 COORDINATES WERE HELD FOR CITY OF BELLINGHAM DESIGNATION #4457:

NORTHING = 644,441.99 USFT
EASTING = 1,239,508.97 USFT

2. BASIS OF BEARINGS: FOUND CITY OF BELLINGHAM BRASS SURFACE MONUMENT AT THE CENTERLINE INTERSECTION OF C STREET AND MAPLE STREET. WSE CONTROL POINT #900, C.O.B. DESIGNATION #2100. HELD DERIVED INVERSE BETWEEN THE ABOVE - MENTIONED CONTROL POINT #4457 AND #2100, SAID BEARING BEING S 55°20'47" E, A DISTANCE OF 2007.45'. THE FOLLOWING PUBLISHED NAD83/98 COORDINATES WERE HELD FOR CITY OF BELLINGHAM DESIGNATION #2100:

NORTHING = 643,300.53 USFT
EASTING = 1,241,160.31USFT

3. BASIS OF ELEVATIONS: ELEVATIONS ARE NAVD88 VALUES BASED UPON HOLDING THE RECORD ELEVATION OF 18.38' AT THE ABOVE-MENTIONED C.O.B.#4457 PER THE AMENDED RECORD OF SURVEY OF THE WATERFRONT DISTRICT, A.F. No. 2080302393.

VOLUME OF SOIL STOCKPILE AS OF 10-21-2015

46,194 CUBIC YARDS ±

SURVEY CONTROL POINTS (NAD83/98, NAVD88)

POINT	***NORTHING***	***EASTING***	***ELEV.***	***DESCRIPTION***
105	644624.17	1240555.38	14.68	REBAR AND PLASTIC CAP
106	644408.42	1240361.51	12.58	BERNTSEN SPIKE
107	644231.63	1240497.57	32.54	REBAR AND PLASTIC CAP
108	644470.79	1240755.98	31.40	REBAR AND PLASTIC CAP

LEGEND

△	= WSE CONTROL POINT
□#	= PROPOSED TEST PIT LOCATION (PER LANDAU)
● 14.0	= SPOT ELEVATION (TYP)

WILSON ENGINEERING, LLC
805 DUPONT STREET
BELLINGHAM, WA 98225
(360) 733-6100 • FAX (360) 647-9061
www.wilsonengineering.com

Wilson
SURVEY/ENGINEERING

DESIGNED BY
DRAWN BY RB
CHECKED BY AKM

LANDAU ASSOCIATES, INC.

BELLINGHAM WASHINGTON

HILTON AVENUE SOIL STOCKPILE
VOLUME EXHIBIT

DATE 10-27-2015
SCALE AS SHOWN
JOB NUMBER 2015-008X

Figure
F.1a-1

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)	▨	**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
			▨	**GP**	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	▨	**GM**	Silty gravel; gravel/sand/silt mixture(s)
			▨	**GC**	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)	▨	**SW**	Well-graded sand; gravelly sand; little or no fines
			▨	**SP**	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)	▨	**SM**	Silty sand; sand/silt mixture(s)
			▨	**SC**	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)		▨	**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
			▨	**CL**	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
			▨	**OL**	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)		▨	**MH**	Inorganic silt; micaceous or diatomaceous fine sand
			▨	**CH**	Inorganic clay of high plasticity; fat clay
			▨	**OH**	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL		▨	**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT	■ ▨	**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK	▨	**RK**	Rock (See Rock Classification)
WOOD	▨	**WD**	Wood, lumber, wood chips
DEBRIS	▨	**DB**	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	- "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	- "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	- "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	- "with gravel," "with sand," "with silt," etc.
	≤ 5%	- "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

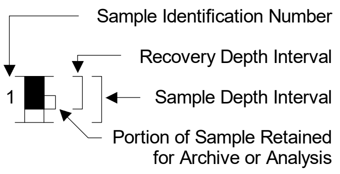
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Single-Tube Core Barrel
f	Double-Tube Core Barrel
g	2.50-inch O.D., 2.00-inch I.D. WSDOT
h	3.00-inch O.D., 2.375-inch I.D. Mod. California
i	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Vibrocore (Rotosonic/Geoprobe)
5	Other - See text if applicable

SAMPLE NUMBER & INTERVAL



Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

Groundwater

▽	Approximate water level at time of drilling (ATD)
▼	Approximate water level at time other than ATD

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Hilton Avenue Stockpile
Bellingham, WA

Soil Classification System and Key

Figure
F.1a-2

HATP-1

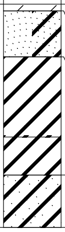
SAMPLE DATA

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data
0		S-1		
	25			
5		S-2		W = 25
	20			W = 17
10		S-3		GS AL
	15			
15		S-4		
20				
25				
30				
35				

Test Pit Completed 10/26/15
Total Depth of Test Pit = 17.0 ft.

SOIL PROFILE

Excavation Method: Tracked Excavator
Ground Elevation (ft): 28.0
Logged By: DSB



USCS Symbol	
DB	Grass and Brown silty SAND with roots
SW-SC	Brown silty fine to medium sand with gravel and trace shells
CL	Gray CLAY with sand and gravel
CL	Gray sandy CLAY with gravel
SC	Gray clayey SAND with gravel and shells

GROUNDWATER

Groundwater not encountered.

HATP-2

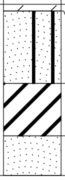
SAMPLE DATA

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data
0	25	S-1		
5	20	S-2		W = 8
10	15	S-3		
15				
20				
25				
30				
35				

Test Pit Completed 10/26/15
Total Depth of Test Pit = 13.0 ft.

SOIL PROFILE

Excavation Method: Tracked Excavator
Ground Elevation (ft): 26.0
Logged By: DSB



USCS Symbol	
DB	Grass and Brown silty SAND with gravel and shells
SW-SM	Brown silty gravelly fine to medium SAND
CL	Gray gravelly sandy CLAY
SW	Brown medium SAND with gravel and trace silt

GROUNDWATER

Groundwater not encountered.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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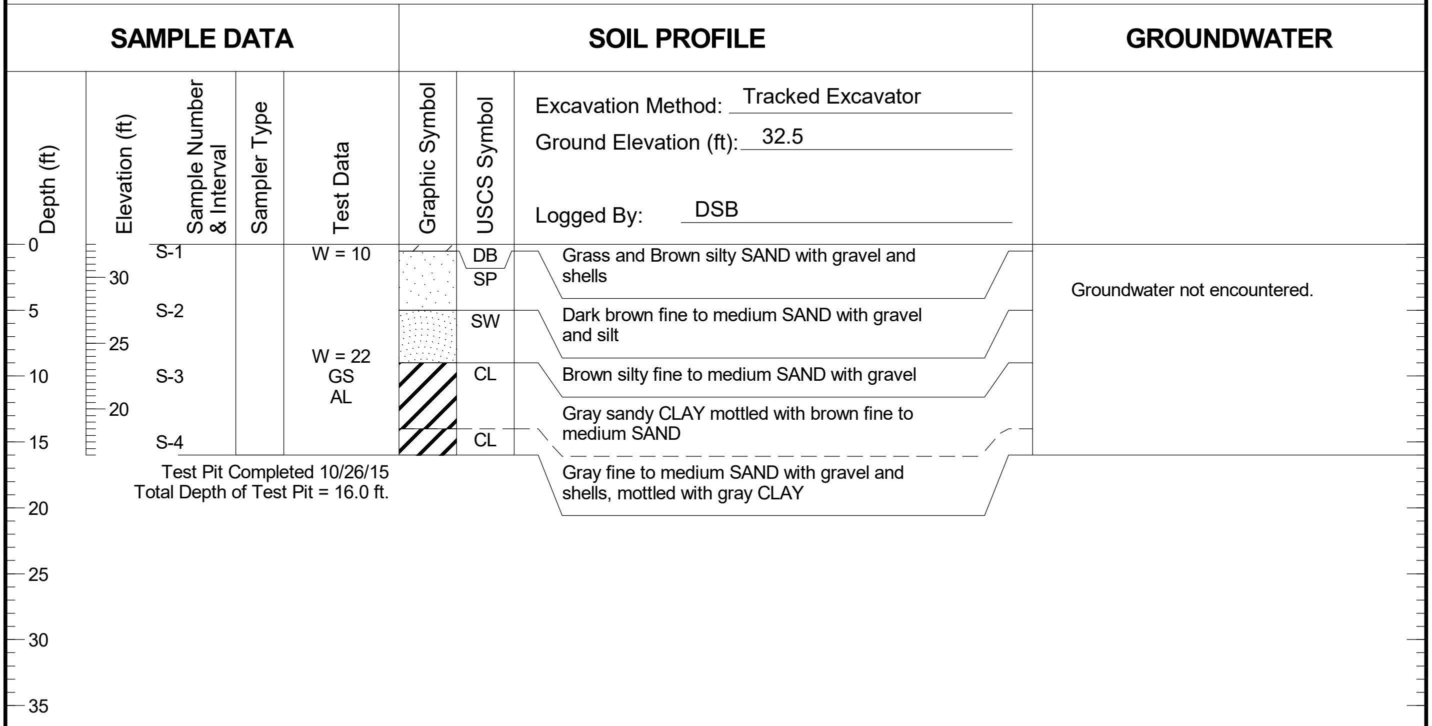
Hilton Avenue Stockpile
Bellingham, WA

Log of Test Pits

Figure
F.1a-3

HATP-3



Excavation Method: Tracked Excavator
Ground Elevation (ft): 32.5
Logged By: DSB

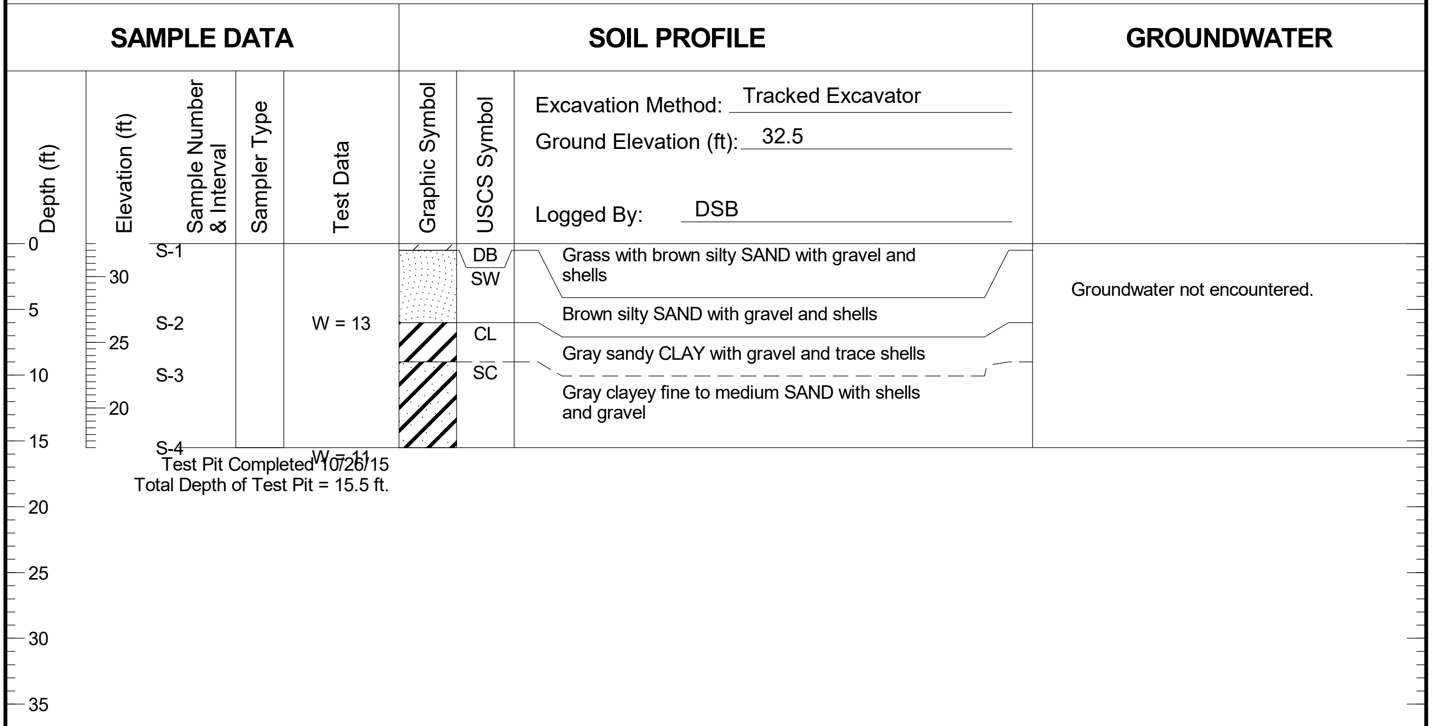
Sample Number & Interval	Test Data
S-1	W = 10
S-2	
S-3	W = 22 GS AL
S-4	

USCS Symbol	Description
DB	Grass and Brown silty SAND with gravel and shells
SP	Dark brown fine to medium SAND with gravel and silt
SW	Brown silty fine to medium SAND with gravel
CL	Gray sandy CLAY mottled with brown fine to medium SAND
CL	Gray fine to medium SAND with gravel and shells, mottled with gray CLAY

Groundwater not encountered.

Test Pit Completed 10/26/15
Total Depth of Test Pit = 16.0 ft.

HATP-4



Excavation Method: Tracked Excavator
Ground Elevation (ft): 32.5
Logged By: DSB

Sample Number & Interval	Test Data
S-1	
S-2	W = 13
S-3	
S-4	W = 11

USCS Symbol	Description
DB	Grass with brown silty SAND with gravel and shells
SW	Brown silty SAND with gravel and shells
CL	Gray sandy CLAY with gravel and trace shells
SC	Gray clayey fine to medium SAND with shells and gravel

Groundwater not encountered.

Test Pit Completed 10/26/15
Total Depth of Test Pit = 15.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Hilton Avenue Stockpile
Bellingham, WA

Log of Test Pits

Figure
F.1a-4

HATP-5

SAMPLE DATA | **SOIL PROFILE** | **GROUNDWATER**

Excavation Method: Tracked Excavator

Ground Elevation (ft): 31.5

Logged By: DSB

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Soil Profile	Groundwater
0		S-1				DB	Grass with brown silty fine to medium SAND with gravel	Groundwater not encountered.
	30				░	SW	Brown gravelly fine to medium SAND with silt and trace shells	
5	25	S-2		W = 7 GS	░			
10	20	S-3			▨	CL	Gray sandy CLAY with gravel and shells	
15		S-4		W = 4		SW	Brown gravelly fine to medium SAND with silt	
20								
25								
30								
35								

Test Pit Completed 10/26/15
Total Depth of Test Pit = 16.0 ft.

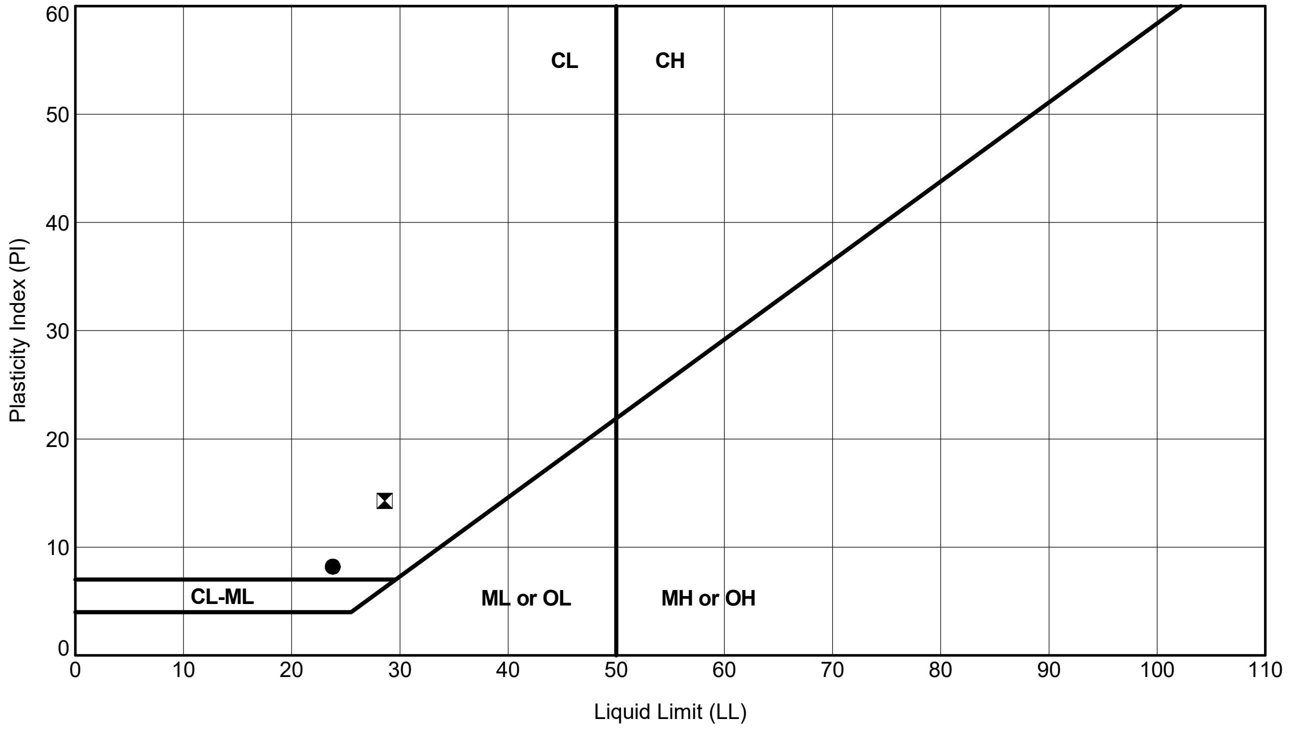
Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Hilton Avenue Stockpile
Bellingham, WA

Log of Test Pits

Figure
F.1a-5



ATTERBERG LIMIT TEST RESULTS

Symbol	Exploration Number	Sample Number	Depth (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	HATP-1		10.0	24	16	8	17	Clayey SAND with gravel	SC
⧗	HATP-3		10.0	29	14	15	22	Sandy CLAY with trace gravel	CL

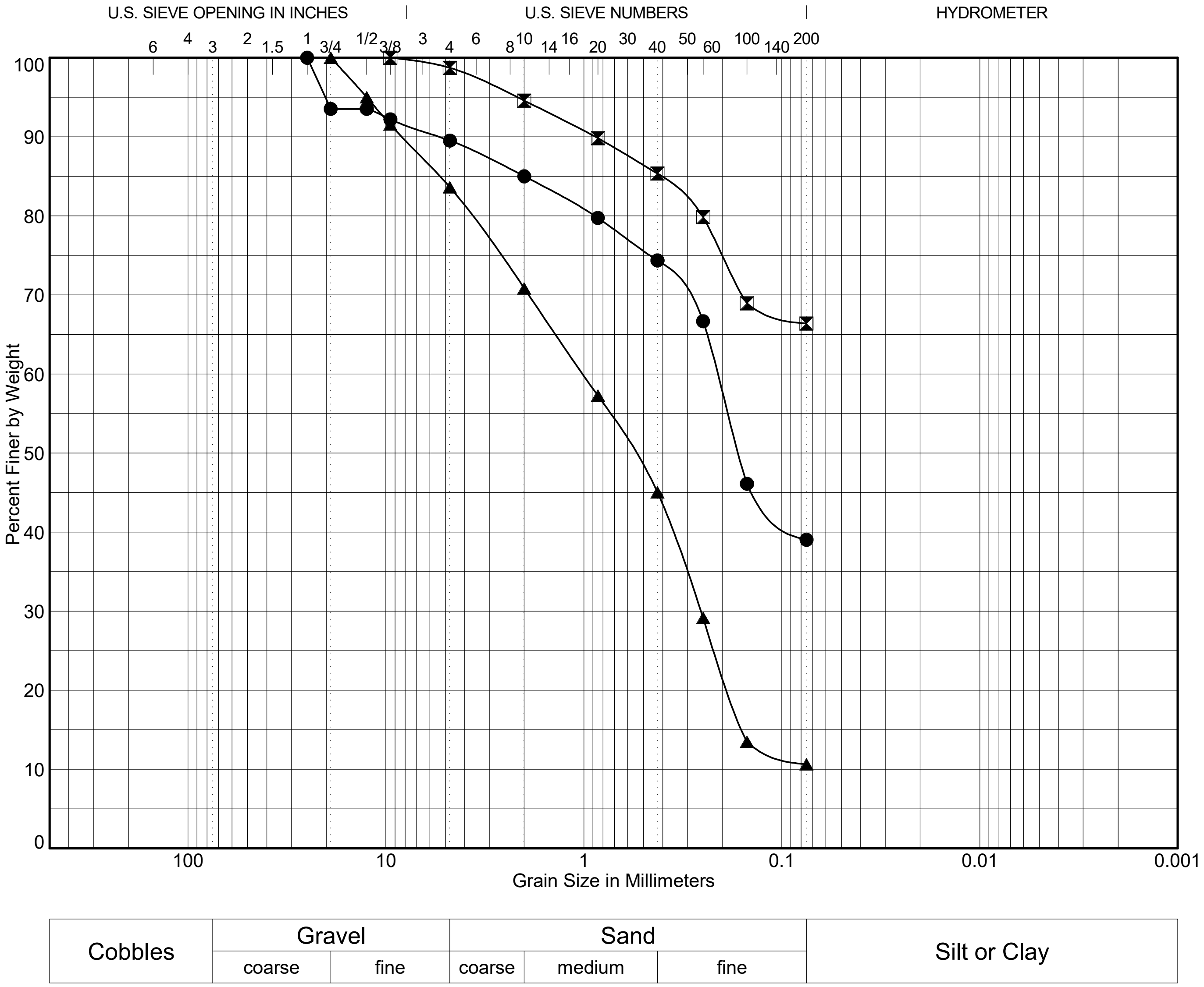
ASTM D 4318 Test Method

LANDAU ASSOCIATES

Hilton Avenue Stockpile
Bellingham, WA

Plasticity Chart

Figure
F.1a-6



	Point	Depth	Classification	LL	PL	PI	C_c	C_u
●	HATP-1	10.0	Clayey SAND with gravel (SC)	24	16	8		
⧗	HATP-3	10.0	Sandy CLAY with trace gravel (CL)	29	14	15		
▲	HATP-5	5.0	Gravelly SAND with silt (SW)				1.02	15.70

	Point	Depth	D_{100}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	HATP-1	10.0	25	0.212	0.165			6.5	4.0	4.5	10.6	35.3	39.0
⧗	HATP-3	10.0	9.5					0.0	1.3	4.1	9.2	19.0	66.4
▲	HATP-5	5.0	19	1.01	0.563	0.257		0.0	16.4	12.8	25.8	34.4	10.6

$C_c = D_{30}^2/(D_{60} * D_{10})$ To be well graded: $1 < C_c < 3$ and

$C_u = D_{60}/D_{10}$ $C_u > 4$ for GW or $C_u > 6$ for SW

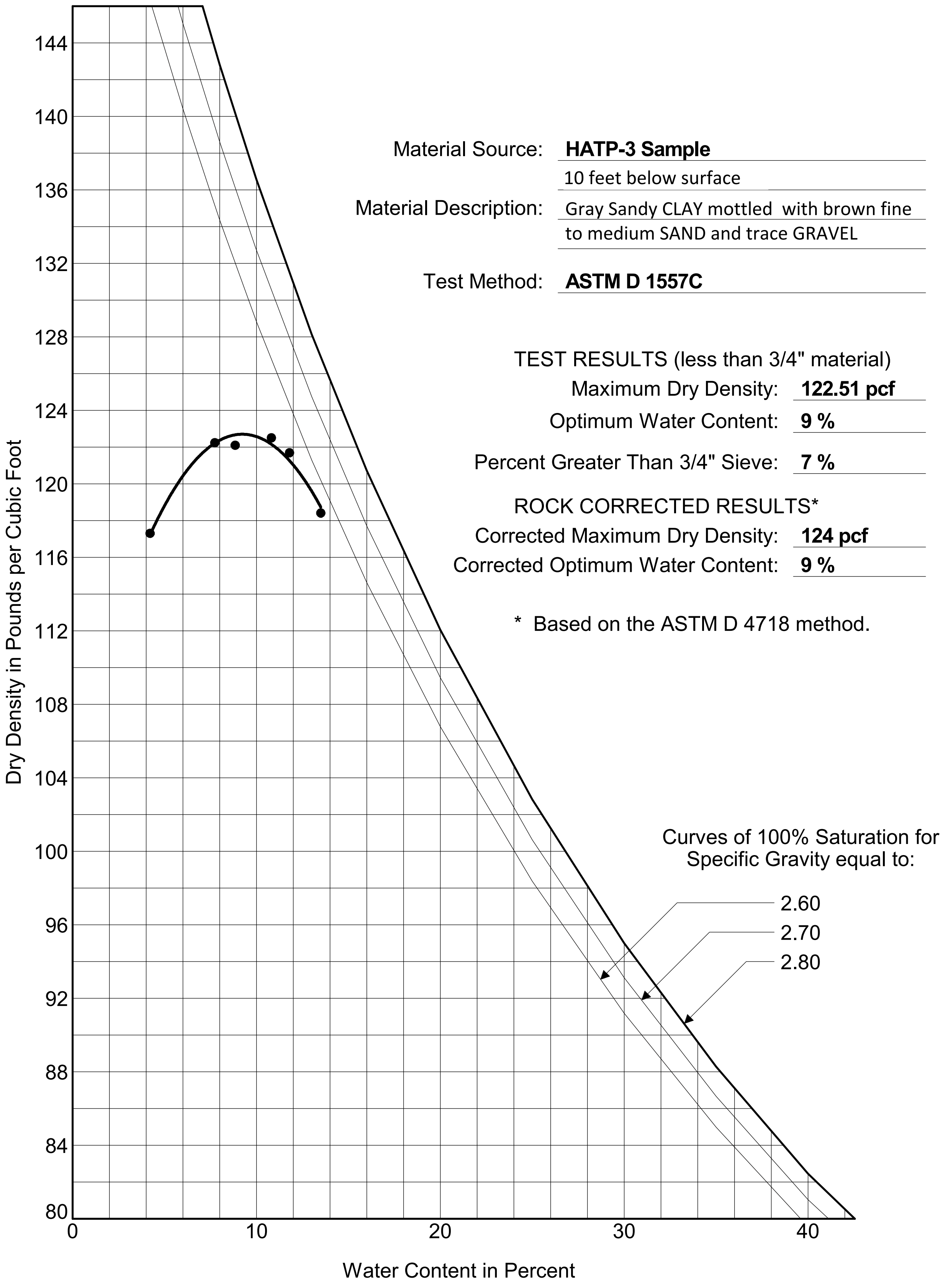
001037.040.041 2/10/16 N:\PROJECTS\1037.040.041.GPJ GRAIN SIZE W/STATS

LANDAU ASSOCIATES

Hilton Avenue Stockpile
Bellingham, WA

Grain Size Test Data

Figure
F.1a-7



Material Source: **HATP-3 Sample**
10 feet below surface

Material Description: Gray Sandy CLAY mottled with brown fine to medium SAND and trace GRAVEL

Test Method: **ASTM D 1557C**

TEST RESULTS (less than 3/4" material)

Maximum Dry Density: **122.51 pcf**

Optimum Water Content: **9 %**

Percent Greater Than 3/4" Sieve: **7 %**

ROCK CORRECTED RESULTS*

Corrected Maximum Dry Density: **124 pcf**

Corrected Optimum Water Content: **9 %**

* Based on the ASTM D 4718 method.

001037.040.041 2/10/16 N:\PROJECTS\1037.040.041.GPJ COMPACTION FIGURE (PARABOLA WITH POINTS)

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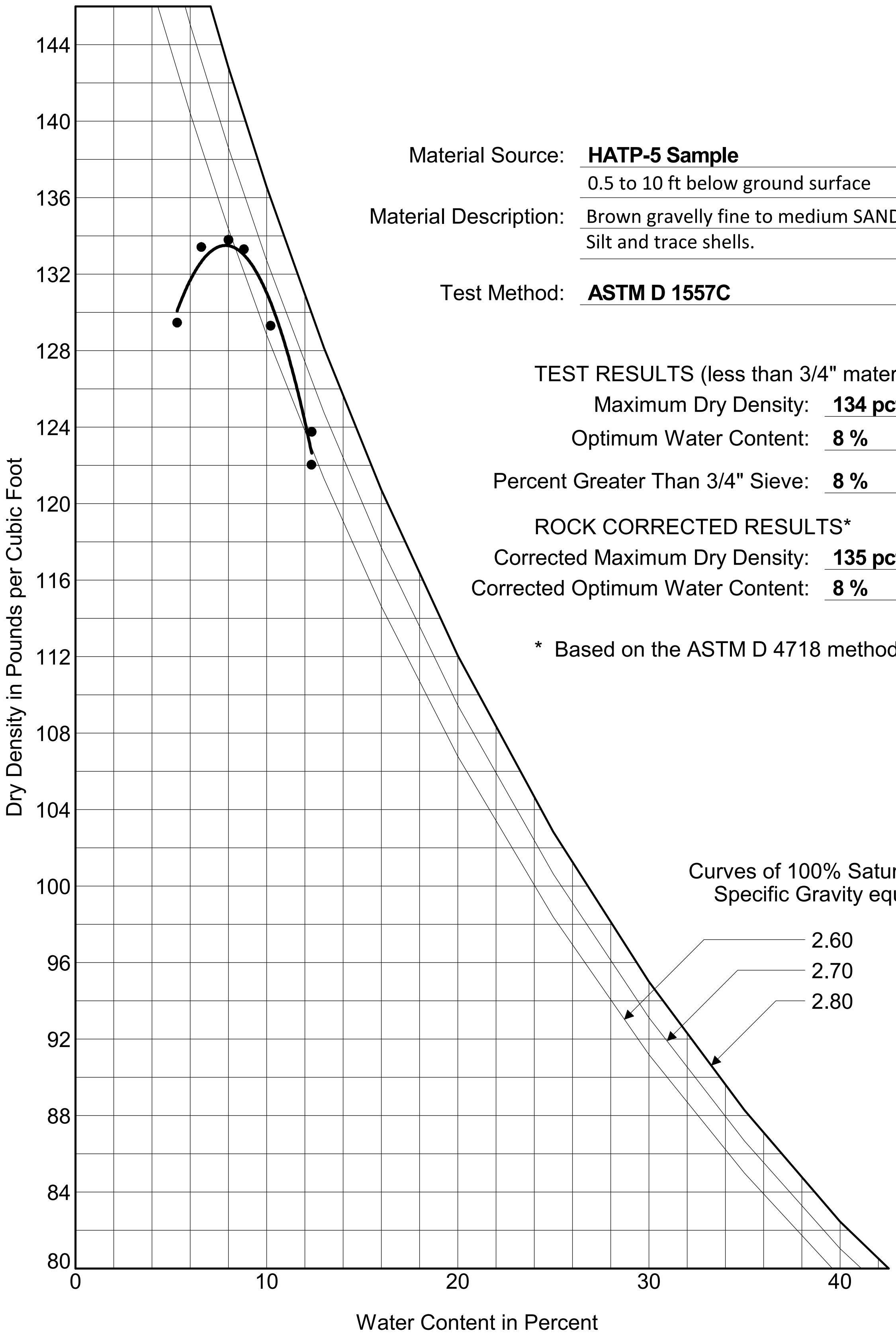
Hilton Avenue Stockpile
Bellingham, WA

Moisture-Density Relationship

Figure
F.1a-8



Material Source: **HATP-5 Sample**
0.5 to 10 ft below ground surface

Material Description: Brown gravelly fine to medium SAND with Silt and trace shells.

Test Method: **ASTM D 1557C**

TEST RESULTS (less than 3/4" material)
Maximum Dry Density: **134 pcf**
Optimum Water Content: **8 %**

Percent Greater Than 3/4" Sieve: **8 %**

ROCK CORRECTED RESULTS*
Corrected Maximum Dry Density: **135 pcf**
Corrected Optimum Water Content: **8 %**

* Based on the ASTM D 4718 method.

001037.040.041 2/10/16 N:\PROJECTS\1037.040.041.GPJ COMPACTION FIGURE (PARABOLA WITH POINTS)

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Hilton Avenue Stockpile
Bellingham, WA

Moisture-Density Relationship

Figure
F.1a-9

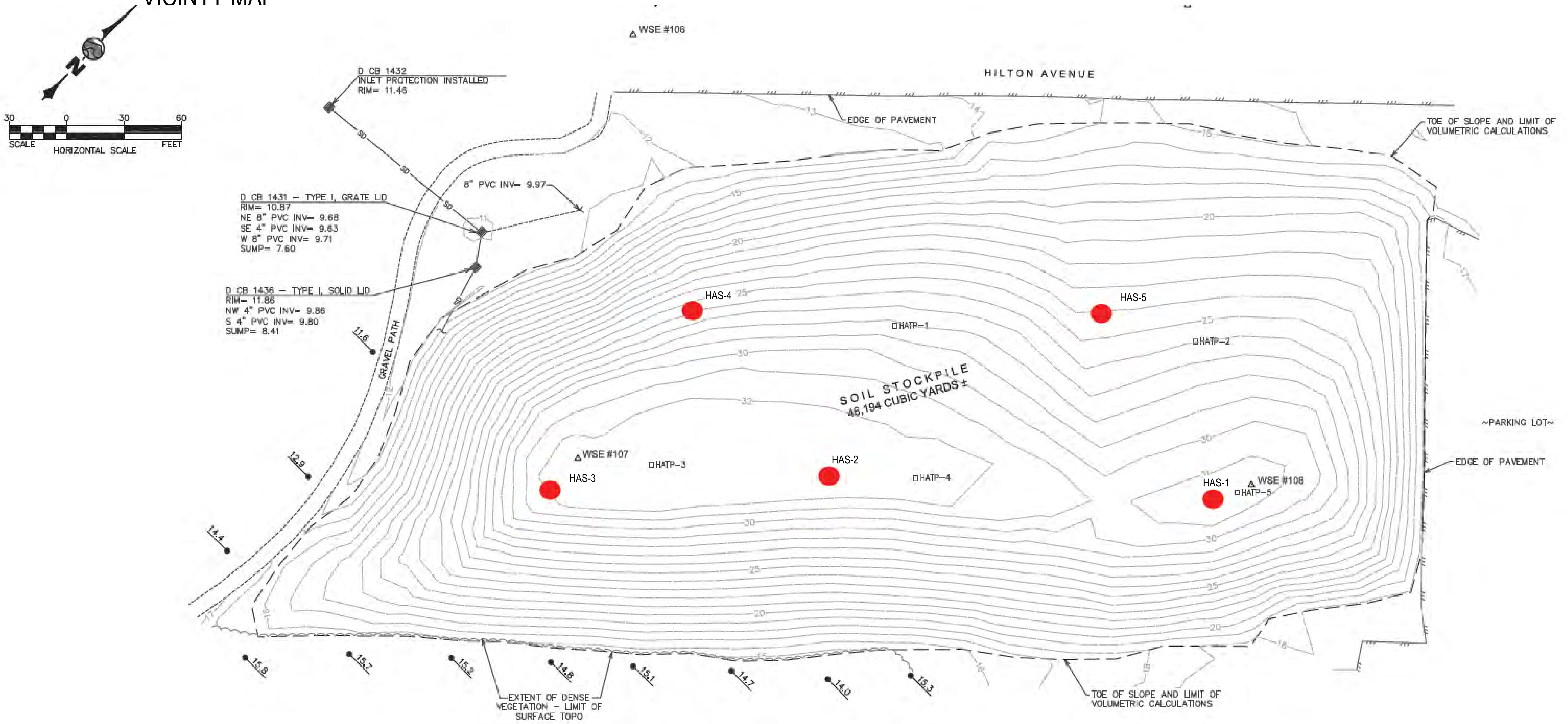
ATTACHMENT F.1b

Chemical Analysis – 2015

VICINITY MAP

Legend

●	HAS-	Boring Location for Composite Sample (Landau Associates 12/10/15)
☐	HATP-	Test Pit Location for Geotechnical Testing (Landau Associates 10/26/15)
—20—		Existing Contours NAVD88 (Wilson Survey/Engineering 10/27/15)



LANDAU ASSOCIATES, INC.

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Soil Stockpile Evaluation
Hilton Avenue
Port of Bellingham, Washington

Composite Sample Boring Locations

Figure
F.1b-1

HAS-1

SAMPLE DATA | SOIL PROFILE | GROUNDWATER

Drilling Method: Direct Push

Ground Elevation (ft): 31

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		GROUNDWATER
0						GP	Gray/brown, sandy GRAVEL (medium dense, damp) (no odor, no sheen)	
		d3				SP-SM	Gray, fine to coarse SAND with silt (medium dense, damp) (no odor, no sheen)	Groundwater not encountered.
5	HAS-1 composited from every interval	d3					No Recovery	
10		d3				ML	Gray/brown SILT with sand (loose to medium stiff, damp) (no odor, no sheen)	
15		d3				SM	Light brown, medium to coarse SAND (moist) (loose) (no odor, no sheen)	
20								
25								

Boring Completed 12/10/15
Total Depth of Boring = 20.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1037. 1/14/16 N:\PROJECTS\0001037.060.061.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

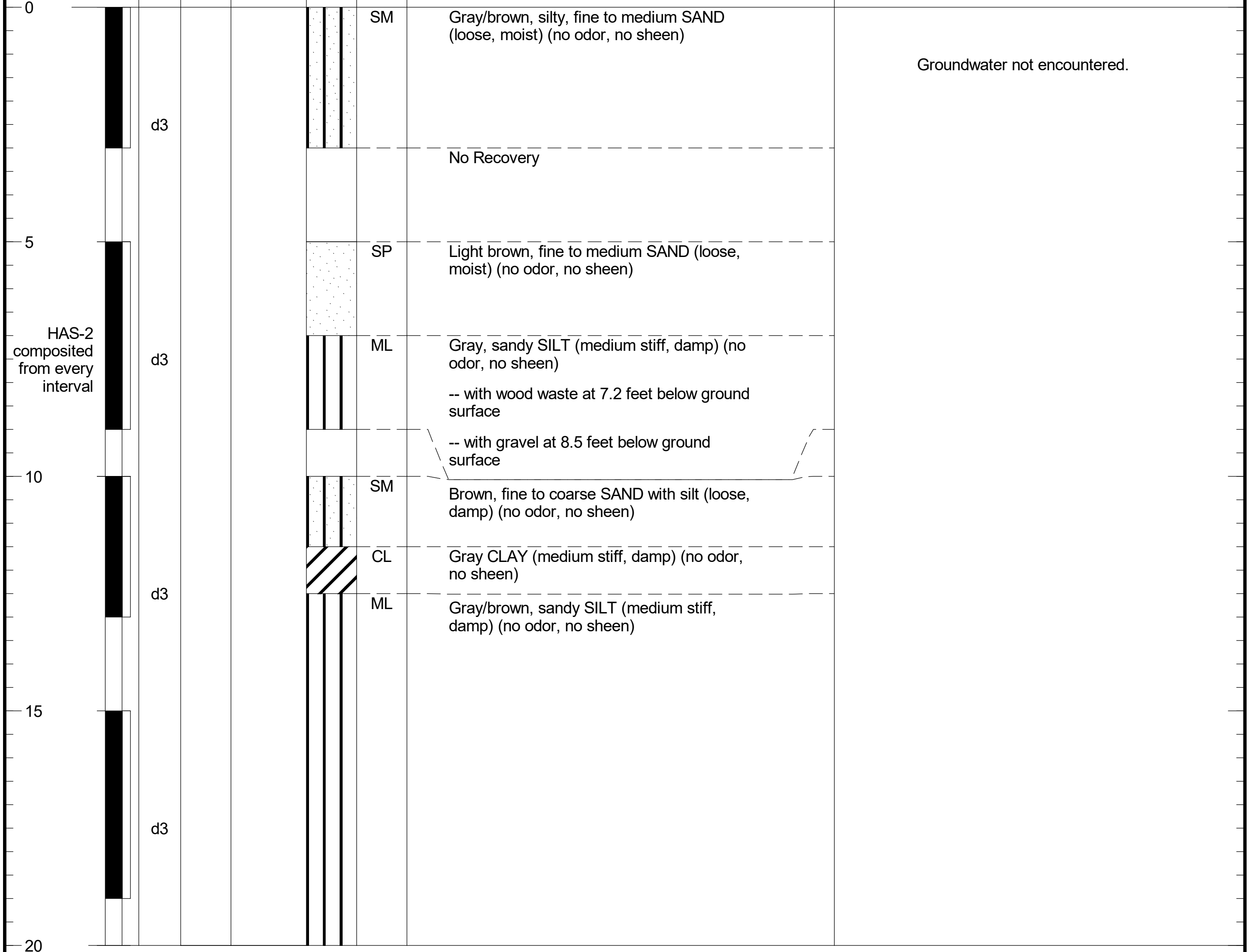
Cornwall Ave - Hilton Ave
Stockpile
Bellingham, Washington

Log of Boring HAS-1

Figure
F.1b-2

HAS-2

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): 32	



SM — Gray/brown, silty, fine to medium SAND (loose, moist) (no odor, no sheen)

No Recovery

SP — Light brown, fine to medium SAND (loose, moist) (no odor, no sheen)

ML — Gray, sandy SILT (medium stiff, damp) (no odor, no sheen)

-- with wood waste at 7.2 feet below ground surface

-- with gravel at 8.5 feet below ground surface

SM — Brown, fine to coarse SAND with silt (loose, damp) (no odor, no sheen)

CL — Gray CLAY (medium stiff, damp) (no odor, no sheen)

ML — Gray/brown, sandy SILT (medium stiff, damp) (no odor, no sheen)

Groundwater not encountered.

Boring Completed 12/10/15
Total Depth of Boring = 20.0 ft.

25

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Ave - Hilton Ave
Stockpile
Bellingham, Washington

Log of Boring HAS-2

Figure
F.1b-3

HAS-3

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol	Drilling Method: Direct Push Ground Elevation (ft): 32	
0						SM	Gray/brown, silty, fine to medium SAND with gravel (medium dense, moist) (no odor, no sheen)	Groundwater not encountered.
		d3						
5								
	HAS-3 composited from every interval	d3					-- with CLAY from 6.7 to 6.9 feet below ground surface	
10						CL	Gray, sandy CLAY with sand (soft, damp) (no odor, no sheen)	
		d3				SM	Gray/brown, silty, fine to coarse SAND (loose, damp) (no odor, no sheen)	
							No recovery	
15						CL	Gray CLAY (soft, damp) (no odor, no sheen)	
						SM	Gray, sandy soft (loose, damp) (no odor, no sheen)	
		d3					-- with gravel at 17.5 feet below ground surface	
							-- with wood debris at 17.7 feet below ground surface	
20								
25								

Boring Completed 12/10/15
Total Depth of Boring = 20.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Ave - Hilton Ave
Stockpile
Bellingham, Washington

Log of Boring HAS-3

Figure
F.1b-4

HAS-4

Drilling Method: Direct Push

Ground Elevation (ft): 25

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		
0						SM	Gray/brown, silty, fine to coarse SAND (medium dense, damp) (no odor, no sheen)	Groundwater not encountered.
		d3				CL	Gray CLAY (soft, damp) (no odor, no sheen)	
							No recovery	
5						SM	Gray, silty SAND (loose, wet) (no odor, no sheen)	
						CL	Gray, sandy CLAY (medium stiff, damp) (no odor, no sheen)	
	HAS-4 composited from every interval	d3				ML	Gray, sandy SILT (medium stiff, damp) (no odor, no sheen)	
10						SM	Gray/brown, silty, fine to coarse SAND (loose, damp) (no odor, no sheen)	
		d3				CL	Gray CLAY with trace sand (medium stiff, moist) (no odor, no sheen)	
15								

Boring Completed 12/10/15
Total Depth of Boring = 15.0 ft.

20

25

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

LANDAU ASSOCIATES

Cornwall Ave - Hilton Ave
Stockpile
Bellingham, Washington

Log of Boring HAS-4

Figure
F.1b-5

HAS-5

Drilling Method: Direct Push

Ground Elevation (ft): 24

SAMPLE DATA					SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	Graphic Symbol	USCS Symbol		
0		d3				SM	Brown, fine to coarse SAND with gravel (loose, wet) (no odor, no sheen)	Groundwater not encountered.
							No Recovery	
5	HAS-5 composited from every interval	d3				SM	Gray, clayey, fine to coarse SAND (medium dense) (no odor, no sheen)	
						CL	Gray CLAY (medium stiff, wet) (no odor, no sheen)	
						SM	Gray/brown, silty, fine to coarse SAND (medium dense, moist) (no odor, no sheen)	
10		d3				SP	Light brown, fine to medium SAND (loose, moist) (no odor, no sheen)	
15								
20								
25								

Boring Completed 12/10/15
Total Depth of Boring = 15.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

1037. 1/14/16 N:\PROJECTS\0001037.060.061.GPJ SOIL BORING LOG

LANDAU ASSOCIATES

Cornwall Ave - Hilton Ave
Stockpile
Bellingham, Washington

Log of Boring HAS-5

Figure
F.1b-6

Table F.1b-1
Preliminary Screening Levels for Determination of Analytical Method
Hilton Avenue Soil Characterization for Cornwall Avenue Landfill
Bellingham, Washington

		Soil, Method B, Most-Restrictive Standard Formula Value, Direct Contact (ingestion only), Unrestricted Land Use (mg/kg)^{a,b} *(mB)*	Soil Protective of Terrestrial Species (mg/kg)^{c} *(TEE)*	Marine Sediment Dry Weight Equivalent SQS (mg/kg) *(SQS)*	**Unsaturated Soil** Concentration Protective of Leachability to Groundwater for **Unrestricted** Land Use (mg/kg)^{d} *(gwl-u)*	**Saturated Soil** Concentration Protective of Leachability to Groundwater for **Unrestricted** Land Use (mg/kg)^{d} *(gwl-s)*	Natural Background Concentrations^{e} *(back)*	Laboratory Reporting Limit^{j} *PQL*	Preliminary Screening Level for Determination of Analytical Method	Rationale for Preliminary Screening Level	Proposed Analytical Method
Total Petroleum Hydrocarbons											
Diesel Range Hydrocarbons	68334-30-5	¥	200					25	200	TEE	TPH-HCID/TPH-Dx
Oil Range Hydrocarbons	TPH-Oil	¥						100	--	--	TPH-HCID/TPH-Dx
Heavy Metals											
Arsenic	7440-38-2	0.67	10	57	0.29	0.015	20	0.5	20^{f}	back	EPA 6010C
Chromium (Total)	7440-47-3		42	260			48	0.5	48^{f}	back	EPA 6010C
Copper	7440-50-8	3,200	50	390	1.1	0.053	36	0.2	36^{f}	back	EPA 6010C
Lead	7439-92-1		50	450	1600	81	24	0.1	50	TEE	EPA 6010C
Mercury^{g}	7439-97-6		0.1	0.41	0.026	0.0013	0.07	0.025	0.07^{f}	back	EPA 7471A
Zinc	7440-66-6	24,000	86	410	100	5	85	1	85^{f}	back	EPA 6010C
Polycyclic Aromatic Hydrocarbons (PAHs)											
Anthracene	120-12-7	24,000		0.96	47	2.3		0.005	0.96	SQS	EPA 8270D
Benzo(g,h,i)perylene	191-24-2			0.67	N/A	N/A		0.005	0.67	SQS	EPA 8270D
Fluoranthene	206-44-0	3,200		1.7	34	1.7		0.005	1.7	SQS / gwl-s	EPA 8270D
Fluorene	86-73-7	3,200	30	0.54	4.9	0.25		0.005	0.25	gwl-s	EPA 8270D
Phenanthrene	85-01-8			1.5	N/A	N/A		0.005	1.5	SQS	EPA 8270D
Pyrene	129-00-0	2,400		2.6	220	11		0.005	2.6	SQS	EPA 8270D
1-Methylnaphthalene	90-12-0	35			N/A	N/A		0.005	35	mB	EPA 8270D
2-Methylnaphthalene	91-57-6	320		0.67	7.9	0.4		0.005	0.4	gwl-s	EPA 8270D
Naphthalene^{g}	91-20-3	1,600		2.1	21	1.1		0.005	1.1	gwl-s	EPA 8270D
Benz(a)anthracene	56-55-3	1.4		1.3	0.76	0.038		0.005	0.038	gwl-s	EPA 8270D
Benzo(b)fluoranthene	205-99-2	1.4		3.2	2.5	0.13		0.005	0.13	gwl-s	EPA 8270D
Benzo(k)fluoranthene	207-08-9	14		3.2	3.3	0.17		0.005	0.17	gwl-s	EPA 8270D
Chrysene	218-01-9	140		1.4	2.6	0.13		0.005	0.13	gwl-s	EPA 8270D
Other Semi-Volatile Organics											
2,4-Dimethylphenol	105-67-9	1,600		0.029	150	7.50		0.05	0.05	PQL	EPA 8270D
2-Methylphenol	95-48-7	4,000		0.063	N/A	N/A		0.02	0.063	SQS	EPA 8270D
Other Semi-Volatile Organics (continued)											
4-Methylphenol	106-44-5	400		0.67	N/A	N/A		0.02	0.67	SQS	EPA 8270D
Benzoic acid	65-85-0	320,000		0.65	N/A	N/A		0.2	0.65	SQS	EPA 8270D
Dibenzofuran	132-64-9	80		0.54	3.1	0.16		0.02	0.16	gwl-s	EPA 8270D
Diethyl phthalate	84-66-2	64,000	100	0.2	13	0.69		0.02	0.20	SQS	EPA 8270D
Dimethyl phthalate	131-11-3		200	0.071	N/A	N/A		0.02	0.071	SQS	EPA 8270D
Pentachlorophenol	87-86-5	2.5	3	0.36	1.3	0.065		0.1	0.1	PQL	EPA 8270D
Phenol	108-95-2	24,000	30	0.42	3000	180		0.03	0.42	SQS	EPA 8270D
Retene	483-65-8			N/A	N/A	N/A			--	--	EPA 8270D
Dioxins/Furans											
1,2,3,4,6,7,8-HpCDD	35822-46-9							0.000001	--	--	EPA 1613
OCDD	3268-87-9							0.00001	--	--	EPA 1613
Chlorinated dibenzo-p-dioxins (total) (TEQ)^{i}			0.000002					0.000001	0.000002	TEE	EPA 1613
OCDF	39001-02-0							0.000002	--	--	EPA 1613
Chlorinated dibenzofurans (total) (TEQ)^{i}			0.000002					0.000001	0.000002	TEE	EPA 1613
Summed Dioxin/Furan TEQ	2,3,7,8 TCDD	0.000011					0.0000052^{j}	0.000001	0.000011	mB	EPA 1613

Table F.1b-1
Preliminary Screening Level for Determination of Analytical Method
Hilton Avenue Soil Characterization for Cornwall Avenue Landfill
Bellingham, Washington

Numerical Criteria Notes:

Blank cells are intentional.

a Values taken from Ecology's CLARC Database May 15, 2012; except as noted.

b Method B values are most restrictive of carcinogenic or non-carcinogenic values presented in Ecology's CLARC Database, pulled on May 15, 2012.

c Most stringent criterion for plants, soil biota, or wildlife in WAC 173-340-900 Table 749-3. For sites that qualify for a simplified TEE evaluation, use Table 749-2.

d Calculated values from 3-phase model, per MTCA Equation 747-1, with groundwater value (Cw) as most stringent value from groundwater screening level process (Table 1), and Dilution Factor = 20.

e Values are from Ecology’s Natural Background Soil Metals Concentrations in Washington State (Ecology 1994).

f Adjusted to compensate for natural background concentrations.

g Analyte has the potential to contaminate indoor air to unacceptable levels via the vapor intrusion pathway, per Table B-1 (Appendix B) of Ecology's Guidance for Evaluation of Soil Vapor Intrusion (Ecology 2009). Consult with Ecology, as a site-specific vapor intrusion evaluation may be necessary.

h Value based on total benzofluoranthenes.

i Calculated using avian and mammalian TEQs (World Health Organization 2005) Toxic Equivalency Factors used for calculation of dioxin/furan TEQ (van den Berg et al. 2006).

j Value from Dave Bradley's Natural Background for Dioxins/Furans in Washington Soils—Technical Memorandum #8 (Ecology 2010).

j PQLs derived from the Harris Avenue Shipyard RI/FS Screening Level Workbook

¥ Cleanup level can be calculated using volatile petroleum hydrocarbon (VPH) and extractable petroleum hydrocarbon (EPH) data, per WAC 173-340-700(8)(ii).

Abbreviations:

CAS	Chemical Abstracts Service.
CLARC	Cleanup Levels and Risk Calculation.
Ecology	Washington State Department of Ecology.
HpCDD	Heptachlorodibenzo-p-dioxin.
MTCA	Model Toxics Control Act.
OCDD	Octachlorodibenzo-p-dioxin.
OCDF	Octachlorodibenzofuran.
TEE	Terrestrial ecological evaluation.
TEF	Toxic equivalency factor.
TEQ	Toxic equivalent quantity.
TPH	Total petroleum hydrocarbons.
USEPA	U.S. Environmental Protection Agency.
WAC	Washington Administrative Code.

Table F.1b-2
Hilton Avenue Soil Analytical Results - Detections
Cornwall Avenue Landfill
Bellingham, Washington

Analyte	Screening Level Protective of Most Stringent Potential Pathway^b	Sample Location, Laboratory ID, Sample Date, and Results				
		HAS-1 ASM9A 10332961001 12/10/2015	HAS-2 ASM9B 10332961002 12/10/2015	HAS-3 ASM9C 10332961003 12/10/2015	HAS-4 ASM9D 10332961004 12/10/2015	HAS-5 ASM9E 10332961005 12/10/2015
Total Organic Carbon (%) Plumb, 1981						
Total Organic Carbon	--	**0.69** J	**0.933** J	**1.93** J	**0.979** J	**0.759** J
Total Metals (mg/kg) EPA-6010C/EPA-7471A						
Arsenic	20	10 U	**6**	**6**	**6**	**6**
Chromium	48	**46** J	**26.8**	**29.5**	**30.8**	**22.7**
Copper	36	**40.7** J	**19.1**	**21.4**	**22.6**	**28.0**
Lead	50	6 U	**2**	**3**	**3**	**28**
Mercury	0.07	**0.03**	**0.03**	**0.04**	**0.04**	**0.02**
Zinc	85	**73** J	**39**	**43**	**49**	**83**
Total Petroleum Hydrocarbons (mg/kg) **NWTPH-Dx**						
Diesel-range organics	200	NA	NA	NA	NA	**29**
Oil-range organics	--	NA	NA	NA	NA	**170**
Semivolatile Organic Compounds (ug/kg) SW8270D						
Phenol	420	19 U	19 U	19 U	20 U	110 U
2-Methylphenol	63	19 U	19 U	19 U	20 U	110 U
4-Methylphenol	670	19 U	**20**	**27**	**30**	110 U
2,4-Dimethylphenol	50	95 U	94 U	95 U	98 U	560 U
Benzoic Acid	650	**210**	190 U	190 U	**260**	1100 U
Naphthalene	1,100	**23**	**43**	**48**	**91**	110 U
2-Methylnaphthalene	400	**33**	**66**	**68**	**130**	110 U
Dimethylphthalate	71	**24**	**39**	**57**	20 U	110 U
Dibenzofuran	160	**19**	**36**	**38**	**63**	110 U
Diethylphthalate	200	19 U	19 U	19 U	20 U	110 U
Fluorene	250	19 U	19 U	19 U	20 U	110 U
Pentachlorophenol	100	95 U	94 U	95 U	98 U	560 U
Phenanthrene	1,500	**23**	**28**	**30**	**40**	110 U
Anthracene	960	19 U	19 U	19 U	20 U	110 U
Fluoranthene	1,700	19 U	**19**	**19**	**20**	110 U
Pyrene	2,600	19 U	**21**	19 U	**29**	110 U
Benzo(a)anthracene	38	19 U	19 U	19 U	20 U	110 U
Chrysene	130	19 U	19 U	19 U	20 U	110 U
Benzo(g,h,i)perylene	670	**28**	19 U	19 U	**24**	110 U
Retene	--	**130**	**250**	**320**	**370**	**330**
1-Methylnaphthalene	35,000	**28**	**55**	**60**	**120**	110 U
Total Benzofluoranthenes	150^c	38 U	38 U	38 U	39 U	220 U
Dioxins/Furans (ng/kg) EPA 1613						
1,2,3,4,6,7,8-HpCDD	--	**10**	**7.7**	**12**	**8.6**	**38**
OCDF	--	10 U	10 U	10 U	10 U	**16**
OCDD	--	**140**	**79**	**140**	**90**	**380**
Total TCDD	2	1 U	1 U	1 U	1 U	**1.6**
Total PeCDF	--	5 U	5 U	5 U	5 U	**5.3**
Total HpCDF	--	5 U	5 U	5 U	5 U	**11**
Total HpCDD	--	**27**	**24**	**34**	**26**	**70**
2,3,7,8 TCDD TEQ	11	**0.24**	**0.16**	**0.25**	**0.18**	**0.78**

[a] Preliminary screening level developed to determine the required laboratory reporting limits.

[b] Soil screening levels based on potential pathways identified by Ecology. Includes consideration of direct contact, terrestrial ecological exposure, marine sediment, and protection of groundwater for unsaturated and saturated soil

[c] Screening value based on average of Benzo(b)fluoranthene and Benzo(k)fluoranthene

U = Indicates the compound was not detected at the reported concentration.
J = Indicates the analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
Bold = Detected compound.
Blue shading = Exceedance of screening level protective of groundwater.
EPA = US Environmental Protection Agency
ug/kg = micrograms per kilogram
mg/kg = milligrams per kilogram
ng/kg = nanograms per kilogram
NA = not analyzed
TEQ = toxicity equivalent

ATTACHMENT F.1c

Chemical Analysis – Historical Data

Table F.1c-3
1998 Analytical Results
Hilton Avenue Soil Samples

Analyte	Screening Level[a]	Sample Location, Lab ID, and Sample Date				
		TP-1 B809044-01 9/1/1998	TP-2 B809044-02 9/1/1998	TP-3 B809044-03 9/1/1998	TP-4 B809044-04 9/1/1998	TP-5 B809044-05 9/1/1998
TOTAL METALS (mg/kg) **EPA Method 6020/7471A**						
Antimony		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Arsenic	20[b]	**2.60**	**2.15**	**2.25**	**2.60**	**2.22**
Beryllium		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Cadmium		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Chromium	48[c]	**13.3**	**16.5**	**11.2**	**14.0**	**17.5**
Copper	36[c]	**11.3**	**11.3**	**17.2**	**8.43**	**13.4**
Lead	250[b]	**2.77**	**2.80**	**1.69**	**1.97**	**2.25**
Nickel	48[c]	**15.2**	**16.2**	**11.4**	**12.1**	**38.8**
Selenium		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Silver		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Thallium		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Zinc	85[c]	**25.7**	**27.4**	**20.1**	**21.7**	**23.6**
Mercury	2[b]	0.100 U	0.100 U	**0.105**	0.100 U	0.100 U
CONVENTIONALS						
Cyanide (total) (mg/kg; EPA 9010B)		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
PCBs (ug/kg) **EPA Method 8082**						
Aroclor 1016		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1221		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1232		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1242		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1248		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1254		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1260		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1262		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U
Aroclor 1268		50.0 U	50.0 U	50.0 U	50.0 U	50.0 U

Table F.1c-3
1998 Analytical Results
Hilton Avenue Soil Samples

Analyte	Screening Level[a]	Sample Location, Lab ID, and Sample Date				
		TP-1 B809044-01 9/1/1998	TP-2 B809044-02 9/1/1998	TP-3 B809044-03 9/1/1998	TP-4 B809044-04 9/1/1998	TP-5 B809044-05 9/1/1998
VOLATILES (mg/kg) **EPA Method 8260B**						
Acetone		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Benzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bromodichloromethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bromoform		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bromomethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Butanone		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Carbon disulfide		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Carbon tetrachloride		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Chlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Chloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Chloroform		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Chloromethane		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Dibromochloromethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,2-Dichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,3-Dichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,4-Dichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,1-Dichloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,2-Dichloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,1-Dichloroethene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
cis-1,2-Dichloroethene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
trans-1,2-Dichloroethene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,2-Dichloropropane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
cis-1,3-Dichloropropene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
trans-1,3-Dichloropropene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Ethylbenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Hexanone		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Methylene chloride		1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
4-Methyl-2-pentanone		2.00 U	2.00 U	2.00 U	2.00 U	2.00 U
Styrene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,1,2,2-Tetrachloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Tetrachloroethene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Toluene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,1,1-Trichloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,1,2-Trichloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Trichloroethene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Vinyl chloride		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Xylenes (total)		0.400 U	0.400 U	0.400 U	0.400 U	0.400 U

Table F.1c-3
1998 Analytical Results
Hilton Avenue Soil Samples

Analyte	Screening Level[a]	Sample Location, Lab ID, and Sample Date				
		TP-1 B809044-01 9/1/1998	TP-2 B809044-02 9/1/1998	TP-3 B809044-03 9/1/1998	TP-4 B809044-04 9/1/1998	TP-5 B809044-05 9/1/1998
SEMIVOLATILES (mg/kg) **EPA Method 8270C**						
Acenaphthene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Acenaphthylene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Aniline		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Anthracene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Benzoic acid		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Benzo(a)anthracene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Benzo(b)fluoranthene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Benzo(k)fluoranthene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Benzo(g,h,i)perylene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Benzo(a)pyrene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Benzyl alcohol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bis(2-chloroethoxy)methane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bis(2-chloroethyl)ether		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bis(2-chloroisopropyl)ether		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Bis(2-ethylhexyl)phthalate		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
4-Bromophenyl phenyl ether		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Butyl benzyl phthalate		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Carbazole		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
4-Chloroaniline		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Chloronaphthalene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
4-Chloro-3-methyphenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Chlorophenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
4-Chlorophenyl phenyl ether		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Chrysene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Dibenz(a,h)anthracene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Dibenzofuran		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Di-n-butyl phthalate		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
1,3-Dichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,4-Dichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,2-Dichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
3,3'-Dichlorobenzidine		5.00 U	5.00 U	5.00 U	5.00 U	5.00 U
2,4-Dichlorophenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Diethyl phthalate		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2,4-Dimethylphenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Dimethyl phthalate		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
4,6-Dinitro-2-methylphenol		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
2,4-Dinitrophenol		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
2,4-Dinitrotoluene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2,6-Dinitrotoluene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Di-n-octyl phthalate		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Fluoranthene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Fluorene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Hexachlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Hexachlorobutadiene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Hexachlorocyclopentadiene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U

Table F.1c-3
1998 Analytical Results
Hilton Avenue Soil Samples

Analyte	Screening Level[a]	Sample Location, Lab ID, and Sample Date				
		TP-1 B809044-01 9/1/1998	TP-2 B809044-02 9/1/1998	TP-3 B809044-03 9/1/1998	TP-4 B809044-04 9/1/1998	TP-5 B809044-05 9/1/1998
Hexachloroethane		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Indeno(1,2,3-cd)pyrene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Isophorone		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Methylnaphthalene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Methylphenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
3&4-Methylphenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Naphthalene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Nitroaniline		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
3-Nitroaniline		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
4-Nitroaniline		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Nitrobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2-Nitrophenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
4-Nitrophenol		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
N-Nitrosodiphenylamine		0.200 U	0.200 U	0.200 U	0.200 U	0.200 U
N-Nitrosodi-n-propylamine		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Pentachlorophenol		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Phenanthrene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Phenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Pyrene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
1,2,4-Trichlorobenzene		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
2,4,5-Trichlorophenol		0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
2,4,6-Trichlorophenol		0.100 U	0.100 U	0.100 U	0.100 U	0.100 U

Footnotes

[a] Screening levels only developed for detected constituents. , and based on MTCA Method A

[b] Method A cleanup level for unrestricted site use

[c] Natural background

U = Indicates the compound was not detected at the reported concentration.

Bold = Detected compound.

Box = Exceedance of screening level.

EPA = US Environmental Protection Agency

ug/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

PCB = polychlorinated biphenyls

Environmental Site Assessment
Squalicum Peninsula Project
GeoEngineers, November 1998

Report
Environmental Site Assessment
Proposed Squalicum Peninsula Project
Bellingham, Washington

November 24, 1998

For
Port of Bellingham

F-2-7-H-00288

GeoEngineers

File No. 0307-024-02-5150

GeoEngineers

November 24, 1998

Consulting Engineers
and Geoscientists
Offices in Washington,
Oregon, and Alaska

Port of Bellingham
P.O. Box 1677
Bellingham, Washington 98227-1677

Attention: Adam Fulton

We are pleased to submit three copies of our report entitled "Environmental Site Assessment, Proposed Squalicum Peninsula Project, Bellingham, Washington." Our environmental services were completed in general accordance with our standard agreement with the Port of Bellingham dated September 2, 1998. Results of the chemical analytical testing were previously forwarded to the Port in our memorandum dated September 23, 1998.

We appreciate the opportunity to provide environmental services for the proposed project. Please call if you have any questions regarding this report.

Yours very truly,
GeoEngineers, Inc.

J. Robert Gordon, P.E.
Principal

REC:JRG:dam
030702402R.doc

File No. 0307-024-02-5150

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REPORT
ENVIRONMENTAL SITE ASSESSMENT
PROPOSED SQUALICUM PENINSULA PROJECT
BELLINGHAM, WASHINGTON

INTRODUCTION

This report presents the results of our environmental site assessment services for the proposed Squalicum Peninsula Project to be located in Bellingham, Washington. The site is located along Bellingham Bay as shown in the Vicinity Map, Figure 1.

The site is located on the Squalicum Peninsula at the western terminus of Thomas Glen Drive in the northeast quarter of Section 25, Township 38 North, Range 2 East. The Squalicum Peninsula was constructed by placing a sand and gravel dike around the perimeter of what is now the peninsula and placing dredge spoils from the surrounding area into the enclosed area. The Squalicum Peninsula Project will consist of three buildings with a single, continuous underground parking garage. At the time of our environmental study, the footprint of the parking garage had a proposed footprint of approximately 100,000 square feet in the configuration shown in the Site Plan, Figure 2. At the time of this study, it was envisioned that the parking garage floor elevation would be approximately 12 feet, which is about 6 feet below existing grades. Approximately 25,000 cubic yards of soil will be excavated, of which half will be kept on site for landscaping berms and the other half will be exported off-site to as yet undetermined sites. We understand the Port and/or the excavation contractor may identify specific disposal sites.

SCOPE

It has been confirmed through various studies that some Bellingham Bay sediments are contaminated from previous historical industrial and/or commercial activities. Because of the concern for contaminated materials being present within the dredge fill soils that were used to create the peninsula, the Port of Bellingham (POB) requested these environmental site assessment services to evaluate potential environmental liabilities with off-site disposal of the soils for the proposed Squalicum Peninsula Project. Our specific scope of services that were performed based on discussions with POB staff is outlined below:

1. Obtain and review available information from the POB, including the U.S. Coast Guard (USCG) environmental report and reports related to the cleanup of Bellingham Bay and Bellingham Bay Demonstration Project.
2. Perform a visual evaluation of potential contamination of the fill soil samples obtained during our concurrent geotechnical exploration for the proposed Squalicum Peninsula Project.
3. Excavate five test pits within the proposed parking garage excavation with a backhoe subcontracted to GEI.
4. Visually evaluate the fill soils encountered within the test pits to the proposed basement elevation for the presence of potential contamination and collect one composite soil sample from each test pit for chemical analytical testing.

5. Conduct field screening on portions of each soil sample for evidence of contamination using visual, water sheen and headspace vapor screening methods.
6. Submit one soil sample from each test pit for chemical analysis of WTPH-HCID (Washington total petroleum hydrocarbons - hydrocarbon identification) and Priority Pollutants, including: polychlorinated biphenyls (PCBs) by EPA Method 8082, volatile organic compounds (VOCs) by EPA Method 8240, semivolatile organic compounds (SVOCs) by EPA Method 8270, cyanide and priority pollutant metals by various EPA methods.
7. Evaluate our field observations and the analytical results with respect to environmental and regulatory concerns, including Model Toxics Control Act (MTCA) Method A cleanup levels. The metals will also be compared to "typical background levels."
8. Coordinate results with the POB and provide preliminary results as soon as information is available.
9. Prepare a written report that summarizes the results and our conclusions.

REVIEW OF AVAILABLE INFORMATION

GENERAL

Historical information obtained from the Port of Bellingham indicates that no development or site uses occurred prior to the construction of the peninsula and the site has no known history of potential environmental conditions. The Squalicum Peninsula was created in the early 1980s by placing dredge spoils within perimeter dikes during dredging of the I & J waterway for a Corps of Engineers project. The I & J Waterway is located on the southeast side of the peninsula. The marina on the northwest side of the site was constructed after the peninsula was completed.

SEDIMENT QUALITY DATA REVIEW - WHATCOM WATERWAY

The following two reports were reviewed to obtain information regarding sediment quality in the I &J Waterway and to evaluate whether dredged fill at the site may be contaminated:

- "Draft Remedial Investigation Report, Whatcom Waterway, Bellingham, Washington," prepared by Hart Crowser for Georgia-Pacific West, Inc., dated May 7, 1996
- "Final Remedial Investigation/Feasibility Study Work Plan, Whatcom Waterway Site, Bellingham, Washington," prepared by Hart Crowser, for Georgia-Pacific West, Inc., dated September 3, 1997.

The reports contained a review of sediment data from 17 samples collected in the I & J Waterway prior to 1996 and 16 samples collected in 1996 as part of the Georgia Pacific remedial investigation (RI). The data were reviewed and evaluated for potential contaminants with respect to MTCA Method A, B and C Cleanup levels.

The chemical analytical data generally indicates that mercury is the primary chemical of concern in the I & J Waterway. The Georgia Pacific (GP) plant located south of the Whatcom Creek Waterway (Figure 1) is the likely source of the mercury contamination. Other chemical compounds were either not detected or were detected at concentrations less than MTCA cleanup levels. The chemical data is summarized below:

- **Mercury** concentrations ranged from 0.07 to 6.7 milligrams per kilogram (mg/kg) in the 33 samples. The MTCA Method A cleanup level for mercury is 1.0 mg/kg. Concentrations of mercury detected in 8 of 33 samples exceeded the cleanup level.
- **Bis (2-ethylhexl)phthlate** was detected in two samples at concentrations less than the MTCA Method C cleanup level.
- **2,4- Dimethylphenol** was detected in three samples at concentrations less than the MTCA Method C cleanup level.
- **4-methylphenol** was detected in two samples. Cleanup levels have not been established for 4-methylphenol.
- **2-methylphenol** was detected in two samples. Cleanup levels have not been established for 2-methylphenol.
- **Phenol** was detected in two samples at concentrations less than the MTCA Method C cleanup level.
- **Acenaphthene** was detected in one sample at concentrations less than the MTCA Method C cleanup level.

Hart Crowser concluded that in general, mercury concentrations in surface sediments were significantly less than concentrations detected at depth reflecting the implementation of source controls by GP beginning in the early 1970s, and associated sediment natural recovery.

Sediment transport was likely very different prior to construction of the Squalicum Peninsula and it is difficult to interpret what the sediment quality of the I & J Waterway may have been at the time the dredging and subsequent creation of the peninsula occurred. However, mercury concentrations in sediment at some locations in the I & J Waterway are currently greater than MTCA cleanup levels and it is possible that material dredged from the waterway in the 1980s contained similar mercury concentrations.

Concentrations of organic compounds detected in sediment samples collected from the I & J waterway were generally well below Method B and C cleanup levels. It is our opinion that organic compounds are not chemicals of concern in dredge fill at the Peninsula.

Based on review of the RI and existing sediment data, we conclude that the selected suite of chemical analytical tests is adequate for the determination of environmental soil conditions at the subject site.

USCG BELLINGHAM RELOCATION

Other information obtained from the POB was contained in a USCG letter report titled "Results of Test Pit Sampling, USCG Station Bellingham Relocation, Contract No. DTCG50-94-D0643R10, TC No. 0908-01, prepared by Tetra Tech, Inc., dated April 17, 1996. The Coast Guard site is located along the same side of the I & J Waterway to the east of the subject site. Therefore, this site is also comprised of similar dredged soils. The consultant completed five test pits and submitted soil samples for chemical analysis. The data were reviewed based on the laboratory reporting limits, MTCA Methods A and Method B cleanup levels, as appropriate. The results of the laboratory testing is summarized below:

- **Organopesticides and PCBs** were analyzed in accordance with EPA Method 8081. No compounds were detected greater than the laboratory reporting limits.
- **VOC** analyses were conducted in accordance with EPA Method 8240. A concentration of 1.1 mg/kg of 2-butanone (also known as methyl ethyl ketone or MEK) was detected in three test pits. This concentration is less than the MTCA Method B soil cleanup. No other VOCs were detected greater than laboratory reporting limits.
- **Polynuclear Aromatic Hydrocarbons (PAHs)** were analyzed in accordance with EPA Method 8310. Concentrations of chrysene ranging from 0.013 to 0.59 mg/kg were detected in the five test pit samples. These concentrations are less than the MTCA Method A cleanup level. No other PAHs were detected at concentrations greater than the laboratory reporting limits.
- **Metals** arsenic, cadmium, chromium, and lead were analyzed by EPA Method 6010. Chromium was detected from 12 to 19 mg/kg in all five samples. These concentrations are less than the MTCA Method A cleanup level. No other metals were detected at concentrations greater than the laboratory reporting limits. Mercury was not detected at or above the detection limit of 0.05 mg/kg.
- **TPH** were analyzed according to the Washington Hydrocarbon Identification Method WTPH-HCID. The presence of heavy oil was identified in one sample. This sample and two other samples were analyzed for the presence of heavy oil range hydrocarbons using Washington Method WTPH-D/Extended with no TPH detected at concentrations greater than the laboratory reporting limits using this confirmation analysis.

Detection of the chemicals 2-butanone, chrysene, heavy oil and the metal chromium were identified in some of the samples collected by Tetra Tech. None of the concentrations detected were greater than pertinent state cleanup levels. This information is consistent with previous sampling results, although potential sources of the chemical compounds identified were not speculated in the report.

SITE CONDITIONS

GENERAL

Historical conditions as provided to us were discussed previously. Information available suggests that the site has no history of development other than Squalicum Peninsula which was constructed in the early 1980s. Development on the western end of the peninsula has been limited to a restaurant located north of the project site, pavement, utilities and other infrastructure for the peninsula.

SURFACE CONDITIONS

We performed a site surface reconnaissance during test pit exploration on September 1, 1998. The site is generally flat with no improvements. Vegetation consists of mostly grass and weeds. As stated previously, the only other development in the immediate vicinity is a restaurant to the north with marina moorage facilities located north of the restaurant. An existing USCG facility is located on the Peninsula to the east, on the north side of Thomas Glen Drive, closer to Roeder Avenue. A new USCG facility is under construction along the I&J Waterway, east of the site.

The land mass on the other side of the I&J Waterway is also man made, likely a combination of dredge material and land-based filling operations. Several commercial and industrial facilities are located in that area, a Georgia Pacific lagoon and a closed landfill. Additional environmental studies are available regarding the landfill site. Based on our knowledge of the area, it appears unlikely that the landfill has impacted Squalicum Peninsula.

SUBSURFACE CONDITIONS

General

GeoEngineers has performed subsurface explorations several times at the site at the request of the Port of Bellingham or other members of the Squalicum Peninsula Project design team. At three different times, explorations were accomplished for geotechnical purposes. In addition, specific explorations were conducted for this environmental study. A summary of our observations is presented below.

Geotechnical Explorations

We excavated four test pits on the peninsula in April 1998 to install temporary piezometers to measure ground water levels. The results are discussed in our memorandum to the POB dated April 29, 1998. The test pits were excavated to depths ranging from 11 to 14 feet below the existing ground surface. Two test pits were located within or close to the proposed parking garage footprint. Dredge sand was encountered in both test pits to depths ranging from 11 to 13 feet. Soft silt was encountered toward the bottom of these test pits. Ground water was observed in all the test pits and measured from 9 to slightly over 11 feet below the existing ground surface.

Three test pits were excavated on the Peninsula in August 1997 north of the proposed parking garage to evaluate subsurface conditions for a proposed stormwater infiltration system. The results are discussed in our memorandum to Wilson Engineering dated August 7, 1997. The test pits were completed to depths of 8 to 11 feet. Below a surficial layer of gravel approximately one foot thick, gray fine sand with silt, occasional gravel and trace sea shells was encountered to the bottom of all three test pits at depths of 8 to 12 feet. Occasional clay clasts were encountered from near surface to a maximum depth of 3 feet in two test pits. Groundwater was encountered at an approximate depth of 10 feet below ground surface in the deeper test pit.

We completed ten test borings in August 1998 to evaluate subsurface conditions for geotechnical design considerations for the proposed parking garage. The geotechnical report is being completed concurrently with this ESA report. The approximate locations of the borings are shown in Figure 2. Seven of the borings are located within the proposed footprint for the parking garage. The borings were completed to depths ranging between 29 and 49 feet below the existing ground surface. The borings are included in Appendix A after the test pit logs for this ESA. Primarily dredge sand was encountered to an approximate depth of 18 feet. In several of the borings, a layer of soft clay was encountered from 7 to 10 feet deep. This is also likely dredged material. Ground water was observed between 10.5 and 15 feet below the ground surface during drilling operations.

None of these explorations were accomplished for environmental purposes. However, we did not observe evidence of subsurface contamination during the exploration procedures. We also observed all the samples obtained from the test borings. We did not observe evidence of contamination when visually evaluating the samples for our geotechnical laboratory program.

ESA Explorations

Potential contamination was evaluated for this ESA by visually evaluating the subsurface conditions, performing field screening on all soil samples obtained from the test pits and submitting one soil sample from each test pit for chemical analytical testing. Five test pits were accomplished within the proposed parking garage footprint on September 1, 1998. Details regarding the exploration and field screening programs are presented in Appendix A. Details regarding the chemical analytical program including the quality assurance/quality control (QA/QC) are presented in Appendix B. The analytical data from the laboratory are presented in Appendix B. Standard EPA analytical methodologies were used for the analyses. Results from our field observations and the chemical testing are discussed individually below and a summary of the metals data is presented in Table 1.

The subsurface conditions were very consistent at all the test pit locations and consistent with previous explorations. Fine to medium sand with a trace of silt, occasional shells and silt clasts (dredge material) was encountered in each test pit to the depth explored at 6 feet. No visual evidence of contamination was observed in any of the test pits for this ESA nor in any of the geotechnical explorations. Soil samples were obtained at 2, 4 and 6 feet of depth in all the test pits. No unusual soil colors or textures were observed in the soil samples, although a significant odor was present in some of the original mudline deposits. This is not unusual. No significant sheen was observed in any of the soil samples during water sheen screening.

CHEMICAL TESTING

SOIL CLEANUP CRITERIA

MTCA establishes requirements for assessment and cleanup of upland contaminated sites. The regulations that enforce MTCA are included in WAC (Washington Administrative Code) 173-340. MTCA provides three methods (Methods A, B and C) for establishing cleanup levels for soil and ground water. Method A is intended to be used for sites where the cleanup action may be routine or involve relatively few hazardous substances. Method A cleanup levels are specified in the tables of WAC 173-340-720 and -740. These cleanup levels are appropriate for determining whether upland disposal of fill soils would present a regulatory concern.

ANALYTICAL RESULTS

The suite of chemical testing is described in the "Scope" section of this report. The individual analytes are indicated on the laboratory reports in Appendix B. No petroleum hydrocarbons, PCBs, VOCs, SVOCs, were detected in any of the samples. Cyanide was not detected.

No concentrations of metals were detected greater than the MTCA Method A cleanup level. No metals were detected at concentrations greater than typical Puget Sound soils, with the exception of one mercury sample at a concentration of 0.105 mg/kg. This value is only slightly greater than the published background concentration of 0.07 mg/kg, and significantly less than the cleanup level of 1.0 mg/kg.

CONCLUSIONS

We did not observe field evidence of subsurface contamination while performing the test pits at the site nor any of the geotechnical explorations at the site. The chemical analytical results did not disclose any contaminants above pertinent cleanup levels or metals significantly above Puget Sound background levels. While it must be recognized that subsurface contamination could be present within the fill soils in areas not tested, we did not observe indications of contamination based on our field explorations and chemical analytical testing. We conclude that the results of our research and testing indicate a very low likelihood of contamination greater than MTCA Method A cleanup levels in the dredge sand to the depth explored. The results also indicate that the dredge sand encountered is suitable for upland disposal as an unregulated fill material as proposed by the Port of Bellingham.

Some of the sediments in the area have had mercury contamination greater than the MTCA Method A cleanup level. We are not aware of detailed dredging information in the area or sediment transport accumulations in the area. It is possible that some of the original sediments could be contaminated with mercury. The dredging could have mixed these sediments throughout the dredged material within the Peninsula such that the concentrations are well below cleanup levels. However, if discrete areas of these historical surficial sediments were able to accumulate within the Peninsula during the dredging operations, isolated areas of contamination could be present. The historical sediments would be expected to consist of organic and inorganic fine-grained silts and clays, not the sands encountered to the proposed foundation elevation for the parking garage. If a significant quantity of fine-grained sediments will be excavated and disposed and there is a concern regarding contamination, these materials could be evaluated by submitting samples for mercury testing only.

LIMITATIONS

This report has been prepared for use by the Port of Bellingham. This report may be made available to regulatory agencies, parties who may receive soils excavated from the subject site, and other agents for the Port of Bellingham. The report is not intended for use by others and the information contained herein is not applicable to other sites.

The findings and conclusions in this report are based on the above-described data. GeoEngineers has relied upon information provided by others regarding historical conditions and sampling procedures. This report provides information regarding the targeted sampling and testing but does not provide definitive information with regard to additional contamination, past uses, operations or incidents at the site. A potential always exists for areas of contamination that were not identified during this study.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

◆

We appreciate the opportunity to provide these services to you on this project. If you have any questions regarding this report or if we can provide additional services, please call.

Respectfully submitted,

GeoEngineers, Inc.

Robert E. Curtis

Robert E. Curtis
Staff Geologist

J. Robert Gordon, P.E.
Principal

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TABLE 1

SUMMARY OF SOIL CHEMICAL ANALYTICAL RESULTS[1]

Test Pit Number[2]	Date Sampled	Priority Pollutant Metals[3] (mg/kg)												
		Sb	As	Be	Cd	Cr	Cu	Pb	Ni	Se	Ag	Tl	Zn	Hg
TP-1	9/1/98	ND	2.60	ND	ND	13.3	11.3	2.77	15.2	ND	ND	ND	25.7	ND
TP-2	9/1/98	ND	2.15	ND	ND	16.5	11.3	2.80	16.2	ND	ND	ND	27.4	ND
TP-3	9/1/98	ND	2.25	ND	ND	11.2	17.2	1.69	11.4	ND	ND	ND	20.1	0.105
TP-4	9/1/98	ND	2.60	ND	ND	14.0	8.43	1.97	12.1	ND	ND	ND	21.7	ND
TP-5	9/1/98	ND	2.22	ND	ND	17.5	13.4	2.25	38.8	ND	ND	ND	23.6	ND
MTCA Method A Cleanup Levels		NA	20	NA	2	100	NA	250	NA	NA	NA	NA	NA	1.0
Average Puget Sound Soils[4]		NA	7	0.6	1.0	48	36	24	48	NA	NA	NA	85	0.07

Notes:

[1] Chemical analysis conducted by North Creek Analytical of Bothell, WA. Laboratory report presented in Appendix B.

[2] Approximate test pit location shown in Figure 2.

[3] Priority Pollutant Metals by EPA Method 6020; Hg by EPA Method 7471A.

[4] Average Puget Sound concentrations from "Natural Background Soil Metals Concentrations in Washington State," Washington State Department of Ecology Publication #94-115, October 1994, Table 1.

mg/kg = milligrams per kilogram

ND = not detected

MTCA = Model Toxics Control Act

NA = not applicable

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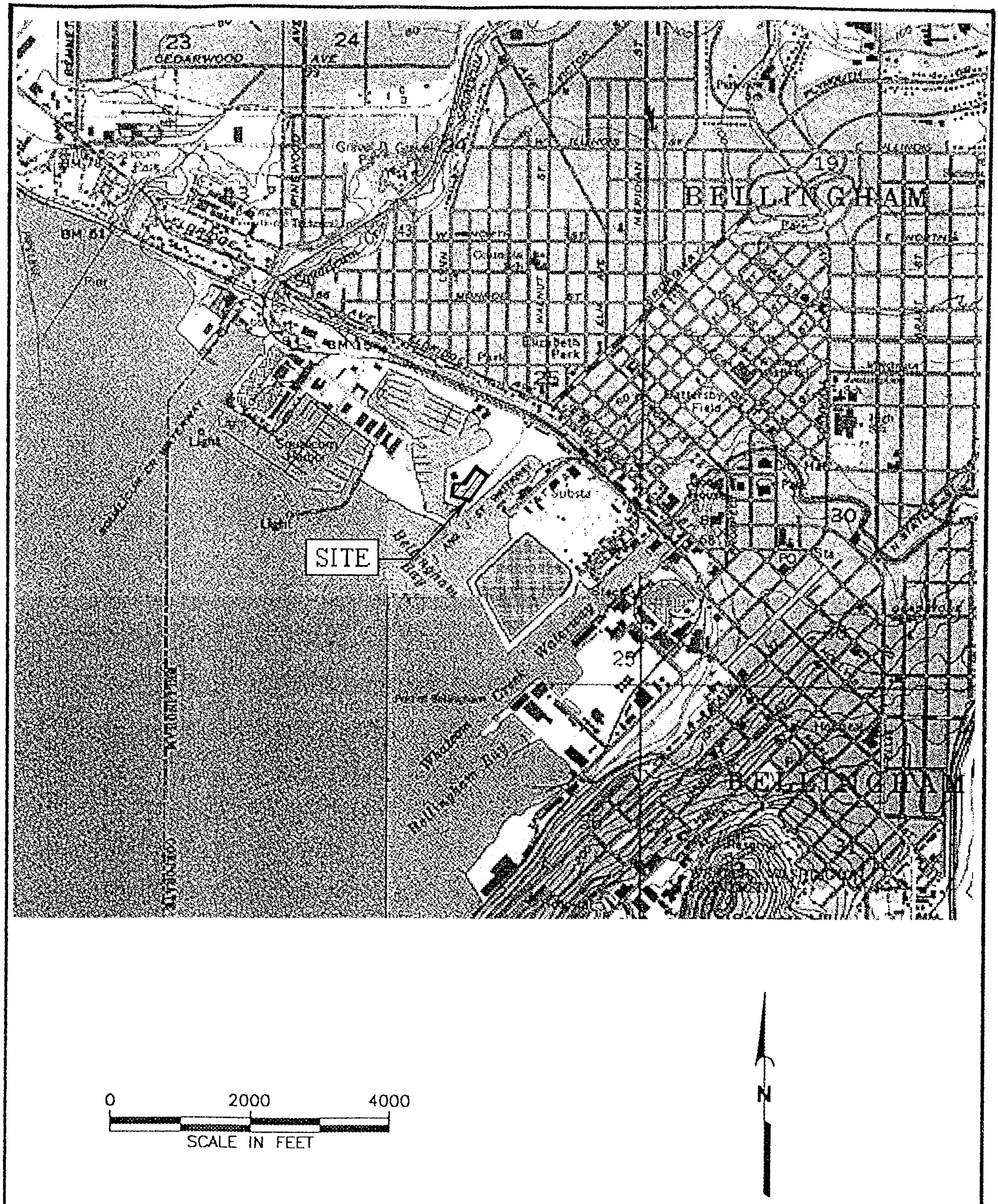

Reference:

USGS 7.5' topographic quadrangle map "North and South Bellingham, WA." dated 1954 photorevised 1972. (Printed from TOPO! ©1997 Wildflower Productions)

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VICINITY MAP

FIGURE 1

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8X11USGS.DWG

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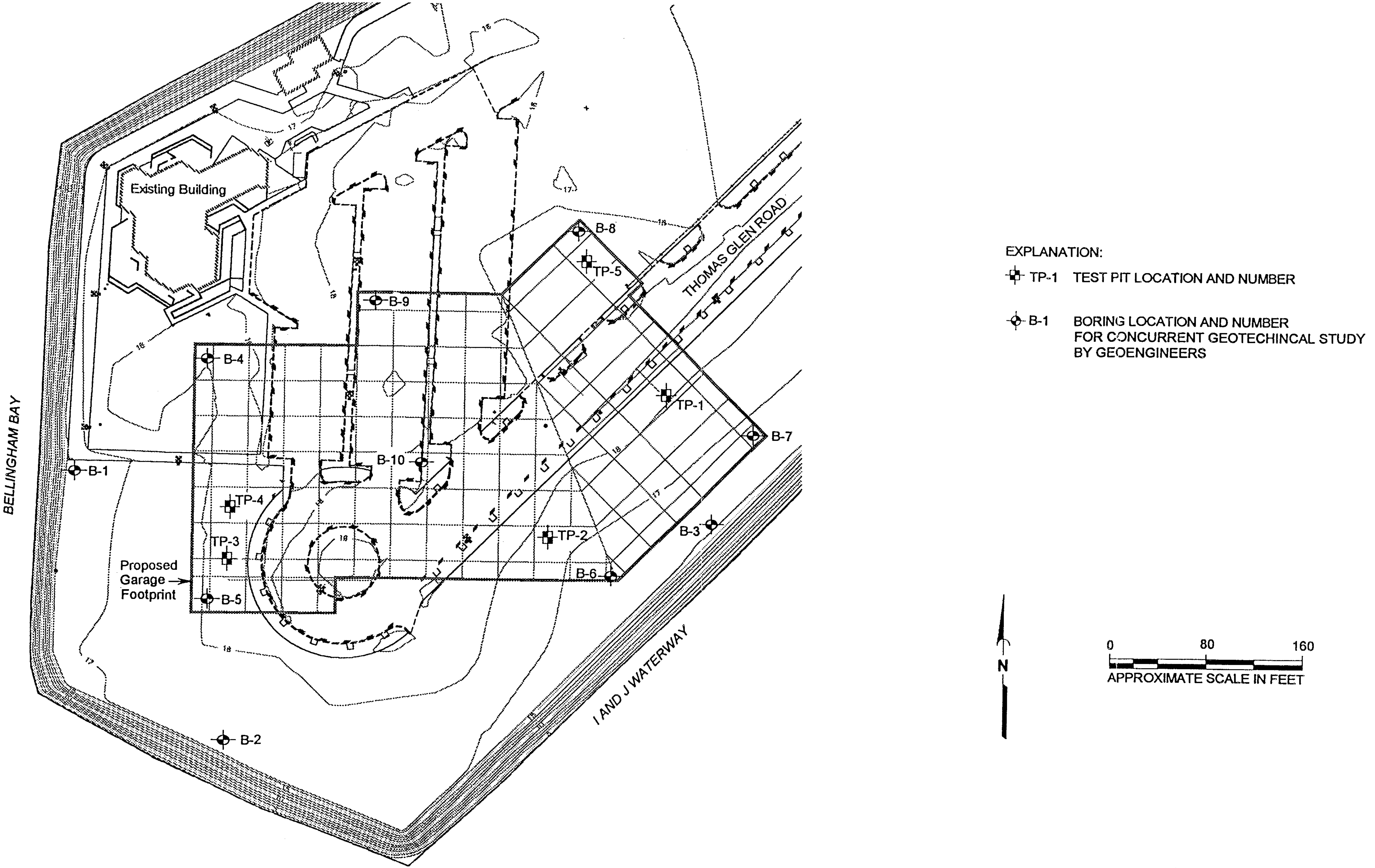

Reference: Site Plan provided by Wilson Engineering dated 10/13/98.

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SITE PLAN

FIGURE 2

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS AND SOIL SAMPLING PROGRAM

The main purposes of the field exploration program for this study were to observe representative subsurface conditions within the fill at the site and to obtain soil samples for chemical testing. This was accomplished by excavating five test pits on September 1, 1998 at the approximate locations shown in Figure 2. The test pits were excavated to a depth of 6 feet, which is to the finished floor elevation at the time of our study. A geologist from our staff located the test pits, evaluated and classified the soils encountered, and prepared a detailed log of each test pit. Soils encountered were classified visually in general accordance with ASTM D-2488-83, which is described in Figure A-1. A key to the boring log symbols is presented in Figure 2. The test pit logs are provided in Figures A-3 and A-4. The test borings from the geotechnical exploration program for the proposed Squalicum Peninsula Project are presented in Figures A-5 through A-14.

Discrete soil samples were collected from each test pit at depths of 2, 4 and 6 feet. The samples were composited in the field into one sample as representative of the soil profile during excavation. The soil samples were collected using a stainless steel spoon and mixed in a stainless steel bowl. The soil sampling equipment and bowl were decontaminated between samples. The soil samples were placed in glass sample jars provided by the analytical laboratory and kept cool prior to and during transport to North Creek Analytical in Bothell, Washington. Information noted on the sample labels included the job number, test pit number, sample number and sampling date. Chain-of-custody records were maintained.

Analytical results and conclusions are discussed in the text and the results of the metals testing is summarized in Table 1. Details regarding the chemical analytical program and the laboratory reports are presented in Appendix B.

FIELD SCREENING OF SOIL SAMPLES

Our field representatives conducted field screening on all soil samples obtained from the test pits. Field screening results are used as a general guideline to delineate areas of possible petroleum-related contamination. In addition, screening results are used to aid in the selection of soil samples for chemical analysis. The field screening methods used include visual examination and water sheen screening. The field screening results did not indicate a significant potential presence of contamination.

Visual screening consists of inspecting the soil for stains indicative of fuel-related and some other contaminants. Visual screening is generally more effective when contamination is related to heavy petroleum hydrocarbons such as motor oil, or when hydrocarbon concentrations are high. Sheen screening and headspace screening are more sensitive methods that have been effective in detecting contamination at concentrations less than regulatory cleanup guidelines. Sheen screening involves placing soil in water and observing the water surface for signs of sheen. No sheens were evident during field screening.

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More Than 50% Retained on No. 200 Sieve	GRAVEL More Than 50% of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More Than 50% of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More Than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less Than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or More	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D2487-90.
3. Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry -	Absence of moisture, dusty, dry to the touch
Moist -	Damp, but no visible water
Wet -	Visible free water or saturated, usually soil is obtained from below water table

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SOIL CLASSIFICATION SYSTEM

FIGURE A-1

LABORATORY TESTS:

CA	Chemical Analysis

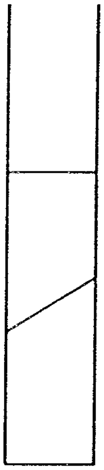
FIELD SCREENING TESTS:

Headspace vapor concentration data given in parts per million

Sheen classification system:

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

SOIL GRAPH:



SM Soil Group Symbol (See Note 2)

Distinct Contact Between Soil Strata

Gradual or Approximate Location of Change Between Soil Strata

▽ Water Level

Bottom of Boring

BLOW COUNT/SAMPLE DATA:

Blows required to drive a 2.4-inch I.D. split-barrel sampler 12 inches or other indicated distances using a 300-pound hammer falling 30 inches.

- 22 ■ Location of relatively undisturbed sample
- 12 ☒ Location of disturbed sample
- 17 ☐ Location of sampling attempt with no recovery

Blows required to drive a 1.5-inch I.D. (SPT) split-barrel sampler 12 inches or other indicated distances using a 140-pound hammer falling 30 inches.

- 10 ◨ Location of sample obtained in general accordance with Standard Penetration Test (ASTM D 1586) procedures
- 26 ◫ Location of SPT sampling attempt with no recovery

▤ Location of grab sample

"P" indicates sampler pushed with weight of hammer or against weight of drill rig.

NOTES:

1. The reader must refer to the discussion in the report text, the Key to Boring Log Symbols and the exploration logs for a proper understanding of subsurface conditions.
2. Soil classification system is summarized in Figure A-1.

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KEY TO BORING LOG SYMBOLS

FIGURE A-2

GEI 121-90 Rev. 2/94

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT TP- 1
0.0 - 6.0	SP	Gray fine to medium sand with trace of silt and occasional gravel (loose to medium sense, moist)(fill) Note: Occasional silt lenses mixed in at various elevations Test pit completed at 6.0 feet on 9/1/98 No ground water seepage observed Slight caving observed full depth Composite soil samples obtained from 2.0, 4.0 and 6.0 feet
		TEST PIT TP-2
0.0 - 6.0	SP	Gray fine to medium sand with trace of silt, shells and coarse sand (loose to medium dense, moist)(fill) Note: Occasional silt lenses mixed in at various elevations Test pit completed at 6.0 feet on 9/1/98 No ground water seepage observed Slight caving observed full depth Composite soil samples obtained from 2.0, 4.0 and 6.0 feet
		TEST PIT TP-3
0.0 - 6.0	SP	Gray fine to medium sand with trace of silt, coarse sand and shells (loose to medium dense, moist)(fill) Note: Occasional clay/silt lenses at various elevations Test pit completed at 6.0 feet on 9/1/98 No ground water seepage observed No caving observed Composite soil samples obtained from 2.0, 4.0 and 6.0 feet

THE DEPTHS OF THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT

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LOG OF TEST PIT

FIGURE A-3

LOG OF TEST PIT

DEPTH BELOW GROUND SURFACE (FEET)	SOIL GROUP CLASSIFICATION SYMBOL	DESCRIPTION
		TEST PIT TP- 4
0.0 - 6.0	SP	Gray fine to medium sand with trace of silt, coarse sand and shells (medium dense, moist)(fill) Note: Occasional silt/clay lenses at various elevations Test pit completed at 6.0 feet on 9/1/98 No ground water seepage observed No caving observed Composite soil samples obtained at 2.0, 4.0 and 6.0 feet
		TEST PIT TP-5
0.0 - 6.0	SP	Gray fine to medium sand with trace of silt, coarse sand and shells (medium dense, moist)(fill) Note: Occasional clay/silt lenses/balls at various elevations Test pit completed at 6.0 feet on 9/1/98 No ground water seepage observed No caving observed Composite soil samples obtained at 2.0, 4.0 and 6.0 feet

THE DEPTHS OF THE TEST PIT LOGS, ALTHOUGH SHOWN TO 0.1 FOOT, ARE BASED ON AN AVERAGE OF MEASUREMENTS ACROSS THE TEST PIT AND SHOULD BE CONSIDERED ACCURATE TO 0.5 FOOT

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LOG OF TEST PIT

FIGURE A-4

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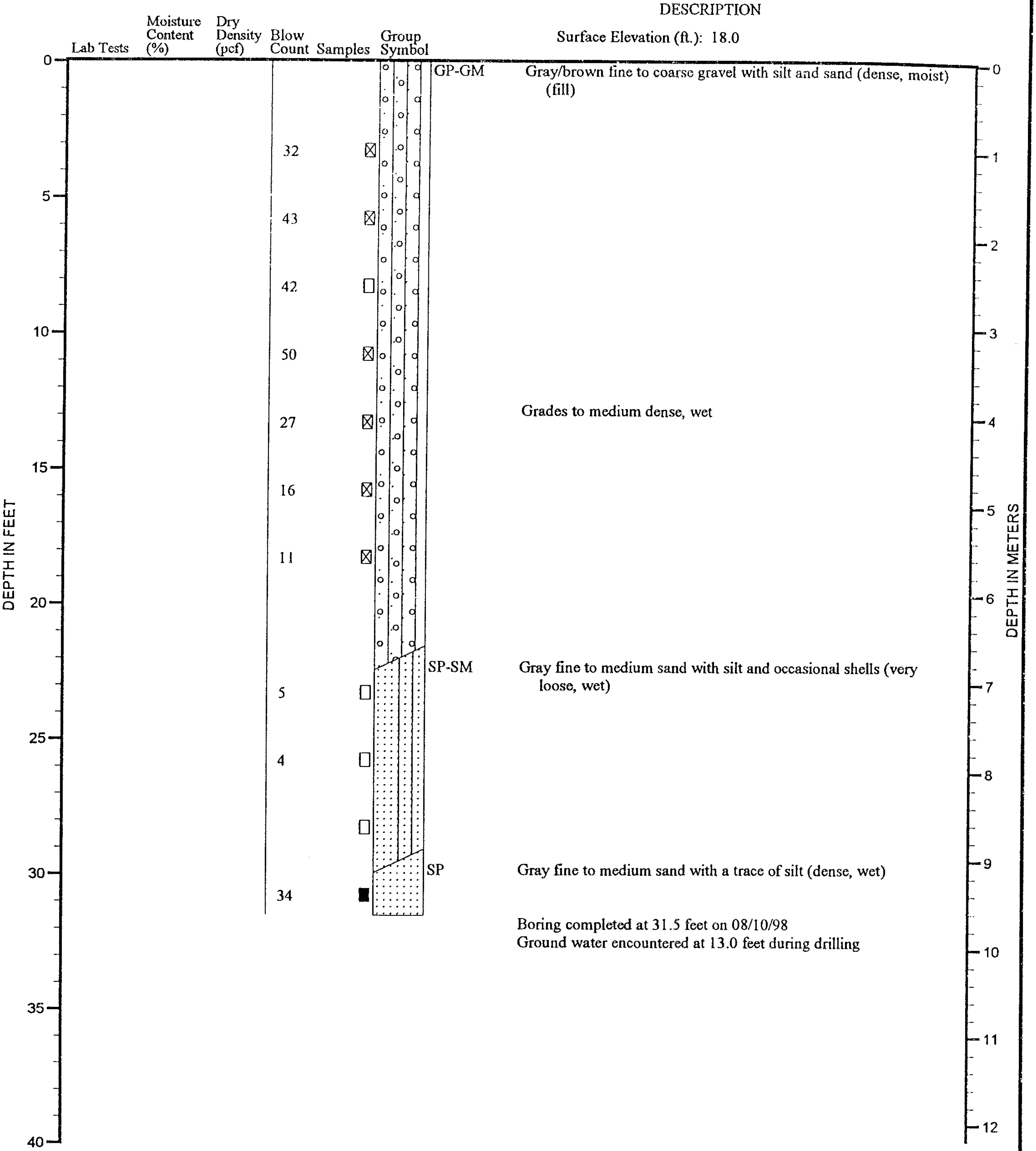
TEST DATA

BORING B-1



DESCRIPTION

Surface Elevation (ft.): 18.0

GP-GM Gray/brown fine to coarse gravel with silt and sand (dense, moist) (fill)

Grades to medium dense, wet

SP-SM Gray fine to medium sand with silt and occasional shells (very loose, wet)

SP Gray fine to medium sand with a trace of silt (dense, wet)

Boring completed at 31.5 feet on 08/10/98
Ground water encountered at 13.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

DEA:ja 9/18/98

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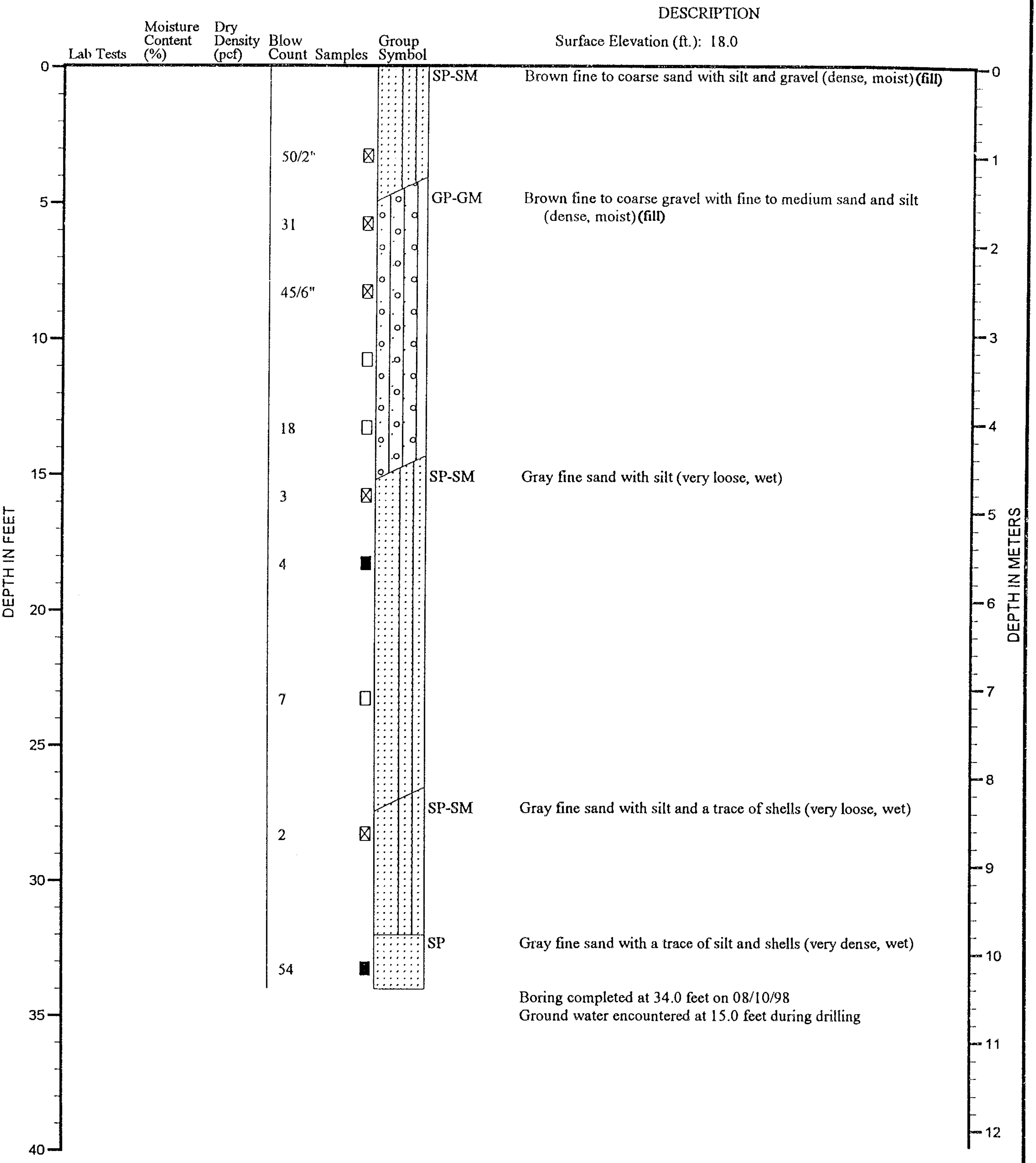
LOG OF BORING

FIGURE A- 5

TEST DATA

BORING B-2



SP-SM Brown fine to coarse sand with silt and gravel (dense, moist) **(fill)**

GP-GM Brown fine to coarse gravel with fine to medium sand and silt (dense, moist) **(fill)**

SP-SM Gray fine sand with silt (very loose, wet)

SP-SM Gray fine sand with silt and a trace of shells (very loose, wet)

SP Gray fine sand with a trace of silt and shells (very dense, wet)

Boring completed at 34.0 feet on 08/10/98
Ground water encountered at 15.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

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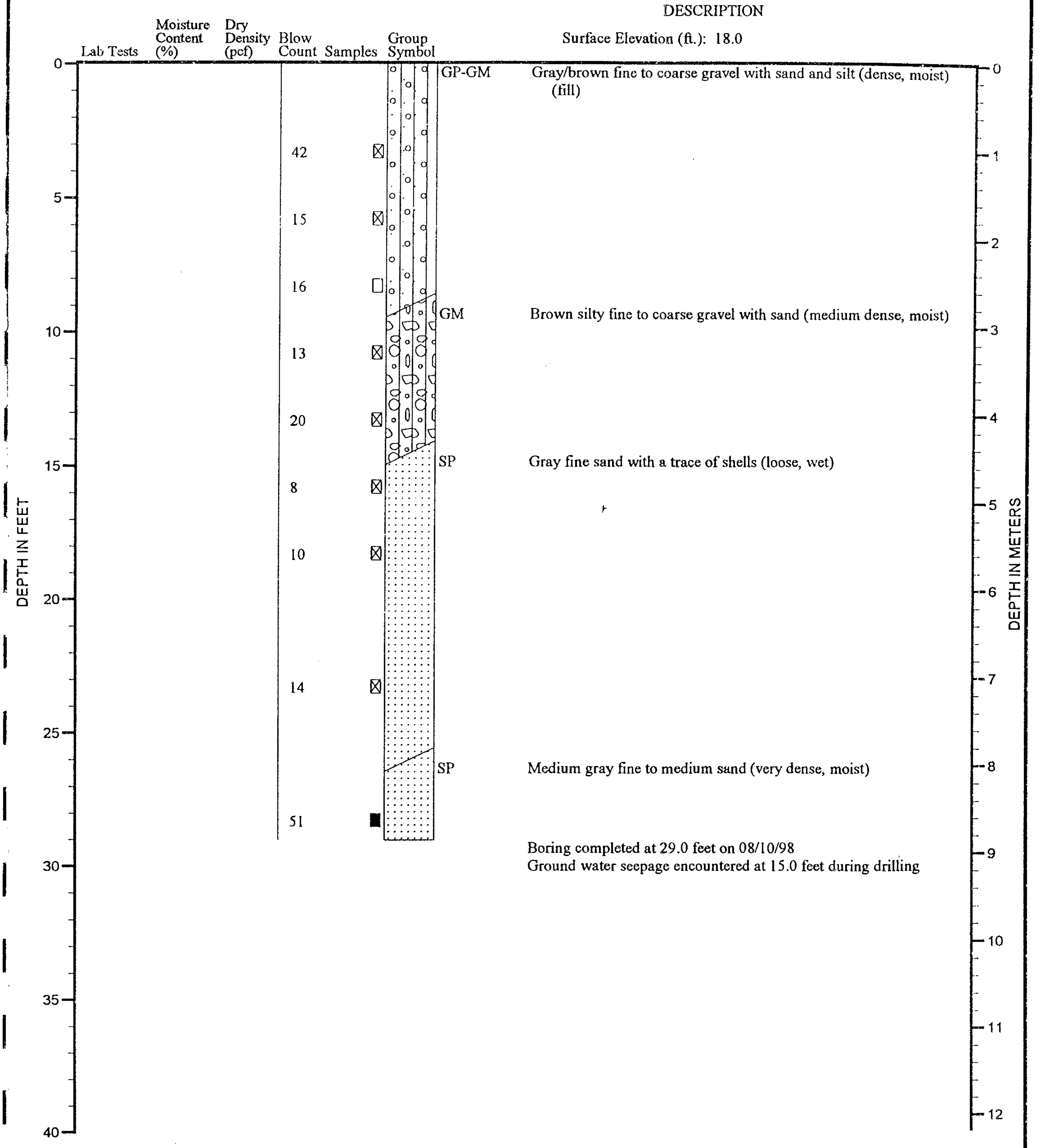
LOG OF BORING

FIGURE A-6

TEST DATA

BORING B-3



DESCRIPTION

Surface Elevation (ft.): 18.0

Gray/brown fine to coarse gravel with sand and silt (dense, moist) (fill)

Brown silty fine to coarse gravel with sand (medium dense, moist)

Gray fine sand with a trace of shells (loose, wet)

Medium gray fine to medium sand (very dense, moist)

Boring completed at 29.0 feet on 08/10/98
Ground water seepage encountered at 15.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

:DEA:ja 9/18/98

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LOG OF BORING

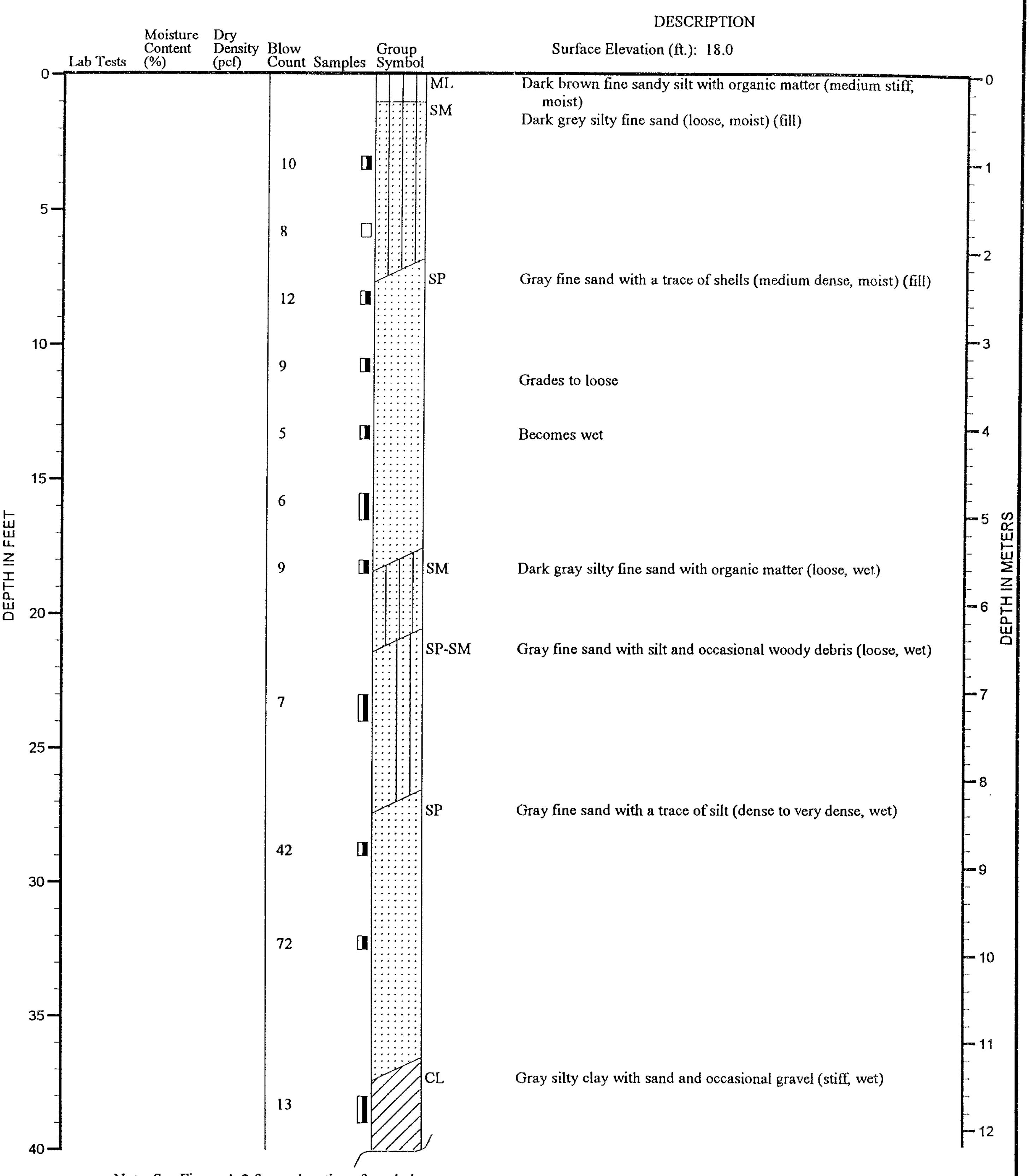
FIGURE A-7

TEST DATA

BORING B-4

DESCRIPTION

Surface Elevation (ft.): 18.0



Blow Count	Group Symbol	Description
	ML	Dark brown fine sandy silt with organic matter (medium stiff, moist)
	SM	Dark grey silty fine sand (loose, moist) (fill)
10		
8		
	SP	Gray fine sand with a trace of shells (medium dense, moist) (fill)
12		
9		Grades to loose
5		Becomes wet
6		
9	SM	Dark gray silty fine sand with organic matter (loose, wet)
	SP-SM	Gray fine sand with silt and occasional woody debris (loose, wet)
7		
	SP	Gray fine sand with a trace of silt (dense to very dense, wet)
42		
72		
	CL	Gray silty clay with sand and occasional gravel (stiff, wet)
13		

Note: See Figure A-2 for explanation of symbols

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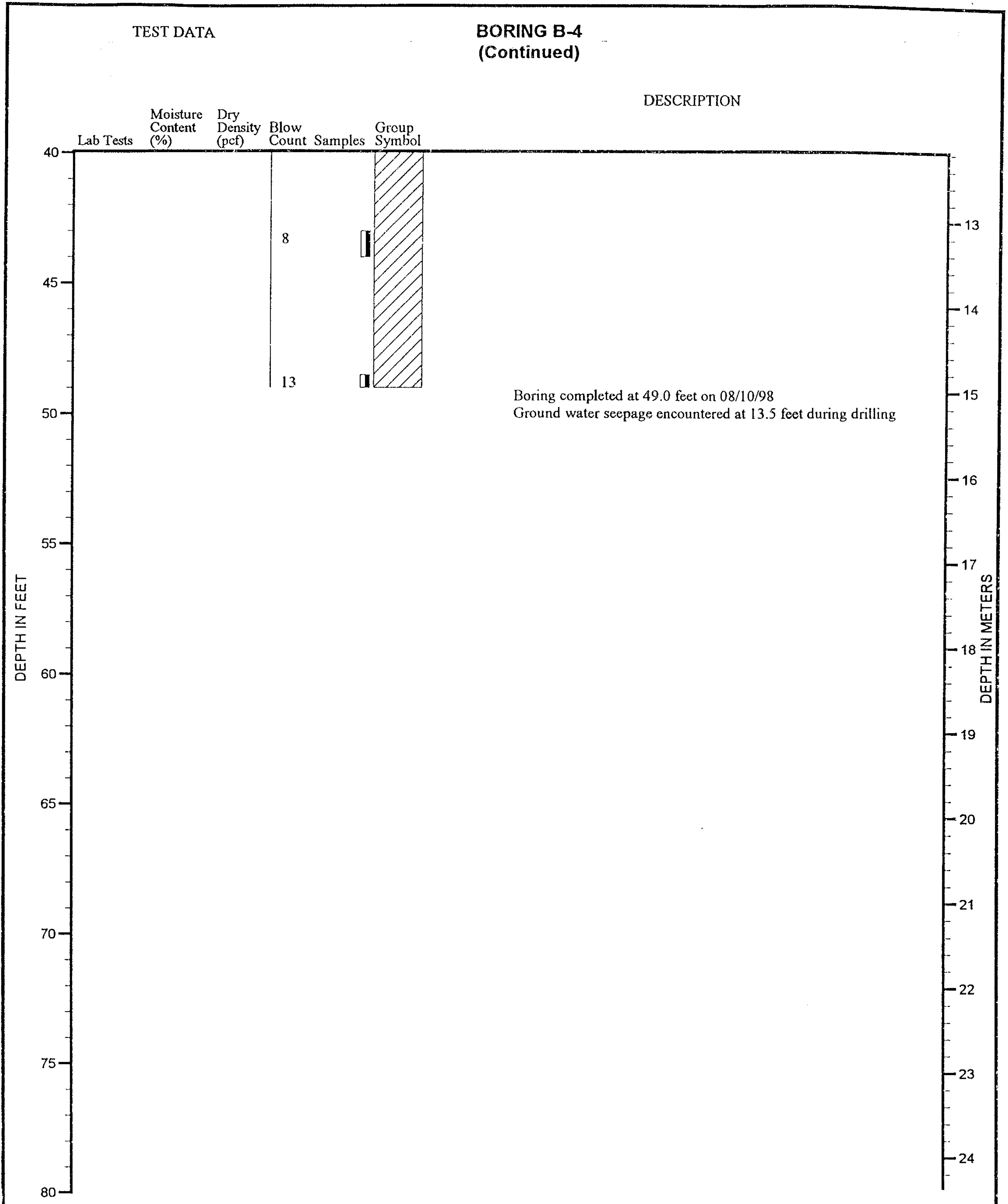
LOG OF BORING

FIGURE A-8

BORING B-4
(Continued)



Boring completed at 49.0 feet on 08/10/98
Ground water seepage encountered at 13.5 feet during drilling

Note: See Figure A-2 for explanation of symbols

GeoEngineers

LOG OF BORING

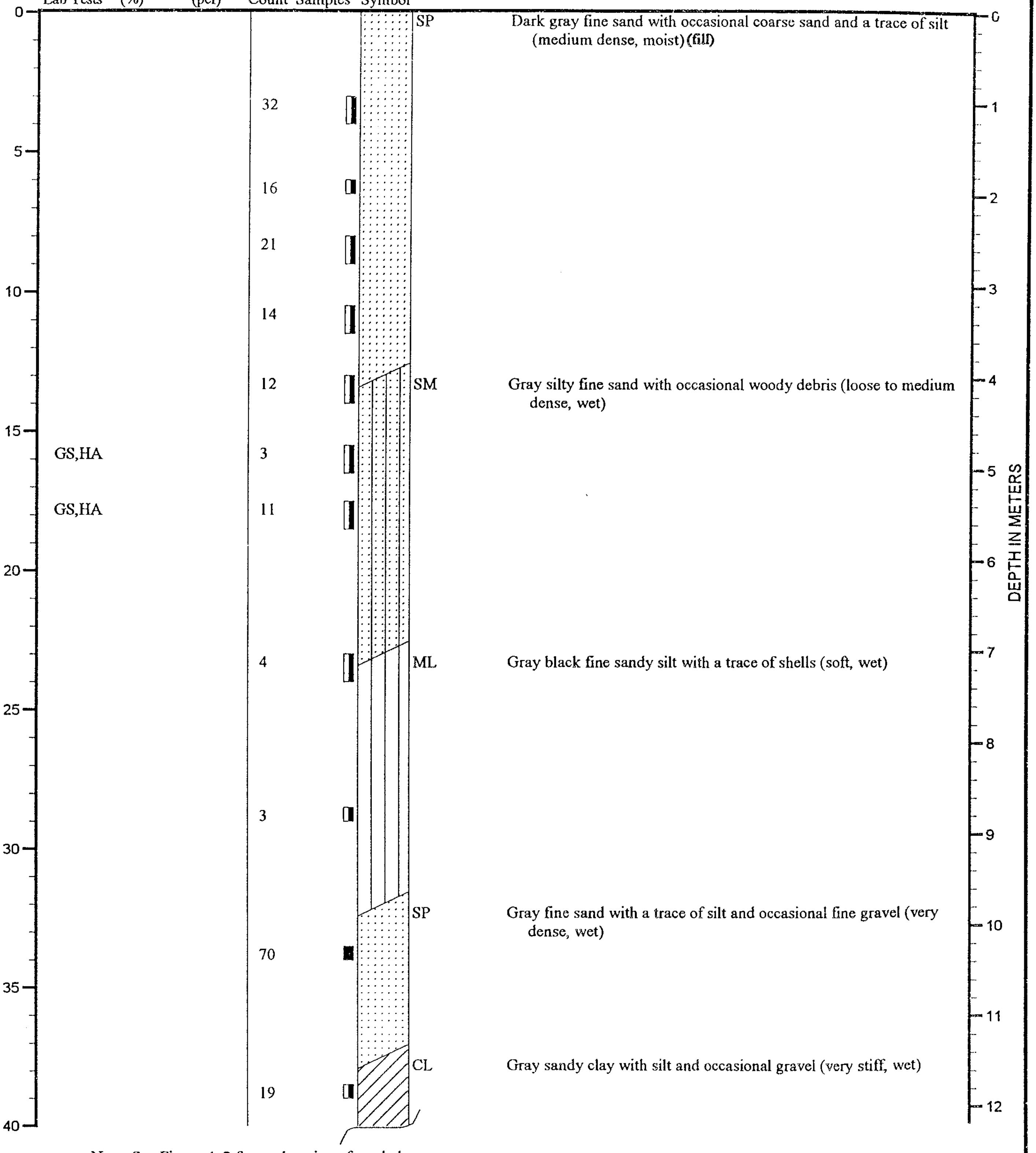
FIGURE A-8

TEST DATA

BORING B-5

DESCRIPTION

Surface Elevation (ft.): 18.0



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	DESCRIPTION
					SP	Dark gray fine sand with occasional coarse sand and a trace of silt (medium dense, moist) (fill)
			32			
			16			
			21			
			14			
			12		SM	Gray silty fine sand with occasional woody debris (loose to medium dense, wet)
GS,HA			3			
GS,HA			11			
			4		ML	Gray black fine sandy silt with a trace of shells (soft, wet)
			3			
					SP	Gray fine sand with a trace of silt and occasional fine gravel (very dense, wet)
			70			
					CL	Gray sandy clay with silt and occasional gravel (very stiff, wet)
			19			

Note: See Figure A-2 for explanation of symbols

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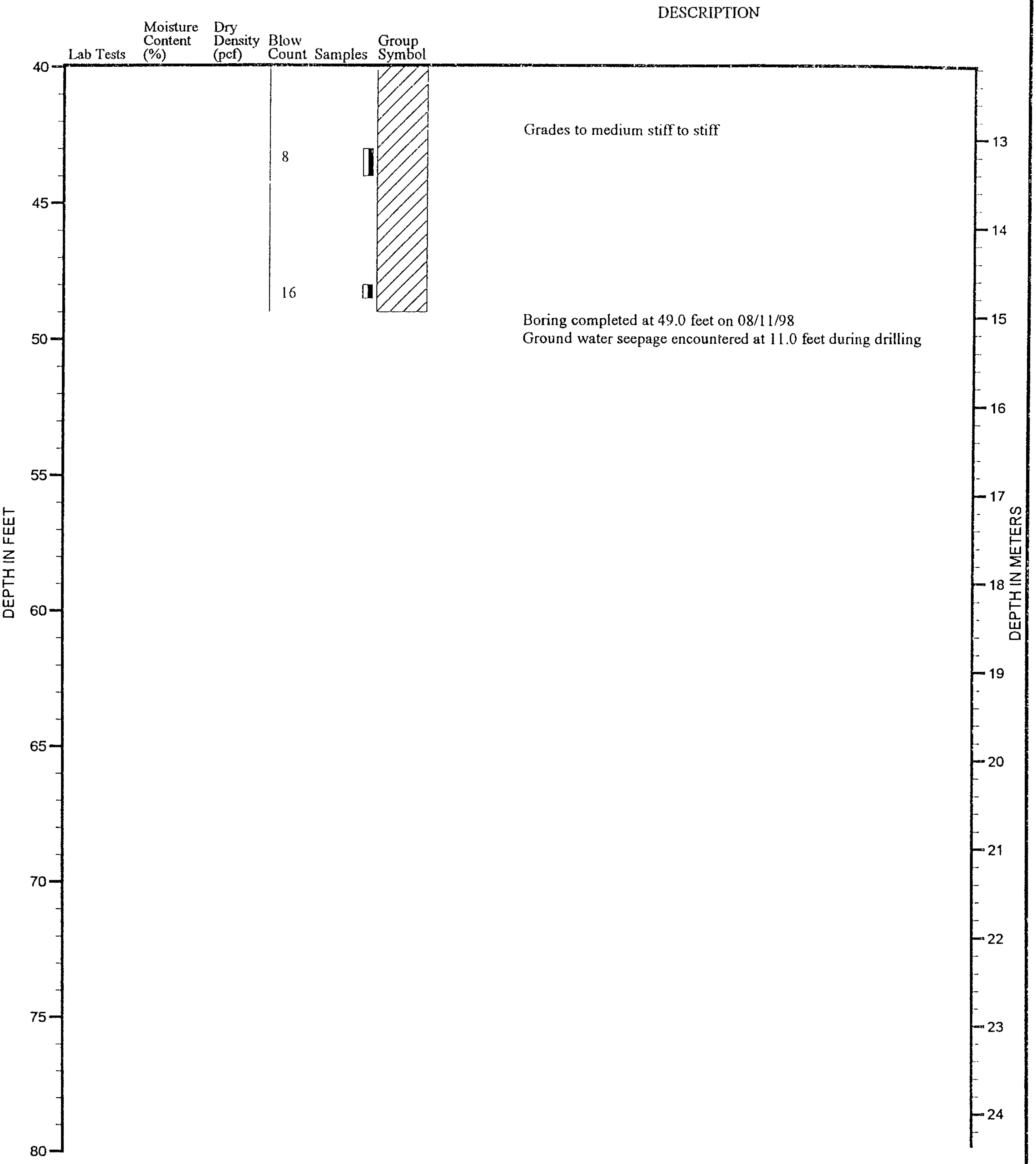
LOG OF BORING

FIGURE A-9

TEST DATA

BORING B-5
(Continued)



Grades to medium stiff to stiff

Boring completed at 49.0 feet on 08/11/98
Ground water seepage encountered at 11.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

GeoEngineers

LOG OF BORING

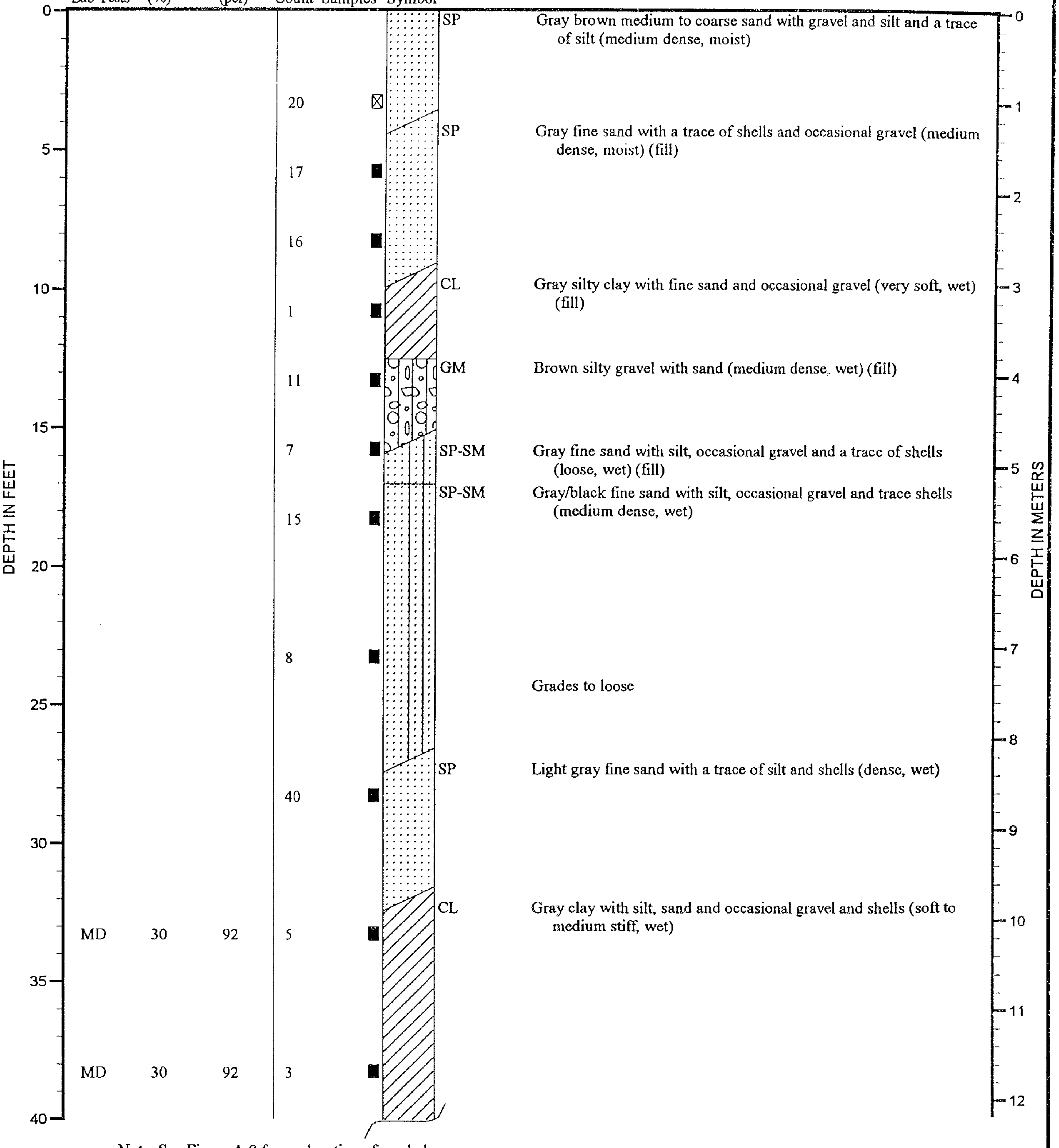
FIGURE A-9

TEST DATA

BORING B-6

DESCRIPTION

Surface Elevation (ft.): 18.0



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	Description
					SP	Gray brown medium to coarse sand with gravel and silt and a trace of silt (medium dense, moist)
			20	☒		
					SP	Gray fine sand with a trace of shells and occasional gravel (medium dense, moist) (fill)
			17	■		
			16	■		
					CL	Gray silty clay with fine sand and occasional gravel (very soft, wet) (fill)
			1	■		
					GM	Brown silty gravel with sand (medium dense, wet) (fill)
			11	■		
			7	■	SP-SM	Gray fine sand with silt, occasional gravel and a trace of shells (loose, wet) (fill)
					SP-SM	Gray/black fine sand with silt, occasional gravel and trace shells (medium dense, wet)
			15	■		
			8	■		
						Grades to loose
					SP	Light gray fine sand with a trace of silt and shells (dense, wet)
			40	■		
					CL	Gray clay with silt, sand and occasional gravel and shells (soft to medium stiff, wet)
MD	30	92	5	■		
MD	30	92	3	■		

Note: See Figure A-2 for explanation of symbols

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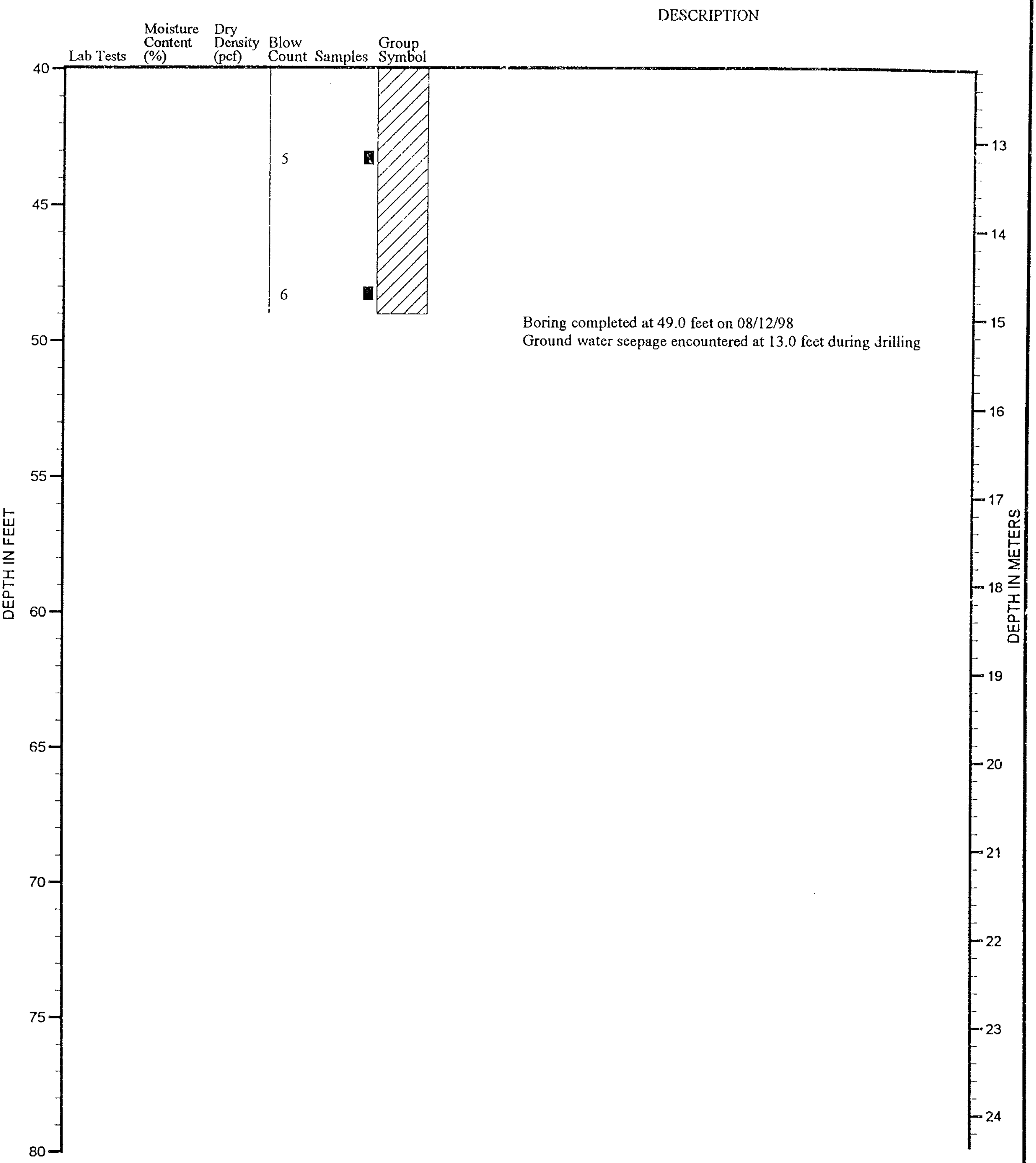
LOG OF BORING

FIGURE A-10

TEST DATA

BORING B-6
(Continued)



Boring completed at 49.0 feet on 08/12/98
Ground water seepage encountered at 13.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

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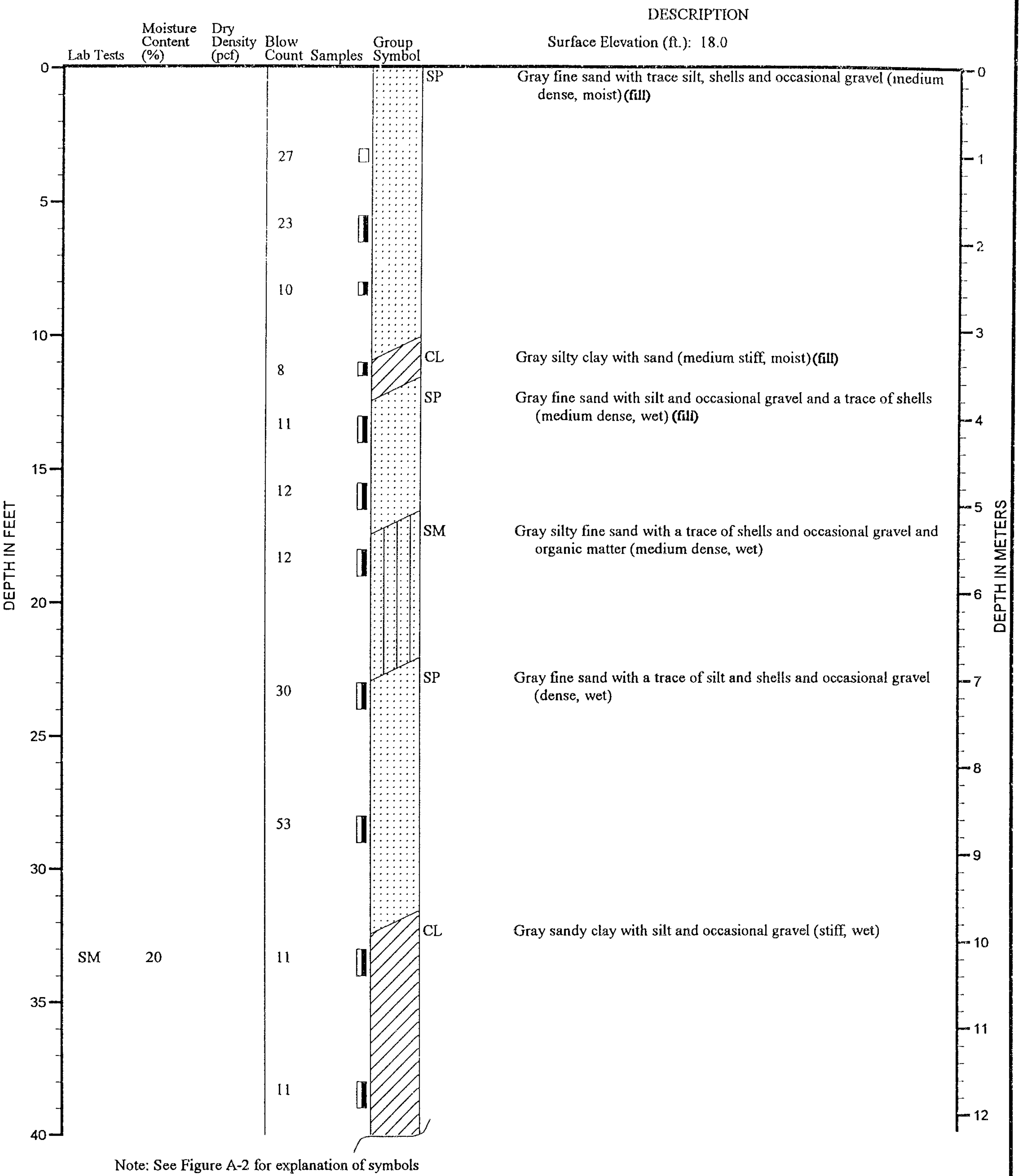
LOG OF BORING

FIGURE A-10

TEST DATA

BORING B-7



DESCRIPTION

Surface Elevation (ft.): 18.0

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples	Group Symbol	DESCRIPTION
					SP	Gray fine sand with trace silt, shells and occasional gravel (medium dense, moist) **(fill)**
			27			
			23			
			10			
					CL	Gray silty clay with sand (medium stiff, moist) **(fill)**
			8			
					SP	Gray fine sand with silt and occasional gravel and a trace of shells (medium dense, wet) **(fill)**
			11			
			12			
					SM	Gray silty fine sand with a trace of shells and occasional gravel and organic matter (medium dense, wet)
			12			
					SP	Gray fine sand with a trace of silt and shells and occasional gravel (dense, wet)
			30			
			53			
					CL	Gray sandy clay with silt and occasional gravel (stiff, wet)
SM	20		11			
			11			

Note: See Figure A-2 for explanation of symbols

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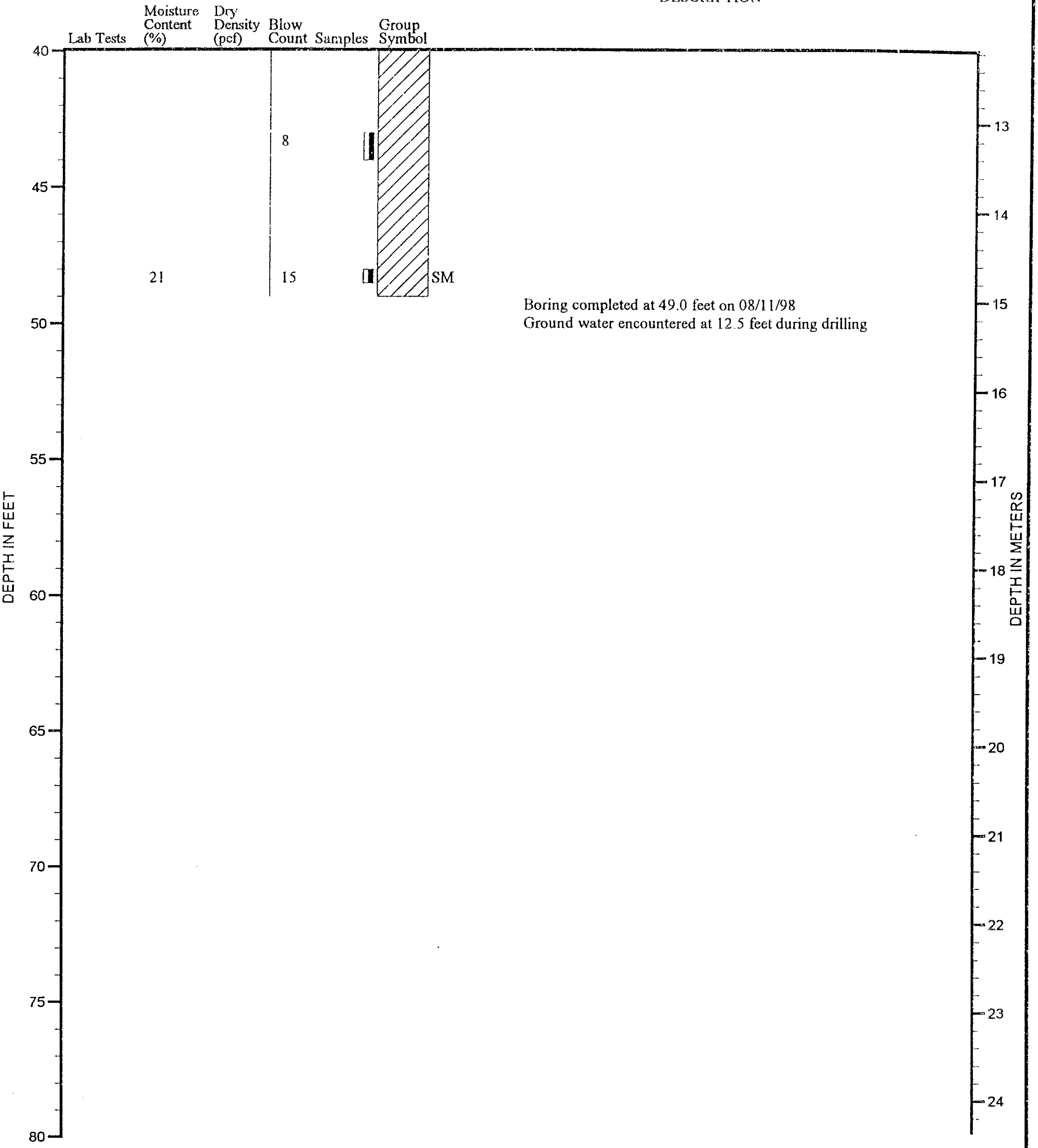
LOG OF BORING

FIGURE A-11

TEST DATA

BORING B-7
(Continued)

DESCRIPTION



Boring completed at 49.0 feet on 08/11/98
Ground water encountered at 12.5 feet during drilling

Note: See Figure A-2 for explanation of symbols

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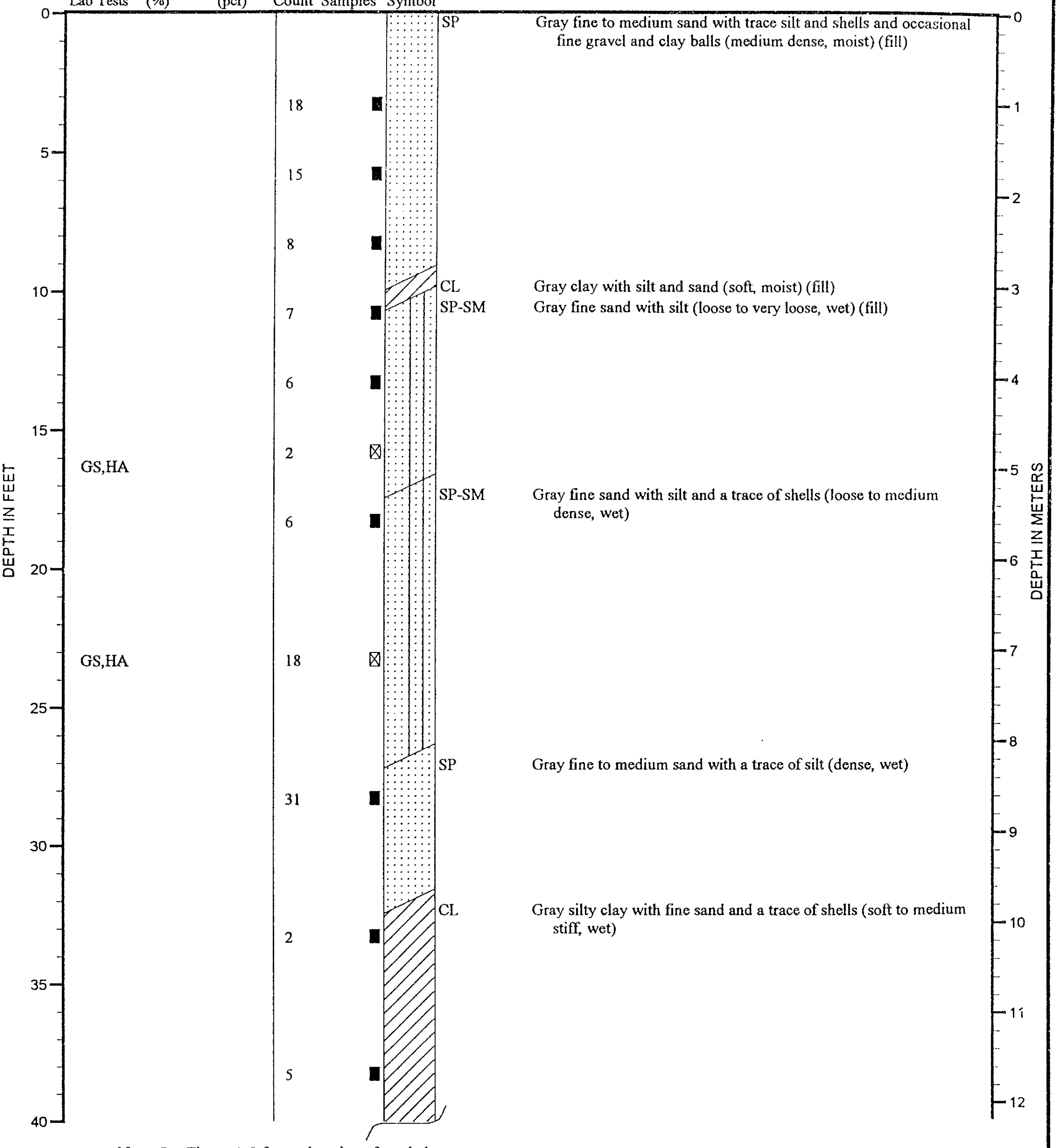
LOG OF BORING

FIGURE A-11

TEST DATA

BORING B-8



Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples
			18	■
			15	■
			8	■
			7	■
			6	■
GS,HA			2	☒
			6	■
GS,HA			18	☒
			31	■
			2	■
			5	■

DESCRIPTION

Surface Elevation (ft.): 18.0

Group Symbol	Description
SP	Gray fine to medium sand with trace silt and shells and occasional fine gravel and clay balls (medium dense, moist) (fill)
CL	Gray clay with silt and sand (soft, moist) (fill)
SP-SM	Gray fine sand with silt (loose to very loose, wet) (fill)
SP-SM	Gray fine sand with silt and a trace of shells (loose to medium dense, wet)
SP	Gray fine to medium sand with a trace of silt (dense, wet)
CL	Gray silty clay with fine sand and a trace of shells (soft to medium stiff, wet)

Note: See Figure A-2 for explanation of symbols

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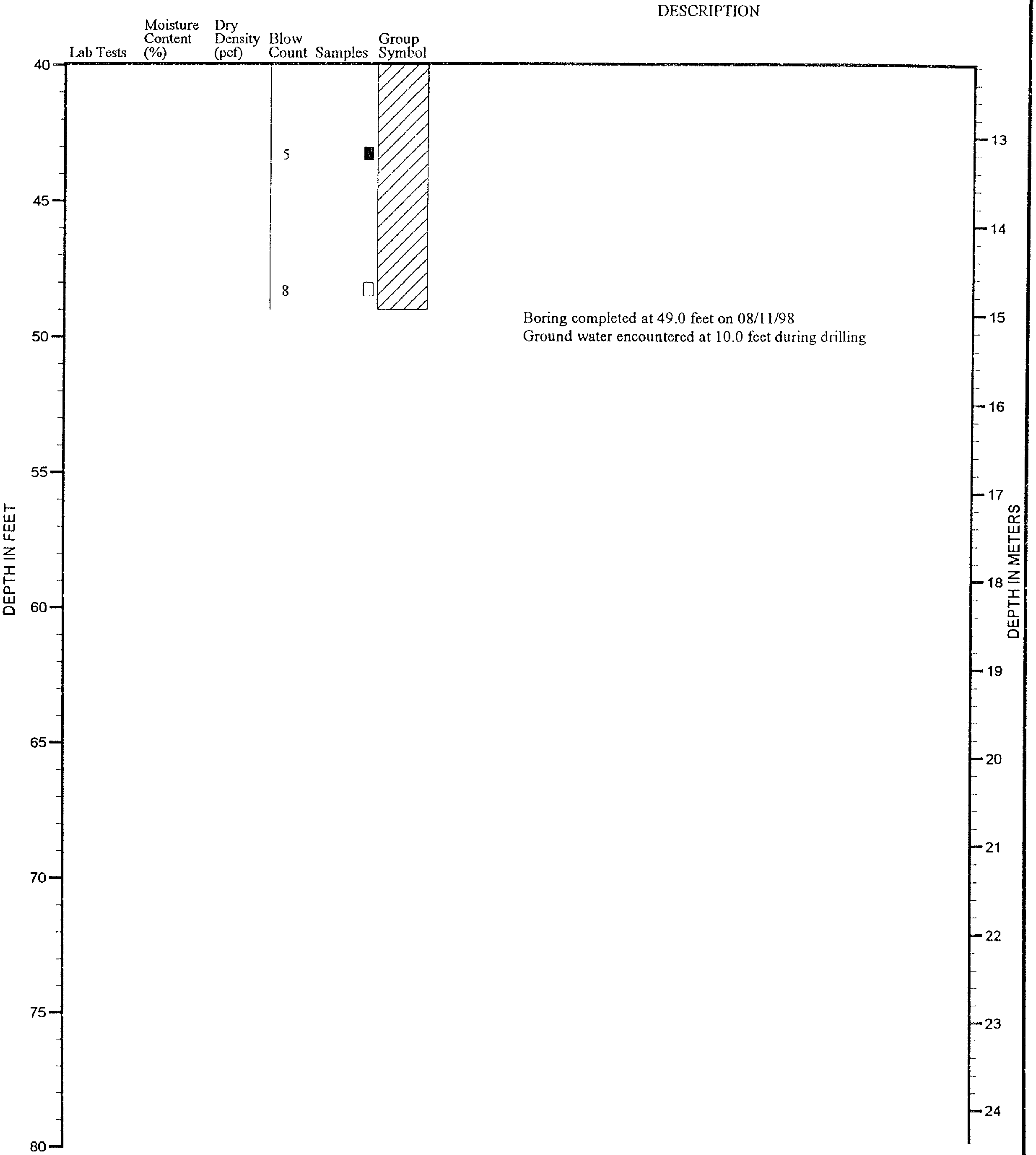
LOG OF BORING

FIGURE A-12

TEST DATA

BORING B-8
(Continued)



Boring completed at 49.0 feet on 08/11/98
Ground water encountered at 10.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

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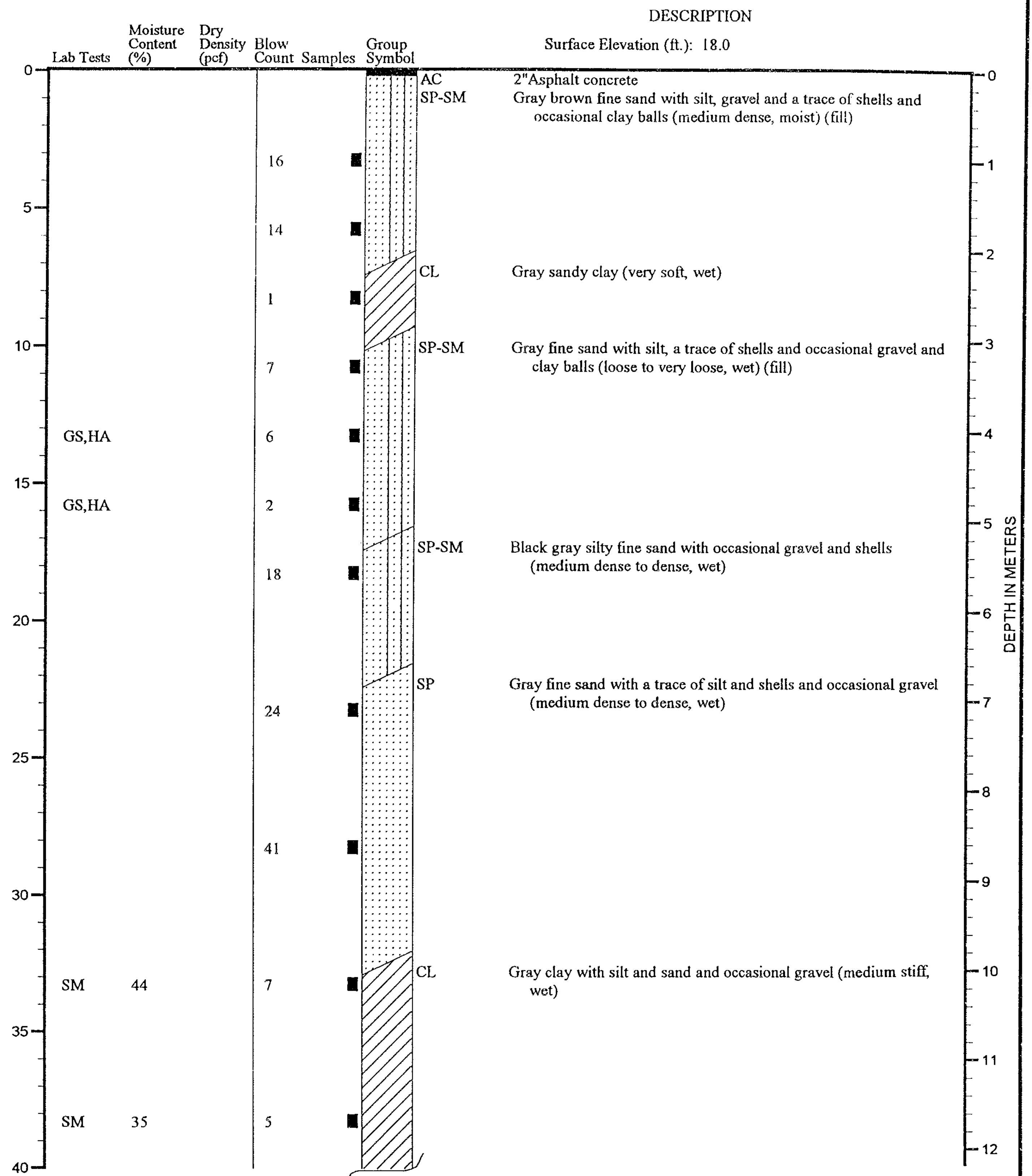
LOG OF BORING

FIGURE A-12

BORING B-9



TEST DATA

Lab Tests	Moisture Content (%)	Dry Density (pcf)	Blow Count	Samples
			16	■
			14	■
			1	■
			7	■
GS,HA			6	■
GS,HA			2	■
			18	■
			24	■
			41	■
SM	44		7	■
SM	35		5	■

DESCRIPTION

Surface Elevation (ft.): 18.0

Group Symbol	Description
AC	2"Asphalt concrete
SP-SM	Gray brown fine sand with silt, gravel and a trace of shells and occasional clay balls (medium dense, moist) (fill)
CL	Gray sandy clay (very soft, wet)
SP-SM	Gray fine sand with silt, a trace of shells and occasional gravel and clay balls (loose to very loose, wet) (fill)
SP-SM	Black gray silty fine sand with occasional gravel and shells (medium dense to dense, wet)
SP	Gray fine sand with a trace of silt and shells and occasional gravel (medium dense to dense, wet)
CL	Gray clay with silt and sand and occasional gravel (medium stiff, wet)

Note: See Figure A-2 for explanation of symbols

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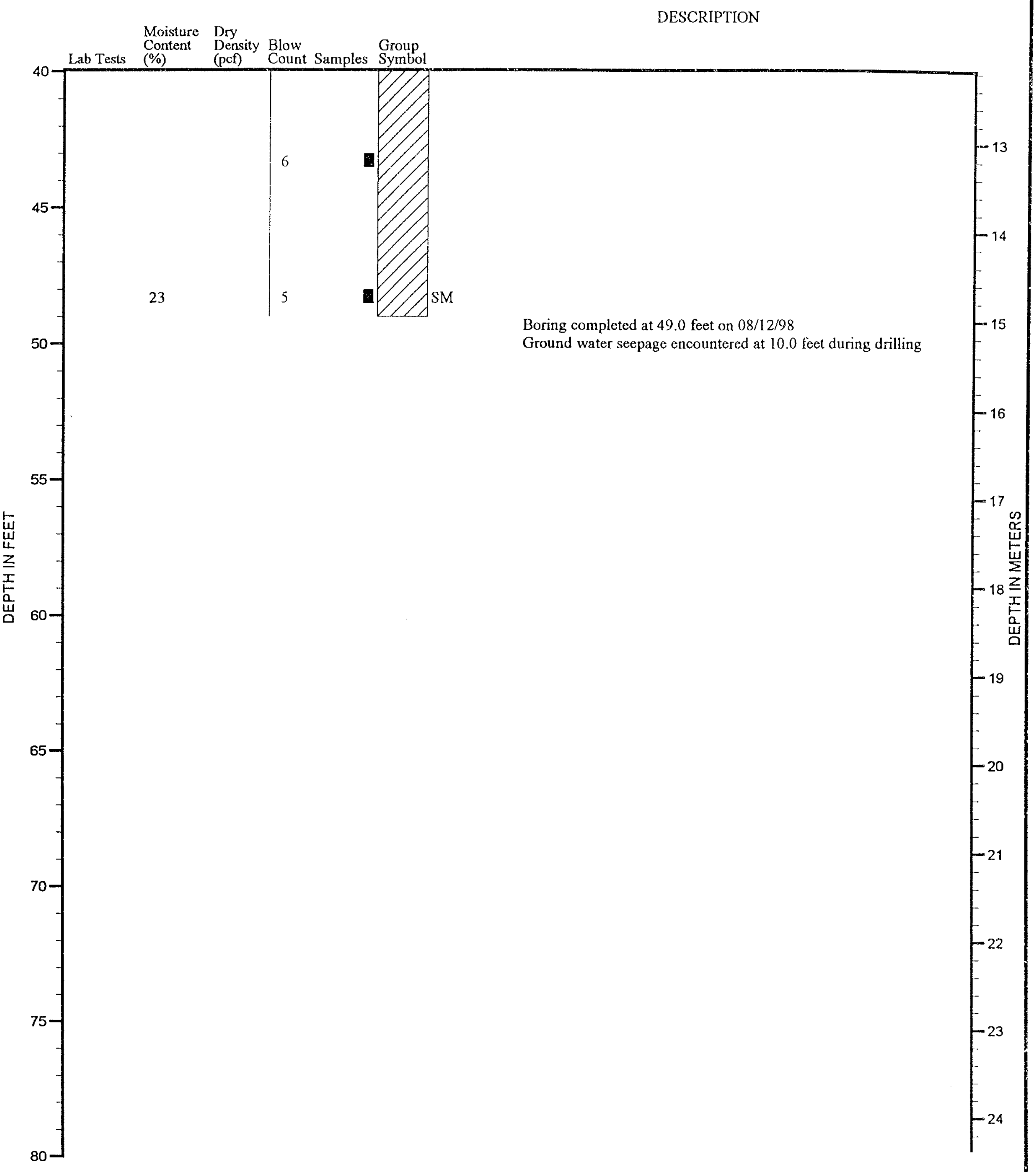
LOG OF BORING

FIGURE A-13

BORING B-9
(Continued)



Boring completed at 49.0 feet on 08/12/98
Ground water seepage encountered at 10.0 feet during drilling

Note: See Figure A-2 for explanation of symbols

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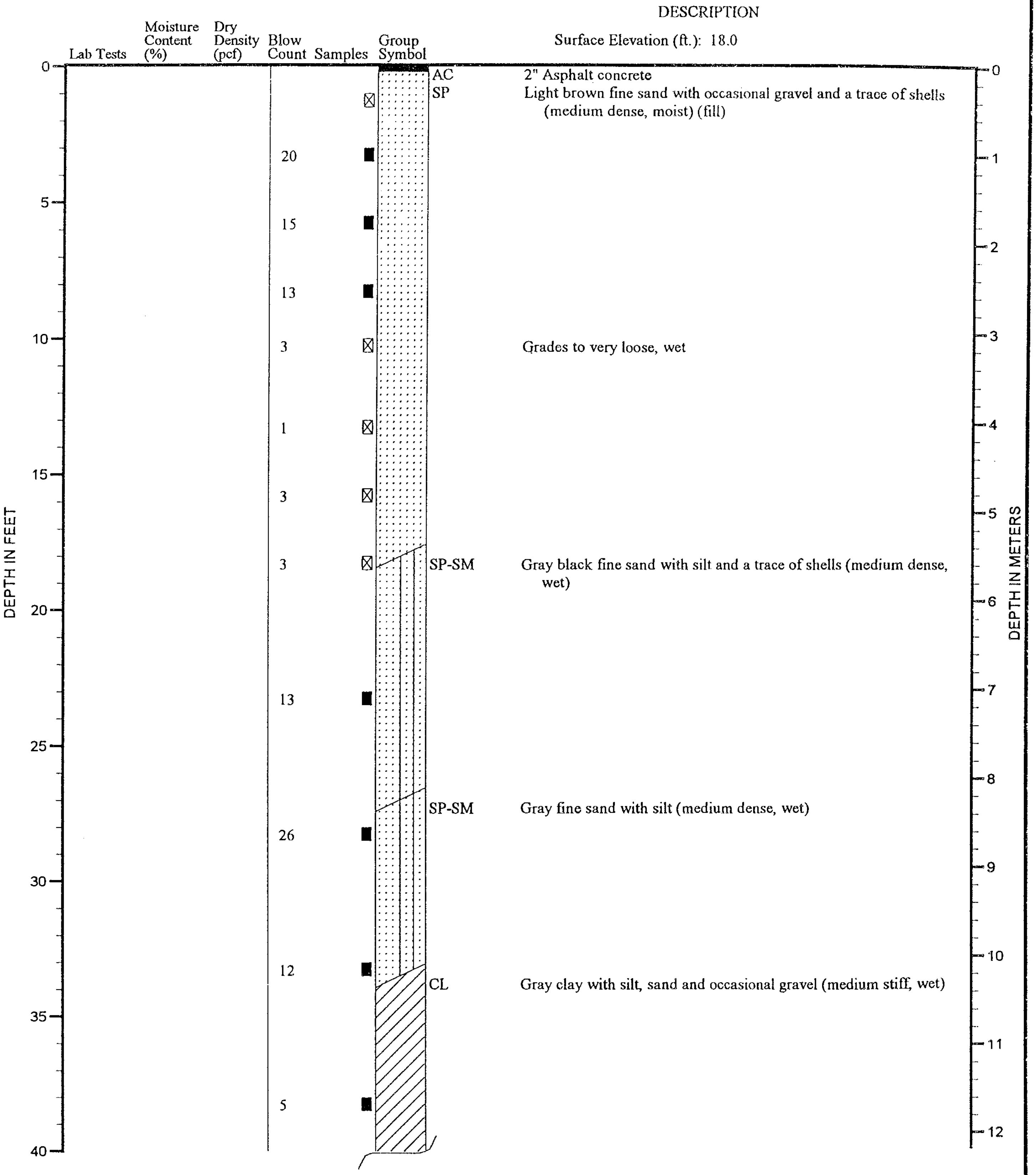
LOG OF BORING

FIGURE A-13

BORING B-10



Surface Elevation (ft.): 18.0

2" Asphalt concrete

Light brown fine sand with occasional gravel and a trace of shells (medium dense, moist) (fill)

Grades to very loose, wet

Gray black fine sand with silt and a trace of shells (medium dense, wet)

Gray fine sand with silt (medium dense, wet)

Gray clay with silt, sand and occasional gravel (medium stiff, wet)

Note: See Figure A-2 for explanation of symbols

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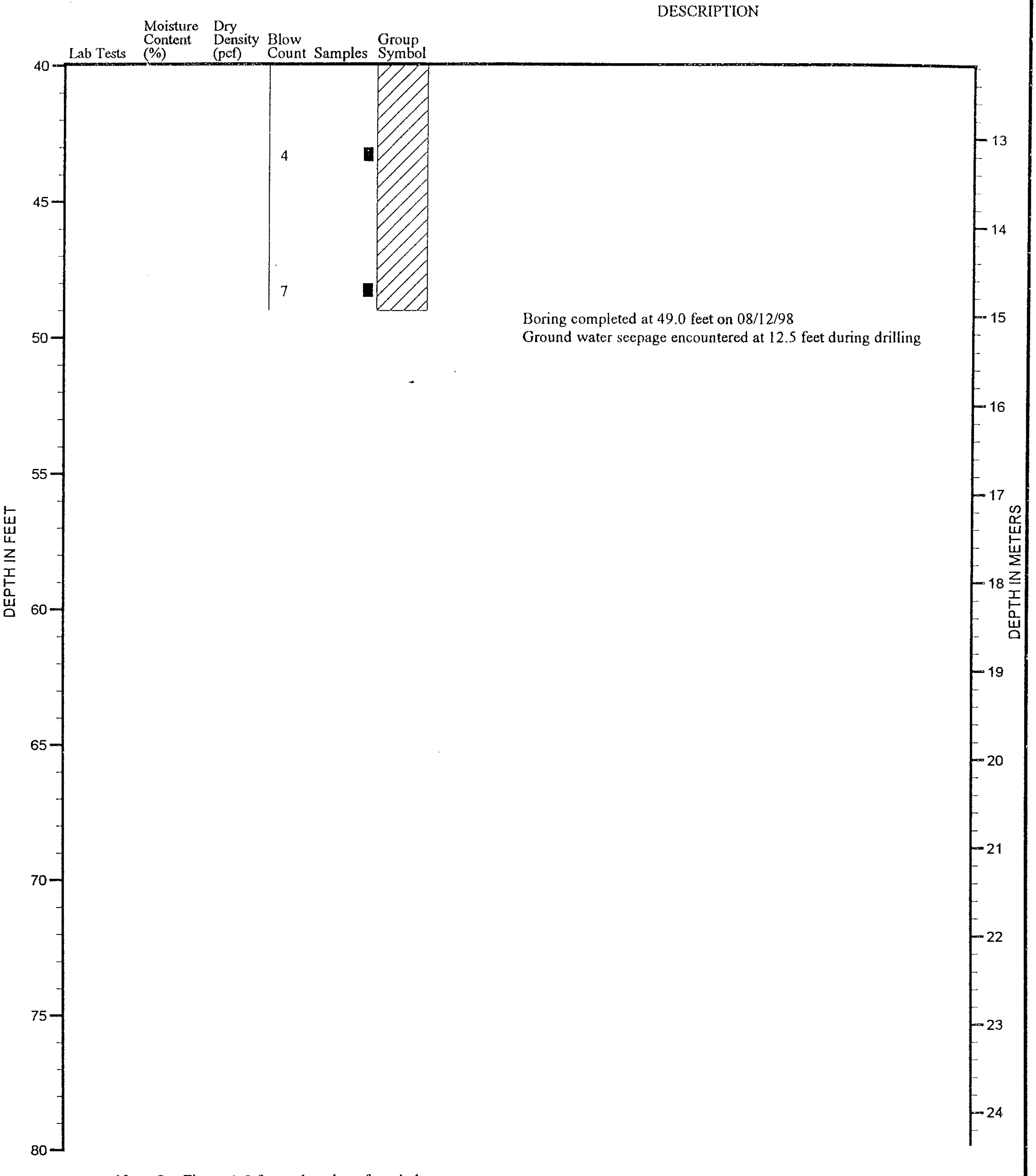
LOG OF BORING

FIGURE A-14

TEST DATA

BORING B-10
(Continued)



Boring completed at 49.0 feet on 08/12/98
Ground water seepage encountered at 12.5 feet during drilling

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING

FIGURE A-14

APPENDIX B

ATTACHMENT B

CHEMICAL ANALYTICAL PROGRAM

ANALYTICAL METHODS

Chain-of-custody procedures were followed during the transport of the field samples to the analytical laboratory. The samples were held in cold storage pending extraction and/or analysis. The analytical results, analytical methods reference and laboratory QA/QC (quality assurance/quality control) records are included in this attachment. The analytical results are also summarized in the text and tables of this report.

ANALYTICAL DATA REVIEW

The laboratory maintains an internal quality assurance program as documented in its laboratory quality assurance manual. The laboratory uses a combination of blanks, surrogate recoveries, duplicates, matrix spike recoveries, matrix spike duplicate recoveries, blank spike recoveries and blank spike duplicate recoveries to evaluate the validity of the analytical results. The laboratory also uses data quality goals for individual chemicals or groups of chemicals based on the long-term performance of the test methods. The data quality goals are included in the laboratory reports. The laboratory compared each group of samples with the existing data quality goals and noted any exceptions in the laboratory report. No additional data review was performed on the analytical results and QA/QC.

ANALYTICAL DATA REVIEW SUMMARY

Some minor data quality exceptions were documented by the laboratory. The laboratory concludes that the exceptions do not compromise the integrity of the data. We conclude that the data is acceptable for use in interpreting the conclusions in this report.

NORTH CREEK ANALYTICAL
Environmental Laboratory Services

BOTHELL ▪ (425) 420-9200 ▪ FAX 420-9210
SPOKANE ▪ (509) 924-9200 ▪ FAX 924-9290
PORTLAND ▪ (503) 906-9200 ▪ FAX 906-9210

GeoEngineers
SEP 24 1998
ROUTING JRG ☐ file ☐ ☐ ☐
FILE # 0307-024-02

Geo Engineers - Bellingham 600 Dupont St. Bellingham, WA 98225	Project: Port of Bellingham Project Number: 0307-024-02 Project Manager: Jay Gordon	Sampled: 9/1/98 Received: 9/2/98 Reported: 9/21/98 11:40

ANALYTICAL REPORT FOR SAMPLES:

Sample Description	Laboratory Sample Number	Sample Matrix	Date Sampled
TP-1	B809044-01	Soil	9/1/98
TP-2	B809044-02	Soil	9/1/98
TP-3	B809044-03	Soil	9/1/98
TP-4	B809044-04	Soil	9/1/98
TP-5	B809044-05	Soil	9/1/98

North Creek Analytical - Bothell

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported:	9/21/98 11:40

Total Metals by EPA 6000/7000 Series Methods
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Specific Method	Reporting Limit	Result	Units	Notes*
P-1			B809044-01				Soil	
Antimony	0980239	9/8/98	9/10/98	EPA 6020	0.500	ND	mg/kg dry	
Arsenic	"	"	"	EPA 6020	0.500	**2.60**	"	
eryllium	"	"	"	EPA 6020	0.500	ND	"	
admium	"	"	"	EPA 6020	0.500	ND	"	
Chromium	"	"	"	EPA 6020	0.500	**13.3**	"	
Copper	"	"	"	EPA 6020	0.500	**11.3**	"	
ead	"	"	"	EPA 6020	0.500	**2.77**	"	
Nickel	"	"	"	EPA 6020	0.500	**15.2**	"	
Selenium	"	"	"	EPA 6020	0.500	ND	"	
ilver	"	"	"	EPA 6020	0.500	ND	"	
hallium	"	"	"	EPA 6020	0.500	ND	"	
Zinc	"	"	"	EPA 6020	5.00	**25.7**	"	
Mercury	0980262	9/9/98	"	EPA 7471A	0.100	ND	"	
TP-2			B809044-02				Soil	
Antimony	0980239	9/8/98	9/10/98	EPA 6020	0.500	ND	mg/kg dry	
rsenic	"	"	"	EPA 6020	0.500	**2.15**	"	
eryllium	"	"	"	EPA 6020	0.500	ND	"	
Cadmium	"	"	"	EPA 6020	0.500	ND	"	
Chromium	"	"	"	EPA 6020	0.500	**16.5**	"	
opper	"	"	"	EPA 6020	0.500	**11.3**	"	
Lead	"	"	"	EPA 6020	0.500	**2.80**	"	
Nickel	"	"	"	EPA 6020	0.500	**16.2**	"	
Selenium	"	"	"	EPA 6020	0.500	ND	"	
Silver	"	"	"	EPA 6020	0.500	ND	"	
Thallium	"	"	"	EPA 6020	0.500	ND	"	
inc	"	"	"	EPA 6020	5.00	**27.4**	"	
lercury	0980262	9/9/98	"	EPA 7471A	0.100	ND	"	
TP-3			B809044-03				Soil	
ntimony	0980239	9/8/98	9/10/98	EPA 6020	0.500	ND	mg/kg dry	
Arsenic	"	"	"	EPA 6020	0.500	**2.25**	"	
Beryllium	"	"	"	EPA 6020	0.500	ND	"	
admium	"	"	"	EPA 6020	0.500	ND	"	
hromium	"	"	"	EPA 6020	0.500	**11.2**	"	
Copper	"	"	"	EPA 6020	0.500	**17.2**	"	
Lead	"	"	"	EPA 6020	0.500	**1.69**	"	
ickel	"	"	"	EPA 6020	0.500	**11.4**	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project:	Port of Bellingham		Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02		Received:	9/2/98
Bellingham, WA 98225	Project Manager:	Jay Gordon		Reported:	9/21/98 11:40

Total Metals by EPA 6000/7000 Series Methods
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Specific Method	Reporting Limit	Result	Units	Notes*
TP-3 (continued)			B809044-03				**Soil**	
Selenium	0980239	9/8/98	9/10/98	EPA 6020	0.500	ND	mg/kg dry	
Silver	"	"	"	EPA 6020	0.500	ND	"	
Thallium	"	"	"	EPA 6020	0.500	ND	"	
Zinc	"	"	"	EPA 6020	5.00	**20.1**	"	
Mercury	0980262	9/9/98	"	EPA 7471A	0.100	**0.105**	"	
TP-4			B809044-04				**Soil**	
Antimony	0980239	9/8/98	9/10/98	EPA 6020	0.500	ND	mg/kg dry	
Arsenic	"	"	"	EPA 6020	0.500	**2.60**	"	
Beryllium	"	"	"	EPA 6020	0.500	ND	"	
Cadmium	"	"	"	EPA 6020	0.500	ND	"	
Chromium	"	"	"	EPA 6020	0.500	**14.0**	"	
Copper	"	"	"	EPA 6020	0.500	**8.43**	"	
Lead	"	"	"	EPA 6020	0.500	**1.97**	"	
Nickel	"	"	"	EPA 6020	0.500	**12.1**	"	
Selenium	"	"	"	EPA 6020	0.500	ND	"	
Silver	"	"	"	EPA 6020	0.500	ND	"	
Thallium	"	"	"	EPA 6020	0.500	ND	"	
Zinc	"	"	"	EPA 6020	5.00	**21.7**	"	
Mercury	0980262	9/9/98	"	EPA 7471A	0.100	ND	"	
TP-5			B809044-05				**Soil**	
Antimony	0980239	9/8/98	9/10/98	EPA 6020	0.500	ND	mg/kg dry	
Arsenic	"	"	"	EPA 6020	0.500	**2.22**	"	
Beryllium	"	"	"	EPA 6020	0.500	ND	"	
Cadmium	"	"	"	EPA 6020	0.500	ND	"	
Chromium	"	"	"	EPA 6020	0.500	**17.5**	"	
Copper	"	"	"	EPA 6020	0.500	**13.4**	"	
Lead	"	"	"	EPA 6020	0.500	**2.25**	"	
Nickel	"	"	"	EPA 6020	0.500	**38.8**	"	
Selenium	"	"	"	EPA 6020	0.500	ND	"	
Silver	"	"	"	EPA 6020	0.500	ND	"	
Thallium	"	"	"	EPA 6020	0.500	ND	"	
Zinc	"	"	"	EPA 6020	5.00	**23.6**	"	
Mercury	0980262	9/9/98	"	EPA 7471A	0.100	ND	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Polychlorinated Biphenyls by EPA Method 8082
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-1			**B809044-01**				**Soil**	
Aroclor 1016	0980088	9/3/98	9/4/98		50.0	ND	ug/kg dry	
Aroclor 1221	"	"	"		50.0	ND	"	
Aroclor 1232	"	"	"		50.0	ND	"	
Aroclor 1242	"	"	"		50.0	ND	"	
Aroclor 1248	"	"	"		50.0	ND	"	
Aroclor 1254	"	"	"		50.0	ND	"	
Aroclor 1260	"	"	"		50.0	ND	"	
Aroclor 1262	"	"	"		50.0	ND	"	
Aroclor 1268	"	"	"		50.0	ND	"	
Surrogate: TCX	"	"	"	*40.0-130*		*96.4*	*%*	
TP-2			**B809044-02**				**Soil**	
Aroclor 1016	0980088	9/3/98	9/17/98		50.0	ND	ug/kg dry	
Aroclor 1221	"	"	"		50.0	ND	"	
Aroclor 1232	"	"	"		50.0	ND	"	
Aroclor 1242	"	"	"		50.0	ND	"	
Aroclor 1248	"	"	"		50.0	ND	"	
Aroclor 1254	"	"	"		50.0	ND	"	
Aroclor 1260	"	"	"		50.0	ND	"	
Aroclor 1262	"	"	"		50.0	ND	"	
Aroclor 1268	"	"	"		50.0	ND	"	
Surrogate: TCX	"	"	"	*40.0-130*		*84.8*	*%*	
TP-3			**B809044-03**				**Soil**	
Aroclor 1016	0980088	9/3/98	9/17/98		50.0	ND	ug/kg dry	
Aroclor 1221	"	"	"		50.0	ND	"	
Aroclor 1232	"	"	"		50.0	ND	"	
Aroclor 1242	"	"	"		50.0	ND	"	
Aroclor 1248	"	"	"		50.0	ND	"	
Aroclor 1254	"	"	"		50.0	ND	"	
Aroclor 1260	"	"	"		50.0	ND	"	
Aroclor 1262	"	"	"		50.0	ND	"	
Aroclor 1268	"	"	"		50.0	ND	"	
urrogate: TCX	"	"	"	*40.0-130*		*88.3*	*%*	
TP-4			**B809044-04**				**Soil**	
roclor 1016	0980088	9/3/98	9/17/98		50.0	ND	ug/kg dry	
roclor 1221	"	"	"		50.0	ND	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Polychlorinated Biphenyls by EPA Method 8082
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-4 (continued)			**B809044-04**				**Soil**	
Aroclor 1232	0980088	9/3/98	9/17/98		50.0	ND	ug/kg dry	
Aroclor 1242	"	"	"		50.0	ND	"	
Aroclor 1248	"	"	"		50.0	ND	"	
Aroclor 1254	"	"	"		50.0	ND	"	
Aroclor 1260	"	"	"		50.0	ND	"	
Aroclor 1262	"	"	"		50.0	ND	"	
Aroclor 1268	"	"	"		50.0	ND	"	
Surrogate: TCX	*"*	*"*	*"*	*40.0-130*		*87.6*	*%*	
TP-5			**B809044-05**				**Soil**	
Aroclor 1016	0980088	9/3/98	9/17/98		50.0	ND	ug/kg dry	
Aroclor 1221	"	"	"		50.0	ND	"	
Aroclor 1232	"	"	"		50.0	ND	"	
Aroclor 1242	"	"	"		50.0	ND	"	
Aroclor 1248	"	"	"		50.0	ND	"	
Aroclor 1254	"	"	"		50.0	ND	"	
Aroclor 1260	"	"	"		50.0	ND	"	
Aroclor 1262	"	"	"		50.0	ND	"	
Aroclor 1268	"	"	"		50.0	ND	"	
Surrogate: TCX	*"*	*"*	*"*	*40.0-130*		*92.2*	*%*	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham
600 Dupont St.
Bellingham, WA 98225

Project: Port of Bellingham
Project Number: 0307-024-02
Project Manager: Jay Gordon

Sampled: 9/1/98
Received: 9/2/98
Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-1			**B809044-01**				**Soil**	
Acetone	0980260	9/9/98	9/9/98		2.00	ND	mg/kg dry	
Benzene	"	"	"		0.100	ND	"	
Bromodichloromethane	"	"	"		0.100	ND	"	
Bromoform	"	"	"		0.100	ND	"	
Bromomethane	"	"	"		0.100	ND	"	
2-Butanone	"	"	"		2.00	ND	"	
Carbon disulfide	"	"	"		0.100	ND	"	
Carbon tetrachloride	"	"	"		0.100	ND	"	
Chlorobenzene	"	"	"		0.100	ND	"	
Chloroethane	"	"	"		0.100	ND	"	
Chloroform	"	"	"		0.100	ND	"	
Chloromethane	"	"	"		0.500	ND	"	
Dibromochloromethane	"	"	"		0.100	ND	"	
,2-Dichlorobenzene	"	"	"		0.100	ND	"	
1,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
,1-Dichloroethane	"	"	"		0.100	ND	"	
.2-Dichloroethane	"	"	"		0.100	ND	"	
1,1-Dichloroethene	"	"	"		0.100	ND	"	
is-1,2-Dichloroethene	"	"	"		0.100	ND	"	
ans-1,2-Dichloroethene	"	"	"		0.100	ND	"	
1,2-Dichloropropane	"	"	"		0.100	ND	"	
cis-1,3-Dichloropropene	"	"	"		0.100	ND	"	
ans-1,3-Dichloropropene	"	"	"		0.100	ND	"	
Ethylbenzene	"	"	"		0.100	ND	"	
2-Hexanone	"	"	"		2.00	ND	"	
Methylene chloride	"	"	"		1.00	ND	"	
-Methyl-2-pentanone	"	"	"		2.00	ND	"	
Styrene	"	"	"		0.100	ND	"	
1,1,2,2-Tetrachloroethane	"	"	"		0.100	ND	"	
etrachloroethene	"	"	"		0.100	ND	"	
Toluene	"	"	"		0.100	ND	"	
1,1,1-Trichloroethane	"	"	"		0.100	ND	"	
.1,2-Trichloroethane	"	"	"		0.100	ND	"	
richloroethene	"	"	"		0.100	ND	"	
Vinyl chloride	"	"	"		0.100	ND	"	
Xylenes (total)	"	"	"		0.400	ND	"	
urrogate: 2-Bromopropene	"	"	"	*70.0-130*		*130*	%	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-1 (continued)			**B809044-01**				**Soil**	
Surrogate: 1,2-DCA-d4	*0980260*	*9/9/98*	*9/9/98*	*70.0-130*		*105*	*%*	
Surrogate: Toluene-d8	"	"	"	*70.0-130*		*105*	"	
Surrogate: 4-BFB	"	"	"	*70.0-130*		*97.1*	"	

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-2			**B809044-02**				**Soil**	
Acetone	0980260	9/9/98	9/9/98		2.00	ND	mg/kg dry	
Benzene	"	"	"		0.100	ND	"	
Bromodichloromethane	"	"	"		0.100	ND	"	
Bromoform	"	"	"		0.100	ND	"	
Bromomethane	"	"	"		0.100	ND	"	
2-Butanone	"	"	"		2.00	ND	"	
Carbon disulfide	"	"	"		0.100	ND	"	
Carbon tetrachloride	"	"	"		0.100	ND	"	
Chlorobenzene	"	"	"		0.100	ND	"	
Chloroethane	"	"	"		0.100	ND	"	
Chloroform	"	"	"		0.100	ND	"	
Chloromethane	"	"	"		0.500	ND	"	
Dibromochloromethane	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
1,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,1-Dichloroethane	"	"	"		0.100	ND	"	
1,2-Dichloroethane	"	"	"		0.100	ND	"	
1,1-Dichloroethene	"	"	"		0.100	ND	"	
cis-1,2-Dichloroethene	"	"	"		0.100	ND	"	
trans-1,2-Dichloroethene	"	"	"		0.100	ND	"	
1,2-Dichloropropane	"	"	"		0.100	ND	"	
cis-1,3-Dichloropropene	"	"	"		0.100	ND	"	
trans-1,3-Dichloropropene	"	"	"		0.100	ND	"	
Ethylbenzene	"	"	"		0.100	ND	"	
2-Hexanone	"	"	"		2.00	ND	"	
Methylene chloride	"	"	"		1.00	ND	"	
4-Methyl-2-pentanone	"	"	"		2.00	ND	"	
Styrene	"	"	"		0.100	ND	"	
1,1,2,2-Tetrachloroethane	"	"	"		0.100	ND	"	
Tetrachloroethene	"	"	"		0.100	ND	"	
Toluene	"	"	"		0.100	ND	"	
1,1,1-Trichloroethane	"	"	"		0.100	ND	"	
1,1,2-Trichloroethane	"	"	"		0.100	ND	"	
Trichloroethene	"	"	"		0.100	ND	"	
Vinyl chloride	"	"	"		0.100	ND	"	
Xylenes (total)	"	"	"		0.400	ND	"	
Surrogate: 2-Bromopropene	"	"	"	*70.0-130*		*127*	*%*	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported:	9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-2 (continued)			B809044-02				Soil	
Surrogate: 1,2-DCA-d4	*0980260*	*9/9/98*	*9/9/98*	*70.0-130*		*105*	*%*	
Surrogate: Toluene-d8	"	"	"	*70.0-130*		*111*	"	
Surrogate: 4-BFB	"	"	"	*70.0-130*		*98.6*	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham 600 Dupont St. Bellingham, WA 98225	Project: Port of Bellingham Project Number: 0307-024-02 Project Manager: Jay Gordon	Sampled: 9/1/98 Received: 9/2/98 Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-3			**B809044-03**				**Soil**	
Acetone	0980260	9/9/98	9/9/98		2.00	ND	mg/kg dry	
Benzene	"	"	"		0.100	ND	"	
Bromodichloromethane	"	"	"		0.100	ND	"	
Bromoform	"	"	"		0.100	ND	"	
Bromomethane	"	"	"		0.100	ND	"	
2-Butanone	"	"	"		2.00	ND	"	
Carbon disulfide	"	"	"		0.100	ND	"	
Carbon tetrachloride	"	"	"		0.100	ND	"	
Chlorobenzene	"	"	"		0.100	ND	"	
Chloroethane	"	"	"		0.100	ND	"	
Chloroform	"	"	"		0.100	ND	"	
Chloromethane	"	"	"		0.500	ND	"	
Dibromochloromethane	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
1,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,1-Dichloroethane	"	"	"		0.100	ND	"	
1,2-Dichloroethane	"	"	"		0.100	ND	"	
1,1-Dichloroethene	"	"	"		0.100	ND	"	
cis-1,2-Dichloroethene	"	"	"		0.100	ND	"	
trans-1,2-Dichloroethene	"	"	"		0.100	ND	"	
1,2-Dichloropropane	"	"	"		0.100	ND	"	
cis-1,3-Dichloropropene	"	"	"		0.100	ND	"	
trans-1,3-Dichloropropene	"	"	"		0.100	ND	"	
Ethylbenzene	"	"	"		0.100	ND	"	
2-Hexanone	"	"	"		2.00	ND	"	
Methylene chloride	"	"	"		1.00	ND	"	
4-Methyl-2-pentanone	"	"	"		2.00	ND	"	
Styrene	"	"	"		0.100	ND	"	
1,1,2,2-Tetrachloroethane	"	"	"		0.100	ND	"	
Tetrachloroethene	"	"	"		0.100	ND	"	
Toluene	"	"	"		0.100	ND	"	
1,1,1-Trichloroethane	"	"	"		0.100	ND	"	
1,1,2-Trichloroethane	"	"	"		0.100	ND	"	
Trichloroethene	"	"	"		0.100	ND	"	
Vinyl chloride	"	"	"		0.100	ND	"	
Xylenes (total)	"	"	"		0.400	ND	"	
Surrogate: 2-Bromopropene	"	"	"	*70.0-130*		*123*	%	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

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Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
P-3 (continued)				**B809044-03**			**Soil**	
Surrogate: 1,2-DCA-d4	*0980260*	*9/9/98*	*9/9/98*	*70.0-130*		*100*	*%*	
Surrogate: Toluene-d8	"	"	"	*70.0-130*		*102*	"	
Surrogate: 4-BFB	"	"	"	*70.0-130*		*91.9*	"	

**Refer to end of report for text of notes and definitions.*

teve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-4			**B809044-04**				**Soil**	
Acetone	0980260	9/9/98	9/9/98		2.00	ND	mg/kg dry	
Benzene	"	"	"		0.100	ND	"	
Bromodichloromethane	"	"	"		0.100	ND	"	
Bromoform	"	"	"		0.100	ND	"	
Bromomethane	"	"	"		0.100	ND	"	
2-Butanone	"	"	"		2.00	ND	"	
Carbon disulfide	"	"	"		0.100	ND	"	
Carbon tetrachloride	"	"	"		0.100	ND	"	
Chlorobenzene	"	"	"		0.100	ND	"	
Chloroethane	"	"	"		0.100	ND	"	
Chloroform	"	"	"		0.100	ND	"	
Chloromethane	"	"	"		0.500	ND	"	
Dibromochloromethane	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
1,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,1-Dichloroethane	"	"	"		0.100	ND	"	
1,2-Dichloroethane	"	"	"		0.100	ND	"	
1,1-Dichloroethene	"	"	"		0.100	ND	"	
cis-1,2-Dichloroethene	"	"	"		0.100	ND	"	
rans-1,2-Dichloroethene	"	"	"		0.100	ND	"	
1,2-Dichloropropane	"	"	"		0.100	ND	"	
cis-1,3-Dichloropropene	"	"	"		0.100	ND	"	
rans-1,3-Dichloropropene	"	"	"		0.100	ND	"	
Ethylbenzene	"	"	"		0.100	ND	"	
2-Hexanone	"	"	"		2.00	ND	"	
Methylene chloride	"	"	"		1.00	ND	"	
4-Methyl-2-pentanone	"	"	"		2.00	ND	"	
Styrene	"	"	"		0.100	ND	"	
1,1,2,2-Tetrachloroethane	"	"	"		0.100	ND	"	
Tetrachloroethene	"	"	"		0.100	ND	"	
Toluene	"	"	"		0.100	ND	"	
1,1,1-Trichloroethane	"	"	"		0.100	ND	"	
1,1,2-Trichloroethane	"	"	"		0.100	ND	"	
Trichloroethene	"	"	"		0.100	ND	"	
Vinyl chloride	"	"	"		0 100	ND	"	
Xylenes (total)	"	"	"		0.400	ND	"	
Surrogate: 2-Bromopropene	"	"	"	*70.0-130*		*123*	%	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

eo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
P-4 (continued)			**B809044-04**				**Soil**	
urrogate: 1,2-DCA-d4	*0980260*	*9/9/98*	*9/9/98*	*70.0-130*		*99.5*	*%*	
Surrogate: Toluene-d8	"	"	"	*70.0-130*		*100*	"	
urrogate: 4-BFB	"	"	"	*70.0-130*		*93.3*	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

teve ~~Davis~~, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-5			**B809044-05**				**Soil**	
Acetone	0980260	9/9/98	9/9/98		2.00	ND	mg/kg dry	
Benzene	"	"	"		0.100	ND	"	
Bromodichloromethane	"	"	"		0.100	ND	"	
Bromoform	"	"	"		0.100	ND	"	
Bromomethane	"	"	"		0.100	ND	"	
2-Butanone	"	"	"		2.00	ND	"	
Carbon disulfide	"	"	"		0.100	ND	"	
Carbon tetrachloride	"	"	"		0.100	ND	"	
Chlorobenzene	"	"	"		0.100	ND	"	
Chloroethane	"	"	"		0.100	ND	"	
Chloroform	"	"	"		0.100	ND	"	
Chloromethane	"	"	"		0.500	ND	"	
Dibromochloromethane	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
1,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,1-Dichloroethane	"	"	"		0.100	ND	"	
1,2-Dichloroethane	"	"	"		0.100	ND	"	
1,1-Dichloroethene	"	"	"		0.100	ND	"	
cis-1,2-Dichloroethene	"	"	"		0.100	ND	"	
trans-1,2-Dichloroethene	"	"	"		0.100	ND	"	
1,2-Dichloropropane	"	"	"		0.100	ND	"	
cis-1,3-Dichloropropene	"	"	"		0.100	ND	"	
trans-1,3-Dichloropropene	"	"	"		0.100	ND	"	
Ethylbenzene	"	"	"		0.100	ND	"	
2-Hexanone	"	"	"		2.00	ND	"	
Methylene chloride	"	"	"		1.00	ND	"	
4-Methyl-2-pentanone	"	"	"		2.00	ND	"	
Styrene	"	"	"		0.100	ND	"	
1,1,2,2-Tetrachloroethane	"	"	"		0.100	ND	"	
Tetrachloroethene	"	"	"		0.100	ND	"	
Toluene	"	"	"		0.100	ND	"	
1,1,1-Trichloroethane	"	"	"		0.100	ND	"	
1,1,2-Trichloroethane	"	"	"		0.100	ND	"	
Trichloroethene	"	"	"		0.100	ND	"	
Vinyl chloride	"	"	"		0.100	ND	"	
Xylenes (total)	"	"	"		0.400	ND	"	
Surrogate: 2-Bromopropene	"	"	"	*70.0-130*		*121*	%	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

eo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
ellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
P-5 (continued)			**B809044-05**				**Soil**	
urrogate: 1,2-DCA-d4	*0980260*	*9/9/98*	*9/9/98*	*70.0-130*		*97.6*	*%*	
Surrogate: Toluene-d8	*"*	*"*	*"*	*70.0-130*		*99.0*	*"*	
urrogate: 4-BFB	*"*	*"*	*"*	*70.0-130*		*92.8*	*"*	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

teve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-1			**B809044-01**				**Soil**	
Acenaphthene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Acenaphthylene	"	"	"		0.100	ND	"	
Aniline	"	"	"		0.100	ND	"	
Anthracene	"	"	"		0.100	ND	"	
Benzoic Acid	"	"	"		0.500	ND	"	
Benzo (a) anthracene	"	"	"		0.100	ND	"	
Benzo (b) fluoranthene	"	"	"		0.100	ND	"	
Benzo (k) fluoranthene	"	"	"		0.100	ND	"	
Benzo (ghi) perylene	"	"	"		0.100	ND	"	
Benzo (a) pyrene	"	"	"		0.100	ND	"	
Benzyl alcohol	"	"	"		0.100	ND	"	
Bis(2-chloroethoxy)methane	"	"	"		0.100	ND	"	
Bis(2-chloroethyl)ether	"	"	"		0.100	ND	"	
Bis(2-chloroisopropyl)ether	"	"	"		0.100	ND	"	
Bis(2-ethylhexyl)phthalate	"	"	"		0.500	ND	"	
4-Bromophenyl phenyl ether	"	"	"		0.100	ND	"	
Butyl benzyl phthalate	"	"	"		0.100	ND	"	
Carbazole	"	"	"		0.500	ND	"	
4-Chloroaniline	"	"	"		0.100	ND	"	
2-Chloronaphthalene	"	"	"		0.100	ND	"	
4-Chloro-3-methylphenol	"	"	"		0.100	ND	"	
2-Chlorophenol	"	"	"		0.100	ND	"	
4-Chlorophenyl phenyl ether	"	"	"		0.100	ND	"	
Chrysene	"	"	"		0.100	ND	"	
Dibenz (a.h) anthracene	"	"	"		0.100	ND	"	
Dibenzofuran	"	"	"		0.100	ND	"	
Di-n-butyl phthalate	"	"	"		0.500	ND	"	
1.3-Dichlorobenzene	"	"	"		0.100	ND	"	
1.4-Dichlorobenzene	"	"	"		0.100	ND	"	
1.2-Dichlorobenzene	"	"	"		0.100	ND	"	
3.3'-Dichlorobenzidine	"	"	"		5.00	ND	"	
2.4-Dichlorophenol	"	"	"		0.100	ND	"	
Diethyl phthalate	"	"	"		0.100	ND	"	
2.4-Dimethylphenol	"	"	"		0.100	ND	"	
Dimethyl phthalate	"	"	"		0.100	ND	"	
4.6-Dinitro-2-methylphenol	"	"	"		0.500	ND	"	
2.4-Dinitrophenol	"	"	"		0.500	ND	"	
2.4-Dinitrotoluene	"	"	"		0.100	ND	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

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eo Engineers - Bellingham	Project:	Port of Bellingham		Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02		Received:	9/2/98
ellingham, WA 98225	Project Manager:	Jay Gordon		Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
P-1 (continued)			B809044-01				Soil	
2,6-Dinitrotoluene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Di-n-octyl phthalate	"	"	"		0.500	ND	"	
luoranthene	"	"	"		0.100	ND	"	
luorene	"	"	"		0.100	ND	"	
Hexachlorobenzene	"	"	"		0.100	ND	"	
exachlorobutadiene	"	"	"		0.100	ND	"	
exachlorocyclopentadiene	"	"	"		0.100	ND	"	
Hexachloroethane	"	"	"		0.100	ND	"	
ndeno (1,2,3-cd) pyrene	"	"	"		0.100	ND	"	
sophorone	"	"	"		0.100	ND	"	
-Methylnaphthalene	"	"	"		0.100	ND	"	
2-Methylphenol	"	"	"		0.100	ND	"	
& 4-Methylphenol	"	"	"		0.100	ND	"	
aphthalene	"	"	"		0.100	ND	"	
2-Nitroaniline	"	"	"		0.500	ND	"	
-Nitroaniline	"	"	"		0.500	ND	"	
-Nitroaniline	"	"	"		0.500	ND	"	
Nitrobenzene	"	"	"		0.100	ND	"	
2-Nitrophenol	"	"	"		0.100	ND	"	
-Nitrophenol	"	"	"		0.500	ND	"	
-Nitrosodiphenylamine	"	"	"		0.200	ND	"	
N-Nitrosodi-n-propylamine	"	"	"		0.100	ND	"	
entachlorophenol	"	"	"		0.500	ND	"	
henanthrene	"	"	"		0.100	ND	"	
Phenol	"	"	"		0.100	ND	"	
Pyrene	"	"	"		0.100	ND	"	
,2,4-Trichlorobenzene	"	"	"		0.100	ND	"	
,4,5-Trichlorophenol	"	"	"		0.500	ND	"	
2,4,6-Trichlorophenol	"	"	"		0.100	ND	"	
urrogate: 2-FP	"	"	"	*19.0-141*		*77.6*	%	
urrogate: Phenol-d6	"	"	"	*44.0-128*		*71.3*	"	
Surrogate: 2,4,6-TBP	"	"	"	*10.0-137*		*104*	"	
urrogate: Nitrobenzene-d5	"	"	"	*33.0-108*		*71.8*	"	
urrogate: 2-FBP	"	"	"	*51.0-124*		*82.8*	"	
urrogate: p-Terphenyl-d14	"	"	"	*48.0-149*		*88.5*	"	

orth Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

teve Davis, Project Manager

Geo Engineers - Bellingham	Project:	Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager:	Jay Gordon	Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-2			B809044-02				Soil	
Acenaphthene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Acenaphthylene	"	"	"		0.100	ND	"	
Aniline	"	"	"		0.100	ND	"	
Anthracene	"	"	"		0.100	ND	"	
Benzoic Acid	"	"	"		0.500	ND	"	
Benzo (a) anthracene	"	"	"		0.100	ND	"	
Benzo (b) fluoranthene	"	"	"		0.100	ND	"	
Benzo (k) fluoranthene	"	"	"		0.100	ND	"	
Benzo (ghi) perylene	"	"	"		0.100	ND	"	
Benzo (a) pyrene	"	"	"		0.100	ND	"	
Benzyl alcohol	"	"	"		0.100	ND	"	
Bis(2-chloroethoxy)methane	"	"	"		0.100	ND	"	
Bis(2-chloroethyl)ether	"	"	"		0.100	ND	"	
Bis(2-chloroisopropyl)ether	"	"	"		0.100	ND	"	
Bis(2-ethylhexyl)phthalate	"	"	"		0.500	ND	"	
4-Bromophenyl phenyl ether	"	"	"		0.100	ND	"	
Butyl benzyl phthalate	"	"	"		0.100	ND	"	
Carbazole	"	"	"		0.500	ND	"	
4-Chloroaniline	"	"	"		0.100	ND	"	
2-Chloronaphthalene	"	"	"		0.100	ND	"	
-Chloro-3-methylphenol	"	"	"		0.100	ND	"	
2-Chlorophenol	"	"	"		0.100	ND	"	
4-Chlorophenyl phenyl ether	"	"	"		0.100	ND	"	
Chrysene	"	"	"		0.100	ND	"	
Dibenz (a,h) anthracene	"	"	"		0.100	ND	"	
Dibenzofuran	"	"	"		0.100	ND	"	
Di-n-butyl phthalate	"	"	"		0.500	ND	"	
,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
,3'-Dichlorobenzidine	"	"	"		5.00	ND	"	
2,4-Dichlorophenol	"	"	"		0.100	ND	"	
Diethyl phthalate	"	"	"		0.100	ND	"	
,4-Dimethylphenol	"	"	"		0.100	ND	"	
Dimethyl phthalate	"	"	"		0.100	ND	"	
4,6-Dinitro-2-methylphenol	"	"	"		0.500	ND	"	
,4-Dinitrophenol	"	"	"		0.500	ND	"	
,4-Dinitrotoluene	"	"	"		0.100	ND	"	

North Creek Analytical - Bothell

Refer to end of report for text of notes and definitions.

teve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-2 (continued)			**B809044-02**				**Soil**	
2,6-Dinitrotoluene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Di-n-octyl phthalate	"	"	"		0.500	ND	"	
Fluoranthene	"	"	"		0.100	ND	"	
Fluorene	"	"	"		0.100	ND	"	
Hexachlorobenzene	"	"	"		0.100	ND	"	
Hexachlorobutadiene	"	"	"		0.100	ND	"	
Hexachlorocyclopentadiene	"	"	"		0.100	ND	"	
Hexachloroethane	"	"	"		0.100	ND	"	
Indeno (1,2,3-cd) pyrene	"	"	"		0.100	ND	"	
Isophorone	"	"	"		0.100	ND	"	
2-Methylnaphthalene	"	"	"		0.100	ND	"	
2-Methylphenol	"	"	"		0.100	ND	"	
3 & 4-Methylphenol	"	"	"		0.100	ND	"	
Naphthalene	"	"	"		0.100	ND	"	
2-Nitroaniline	"	"	"		0.500	ND	"	
3-Nitroaniline	"	"	"		0.500	ND	"	
4-Nitroaniline	"	"	"		0.500	ND	"	
Nitrobenzene	"	"	"		0.100	ND	"	
2-Nitrophenol	"	"	"		0.100	ND	"	
4-Nitrophenol	"	"	"		0.500	ND	"	
N-Nitrosodiphenylamine	"	"	"		0.200	ND	"	
N-Nitrosodi-n-propylamine	"	"	"		0.100	ND	"	
Pentachlorophenol	"	"	"		0.500	ND	"	
Phenanthrene	"	"	"		0.100	ND	"	
Phenol	"	"	"		0.100	ND	"	
Pyrene	"	"	"		0.100	ND	"	
1,2,4-Trichlorobenzene	"	"	"		0.100	ND	"	
2,4,5-Trichlorophenol	"	"	"		0.500	ND	"	
2,4,6-Trichlorophenol	"	"	"		0.100	ND	"	
Surrogate: 2-FP	"	"	"	*19.0-141*		[illegible]	%	
Surrogate: Phenol-d6	"	"	"	*44.0-128*		*72.6*	"	
Surrogate: 2,4,6-TBP	"	"	"	*10.0-137*		*101*	"	
Surrogate: Nitrobenzene-d5	"	"	"	*33.0-108*		*72.0*	"	
Surrogate: 2-FBP	"	"	"	*51.0-124*		*78.3*	"	
Surrogate: p-Terphenyl-d14	"	"	"	*48.0-149*		*89.1*	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project:	Port of Bellingham		Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02		Received:	9/2/98
Bellingham, WA 98225	Project Manager:	Jay Gordon		Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-3			**B809044-03**				**Soil**	
Acenaphthene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Acenaphthylene	"	"	"		0.100	ND	"	
Aniline	"	"	"		0.100	ND	"	
Anthracene	"	"	"		0.100	ND	"	
Benzoic Acid	"	"	"		0.500	ND	"	
Benzo (a) anthracene	"	"	"		0.100	ND	"	
Benzo (b) fluoranthene	"	"	"		0.100	ND	"	
Benzo (k) fluoranthene	"	"	"		0.100	ND	"	
Benzo (ghi) perylene	"	"	"		0.100	ND	"	
Benzo (a) pyrene	"	"	"		0.100	ND	"	
Benzyl alcohol	"	"	"		0.100	ND	"	
Bis(2-chloroethoxy)methane	"	"	"		0.100	ND	"	
Bis(2-chloroethyl)ether	"	"	"		0.100	ND	"	
Bis(2-chloroisopropyl)ether	"	"	"		0.100	ND	"	
Bis(2-ethylhexyl)phthalate	"	"	"		0.500	ND	"	
4-Bromophenyl phenyl ether	"	"	"		0.100	ND	"	
Butyl benzyl phthalate	"	"	"		0.100	ND	"	
Carbazole	"	"	"		0.500	ND	"	
4-Chloroaniline	"	"	"		0.100	ND	"	
2-Chloronaphthalene	"	"	"		0.100	ND	"	
4-Chloro-3-methylphenol	"	"	"		0.100	ND	"	
2-Chlorophenol	"	"	"		0.100	ND	"	
4-Chlorophenyl phenyl ether	"	"	"		0.100	ND	"	
Chrysene	"	"	"		0.100	ND	"	
Dibenz (a.h) anthracene	"	"	"		0.100	ND	"	
Dibenzofuran	"	"	"		0.100	ND	"	
Di-n-butyl phthalate	"	"	"		0.500	ND	"	
1.3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1.2-Dichlorobenzene	"	"	"		0.100	ND	"	
3.3'-Dichlorobenzidine	"	"	"		5.00	ND	"	
2.4-Dichlorophenol	"	"	"		0.100	ND	"	
Diethyl phthalate	"	"	"		0.100	ND	"	
2.4-Dimethylphenol	"	"	"		0.100	ND	"	
Dimethyl phthalate	"	"	"		0.100	ND	"	
4.6-Dinitro-2-methylphenol	"	"	"		0.500	ND	"	
2.4-Dinitrophenol	"	"	"		0.500	ND	"	
2.4-Dinitrotoluene	"	"	"		0.100	ND	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported. 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-3 (continued)			**B809044-03**				**Soil**	
2.6-Dinitrotoluene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Di-n-octyl phthalate	"	"	"		0.500	ND	"	
Fluoranthene	"	"	"		0.100	ND	"	
Fluorene	"	"	"		0.100	ND	"	
Hexachlorobenzene	"	"	"		0.100	ND	"	
Hexachlorobutadiene	"	"	"		0.100	ND	"	
Hexachlorocyclopentadiene	"	"	"		0.100	ND	"	
Hexachloroethane	"	"	"		0.100	ND	"	
Indeno (1,2,3-cd) pyrene	"	"	"		0.100	ND	"	
Isophorone	"	"	"		0.100	ND	"	
2-Methylnaphthalene	"	"	"		0 100	ND	"	
2-Methylphenol	"	"	"		0.100	ND	"	
3 & 4-Methylphenol	"	"	"		0.100	ND	"	
Naphthalene	"	"	"		0.100	ND	"	
2-Nitroaniline	"	"	"		0.500	ND	"	
3-Nitroaniline	"	"	"		0.500	ND	"	
4-Nitroaniline	"	"	"		0.500	ND	"	
Nitrobenzene	"	"	"		0.100	ND	"	
2-Nitrophenol	"	"	"		0.100	ND	"	
4-Nitrophenol	"	"	"		0.500	ND	"	
N-Nitrosodiphenylamine	"	"	"		0.200	ND	"	
N-Nitrosodi-n-propylamine	"	"	"		0.100	ND	"	
Pentachlorophenol	"	"	"		0.500	ND	"	
Phenanthrene	"	"	"		0.100	ND	"	
Phenol	"	"	"		0.100	ND	"	
Pyrene	"	"	"		0.100	ND	"	
1.2.4-Trichlorobenzene	"	"	"		0.100	ND	"	
2.4.5-Trichlorophenol	"	"	"		0.500	ND	"	
2,4,6-Trichlorophenol	"	"	"		0.100	ND	"	
Surrogate: 2-FP	"	"	"	*19.0-141*		*72.6*	%	
Surrogate: Phenol-d6	"	"	"	*44.0-128*		*69.7*	"	
Surrogate: 2,4,6-TBP	"	"	"	*10.0-137*		*103*	"	
Surrogate: Nitrobenzene-d5	"	"	"	*33.0-108*		*70.9*	"	
Surrogate: 2-FBP	"	"	"	*51.0-124*		*86.3*	"	
Surrogate: p-Terphenyl-d14	"	"	"	*48.0-149*		*85.7*	"	

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
P-4			**B809044-04**				**Soil**	
Acenaphthene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Acenaphthylene	"	"	"		0.100	ND	"	
Aniline	"	"	"		0.100	ND	"	
Anthracene	"	"	"		0.100	ND	"	
Benzoic Acid	"	"	"		0.500	ND	"	
Benzo (a) anthracene	"	"	"		0.100	ND	"	
Benzo (b) fluoranthene	"	"	"		0.100	ND	"	
Benzo (k) fluoranthene	"	"	"		0.100	ND	"	
Benzo (ghi) perylene	"	"	"		0.100	ND	"	
Benzo (a) pyrene	"	"	"		0.100	ND	"	
Benzyl alcohol	"	"	"		0.100	ND	"	
Bis(2-chloroethoxy)methane	"	"	"		0.100	ND	"	
Bis(2-chloroethyl)ether	"	"	"		0.100	ND	"	
Bis(2-chloroisopropyl)ether	"	"	"		0.100	ND	"	
Bis(2-ethylhexyl)phthalate	"	"	"		0.500	ND	"	
4-Bromophenyl phenyl ether	"	"	"		0.100	ND	"	
Butyl benzyl phthalate	"	"	"		0.100	ND	"	
Carbazole	"	"	"		0.500	ND	"	
4-Chloroaniline	"	"	"		0.100	ND	"	
-Chloronaphthalene	"	"	"		0.100	ND	"	
-Chloro-3-methylphenol	"	"	"		0.100	ND	"	
2-Chlorophenol	"	"	"		0.100	ND	"	
4-Chlorophenyl phenyl ether	"	"	"		0.100	ND	"	
Chrysene	"	"	"		0.100	ND	"	
Dibenz (a,h) anthracene	"	"	"		0.100	ND	"	
Dibenzofuran	"	"	"		0.100	ND	"	
Di-n-butyl phthalate	"	"	"		0.500	ND	"	
,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
,3'-Dichlorobenzidine	"	"	"		5.00	ND	"	
2,4-Dichlorophenol	"	"	"		0.100	ND	"	
Diethyl phthalate	"	"	"		0.100	ND	"	
,4-Dimethylphenol	"	"	"		0.100	ND	"	
Dimethyl phthalate	"	"	"		0.100	ND	"	
4,6-Dinitro-2-methylphenol	"	"	"		0.500	ND	"	
,4-Dinitrophenol	"	"	"		0.500	ND	"	
,4-Dinitrotoluene	"	"	"		0.100	ND	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-4 (continued)			**B809044-04**				**Soil**	
2,6-Dinitrotoluene	0980087	9/3/98	9/3/98		0.100	ND	mg/kg dry	
Di-n-octyl phthalate	"	"	"		0.500	ND	"	
Fluoranthene	"	"	"		0.100	ND	"	
Fluorene	"	"	"		0.100	ND	"	
Hexachlorobenzene	"	"	"		0.100	ND	"	
Hexachlorobutadiene	"	"	"		0.100	ND	"	
Hexachlorocyclopentadiene	"	"	"		0.100	ND	"	
Hexachloroethane	"	"	"		0.100	ND	"	
Indeno (1,2,3-cd) pyrene	"	"	"		0.100	ND	"	
Isophorone	"	"	"		0.100	ND	"	
2-Methylnaphthalene	"	"	"		0.100	ND	"	
2-Methylphenol	"	"	"		0.100	ND	"	
3 & 4-Methylphenol	"	"	"		0.100	ND	"	
Naphthalene	"	"	"		0.100	ND	"	
2-Nitroaniline	"	"	"		0.500	ND	"	
3-Nitroaniline	"	"	"		0.500	ND	"	
4-Nitroaniline	"	"	"		0.500	ND	"	
Nitrobenzene	"	"	"		0.100	ND	"	
2-Nitrophenol	"	"	"		0.100	ND	"	
4-Nitrophenol	"	"	"		0.500	ND	"	
N-Nitrosodiphenylamine	"	"	"		0.200	ND	"	
N-Nitrosodi-n-propylamine	"	"	"		0.100	ND	"	
Pentachlorophenol	"	"	"		0.500	ND	"	
Phenanthrene	"	"	"		0.100	ND	"	
Phenol	"	"	"		0.100	ND	"	
Pyrene	"	"	"		0.100	ND	"	
1,2,4-Trichlorobenzene	"	"	"		0.100	ND	"	
2,4,5-Trichlorophenol	"	"	"		0.500	ND	"	
2,4,6-Trichlorophenol	"	"	"		0.100	ND	"	
Surrogate: 2-FP	"	"	"	*19.0-141*		*77.7*	%	
Surrogate: Phenol-d6	"	"	"	*44.0-128*		*71.4*	"	
Surrogate: 2,4,6-TBP	"	"	"	*10.0-137*		*105*	"	
Surrogate: Nitrobenzene-d5	"	"	"	*33.0-108*		*70.3*	"	
Surrogate: 2-FBP	"	"	"	*51.0-124*		*78.9*	"	
Surrogate: p-Terphenyl-d14	"	"	"	*48.0-149*		*78.9*	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-5			**B809044-05**				**Soil**	
Acenaphthene	0980087	9/3/98	9/4/98		0.100	ND	mg/kg dry	
Acenaphthylene	"	"	"		0.100	ND	"	
Aniline	"	"	"		0.100	ND	"	
Anthracene	"	"	"		0.100	ND	"	
Benzoic Acid	"	"	"		0.500	ND	"	
Benzo (a) anthracene	"	"	"		0.100	ND	"	
Benzo (b) fluoranthene	"	"	"		0.100	ND	"	
Benzo (k) fluoranthene	"	"	"		0.100	ND	"	
Benzo (ghi) perylene	"	"	"		0.100	ND	"	
Benzo (a) pyrene	"	"	"		0.100	ND	"	
Benzyl alcohol	"	"	"		0.100	ND	"	
Bis(2-chloroethoxy)methane	"	"	"		0.100	ND	"	
Bis(2-chloroethyl)ether	"	"	"		0.100	ND	"	
Bis(2-chloroisopropyl)ether	"	"	"		0.100	ND	"	
Bis(2-ethylhexyl)phthalate	"	"	"		0.500	ND	"	
4-Bromophenyl phenyl ether	"	"	"		0.100	ND	"	
Butyl benzyl phthalate	"	"	"		0.100	ND	"	
Carbazole	"	"	"		0.500	ND	"	
4-Chloroaniline	"	"	"		0.100	ND	"	
2-Chloronaphthalene	"	"	"		0.100	ND	"	
4-Chloro-3-methylphenol	"	"	"		0.100	ND	"	
2-Chlorophenol	"	"	"		0.100	ND	"	
4-Chlorophenyl phenyl ether	"	"	"		0.100	ND	"	
Chrysene	"	"	"		0.100	ND	"	
Dibenz (a,h) anthracene	"	"	"		0.100	ND	"	
Dibenzofuran	"	"	"		0.100	ND	"	
Di-n-butyl phthalate	"	"	"		0.500	ND	"	
1,3-Dichlorobenzene	"	"	"		0.100	ND	"	
1,4-Dichlorobenzene	"	"	"		0.100	ND	"	
1,2-Dichlorobenzene	"	"	"		0.100	ND	"	
3,3′-Dichlorobenzidine	"	"	"		5.00	ND	"	
2,4-Dichlorophenol	"	"	"		0.100	ND	"	
Diethyl phthalate	"	"	"		0.100	ND	"	
2,4-Dimethylphenol	"	"	"		0.100	ND	"	
Dimethyl phthalate	"	"	"		0.100	ND	"	
4,6-Dinitro-2-methylphenol	"	"	"		0.500	ND	"	
2,4-Dinitrophenol	"	"	"		0.500	ND	"	
2,4-Dinitrotoluene	"	"	"		0.100	ND	"	

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project:	Port of Bellingham		Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02		Received:	9/2/98
Bellingham. WA 98225	Project Manager:	Jay Gordon		Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Surrogate Limits	Reporting Limit	Result	Units	Notes*
TP-5 (continued)			B809044-05				Soil	
2.6-Dinitrotoluene	0980087	9/3/98	9/4/98		0.100	ND	mg/kg dry	
Di-n-octyl phthalate	"	"	"		0.500	ND	"	
Fluoranthene	"	"	"		0.100	ND	"	
Fluorene	"	"	"		0.100	ND	"	
Hexachlorobenzene	"	"	"		0.100	ND	"	
Hexachlorobutadiene	"	"	"		0.100	ND	"	
Hexachlorocyclopentadiene	"	"	"		0.100	ND	"	
Hexachloroethane	"	"	"		0.100	ND	"	
Indeno (1,2,3-cd) pyrene	"	"	"		0.100	ND	"	
Isophorone	"	"	"		0.100	ND	"	
2-Methylnaphthalene	"	"	"		0.100	ND	"	
2-Methylphenol	"	"	"		0.100	ND	"	
3 & 4-Methylphenol	"	"	"		0.100	ND	"	
Naphthalene	"	"	"		0.100	ND	"	
2-Nitroaniline	"	"	"		0.500	ND	"	
3-Nitroaniline	"	"	"		0.500	ND	"	
4-Nitroaniline	"	"	"		0.500	ND	"	
Nitrobenzene	"	"	"		0.100	ND	"	
2-Nitrophenol	"	"	"		0.100	ND	"	
4-Nitrophenol	"	"	"		0.500	ND	"	
N-Nitrosodiphenylamine	"	"	"		0.200	ND	"	
N-Nitrosodi-n-propylamine	"	"	"		0.100	ND	"	
Pentachlorophenol	"	"	"		0.500	ND	"	
Phenanthrene	"	"	"		0.100	ND	"	
Phenol	"	"	"		0.100	ND	"	
Pyrene	"	"	"		0.100	ND	"	
1.2,4-Trichlorobenzene	"	"	"		0.100	ND	"	
2.4.5-Trichlorophenol	"	"	"		0.500	ND	"	
2.4.6-Trichlorophenol	"	"	"		0.100	ND	"	
Surrogate: 2-FP	"	"	"	*19.0-141*		*70.5*	%	
Surrogate: Phenol-d6	"	"	"	*44.0-128*		*71.1*	"	
Surrogate: 2,4,6-TBP	"	"	"	*10.0-137*		*101*	"	
Surrogate: Nitrobenzene-d5	"	"	"	*33.0-108*		*72.8*	"	
Surrogate: 2-FBP	"	"	"	*51.0-124*		*82.7*	"	
Surrogate: p-Terphenyl-d14	"	"	"	*48.0-149*		*90.2*	"	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis. Project Manager

Geo Engineers - Bellingham	Project:	Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager:	Jay Gordon	Reported:	9/21/98 11:40

Conventional Chemistry Parameters by APHA/EPA Methods
North Creek Analytical - Bothell

Analyte	Batch Number	Date Prepared	Date Analyzed	Specific Method	Reporting Limit	Result	Units	Notes*
TP-1			**B809044-01**				**Soil**	
Cyanide (total)	0980549	9/15/98	9/15/98	EPA 9010B	0.500	ND	mg/kg dry	
TP-2			**B809044-02**				**Soil**	
Cyanide (total)	0980549	9/15/98	9/15/98	EPA 9010B	0.500	ND	mg/kg dry	
TP-3			**B809044-03**				**Soil**	
Cyanide (total)	0980549	9/15/98	9/15/98	EPA 9010B	0.500	ND	mg/kg dry	
TP-4			**B809044-04**				**Soil**	
Cyanide (total)	0980549	9/15/98	9/15/98	EPA 9010B	0.500	ND	mg/kg dry	
TP-5			**B809044-05**				**Soil**	
Cyanide (total)	0980549	9/15/98	9/15/98	EPA 9010B	0.500	ND	mg/kg dry	

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project:	Port of Bellingham		Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02		Received:	9/2/98
Bellingham, WA 98225	Project Manager:	Jay Gordon		Reported:	9/21/98 11:40

Dry Weight Determination
North Creek Analytical - Bothell

Sample Name	Lab ID	Matrix	Result	Units
TP-1	B809044-01	Soil	95.5	%
TP-2	B809044-02	Soil	95.4	%
TP-3	B809044-03	Soil	95.4	%
TP-4	B809044-04	Soil	95.2	%
TP-5	B809044-05	Soil	96 2	%

North Creek Analytical - Bothell

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Hydrocarbon Identification by Washington DOE Method WTPH-HCID/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Batch: 0980093	**Date Prepared: 9/3/98**				**Extraction Method: HCID (WA)**					
Blank	**0980093-BLK1**									
Gasoline Range Hydrocarbons	9/4/98			**ND**	mg/kg dry	**20.0**				
Diesel Range Hydrocarbons	"			**ND**	"	**50.0**				
Heavy Oil Range Hydrocarbons	"			**ND**	"	**100**				
Surrogate: 2-FBP	*"*	*DET*		*DET*	*"*	*50.0-150*	*121*			

*Refer to end of report for text of notes and definitions.

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Total Metals by EPA 6000/7000 Series Methods/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Batch: 0980239	**Date Prepared: 9/8/98**				**Extraction Method: EPA 3050B**					
Blank	**0980239-BLK1**									
Antimony	9/10/98			ND	mg/kg dry	0.500				
Arsenic	"			ND	"	0.500				
Beryllium	"			ND	"	0.500				
Cadmium	"			ND	"	0.500				
Chromium	"			ND	"	0.500				
Copper	"			ND	"	0.500				
Lead	"			0.560	"	0.500				B
Nickel	"			ND	"	0.500				
Selenium	"			ND	"	0.500				
Silver	"			ND	"	0.500				
Thallium	"			ND	"	0.500				
Zinc	"			ND	"	5.00				
LCS	**0980239-BS1**									
Antimony	9/10/98	25.0		22.8	mg/kg dry	80.0-120	91.2			
Arsenic	"	25.0		21.4	"	70.0-130	85.6			
Beryllium	"	25.0		20.5	"	80.0-120	82.0			
Cadmium	"	25.0		21.5	"	70.0-130	86.0			
Chromium	"	25.0		22.2	"	80.0-120	88.8			
Copper	"	25.0		23.1	"	80.0-120	92.4			
Lead	"	25.0		24.1	"	80.0-120	96.4			
Nickel	"	25.0		22.8	"	80.0-120	91.2			
Selenium	"	25.0		19.2	"	70.0-130	76.8			
Silver	"	25.0		22.9	"	80.0-120	91.6			
Thallium	"	25.0		23.8	"	80.0-120	95.2			
Zinc	"	25.0		21.8	"	70.0-130	87.2			
Duplicate	**0980239-DUP1**		**B809044-01**							
Antimony	9/10/98		ND	ND	mg/kg dry			20.0		
Arsenic	"		2.60	2.64	"			20.0	1.53	
Beryllium	"		ND	ND	"			20.0		
Cadmium	"		ND	ND	"			20.0		
Chromium	"		13.3	16.7	"			20.0	22.7	1
Copper	"		11.3	10.5	"			20.0	7.34	
Lead	"		2.77	2.79	"			20.0	0.719	
Nickel	"		15.2	15.9	"			20.0	4.50	
Selenium	"		ND	ND	"			20.0		

North Creek Analytical - Bothell

Refer to end of report for text of notes and definitions.

Steve Davis, Project Manager

Total Metals by EPA 6000/7000 Series Methods/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Duplicate (continued)	0980239-DUP1		B809044-01							
Silver	9/10/98		ND	ND	mg/kg dry			20.0		
Thallium	"		ND	ND	"			20.0		
Zinc	"		25.7	23.9	"			20.0	7.26	
Matrix Spike	0980239-MS1		B809044-01							
Antimony	9/10/98	20.0	ND	9.23	mg/kg dry	70.0-130	46.1			2
Arsenic	"	20.0	2.60	17.7	"	70.0-130	75.5			
Beryllium	"	20.0	ND	15.7	"	70.0-130	78.5			
Cadmium	"	20.0	ND	16.3	"	70.0-130	81.5			
Chromium	"	20.0	13.3	30.2	"	70.0-130	84.5			
Copper	"	20.0	11.3	33.0	"	70.0-130	109			
Lead	"	20.0	2.77	21.3	"	70.0-130	92.6			
Nickel	"	20.0	15.2	32.0	"	70.0-130	84.0			
Selenium	"	20.0	ND	13.7	"	70.0-130	68.5			2
Silver	"	20.0	ND	17.7	"	70.0-130	88.5			
Thallium	"	20.0	ND	18.3	"	70.0-130	91.5			
Zinc	"	20.0	25.7	41.5	"	70.0-130	79.0			
Matrix Spike	0980239-MS2		B809044-01							
Antimony	9/10/98	415	ND	399	mg/kg dry	70.0-130	96.1			3
Selenium	"	415	ND	425	"	70.0-130	102			3
Batch: 0980262	Date Prepared: 9/9/98				Extraction Method: EPA 3050B					
Blank	0980262-BLK1									
Mercury	9/10/98			ND	mg/kg dry	0.100				
LCS	0980262-BS1									
Mercury	9/10/98	1.75		2.05	mg/kg dry	80.0-120	117			
Matrix Spike	0980262-MS1		B809044-01							
Mercury	9/10/98	0.503	ND	0.548	mg/kg dry	80.0-120	109			
Matrix Spike Dup	0980262-MSD1		B809044-01							
Mercury	9/10/98	0.476	ND	0.514	mg/kg dry	80.0-120	108	20.0	0.922	

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Polychlorinated Biphenyls by EPA Method 8082/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
<u>Batch: 0980088</u>	<u>Date Prepared: 9/3/98</u>				<u>Extraction Method: EPA 3550B</u>					
<u>Blank</u>	<u>0980088-BLK1</u>									
Aroclor 1016	9/4/98			ND	ug/kg dry	50.0				
Aroclor 1221	"			ND	"	50.0				
Aroclor 1232	"			ND	"	50.0				
Aroclor 1242	"			ND	"	50.0				
Aroclor 1248	"			ND	"	50.0				
Aroclor 1254	"			ND	"	50.0				
Aroclor 1260	"			ND	"	50.0				
Aroclor 1262	"			ND	"	50.0				
Aroclor 1268	"			ND	"	50.0				
Surrogate: TCX	*"*	*6.67*		*6.56*	*"*	*40.0-130*	*98.4*			
<u>LCS</u>	<u>0980088-BS1</u>									
Aroclor 1260	9/4/98	333		216	ug/kg dry	44.0-123	64.9			
Surrogate: TCX	*"*	*6.67*		*6.76*	*"*	*40.0-130*	*101*			
<u>Matrix Spike</u>	<u>0980088-MS1</u>	<u>B809044-01</u>								
Aroclor 1260	9/4/98	349	ND	211	ug/kg dry	28.0-132	60.5			
Surrogate: TCX	*"*	*6.98*		*5.89*	*"*	*40.0-130*	*84.4*			
<u>Matrix Spike Dup</u>	<u>0980088-MSD1</u>	<u>B809044-01</u>								
Aroclor 1260	9/4/98	349	ND	206	ug/kg dry	28.0-132	59.0	23.0	2.51	
Surrogate: TCX	*"*	*6.98*		*6.30*	*"*	*40.0-130*	*90.3*			

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham
600 Dupont St.
Bellingham, WA 98225

Project: Port of Bellingham
Project Number: 0307-024-02
Project Manager: Jay Gordon

Sampled: 9/1/98
Received: 9/2/98
Reported: 9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Batch: 0980260	**Date Prepared: 9/9/98**				**Extraction Method: EPA 5030B [MeOH]**					
Blank	**0980260-BLK1**									
Acetone	9/9/98			ND	mg/kg dry	2.00				
Benzene	"			ND	"	0.100				
Bromodichloromethane	"			ND	"	0.100				
Bromoform	"			ND	"	0.100				
Bromomethane	"			ND	"	0.100				
2-Butanone	"			ND	"	2.00				
Carbon disulfide	"			ND	"	0.100				
Carbon tetrachloride	"			ND	"	0.100				
Chlorobenzene	"			ND	"	0.100				
Chloroethane	"			ND	"	0.100				
Chloroform	"			ND	"	0.100				
Chloromethane	"			ND	"	0.500				
Dibromochloromethane	"			ND	"	0.100				
1,2-Dichlorobenzene	"			ND	"	0.100				
1,3-Dichlorobenzene	"			ND	"	0.100				
1,4-Dichlorobenzene	"			ND	"	0.100				
1,1-Dichloroethane	"			ND	"	0.100				
1,2-Dichloroethane	"			ND	"	0.100				
1,1-Dichloroethene	"			ND	"	0.100				
cis-1,2-Dichloroethene	"			ND	"	0.100				
trans-1,2-Dichloroethene	"			ND	"	0.100				
1,2-Dichloropropane	"			ND	"	0.100				
cis-1,3-Dichloropropene	"			ND	"	0.100				
trans-1,3-Dichloropropene	"			ND	"	0.100				
Ethylbenzene	"			ND	"	0.100				
2-Hexanone	"			ND	"	2.00				
Methylene chloride	"			ND	"	1.00				
4-Methyl-2-pentanone	"			ND	"	2.00				
Styrene	"			ND	"	0.100				
1,1,2,2-Tetrachloroethane	"			ND	"	0.100				
Tetrachloroethene	"			ND	"	0.100				
Toluene	"			0.103	"	0.100				4
1,1,1-Trichloroethane	"			ND	"	0.100				
1,1,2-Trichloroethane	"			ND	"	0.100				
Trichloroethene	"			ND	"	0.100				
Vinyl chloride	"			ND	"	0.100				
Xylenes (total)	"			ND	"	0.400				

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham		Project:	Port of Bellingham	Sampled:	9/1/98
600 Dupont St.		Project Number:	0307-024-02	Received:	9/2/98
Bellingham, WA 98225		Project Manager:	Jay Gordon	Reported:	9/21/98 11:40

Volatile Organic Compounds by EPA Method 8260B/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Blank (continued)	**0980260-BLK1**									
Surrogate: 2-Bromopropene	*9/9/98*	*2.00*		*3.05*	*mg/kg dry*	*70.0-130*	*152*			*5*
Surrogate: 1,2-DCA-d4	*"*	*2.00*		*2.53*	*"*	*70.0-130*	*126*			
Surrogate: Toluene-d8	*"*	*2.00*		*2.78*	*"*	*70.0-130*	*139*			*5*
Surrogate: 4-BFB	*"*	*2.00*		*2.60*	*"*	*70.0-130*	*130*			
LCS	**0980260-BS1**									
Benzene	9/9/98	1.00		0.882	mg/kg dry	70.0-130	88.2			
Chlorobenzene	"	1.00		0.888	"	70.0-130	88.8			
1,1-Dichloroethene	"	1.00		0.861	"	70.0-130	86.1			
Toluene	"	1.00		0.861	"	70.0-130	86.1			
Trichloroethene	"	1.00		0.906	"	70.0-130	90.6			
Surrogate: 2-Bromopropene	*"*	*2.00*		*2.49*	*"*	*70.0-130*	*125*			
Surrogate: 1,2-DCA-d4	*"*	*2.00*		*2.02*	*"*	*70.0-130*	*101*			
Surrogate: Toluene-d8	*"*	*2.00*		*2.07*	*"*	*70.0-130*	*103*			
Surrogate: 4-BFB	*"*	*2.00*		*1.96*	*"*	*70.0-130*	*98.0*			
Matrix Spike	**0980260-MS1**		**B809044-05**							
Benzene	9/9/98	1.04	ND	0.964	mg/kg dry	70.0-130	92.7			
Chlorobenzene	"	1.04	ND	1.00	"	70.0-130	96.2			
1,1-Dichloroethene	"	1.04	ND	0.960	"	70.0-130	92.3			
Toluene	"	1.04	ND	0.953	"	70.0-130	91.6			
Trichloroethene	"	1.04	ND	0.972	"	70.0-130	93.5			
Surrogate: 2-Bromopropene	*"*	*2.08*		*2.47*	*"*	*70.0-130*	*119*			
Surrogate: 1,2-DCA-d4	*"*	*2.08*		*2.03*	*"*	*70.0-130*	*97.6*			
Surrogate: Toluene-d8	*"*	*2.08*		*2.11*	*"*	*70.0-130*	*101*			
Surrogate: 4-BFB	*"*	*2.08*		*2.09*	*"*	*70.0-130*	*100*			
Matrix Spike Dup	**0980260-MSD1**		**B809044-05**							
Benzene	9/9/98	1.04	ND	0.922	mg/kg dry	70.0-130	88.7	15.0	4.41	
Chlorobenzene	"	1.04	ND	0.949	"	70.0-130	91.3	15.0	5.23	
1,1-Dichloroethene	"	1.04	ND	0.895	"	70.0-130	86.1	15.0	6.95	
Toluene	"	1.04	ND	0.896	"	70.0-130	86.2	15.0	6.07	
Trichloroethene	"	1.04	ND	0.942	"	70.0-130	90.6	15.0	3.15	
Surrogate: 2-Bromopropene	*"*	*2.08*		*2.44*	*"*	*70.0-130*	*117*			
Surrogate: 1,2-DCA-d4	*"*	*2.08*		*2.06*	*"*	*70.0-130*	*99.0*			
Surrogate: Toluene-d8	*"*	*2.08*		*2.06*	*"*	*70.0-130*	*99.0*			
Surrogate: 4-BFB	*"*	*2.08*		*2.09*	*"*	*70.0-130*	*100*			

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

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Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled:	9/1/98
1600 Dupont St.	Project Number: 0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Batch: 0980087	**Date Prepared: 9/3/98**				**Extraction Method: EPA 3550B**					
Blank	**0980087-BLK1**									
Acenaphthene	9/3/98			ND	mg/kg dry	0.100				
Acenaphthylene	"			ND	"	0.100				
Aniline	"			ND	"	0.100				
Anthracene	"			ND	"	0.100				
Benzoic Acid	"			ND	"	0.500				
Benzo (a) anthracene	"			ND	"	0.100				
Benzo (b) fluoranthene	"			ND	"	0.100				
Benzo (k) fluoranthene	"			ND	"	0.100				
Benzo (ghi) perylene	"			ND	"	0.100				
Benzo (a) pyrene	"			ND	"	0.100				
Benzyl alcohol	"			ND	"	0.100				
Bis(2-chloroethoxy)methane	"			ND	"	0.100				
Bis(2-chloroethyl)ether	"			ND	"	0.100				
Bis(2-chloroisopropyl)ether	"			ND	"	0.100				
Bis(2-ethylhexyl)phthalate	"			ND	"	0.500				
4-Bromophenyl phenyl ether	"			ND	"	0.100				
Butyl benzyl phthalate	"			ND	"	0.100				
Carbazole	"			ND	"	0.500				
4-Chloroaniline	"			ND	"	0.100				
2-Chloronaphthalene	"			ND	"	0.100				
4-Chloro-3-methylphenol	"			ND	"	0.100				
2-Chlorophenol	"			ND	"	0.100				
4-Chlorophenyl phenyl ether	"			ND	"	0.100				
Chrysene	"			ND	"	0.100				
Dibenz (a.h) anthracene	"			ND	"	0.100				
Dibenzofuran	"			ND	"	0.100				
Di-n-butyl phthalate	"			ND	"	0.500				
1.3-Dichlorobenzene	"			ND	"	0.100				
1.4-Dichlorobenzene	"			ND	"	0.100				
1.2-Dichlorobenzene	"			ND	"	0.100				
3.3´-Dichlorobenzidine	"			ND	"	5.00				
2.4-Dichlorophenol	"			ND	"	0.100				
Diethyl phthalate	"			ND	"	0.100				
2.4-Dimethylphenol	"			ND	"	0.100				
Dimethyl phthalate	"			ND	"	0.100				
4.6-Dinitro-2-methylphenol	"			ND	"	0.500				
2.4-Dinitrophenol	"			ND	"	0.500				

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported:	9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Blank (continued)	**0980087-BLK1**									
2,4-Dinitrotoluene	9/3/98			ND	mg/kg dry	0.100				
2,6-Dinitrotoluene	"			ND	"	0.100				
Di-n-octyl phthalate	"			ND	"	0.500				
Fluoranthene	"			ND	"	0.100				
Fluorene	"			ND	"	0.100				
Hexachlorobenzene	"			ND	"	0.100				
Hexachlorobutadiene	"			ND	"	0.100				
Hexachlorocyclopentadiene	"			ND	"	0.100				
Hexachloroethane	"			ND	"	0.100				
Indeno (1,2,3-cd) pyrene	"			ND	"	0.100				
Isophorone	"			ND	"	0.100				
2-Methylnaphthalene	"			ND	"	0.100				
2-Methylphenol	"			ND	"	0.100				
3 & 4-Methylphenol	"			ND	"	0.100				
Naphthalene	"			ND	"	0.100				
2-Nitroaniline	"			ND	"	0.500				
3-Nitroaniline	"			ND	"	0.500				
4-Nitroaniline	"			ND	"	0.500				
Nitrobenzene	"			ND	"	0.100				
2-Nitrophenol	"			ND	"	0.100				
4-Nitrophenol	"			ND	"	0.500				
N-Nitrosodiphenylamine	"			ND	"	0.200				
N-Nitrosodi-n-propylamine	"			ND	"	0.100				
Pentachlorophenol	"			ND	"	0.500				
Phenanthrene	"			ND	"	0.100				
Phenol	"			ND	"	0.100				
Pyrene	"			ND	"	0.100				
1,2,4-Trichlorobenzene	"			ND	"	0.100				
2,4,5-Trichlorophenol	"			ND	"	0.500				
2,4,6-Trichlorophenol	"			ND	"	0.100				
Surrogate: 2-FP	"	*1.67*		*1.24*	"	*19.0-141*	*74.3*			
Surrogate: Phenol-d6	"	*1.67*		*1.17*	"	*44.0-128*	*70.1*			
Surrogate: 2,4,6-TBP	"	*1.67*		*1.71*	"	*10.0-137*	*102*			
Surrogate: Nitrobenzene-d5	"	*1.67*		*1.24*	"	*33.0-108*	*74.3*			
Surrogate: 2-FBP	"	*1.67*		*1.36*	"	*51.0-124*	*81.4*			
Surrogate: p-Terphenyl-d14	"	*1.67*		*1.42*	"	*48.0-149*	*85.0*			

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham
600 Dupont St.
Bellingham, WA 98225

Project: Port of Bellingham
Project Number: 0307-024-02
Project Manager: Jay Gordon

Sampled: 9/1/98
Received: 9/2/98
Reported: 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
<u>LCS</u>	<u>0980087-BS1</u>									
Acenaphthene	9/3/98	3.33		2.35	mg/kg dry	48.0-110	70.6			
4-Chloro-3-methylphenol	"	6.67		5.43	"	34.0-115	81.4			
2-Chlorophenol	"	6.67		4.87	"	57.0-110	73.0			
1,4-Dichlorobenzene	"	3.33		2.51	"	39.0-110	75.4			
2,4-Dinitrotoluene	"	3.33		2.74	"	50.0-110	82.3			
4-Nitrophenol	"	6.67		5.01	"	26.0-116	75.1			
N-Nitrosodi-n-propylamine	"	3.33		2.46	"	28.0-147	73.9			
Pentachlorophenol	"	6.67		5.33	"	46.0-120	79.9			
Phenol	"	6.67		4.54	"	35.0-110	68.1			
Pyrene	"	3.33		2.34	"	35.0-143	70.3			
1,2,4-Trichlorobenzene	"	3.33		2.92	"	39.0-110	87.7			
Surrogate: 2-FP	"	*1.67*		*1.34*	"	*19.0-141*	*80.2*			
Surrogate: Phenol-d6	"	*1.67*		*1.25*	"	*44.0-128*	*74.9*			
Surrogate: 2,4,6-TBP	"	*1.67*		*1.74*	"	*10.0-137*	*104*			
Surrogate: Nitrobenzene-d5	"	*1.67*		*1.29*	"	*33.0-108*	*77.2*			
Surrogate: 2-FBP	"	*1.67*		*1.41*	"	*51.0-124*	*84.4*			
Surrogate: p-Terphenyl-d14	"	*1.67*		*1.38*	"	*48.0-149*	*82.6*			
<u>Matrix Spike</u>	<u>0980087-MS1</u>		<u>B809044-02</u>							
Acenaphthene	9/3/98	3.49	ND	2.40	mg/kg dry	34.0-122	**68.8**			
4-Chloro-3-methylphenol	"	6.99	ND	5.42	"	26.0-129	**77.5**			
2-Chlorophenol	"	6.99	ND	4.92	"	43.0-131	**70.4**			
1,4-Dichlorobenzene	"	3.49	ND	2.61	"	34.0-131	**74.8**			
2,4-Dinitrotoluene	"	3.49	ND	2.75	"	10.0-126	**78.8**			
4-Nitrophenol	"	6.99	ND	5.08	"	10.0-111	**72.7**			
N-Nitrosodi-n-propylamine	"	3.49	ND	2.47	"	29.0-160	**70.8**			
Pentachlorophenol	"	6.99	ND	5.25	"	46.0-120	**75.1**			
Phenol	"	6.99	ND	4.62	"	41.0-118	**66.1**			
Pyrene	"	3.49	ND	2.35	"	44.0-122	**67.3**			
1,2,4-Trichlorobenzene	"	3.49	ND	2.90	"	10.0-176	**83.1**			
Surrogate: 2-FP	"	*1.75*		*1.38*	"	*19.0-141*	*78.9*			
Surrogate: Phenol-d6	"	*1.75*		*1.28*	"	*44.0-128*	*73.1*			
Surrogate: 2,4,6-TBP	"	*1.75*		*1.86*	"	*10.0-137*	*106*			
Surrogate: Nitrobenzene-d5	"	*1.75*		*1.32*	"	*33.0-108*	*75.4*			
Surrogate: 2-FBP	"	*1.75*		*1.48*	"	*51.0-124*	*84.6*			
Surrogate: p-Terphenyl-d14	"	*1.75*		*1.45*	"	*48.0-149*	*82.9*			

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Semivolatile Organic Compounds by EPA Method 8270C/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Matrix Spike Dup	0980087-MSD1		B809044-02							
Acenaphthene	9/3/98	3.49	ND	2.42	mg/kg dry	34.0-122	69.3	56.0	0.724	
4-Chloro-3-methylphenol	"	6.99	ND	5.61	"	26.0-129	80.3	29.0	3.55	
2-Chlorophenol	"	6.99	ND	4.94	"	43.0-131	70.7	27.0	0.425	
1,4-Dichlorobenzene	"	3.49	ND	2.59	"	34.0-131	74.2	23.0	0.805	
2,4-Dinitrotoluene	"	3.49	ND	2.77	"	10.0-126	79.4	22.0	0.759	
4-Nitrophenol	"	6.99	ND	5.23	"	10.0-111	74.8	43.0	2.85	
N-Nitrosodi-n-propylamine	"	3.49	ND	2.48	"	29.0-160	71.1	25.0	0.423	
Pentachlorophenol	"	6.99	ND	5.10	"	46.0-120	73.0	29.0	2.84	
Phenol	"	6.99	ND	4.68	"	41.0-118	67.0	29.0	1.35	
Pyrene	"	3.49	ND	2.55	"	44.0-122	73.1	31.0	8.26	
1,2,4-Trichlorobenzene	"	3.49	ND	3.01	"	10.0-176	86.2	24.0	3.66	
Surrogate: 2-FP	"	*1.75*		*1.31*	"	*19.0-141*	*74.9*			
Surrogate: Phenol-d6	"	*1.75*		*1.30*	"	*44.0-128*	*74.3*			
Surrogate: 2,4,6-TBP	"	*1.75*		*1.83*	"	*10.0-137*	*105*			
Surrogate: Nitrobenzene-d5	"	*1.75*		*1.32*	"	*33.0-108*	*75.4*			
Surrogate: 2-FBP	"	*1.75*		*1.44*	"	*51.0-124*	*82.3*			
Surrogate: p-Terphenyl-d14	"	*1.75*		*1.53*	"	*48.0-149*	*87.4*			

**Refer to end of report for text of notes and definitions.*

Geo Engineers - Bellingham	Project:	Port of Bellingham	Sampled:	9/1/98
600 Dupont St.	Project Number:	0307-024-02	Received:	9/2/98
Bellingham, WA 98225	Project Manager:	Jay Gordon	Reported:	9/21/98 11:40

Conventional Chemistry Parameters by APHA/EPA Methods/Quality Control
North Creek Analytical - Bothell

Analyte	Date Analyzed	Spike Level	Sample Result	QC Result	Units	Reporting Limit Recov. Limits	Recov. %	RPD Limit	RPD %	Notes*
Batch: 0980549	**Date Prepared: 9/15/98**				**Extraction Method: General Preparation**					
Blank	**0980549-BLK1**									
Cyanide (total)	9/15/98			**ND**	mg/kg dry	0.500				
LCS	**0980549-BS1**									
Cyanide (total)	9/15/98	2.50		1.80	mg/kg dry	62.0-136	72.0			
Duplicate	**0980549-DUP1**		**B809044-02**							
Cyanide (total)	9/15/98		ND	ND	mg/kg dry			25.0		

North Creek Analytical - Bothell

**Refer to end of report for text of notes and definitions.*

Steve Davis, Project Manager

Geo Engineers - Bellingham	Project: Port of Bellingham	Sampled: 9/1/98
600 Dupont St.	Project Number: 0307-024-02	Received: 9/2/98
Bellingham, WA 98225	Project Manager: Jay Gordon	Reported: 9/21/98 11:40

Notes and Definitions

#	Note
B	Analyte detected in the method blank.
1	The RPD value for this QC sample is above the established control limit. Review of associated QC indicates the high RPD does not represent an out-of-control condition for the batch.
2	The spike recovery for this QC sample is outside of established control limits. Review of associated batch QC indicates the recovery for this analyte does not represent an out-of-control condition for the batch.
3	Post-digestion Matrix Spike.
4	Suspected laboratory contaminant.
5	The surrogate recovery for this sample is outside of established control limits. Review of associated QC indicates the recovery for this surrogate does not represent an out-of-control condition.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
Recov.	Recovery
RPD	Relative Percent Difference

North Creek Analytical - Bothell

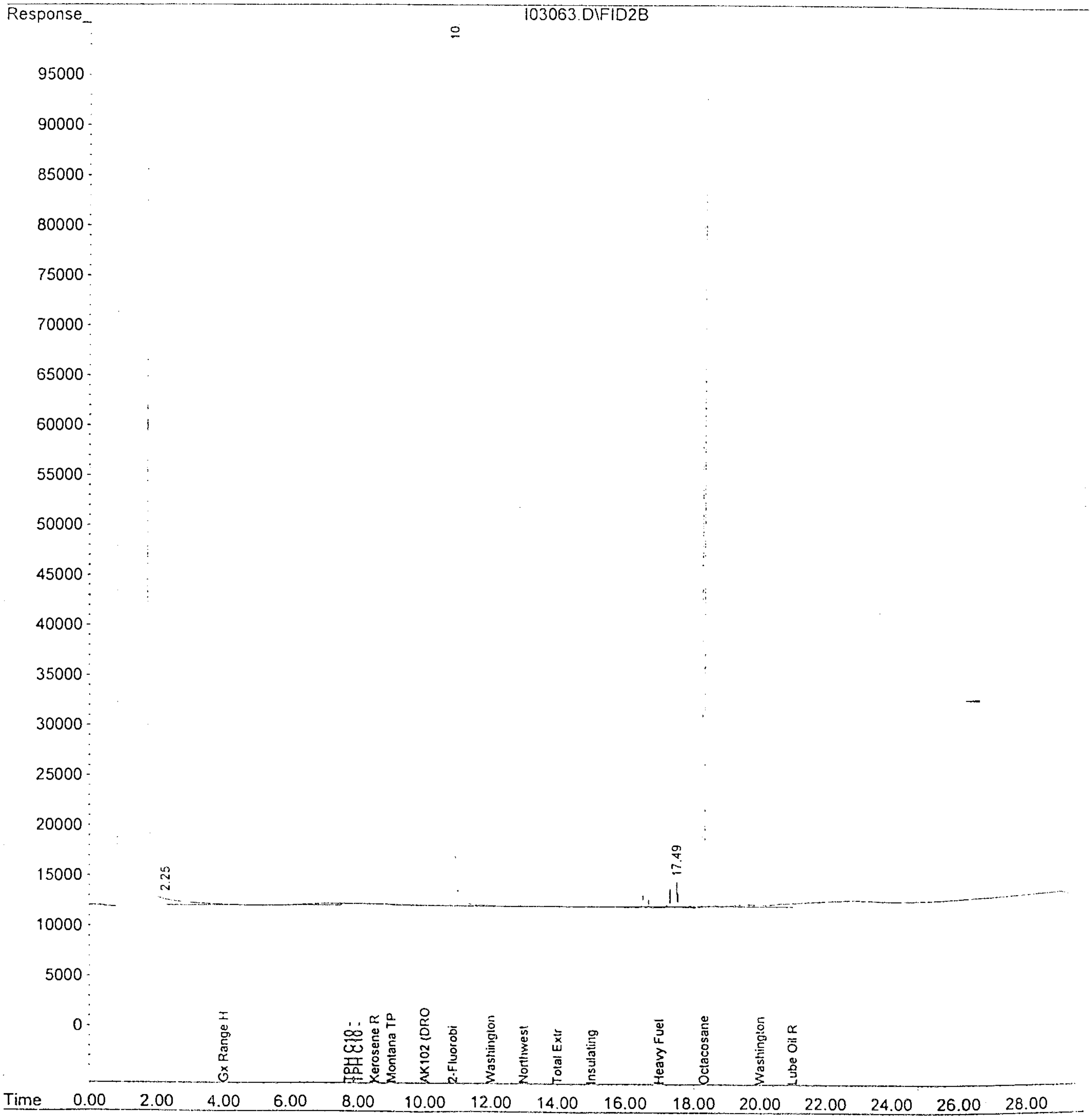
Steve Davis, Project Manager

Quantitation Report

Data File : C:\HPCHEM\1\DATA.SEC\I03063.D
Vial: 29
Acq On : 4 Sep 1998 9:13 am
Operator: CC
Sample : ~~b808044-01~~ B809044-01 ro 9/9
Inst : GC #1
Misc : hs
Multiplr: 1.00
IntFile : SURR.E
Quant Time: Sep 4 11:59 1998 Quant Results File: TPHD2.RES

Quant Method : C:\HPCHEM\1\METHODS\TPHD2.M (Chemstation Integrator)
Title : TPH-D Rear Method
Last Update : Thu Aug 13 16:37:56 1998
Response via : Multiple Level Calibration
DataAcq Meth : TPHD.M

Volume Inj. :
Signal Phase :
Signal Info :

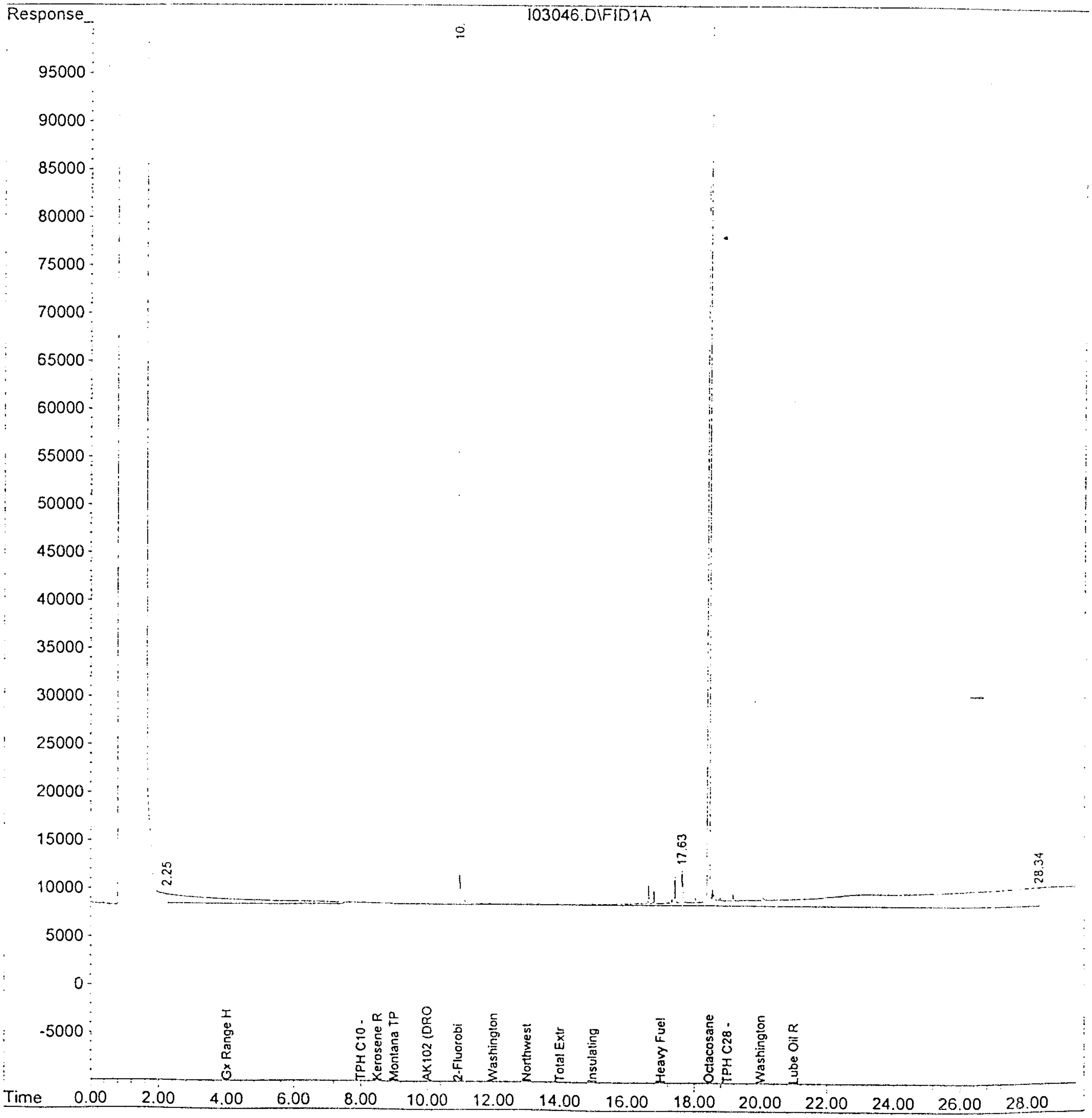


Quantitation Report

```
Data File : C:\HPCHEM\1\DATA\I03046.D                    Vial: 30
Acq On    :  4 Sep 1998   3:23 am                    Operator: CC
Sample    : b809044-02                               Inst    : GC #1
Misc      : hs                                       Multiplr: 1.00
IntFile   : SURR.E
Quant Time: Sep  4 13:16 1998  Quant Results File: TPHD.RES

Quant Method : C:\HPCHEM\1\METHODS\TPHD.M (Chemstation Integrator)
Title        : TPH-D Front Method
Last Update  : Tue Aug 25 16:42:12 1998
Response via : Multiple Level Calibration
DataAcq Meth : TPHD.M

Volume Inj.  :
Signal Phase :
Signal Info  :
```



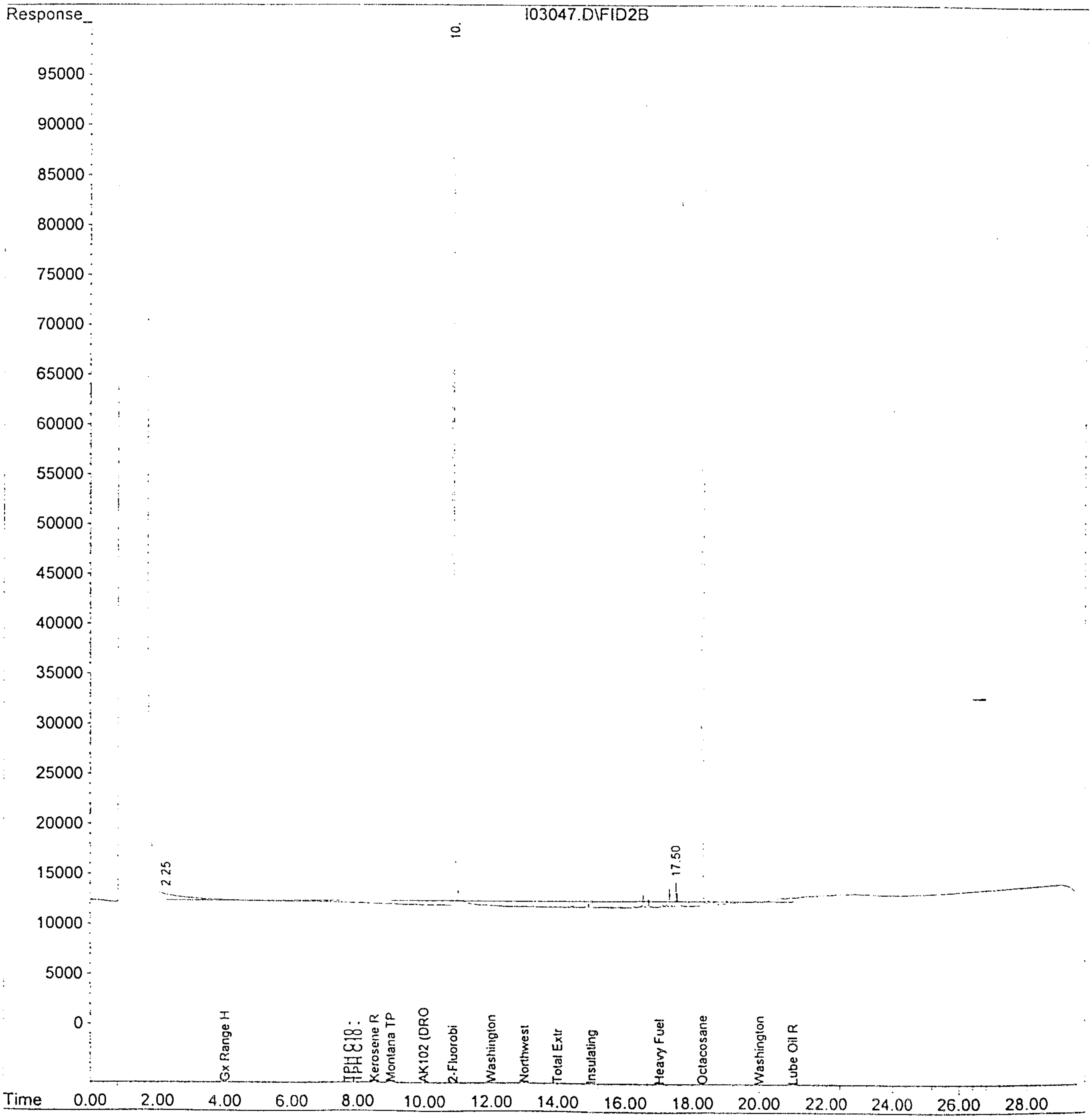
Quantitation Report

Data File : C:\HPCHEM\1\DATA.SEC\I03047.D
Acq On : 4 Sep 1998 4:01 am
Sample : b809044-03
Misc : hs
IntFile : SURR.E
Quant Time: Sep 4 11:51 1998 Quant Results File: TPHD2.RES

Vial: 31
Operator: CC
Inst : GC #1
Multiplr: 1.00

Quant Method : C:\HPCHEM\1\METHODS\TPHD2.M (Chemstation Integrator)
Title : TPH-D Rear Method
Last Update : Thu Aug 13 16:37:56 1998
Response via : Multiple Level Calibration
DataAcq Meth : TPHD.M

Volume Inj. :
Signal Phase :
Signal Info :



Quantitation Report

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Data File : C:\HPCHEM\1\DATA\I03048.D                    Vial: 32
Acq On    :  4 Sep 1998   4:01 am                    Operator: CC
Sample    : b809044-04                               Inst    : GC #1
Misc      : hs                                       Multiplr: 1.00
IntFile   : SURR.E
Quant Time: Sep  4 12:15 1998  Quant Results File: TPHD.RES

Quant Method : C:\HPCHEM\1\METHODS\TPHD.M (Chemstation Integrator)
Title        : TPH-D Front Method
Last Update  : Tue Aug 25 16:42:12 1998
Response via : Multiple Level Calibration
DataAcq Meth : TPHD.M

Volume Inj.  :
Signal Phase :
Signal Info  :
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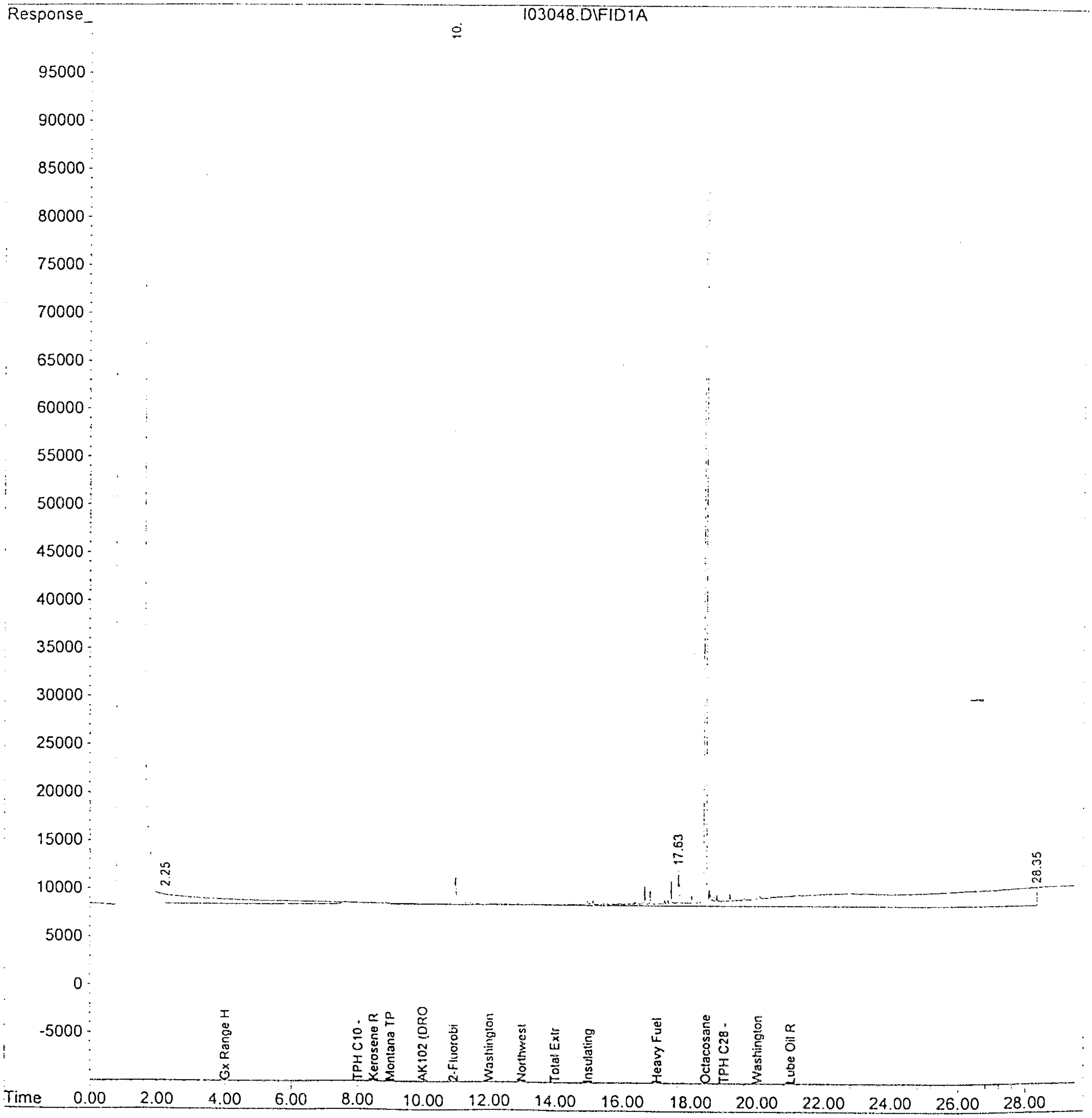

Quantitation Report

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Misc      : hs                                     Multiplr: 1.00
IntFile   : SURR.E
Quant Time: Sep  4 13:29 1998  Quant Results File: TPHD2.RES

Quant Method : C:\HPCHEM\1\METHODS\TPHD2.M (Chemstation Integrator)
Title        : TPH-D Rear Method
Last Update  : Thu Aug 13 16:37:56 1998
Response via : Multiple Level Calibration
DataAcq Meth : TPHD.M

Volume Inj.  :
Signal Phase :
Signal Info  :
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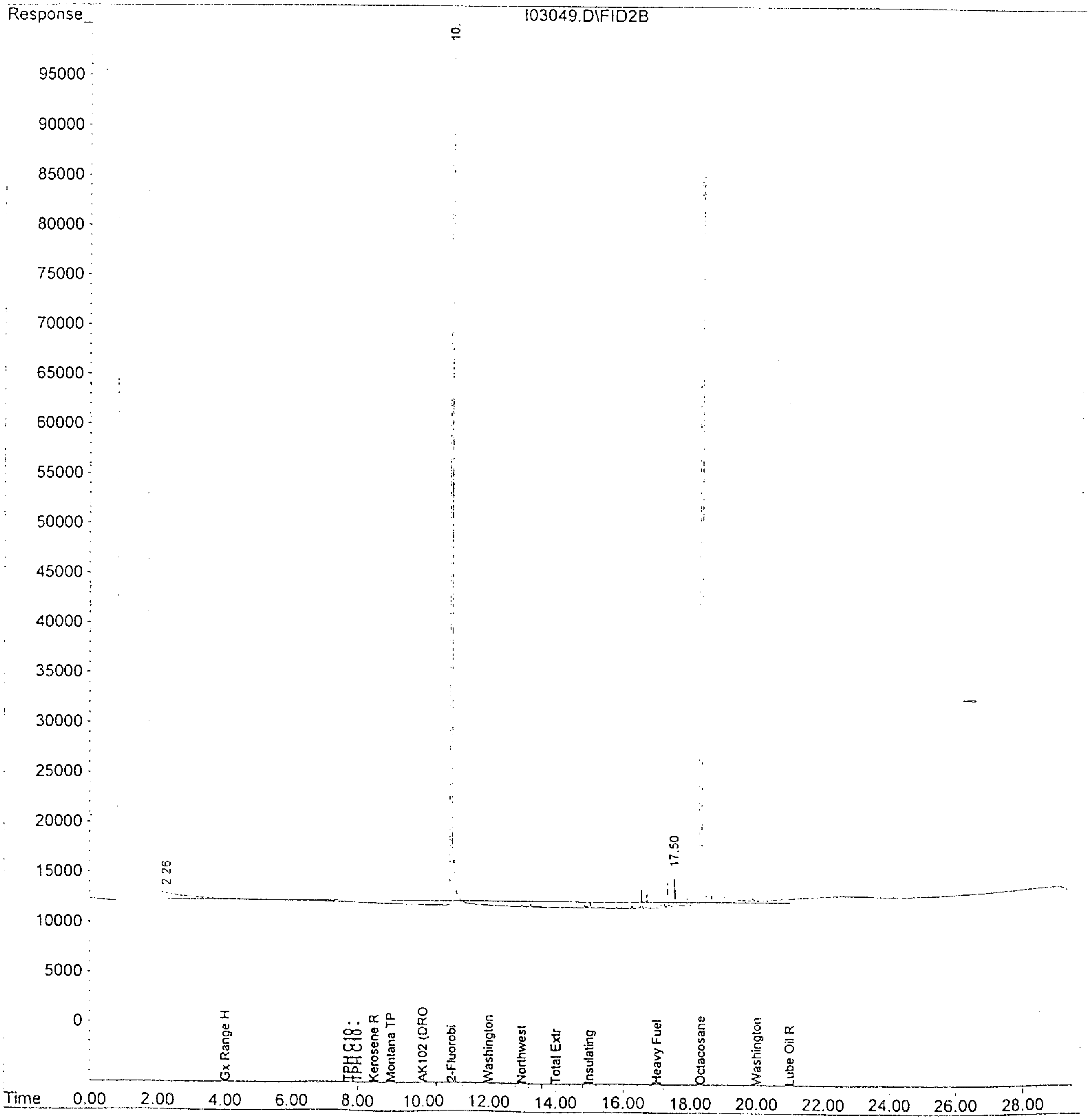


NORTH CREEK ANALYTICAL
Environmental Laboratory Services

18939 120th Avenue N.E., Suite 101, Bothell, WA 98011-9508 (425) 420-9200 FAX 420-9210
East 11115 Montgomery, Suite B, Spokane, WA 99206-4779 (509) 924-9200 FAX 924-9290
9405 S.W. Nimbus Avenue, Beaverton, OR 97008-7132 (503) 906-9200 FAX 906-9210

CHAIN OF CUSTODY REPORT

Work Order # B809044

REPORT TO: J. Gordon - GeoEngineers
ATTENTION:
ADDRESS: 600 Dupont St.
Bellingham, WA 98225
PHONE: 360-647-1510 FAX: 360-647-5044
PROJECT NAME: Port of Bellingham
PROJECT NUMBER: 0307-024-02
SAMPLED BY: Robert E. Curtis

INVOICE TO:
ATTENTION: Geo
ADDRESS:
P.O. NUMBER: NCA QUOTE #:

TURNAROUND REQUEST in Business Days *

Organic & Inorganic Analyses: [✓ 10] Standard ☐ 7 ☐ 5 ☐ 4 ☐ 3 ☐ 2 ☐ 1 ☐ Same Day

Fuels & Hydrocarbon Analyses: ☐ 5 Standard ☐ 3-4 ☐ 2 ☐ 1 ☐ Same Day

☐ OTHER Specify:

* Turnaround Requests less than standard may incur Rush Charges.

Analysis Request:

	CLIENT SAMPLE IDENTIFICATION	SAMPLING DATE/TIME	NCA SAMPLE ID (Laboratory Use Only)	WTPH-HCID	PCBs	VOCs/SVOCs	Cyanide	PP Metals	BTEX	WTPH-G	" -D extended		MATRIX (W, S, A, O)	# OF CONTAINERS	COMMENTS
1	TP-1	9/1/98/1045	B809044-01	X	X	X	X	X	HOLD				Soil	3	HOLD samples for
2	TP-2	" /1105	-02	X	X	X	X	X	HOLD				"	"	BTEX, Gx + Dxt
3	TP-3	" /1115	-03	X	X	X	X	X	HOLD				"	"	for all sample
4	TP-4	" /1130	-04	X	X	X	X	X	HOLD				"	"	↓
5	TP-5	" /1145	-05	X	X	X	X	X	HOLD				"	"	
6															
7															
8															
9															
10															

RELINQUISHED BY (Signature): DATE: 9/2/98
PRINT NAME: MICHAEL R SCHAFFER FIRM: GEI TIME: 08:30

RECEIVED BY (Signature): S. Wideen DATE: 9-2-98
PRINT NAME: S. Wideen FIRM: NCA TIME: 11:00

RELINQUISHED BY (Signature): DATE:
PRINT NAME: FIRM: TIME:

RECEIVED BY (Signature): DATE:
PRINT NAME: FIRM: TIME:

ADDITIONAL REMARKS:
Testing per discussions with Lee Carfioli - THX J

W/CS
10.1

PAGE OF

Dredging and Sediment Analysis
US Army Corp of Engineers
July 1976

NPSEN-PL-ER

26 July 1976

MEMO FOR: RECORD

SUBJECT: Squalicum Small Boat Harbor Expansion: Test Dredging and Sediment Analysis

1. On 21 July 1976 sediment sampling and in-situ water quality monitoring was conducted in conjunction with test dredging in the proposed Squalicum boat basin expansion area. Work was conducted cooperatively by the undersigned and Messrs. Ron Lee and Bill Finfrock (EPA) and Mr. Bob Wunderlich (U.S. F&WS).

2. Six sediment samples were collected using a van Veen grab sampler at the approximate locations indicated on inclosure 1. Samples S-1 and S-2 consisted of a one-half inch thick brown aerobic layer of silt which overlaid anaerobic organic silts. Sample S-3 was at the location of test dredging conducted on 19 to 20 July 1976. Sands, silts, and coal were present in the sample. Sample S-4 was about 100 feet east of the test dredging area and consisted of mostly sand with some small granules of coal. Sample S-5 was almost entirely sand. Sample S-6 was brown in color and appeared to be riverine sediments.

3. All sediment samples will be analyzed for volatile solids, COD, oil and grease, and total mercury, lead, zinc, and sulphides. Samples S-1 and S-6 will be analyzed for PCB's and pesticides. Elutriate analyses on all samples will be done for mercury, lead, and zinc and for PCB and pesticides in samples S-1 and S-6. Dredging area water will be used as a diluent for elutriate tests. Open water disposal area water will be analyzed for mercury, lead, and zinc.

4. In-situ water quality profiles were determined at three locations near the test dredging being conducted on 21 July 1976 (inclosure 1). Water depth at approximately 1400 hours was approximately 8 feet. Station 1 was about 100 feet downstream from the operating dredge (inclosure 1), Station 2 was about 100 feet upstream from the operating dredge (inclosure 1), and Station 3 was northwest of the operating dredge (inclosure 1). Some results were as follows:

Incl 3

NPSEN-PL-ER 26 July 1976
SUBJECT: Squalicum Small Boat Harbor Expansion: Test Dredging and Sediment Analysis

	Station 1			Station 2			Station 3		
	S	MD	B	S	MD	B	S	ND	B
Dissolved Oxygen (mg/1)	6.6	4.7	4.6	6.6	5.7	5.8	6.2	ND	6.7
Conductivity (umho/cm)	14,500	20,000	21,500	14,200	17,000	24,000	14,000	ND	22,000
Temperature (°C)	17.5	17.5	17.3	17.5	17.4	17.3	17.3	ND	17.4

S=Surface MD=Mid-depth B=Bottom
ND=Not determined

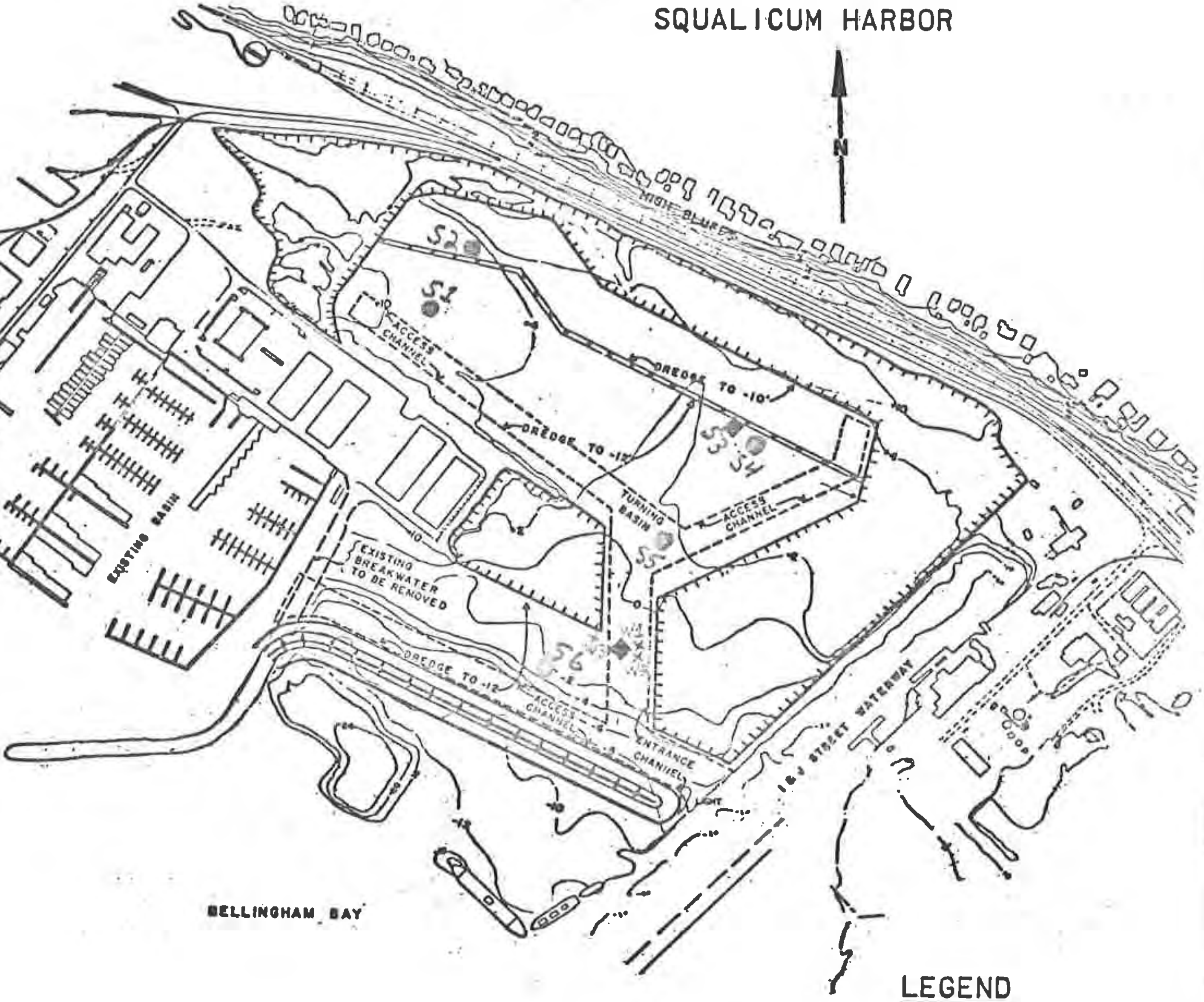
5. Results of sediment analysis should be available in about two weeks. A preliminary determination regarding the acceptibility of the dredged material for open water disposal during basin construction will be made in cooperation with EPA when the data is available.

1 Incl
as

WEINMANN

cc:
Des Br (Cook/Lazo)
Nav & CP ← F&M Br.
Oprs Div
Cooke/McNeely
Dice
Weinmann
ERS File

APPROVED SMALL BOAT BASIN EXPANSION PROJECT AT SQUALICUM HARBOR



SITE PLAN

200' 0' 400' 800'

LEGEND

■ Test CLAM SHELL EXCAVATION (ABOUT 500 CY EACH LOCATION

● S1-S6, Sediment Samples

× W1-W3, Water Quality

U. S. ARMY ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

SQUALICUM HARBOR SOIL TEST

SITE PLAN

BELLINGHAM		WASHINGTON
SIZE	PUBLIC NOTICE	PLATE
DATE 76 MAY 06	NPSEN-DB-1	
DSGN	CHK	SHEET 2 OF 2

Incl 1 to Incl 3

CERTIFICATE

LAUCKS TESTING LABORATORIES
INCORPORATED

(206) 622-0727
1008 WESTERN AVENUE
SEATTLE, WASHINGTON 98104

CHEMISTS
MPLERS • INSPECTORS
YERS • SPECTROGRAPHERS
D-CLINICAL CHEMISTRIES

LABORATORY NO. 56760

DATE August 19, 1976

P.O. DACW 67-73-A0120

Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, WA 98124

T ON SEDIMENT

LE IDENTIFICATION Submitted July 21, 1976 and identified as:

Squalicum Boat Harbor Expansion: Test Dredging & Sediment Analysis.

PERFORMED AND RESULTS: Samples were numbered: S1, S2, S3, S4, S5 and S6.

Samples were passed through a #8 sieve prior to analysis. Only material passing the sieve was analyzed. Percentages retained were as follows:

	S1	S2	S3
% Retained	11	-	10
Description: Major	Wood chips & Bark	-	Rocks
Minor	Rocks	-	-

Routine analyses were then performed on the same with results as follows:

		% as received basis	
Total Solids	26.6	42.2	70.6
		% dry basis	
Chemical Oxygen Demand	19.2	16.4	4.4
Total Volatile Solids	18.5	19.4	4.3
Oil & Grease	.17	.15	.89

Seattle District, Corps of Engineers

	% dry basis		
Zinc, calculated as Zn	.015	.009	.006
Mercury, calculated as Hg	Less/.0001	Less/.0001	Less/.0001
Lead, calculated as Pb	.004	.005	.001
Sulfide, calculated as S	.064	.12	.004
	parts per million, as received		
Poly Chlorinated Bi-phenols	Less/.001	-	-

The elutriate test was performed on the samples with results as follows:

	parts per million (mg/Liter)		
Zinc, calculated as Zn	.040	.032	.026
Mercury, calculated as Hg	Less/.001	Less/.001	Less/.001
Lead, calculated as Pb	.005	Less/.002	.025
Poly Chlorinated Bi-phenols	Less/.001	-	-

The elutriate was examined for the presence of an oil sheen immediately after shaking. With results as follows:

Oil Sheen	no	no	no

CERTIFICATE

LAUCKS TESTING LABORATORIES
INCORPORATED

MAin 2-0727
1008 WESTERN AVENUE
SEATTLE, WASHINGTON 98104

LABORATORY NO. 56760

PAGE 3

Seattle District, Corps of Engineers

mples were passed through a #8 sieve prior to analysis. Only material ssing the sieve was analyzed. Percentages retained were as follows:

	S4	S5	S6
Retained	25	-	-
scription:			
Major	Wood chips & Bark	-	-
Minor	Rocks	-	-

utine analyses were then performed on the samples with results as llows:

		% as received basis	
tal Solids	20.0	76.6	48.2
	Coal ?		% dry basis
emical Oxygen mand	54.0	3.9	12.4
tal Volatile lids	40.0	5.8	10.4
l & Grease	.40	.02	.10
nc, calculated Zn	.010	.003	.006
rcury, calculated Hg	Less/.0001	Less/.0001	Less/.0001
ad, calculated Pb	.005	.001	.002
lfide, calculated S	.075	.001	.033

Seattle District, Corps of Engineers

parts per million, as received

ly Chlorinated -phenols	-	-	Less/.001

e elutriate test was performed on the samples with results as follows:

	S4	S5	S6	Site Water	Disposal Site Water
	parts per million (mg/Liter)				
nc, calculated Zn	.032	.030	.025	.046	.018
rcury, calculated Hg	Less/.001	Less/.001	Less/.001	Less/.001	Less/.001
ad, calculated Pb	.016	Less/.002	Less/.002	Less/.002	Less/.002
ly Chlorinated -phenols	-	-	Less/.001	-	-

e elutriate was examined for the presence of an oil sheen immediately
ter shaking. With results as follows:

l Sheen	no	no	no	-	-

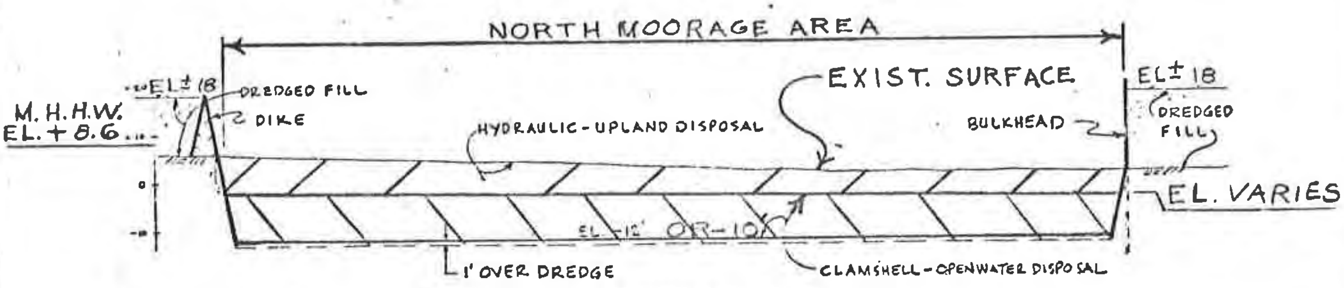
Respectfully submitted,

LAUCKS TESTING LABORATORIES, INC.

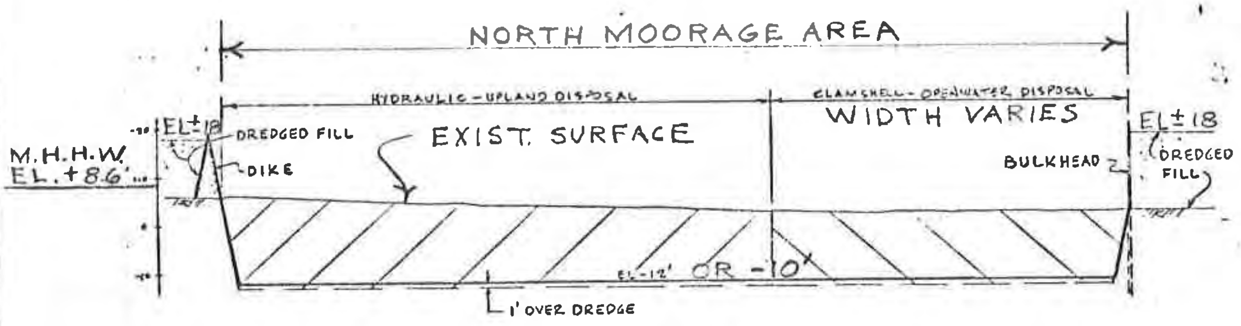
G.F. Anderson

G. F. Anderson

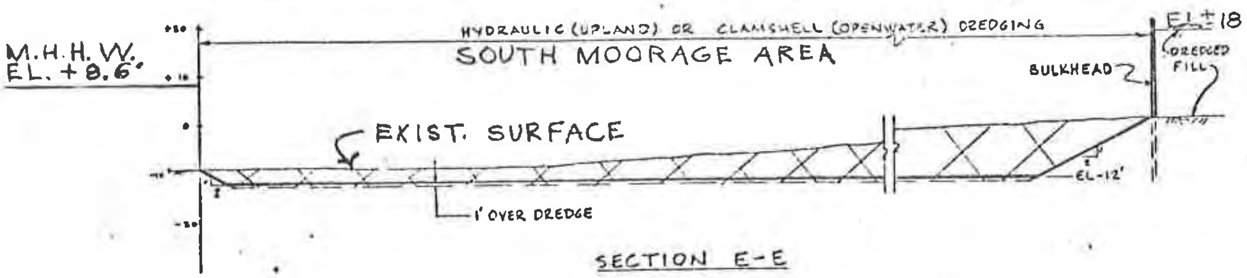
A:mjt



SECTION D-D
OPTION 1 - HORIZONTAL DREDGING



SECTION D-D
OPTION 2 - VERTICAL DREDGING



SECTION E-E

(FOR BREAKWATER, SEE SHEET 1)

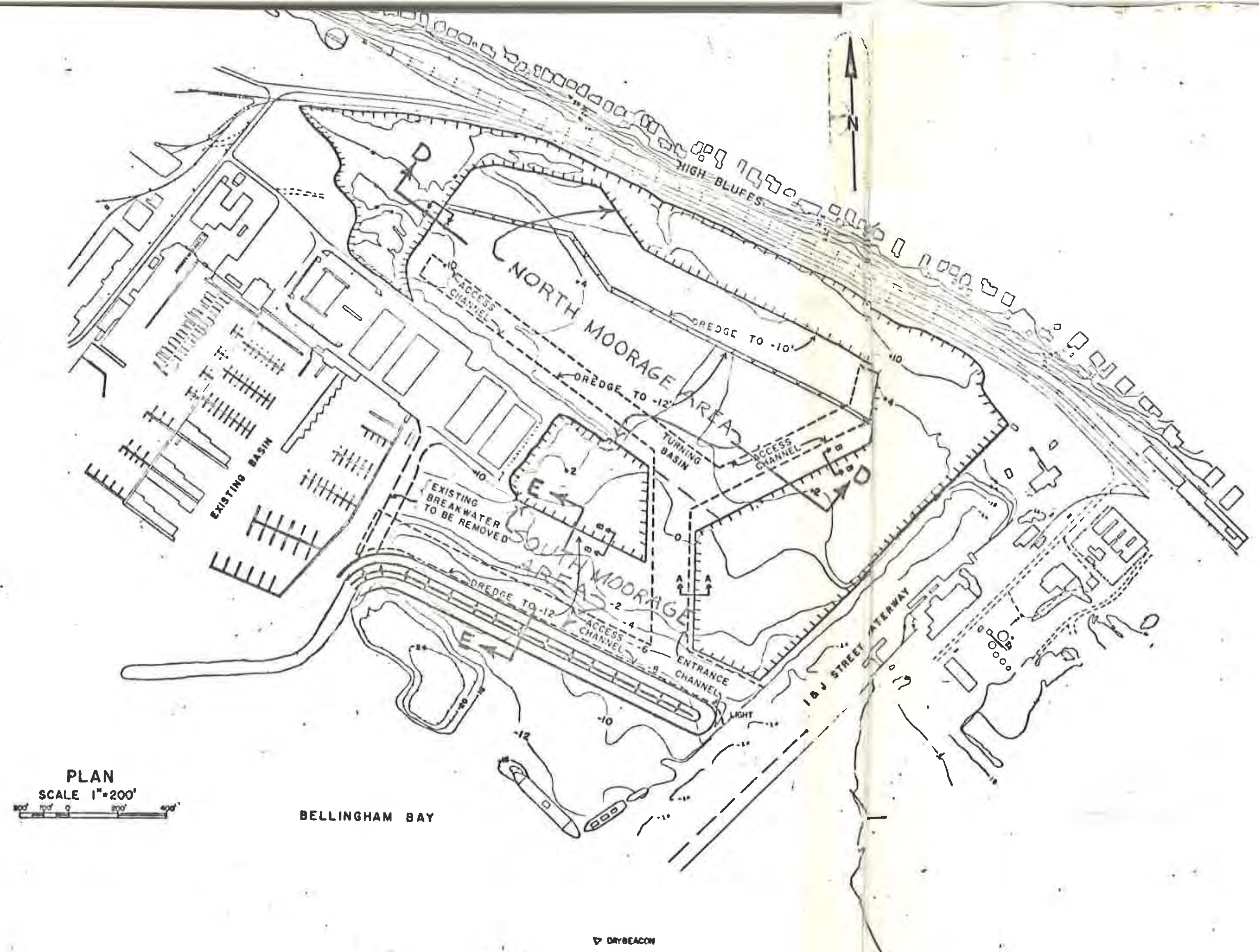
BELLINGHAM, WASHINGTON
SQUALICUM SMALL BOAT
BASIN EXPANSION
PROPOSED DREDGING AND DISPOSAL

SECTIONS

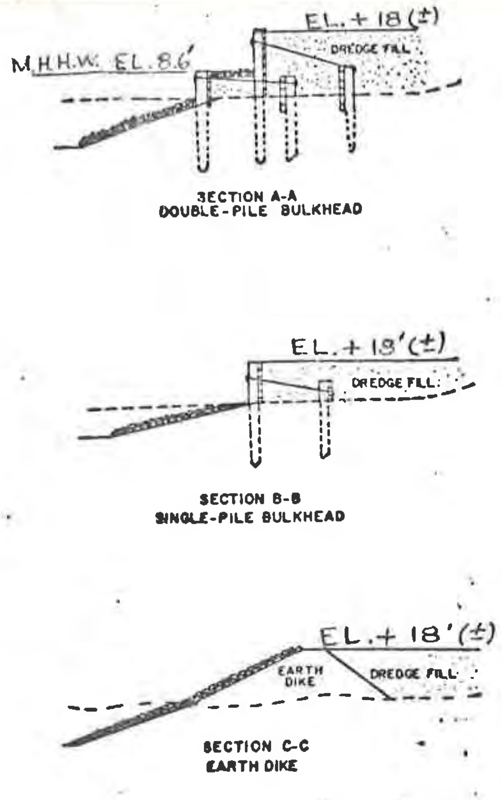
Sheet of Scale: As shown
U. S. Army Engr. District, Seattle, Wash.
Dr.: MAKI Transmitted with report
Tr.: dated 6 OCT 1976
Ck.: LAZO File No.

Incl 4

PLATE 2



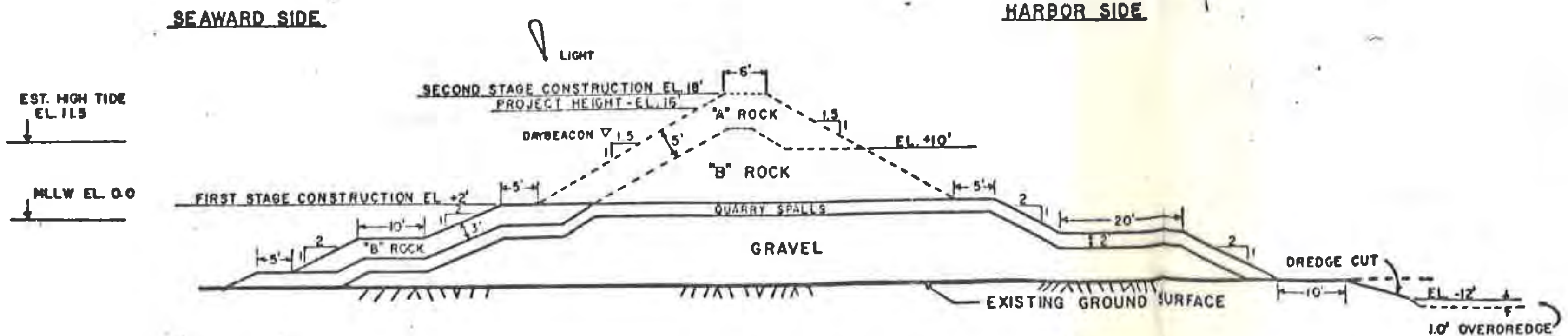
PLAN
SCALE 1"=200'



TYPICAL DREDGE RETAINING STRUCTURES

LEGEND

▣	FILL AREAS
▤	PROPOSED BREAKWATER
⊢⊣	DREDGE SLOPE
- - -	PROPOSED FEDERAL CHANNEL AND TURNING BASIN



TYPICAL BREAKWATER SECTION
SCALE IN FEET

BELLINGHAM, WASHINGTON

SQUALICUM SMALL BOAT BASIN EXPANSION
PROPOSED DREDGING AND DISPOSAL

PLAN AND SECTIONS

In sheets Sheet No.
U. S. Army Engineer District, Seattle, Wash.
Prepared: Submitted:
Chief, Section
Recommended: Approved:
Chief, Planning Branch Chief, Engineering Division
Drawn by: MAKI Transmitted with report File No.
Traced by:
Checked by: LAZO dated 6 OCT 76

PLATE 1

Sheet of

SAME CORRESPONDENCE SENT TO:

Dr. Fred C. Cleaver
Program Director
Columbia Fisheries Program Office
National Marine Fisheries Service
Post Office Box 4332
Portland, Oregon 97208

Donald P. Dubois, Regional Administrator
U.S. Environmental Protection Agency
1200 Sixth Avenue
Seattle, Washington 98101

R. Kahler Martinson, Regional Director
U.S. Fish and Wildlife Service
Post Office Box 3737
Portland, Oregon 97208

J. Norvell Brown, Field Supervisor
Division of Ecological Services
U.S. Fish and Wildlife Service
Post Office Box 1487
Olympia, Washington 98507

John A. Biggs, Director
Department of Ecology
State of Washington
Olympia, Washington 98504

Donald W. Moos, Director
Washington Department of Fisheries
General Administration Building, Room 115
Olympia, Washington 98504

Ralph W. Larson, Director
Washington Department of Game
600 North Capitol Way
Olympia, Washington 98504

Mr. Bert L. Cole
Commissioner of Public Lands
Department of Natural Resources
Public Lands Building
Olympia, Washington 98504

Thomas J. Glenn, General Manager
Port of Bellingham
Post Office Box 728
Bellingham, Washington 98225

Mr. Gregory Waddell
Director of Planning
210 Lottie Street
Bellingham, Washington 98225

Incl 5

APPENDIX F.2

Early Action Completion Report Hilton Avenue Soil Borrow Transfer to Cornwall Landfill Site

DRAFT
Early Action Completion Report
Soil Fill Transfer and Placement
Cornwall Avenue Landfill
Bellingham, Washington

December 21, 2016

Prepared for

Port of Bellingham
Bellingham, Washington

Landau Associates

130 2nd Avenue South
Edmonds, WA 98020
(425) 778-0907

Early Action Completion Report
Soil Fill Transfer and Placement
Cornwall Avenue Landfill
Bellingham, Washington

As the Engineer of Record, it is my opinion that the above referenced project was, to the best of my knowledge and information, constructed and completed in accordance with the plans and specifications as approved by the Washington State Department of Ecology. The construction is documented in this completion report.

Landau Associates

Document prepared by: ____ Kent W. Wiken, PE
Engineer of Record

Document reviewed by: ____ Larry Beard, PE
Project Manager

Date: December 21, 2016
Project No.: 001037.080
File path: "P:\001\037\R\Move Hilton Avenue Soil\Construction Completion\Completion Report\Hilton Av Soil Stockpile Transfer to Cornwall Ave LF Site.docx"
Project Coordinator: KES

TABLE OF CONTENTS

FIGURES

APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

AAM	All American Marine construction site
ASTM	ASTM International
BNSF	Burlington Northern Santa Fe Railway Company
CDF	controlled density fill
City	City of Bellingham
Contractor	Ram Construction General Contractors Inc.
CQA	construction quality assurance
CQC	construction quality control
CSWGP	construction stormwater general permit
DNR	Washington Department of Natural Resources
ECB	erosion control blanket
Ecology	Washington State Department of Ecology
LAI	Landau Associates, Inc.
MTCA	Model Toxics Control Act
Port	Port of Bellingham
Site	Cornwall Avenue Landfill site
SWPPP	stormwater pollution prevention plan
TESC	temporary erosion and sediment control

1.0 INTRODUCTION

This early action completion report documents the successful transfer and placement of fill to the Cornwall Avenue Landfill site (Site) by the Port of Bellingham (Port) in Bellingham, Washington. The early action at the Site was implemented to transfer fill soil from another Port site to the Cornwall Avenue Landfill to create the grades required to establish drainage for the upland cover system being constructed as part of the final cleanup action.

1.1 Site Location

The Site is located at the terminus of Cornwall Avenue adjacent to Bellingham Bay, as shown on Figure 1. The Site is bounded by Bellingham Bay, the R.G. Haley cleanup site (a former wood treating facility), and Burlington Northern Santa Fe Railway Company (BNSF) tracks. The fill soil was placed on the landward side of the inner harbor line, as shown on Figure 1. The inner harbor line represents the boundary between City of Bellingham (City)-owned land and state-owned land.

1.2 Purpose

The Port, the City, and Washington Department of Natural Resources (DNR) are undertaking final cleanup of the Site in accordance with the Washington State Model Toxics Control Act (MTCA; Chapter 173-340 WAC), and the terms of Consent Decree No. 14-2-02593-5. The cleanup includes constructing a cover system over the upland portion of the Site. The final cleanup action is currently under design; however, it is necessary to import approximately 50,000 cubic yards of soil fill to the Site to create sufficient drainage grades for the Site cover system. The Port identified a fill source for the majority of the soil fill required from a soil stockpile on the All American Marine construction site (AAM site) at 1010 Hilton Avenue. This soil stockpile was extensively tested for geotechnical and environmental suitability (Landau Associates 2016a), and the testing results were submitted to the Washington State Department of Ecology (Ecology) with a request that the fill transfer be completed as an "early action" element of the final cleanup action. This early action of placing fill soil on the eastern portion of the Site months or years in advance of the landfill cover construction will provide beneficial preloading, which will minimize the long-term settlement potential and aid in minimizing depressions that could form over time in the cover system. Ecology-approved the early action plan on March 2, 2016.

1.3 Early Action Description

Prior to moving the stockpile material from the AAM site, Ram Construction General Contractors Inc. (Ram Construction; Contractor) constructed a wheel wash near the entrance to the Site, and conducted Site clearing and demolition activities. Site clearing and demolition activities included rubblizing existing asphalt in place, backfilling existing catch basins with controlled density fill (CDF), and mulching vegetation. Additionally, silt fencing was installed around the stockpile areas and drainage ditches, a berm was constructed along the drainage ditch along the east side of the Site adjacent to the BNSF railroad right-of-way, and culverts were installed to maintain stormwater flow under the approach ramps to the stockpile.

The Contractor then began transferring fill material from the stockpile on Hilton Avenue to the Site on June 1, 2016 and continued through June 28, 2016. Approximately 41,350 cubic yards of fill soil were moved from the AAM site and placed in compacted lifts at the Site. Stockpile material was hauled to the Site with end dump truck and pups, placed in 8- to 12-inch-thick loose lifts, and compacted using a smooth drum roller. As shown on Figure 1, two distinct stockpiles were formed on the eastern portion of the Site, with a drainage ditch between them. The Contractor hired the density testing firm Materials Testing & Consulting, Inc. to perform in-place density construction quality control (CQC) testing of the stockpile material. Upon completion of the stockpile import, the stockpiles were bladed and graded to provide adequate drainage, per the plans. The stockpiles were then seeded, fertilized, and covered with an erosion control blanket.

The following report documents the as-built construction, the CQC testing, and the construction quality assurance (CQA) activities conducted during this early action.

1.4 Report Format

This final construction report is presented in the following four sections:

- Section 1.0 presents a general description of the project.
- Section 2.0 presents general requirements of the CQA program and introduces the roles of the entities involved with the construction.
- Section 3.0 present special requirements for specific work items of the construction, including procedures such as materials verification, test standards, testing frequencies, conformance and construction testing, and construction monitoring for each work item.
- Section 4.0 presents methods of documenting and recordkeeping.

1.5 Reference Documents

The following reference documents provide background information regarding the Hilton Avenue Soil Stockpile Transfer to Cornwall Avenue Landfill Site:

- LAI. 2016a. Agency Review Draft, Engineering Design Report, Cornwall Avenue Landfill Site, Bellingham, Washington, Appendix F. March 30.
- LAI. 2016b. Construction Specifications Cornwall Avenue Landfill, Hilton Avenue Soil Stockpile Transfer Plan, Bellingham, Washington. March 3.
- LAI. 2016c. Cornwall Avenue Landfill, Hilton Avenue Soil Stockpile Transfer Plan, Bellingham, Washington, Construction Drawings Issued for Construction. March 4.
- LAI. 2016d. Stormwater Pollution Prevention Plan for Cornwall Avenue Landfill, Hilton Avenue Soil Transfer, Bellingham, Washington (SWPPP including CSWGP). March 3.

The LAI 2016b through 2016d references were included as bid schedule A in a larger bid package for the construction of the AAM site:

- Port of Bellingham. 2016. All American Marine Manufacturing Facility – 2016, Bellingham, Washington. Advertised March 30 and April 3.

2.0 CONSTRUCTION QUALITY ASSURANCE PROGRAM

This section presents the basic elements of the CQA program, including a description of the parties involved with construction and their roles, the scope of the CQA program, construction document control, how nonconforming work was addressed, material submittals, and meetings and coordination.

2.1 Construction Personnel and Responsibilities

The following section describes the entities involved with the construction and their responsibilities during construction activities.

2.1.1 Owner

The owner identified for this project is the Port. Although the City owns the property upon which the fill was placed, the Port was responsible for complying with federal and state regulations governing work on the landfill for this project. The owner also took on roles of construction management. The owner's construction manager provided contract administration, budget, schedule, and coordination between parties. The construction manager requested assistance from the design Engineer of Record throughout the project to resolve construction and regulatory issues.

The owner's construction manager was:

Jon Gibson
Project Engineer
Port of Bellingham
1801 Roeder Ave, Bellingham, WA 98225
(O) (360) 715-7372
(M) (360) 603-6160
jong@portofbellingham.com

2.1.2 Engineer of Record and Construction Quality Assurance

LAI acted as the Engineer of Record and was responsible for the design; therefore, LAI approved all design changes and clarifications to design questions made during construction. The Engineer of Record was also the key point for regulatory contact. During construction, the Engineer of Record was also responsible for construction quality assurance (CQA), verifying construction was being performed in accordance with the design intent, construction drawings, and technical specifications; and preparing this completion report. The Engineer of Record for this project was:

Kent Wiken, PE
Senior Associate Engineer
Landau Associates, Inc.
130 2nd Avenue South, Edmonds, WA 98020
(O) (425) 329-0285
(C) (206) 604-6167
kwiken@landauinc.com

The CQA monitor, representing the Engineer of Record, provided observation of the Contractor's work, performed CQA activities, reviewed and approved Contractor submittals, and provided additional documentation as needed. The CQA monitor observed and documented the activities of the Contractor in sufficient detail and with continuity to provide a high level of confidence that the work product fully complied with the intent of the construction drawings and technical specifications. All observed deviations from the construction drawings and technical specifications were noted and addressed appropriately with the Owner, Contractor, and Engineer of Record. The CQA Monitor also performed tests, when appropriate, to provide a high level of confidence that the characteristics of the work met the requirements of the construction drawings and technical specifications. The CQA Monitor for this project was:

Sean Gertz, EIT
Landau Associates, Inc.
130 2nd Avenue South, Edmonds, WA 98020
(O) (425) 329-0251
(M) (503) 784-8228
sgertz@landauinc.com

2.1.3 Construction Contractor

Ram Construction was the Contractor for construction and was responsible for scheduling and performing the work within the time frame and budget agreed to in the contract, performing the work in accordance with the construction drawings and technical specifications, implementing CQC procedures, and documenting that construction complied with the technical specifications. Ram Construction also cooperated with the owner's construction manager and CQA Monitor to achieve quality construction. The lead for the general Contractor for this project was:

Josh Erholm
Project Manager
Ram Construction General Contractors Inc.
(O) 360-715-8643
(M) 360-961-0460
jerholm@ramconstruction-wa.com

2.1.4 Surveyor

The surveyor, Pacific Surveying & Engineering, Inc., worked under the direction of the Contractor to assist in constructing the project in accordance with the construction drawings and technical specifications, and performed surveys to document as-built conditions and to measure the installed quantities of unit price bid items. Pacific Surveying & Engineering employs a Professional Land Surveyor licensed in the State of Washington that supervised this work. The Surveyor for the project was:

Adam Morrow, PLS
Survey Project Manager, Principal
Pacific Surveying & Engineering, Inc.
(360) 671-7387
AMorrow@psesurvey.com

2.1.5 Independent Geotechnical Testing Company

The independent geotechnical testing company, working under the direction of the Contractor, provided density and moisture testing compacted site soils. The independent geotechnical testing company for this project was:

Curtis Shear
Project Manager
Materials Testing Company, Inc.
777 Chrysler Drive, Burlington, WA 98233
(O) 360-755-1990
curtis.shear@mtc-inc.net

2.2 Construction Quality Assurance Program Scope

A CQA program was implemented by Landau Associates, Inc. (LAI) to monitor, test, verify, and document that construction was completed in accordance with the plans, technical specifications, and the design intent. This program generally included the following:

- Verifying temporary erosion and sediment controls (TESCs) were in place prior to bringing fill to the Site, including silt fence installation, truck wash construction, drainage berm construction, and repair of riprap inlets as shown on the Drawings.
- Confirming clearing of Site vegetation and placement in a thin layer in the fill footprint.
- Confirming pavement demolition and catch basin cleaning then backfilling had been completed prior to bringing fill to the Site.
- Verifying that fill was placed in thin enough lifts for the embankment fill compaction and was properly moisture conditioned and compacted.
- Verifying density testing by the CQC testing lab was representative of conditions, and that loose areas were properly identified and reworked.

- Confirming the density test referenced the correct moisture-density curves for each fill soil type.
- Monitoring that there was no track-out of soil past the property line, and directing corrective action if needed.
- Verifying the Contractor was controlling dust with intermittent watering, and directing corrective action if needed.
- Confirming the Contractor was in compliance with the Ecology Construction Stormwater General Permit (CSWGP), including reviewing weekly discharge monitoring and requesting corrective action as necessary.
- Verifying the finished fill slopes and drainages were seeded and properly covered with erosion control blankets as shown on the Drawings.

2.3 Control of Construction Documents, As-Built Records, and Forms

2.3.1 Project Control of Construction Documents

The Contractor and owner controlled the construction documents, including technical specifications, construction drawings, and change orders. The construction Contractor and owner maintained copies of the most current set of construction drawings and technical specifications. New revisions of technical specifications and construction drawings were created by the Engineer of Record and submitted jointly to the owner, construction Contractor, and the CQA Monitor.

2.3.2 Project Control of As-Built Information

The construction Contractor and the project surveyor collected as-built information. Upon completion of the work, the construction Contractor was responsible for compiling this information into one set of construction drawings and technical specifications. The as-built information was then provided to the Engineer of Record for use in preparing this completion report. The as-built drawings for the project are provided on Figure 1.

2.4 Processing Reports

Copies of geotechnical testing reports for the density and moisture content of the soil were maintained by the CQA Monitor. The test reports were reviewed by the Engineer of Record and the CQA Monitor. The review included a check for mathematical accuracy, conformance to test standards, conformance to technical specifications, and a check for clarity, legibility, traceability, and completeness.

2.5 Correcting Non-Conforming Work

2.5.1 Observation of Non-Conformance

Whenever non-conforming work was observed, the owner's onsite representative or CQA Monitor notified the Contractor as soon as possible. The owner's onsite representative or CQA Monitor first notified the Contractor's foreman or superintendent supervising the work in question and then notified the Contractor's construction manager as appropriate.

2.5.2 Determining Extent of Non-Conformance

Whenever non-conformance was discovered, the construction manager or CQA Monitor determined the extent of the non-conforming work. When appropriate, the Engineer of Record was contacted to determine the appropriate corrective measures or additional testing that was required.

2.5.3 Documenting Non-Conformance

All non-conformances were documented in writing on progress reports, test reports and elsewhere, as appropriate. This documentation occurred immediately upon determining the extent of the non-conformance. During construction, non-conformance events occurred rarely and were resolved via onsite communications between the Owner's construction manager, the CQA Monitor, the Engineer of Record, and the Contractor as necessary.

2.5.4 Corrective Measures

Corrective measures were determined by the requirements of the project plans and specification. The CQA Monitor, owner's onsite representative, and Contractor applied standard construction methods to correct the deficiency.

2.5.5 Verification of Corrective Measures

Once the Contractor notified either the owner's onsite representative or the CQA Monitor that corrective measures were completed, the CQA Monitor and the owner's onsite representative verified and documented the satisfactory completion of the corrective action. Verification was accomplished by observations, re-testing, and/or photographing, as appropriate.

2.6 Materials Submittals

Materials quality verification was evaluated first by material submittals with certificates of compliance. The Contractor identified sources and samples of various construction materials and provided test data or material specification sheets to demonstrate the materials met specifications. Material submittals were also used by the CQA Monitor to establish the acceptability of materials. Material submittals required by the contract were submitted to the construction manager and made available to the Engineer of record who provided acceptance and proper review of submittals as provided in Appendix A.

2.7 Meetings and Coordination

In efforts to effectively communicate, pre-construction and construction progress meetings occurred. Additionally, a clear line of communication was established between the owner's onsite representative, the Contractor, the CQA Monitor, and the Engineer of Record.

2.7.1 Pre-Construction Meeting

A pre-construction meeting was held at the Port office on May 20, 2016. The meeting was attended by the owner, the construction Contractor, the CQA Monitor, and Engineer of Record. The purpose of the pre-construction meeting was to:

- Confirm relationships among the various parties, including lines of authority, lines of communication, and scope of work.
- Confirm responsibilities of each party.
- Identify relevant documents.
- Establish methods for documenting and reporting, and for distributing and storing documents and reports.
- Review critical construction and scheduling aspects of the project.
- Review work area security and health and safety protocols.
- Review and make any appropriate modifications and/or addenda to the various plans, drawings, specifications, and available QC plans so that site-specific considerations and activities are incorporated.
- Reach a consensus on the interpretation of the construction plans and specifications, including methods of determining acceptability of the various components of the work.
- Review the schedule and sequencing for construction of the work, and coordinate construction requirements/logistics for various subcontractors.
- Review survey procedures, methods, equipment, datum, and horizontal and vertical control references to be used for the Contractor's surveys.
- Conduct a reconnaissance of the various project work areas to verify that the construction plans and sequencing and site constraints are understood, and to review appropriate vehicle haul routes and material and equipment storage locations.

2.7.2 Progress Meetings

Progress meetings were held weekly at the Port office. The progress meetings were attended by the owner's onsite representative, construction Contractor, and either the CQA Monitor or the Engineer of Record. The meetings included the following topics:

- Review of the previous period's activities and progress.
- Review of the work locations and activities for the current period.

- Identify the Contractor’s and subcontractor’s personnel and equipment assignments for the current period.
- Discuss any potential construction problems.

3.0 CONSTRUCTION QUALITY ASSURANCE ACTIVITIES

3.1 Introduction

This section summarizes the CQA monitoring and testing activities associated with the project. CQC inspections, observations, and testing activities were conducted by the construction Contractor and its subcontractors; the results were reported to the owner and the CQA Monitor. The owner and the CQA Monitor performed independent inspections and reviews of the CQC work performed by the Contractor. Required CQA included verifying the following were in accordance with plans, specifications and CSWGP:

- Layout and grade control
- TESC installation
- Site clearing and selective demolition
- Soil excavation at the AAM Site to confirm that it did not extend to depths below that shown on the plans
- Soil fill placement
- Site restoration.

This section describes the monitoring and testing performed to assure construction met specified requirements.

3.2 Layout and Grade Control

The Contractor employed a professional surveying firm (Pacific Surveying & Engineering, Inc.) to perform the construction staking, grade control, limited stockpile measurements, and excavation confirmation at the AAM site. The CQA Monitor reviewed the surveyor-provided contour plans (Figure 1) to verify the alignment and grade of the construction elements involved in the soil stockpile placement.

3.3 Temporary Erosion and Sediment Control

TESC measures for the soil stockpile placement were implemented in accordance with Section 31 25 00 of the Specifications and as shown on the drawings. During the installation of TESC measures, the owner's construction manager and CQA Monitor observed that:

- Erosion control blankets (ECBs), silt fencing, drainage ditch modifications, and drainage rip rap repairs were installed as shown on the drawings.
- No excavation was allowed to install the truck wheel wash. The truck wheel wash was located in the area shown on the drawings and was constructed using embankment fill as needed.
- All fills and disturbed areas were seeded and, in sloped areas and ditches, covered with ECB at project completion.

- All stormwater best management practices (BMPs) were installed and functioning in accordance with the stormwater pollution prevention plan (SWPPP).

The Contractor's TESC was installed and functioning correctly and in accordance with project specifications.

3.4 Site Clearing and Selective Demolition

Site clearing and selective demolition was accomplished for the soil stockpile placement in accordance with Section 31 12 00 of the Specifications and as shown on the drawings. During the Site clearing and selective demolition, the owner's construction manager and CQA Monitor observed that:

- The Contractor clearly marked the monitoring wells and other structures to be protected from damage by clearing and demolition activities, and executed the appropriate protection measures.
- All silt fences and temporary sedimentation ponds were in place per the drawings and Section 31 25 00 of the Specifications.
- The Site was cleared of trees and shrubs to the limits shown on the drawings and that cuttings were mulched and spread over designated areas for burial in the embankment fill.
- Water was pumped from existing catch basins and ponded areas to the designated drainage ditch.
- Existing asphalt was ripped and left in place for burial in the embankment fill.
- Existing catch basins were filled to the ground surface with controlled density fill (CDF).

The Contractor completed site clearing in accordance with project drawings and specifications.

3.5 Fill Soil Placement

Fill soil placement was accomplished in accordance with Section 31 23 23 of the specifications and as shown on the drawings. During the stockpile placement, the owner's construction manager and CQA Monitor observed that:

- All site clearing and selective demolition had been completed per the drawings and Section 31 12 00 of the Specifications.
- Stakes defining the limits of the embankment fill were in place.
- Fill soil was placed and compacted in continuous layers not exceeding 12 inches loose.
- Fill soil was maintained near optimum moisture content and was compacted to at least 90 percent of the maximum dry density at a moisture content between 2 percent below to 4 percent above optimum moisture content as determined by ASTM International (ASTM) D 1557.
- Compaction tests were performed in accordance with ASTM D2922, with a minimum of one test per compacted lift in the south pile and one test per compacted lift in the north pile. The test results are located in Appendix B.

- The correct reference moisture-density curve was used to confirm that adequate compaction had been achieved.
- The embankment fill was as-built surveyed to verify height and limits were as per the drawings.
- Fill soil was placed and compacted in horizontal lifts until the height of compacted fill soil was achieved as shown on the drawings.
- The Owner's surveyor installed monuments on the embankment fill for settlement monitoring.

The Contractor completed fill placement in accordance with project drawings and specifications.

3.6 Site Restoration

The owner's construction manager observed the Contractor's work area was cleaned up and that Site restoration activities were completed and adequately restored to a condition acceptable to the Owner. The Engineer of Record prepared a completion punchlist, which the CQA Monitor reviewed with the Contractor onsite on August 22, 2016. A record of LAI review of the completed work is provided as Appendix E.

In summary, punch list identified that the Contractor had failed to establish adequate grass cover though the ECBs (per CSWGP requirements) and did not grade the area north of the fill piles per the contours on drawings. The Contractor reconciled this with the Engineer of Record by providing a drawing on October 5, 2016 showing a drainage swale installed along the north side to prevent ponding, and stating that they will be monitoring grass establishment into November, and will reseed as necessary. This reconciliation of remaining items was approved by the owner.

4.0 DOCUMENTATION

The CQA Monitor, Engineer of Record, and the Owner's construction manager documented that quality assurance requirements were implemented. Documentation consisted of construction progress Site visit reports, email confirmations of progress, geotechnical test reports, design and specification revisions, and this completion report.

4.1 Construction Progress Site Visit Reports

Construction progress site visits were conducted by the either the Engineer of Record or the CQA Monitor at milestone construction completions. These visits consisted of observation of Site construction progress, meetings with the Owner's representatives and the Contractor, review and performance of geotechnical testing, and as needed, non-conformance/corrective measure reports. Daily reports and photographic records of the construction progress site visits can be found in Appendix C.

4.2 Geotechnical Test Reports

In accordance with the specifications, *in situ* density and moisture testing was performed by the independent geotechnical testing company, Materials Testing Company, Inc. The construction of the embankment fill was found to meet compaction specifications. Appendix B contains the geotechnical testing reports.

4.3 Design and Specification Revisions

As a result of regulatory design review, acceptable design and specification revisions were made prior to and during construction. These revisions included:

- Plugging the outlet from the 48-inch-diameter manhole at the south end of the Site that was part of the stormwater management system constructed following demolition of the former GP tissue warehouse, and protecting the concrete inlet structure in-place prior to beginning Site disturbance activities.
- Connecting stormwater ditch flow by installing 25 linear feet of 12-inch-diameter culvert in the ditch that runs between the existing interim placement areas (IPAs) and the new fill areas.
- The Contractor elected to compact all the fill brought to the Site, and not loose stockpile a portion on top of the compacted fill as allowed for on the drawings.

All of these construction revisions were designed by the Engineer of Record, improving the original design and final construction. The complete set of plans with these design revisions and the revised specifications are provided in Appendix D.

4.4 Non-Conformance Reports

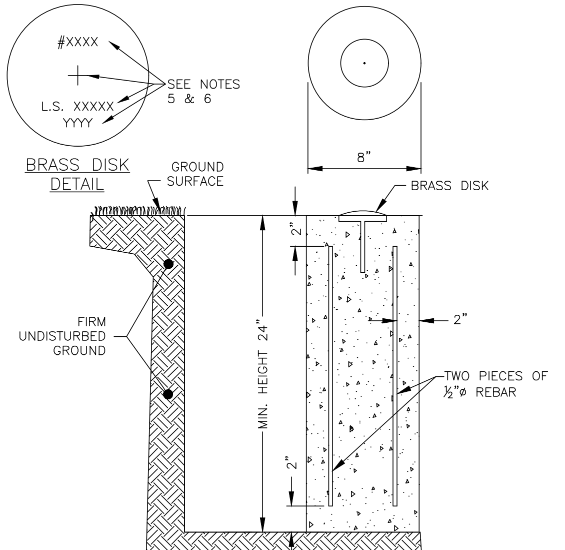
Non-conformance was addressed immediately by the Contractor via communications with the Owner and the CQA Monitor or Engineer of Record. As such there were no formal non-conformance reports.

4.5 Photographs

Construction activities were digitally photographed on a daily basis by the CQA Monitor and emailed to the Engineer of Record. Construction photographs are provided with the daily reports in Appendix C.

5.0 USE OF THIS REPORT

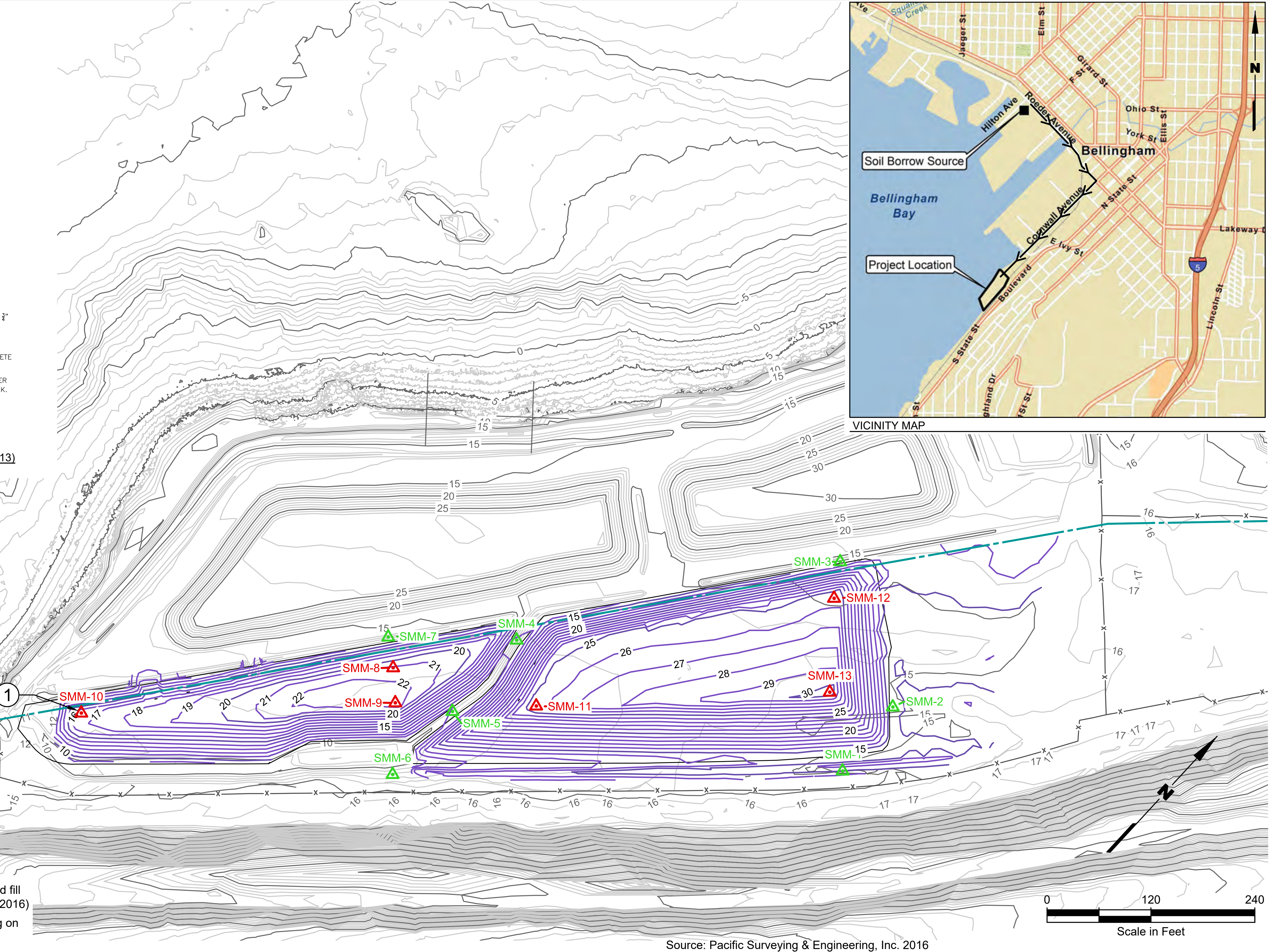
This Early Action Completion report has been prepared for the use of the Port of Bellingham and the Washington State Department of Ecology for specific application to the Cornwall Avenue Landfill Cleanup Project. None of the information, conclusions, and recommendations included in this document can be used for any other project without the express written consent of LAI. Further, the reuse of information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and written authorization by LAI, shall be at the user's sole risk. LAI warrants that within the limitations of scope, schedule, and budget, our services have been provided in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality under similar conditions as this project. We make no other warranty, either express or implied.



NOTES:

1. BRASS DISK WAS EQUAL TO OR BETTER THAN SURV-KAP MODEL M/M-B2 (2" DIAMETER WITH ¾" DIAMETER x 2" SHANK).
2. EXCAVATION WAS FILLED WITH CLASS 4,000 CONCRETE PER APWA SECTION 03 30 04.
3. ALL LOOSE MATERIALS WERE REMOVED FROM THE BOTTOM OF THE HOLE SO THAT THE CONCRETE IS PLACED ON FIRM, UNDISTURBED EARTH.
4. THE TOP OF THE CONCRETE WAS TROWELED SMOOTH AND THE BRASS DISK SET IN THE CENTER FLUSH AND LEVEL SO THAT PUNCH MARK FALLS NO CLOSER THAN ¼" FROM THE EDGE OF DISK.
5. EXACT LOCATION OF CONTROL POINT WAS PUNCHED AFTER CONCRETE HAS BEEN SECURED IN POSITION.
6. DISK WAS STAMPED WITH CITY ASSIGNED MONUMENT NUMBER, SURVEYOR'S LICENSE NUMBER, AND THE YEAR THE MONUMENT IS PUNCHED (YYYY)

1 SETTLEMENT MONITORING SURVEY MONUMENT (TYP. OF 13)
N.T.S.



Source: Pacific Surveying & Engineering, Inc. 2016

Legend

- —15— Existing contours
- —20— Compacted fill placed in June 2016 (approximately 41,355 c.y.)
- —x— Existing fence line
- SSM-8 △ Settlement monitoring monument installed on completed fill on July 5, 2016 (Fill installation completed on June 21, 2016)
- SSM-1 △ Settlement monitoring monument installed prior to filling on May 16, 2016 except SMM-5 destroyed by construction equipment and reinstalled June 16, 2016.
- —·— Inner Harbor Line

LANDAU ASSOCIATES

Early Action Completion Report
Cornwall Avenue Landfill
Bellingham, Washington

As-built Fill Placement

Figure
1

LANDAU ASSOCIATES, INC. | G:\Projects\001037\080\081\F01 As-BuiltFillPlacement.dwg (A) "Figure 1" 12/20/2016

APPENDIX A

Approved Submittals

Landau Associates

Submittal Review

Project Name: All American Marine Manufacturing Facility
Submittal Number: 1
Submittal Description: TESC Materials

The submittal has been reviewed and review action is shown below:

- ☒ No Exceptions Taken
- ☐ Furnish as Corrected
- ☐ Revise and Resubmit
- ☐ Rejected
- ☐ Submit Specified Item

Review Comments:

The following erosion control items relevant to the Cornwall Ave site have been reviewed:

- Item 1 - ACF West Silt Fence
- Item 2 - ACF West Separation Fabric
- Item 4 - ACF West Erosion Blanket
- Item 7 – RAM HD-10 Wheel Wash

The HD-10 wheel wash submittal is a one-page brochure without installation instructions. That is acceptable as long as the wheel wash system components are installed above grade with fill ramps; no excavation into onsite soil is allowed per Dwg. C-2 and the SWPPP for the Hilton Avenue Soil Transfer to the Cornwall Avenue Landfill site.

Reviewed by: David Pischer, PE Date: May 24, 2016

This review is only for general conformance with the design concept of the project and general compliance with the information given in the Contract Documents. Corrections or comments made on or attached to the submittal during this review do not relieve the Contractor from compliance with the requirements of the Contract Documents. Approval of a specific item shall not include approval of an assembly of which the item is a component. Contractor is responsible for: dimensions to be confirmed and correlated on the jobsite, information that pertains solely to the fabrication processes or to the means, methods, techniques, sequences, and procedures of construction, coordination of the Contractor's work with that of all other trades, and for performing all work in a safe and satisfactory manner.

RAM
CONSTRUCTION

LETTER OF TRANSMITTAL

Date:	5/11/2016
Project #	1607
ATTN:	Jon Gibson
RE:	All American Marine

TO: Port of Bellingham
PO Box 1677
Bellingham, WA 98225

We are sending you the following attachments:

The following items: ☐ Shop drawings ☐ Prints ☐ Plans ☐ ______________
☐ Requisitions ☐ Change Orders ☐Samples

Copies	Date	No.	Description
1	5/11/2016	1	ACF West Silt Fence 31-25-00
1	5/11/2016	2	ACF West Separation fabric 31-20-00
1	5/11/2016	3	ACF West Marker Fabric 9-33
1	5/11/2016	4	ACF West Erosion Blanket 31-25-00
1	5/11/2016	5	AACF West Construction Entrance Fabric 31-25-00
1	5/11/2016	6	ACF West CB Protection 31-25-00
1	5/11/2016	7	RAM HD-10 Wheel Wash System

These are transmitted as indicated below:

☐ For your use ☐ Approval as noted ☐ For Approval ☐ As requested
☐ Approved for Construction ☐ For review and comment ☐ Returned for corrections
☐ For payment ☐ Return ☐ Corrected Prints ☐ For bids due: ____________

Remarks: ____

____

____

Received By: ______________________________ Date: ______________________

Signed: ____________________________Title: ______________________________

Copy to: __________________

☐ Recipient’s Copy
☐ Sign & Return
☐ File Copy

Silt Fence
Specification 31-25-00
Section 02540
Paragraph 2.01-A
Supplier ACF West

ACF WEST INC.
GEOSYNTHETIC PRODUCTS

ACF West is a D.B.A. for Northwest Geosynthetics Inc.
2505 Frank Albert Rd E, Suite 111, Fife WA 98424 – PH: 253-922-6641 Fax: 253-922-6642

Description: ACF West "Supported" Silt Fence, ACF-WB-48 uses a woven fabric attached with steel hog rings to galvanized steel support mesh.

Roll size: 48" fabric w/36" support mesh x 100 lineal foot
Available in black or "Hi-Vis" orange

Fabric: The fabric, is a woven network of polypropylene fibers, stabilized to resist degradation due to ultraviolet exposure, and resistant to commonly encountered soil chemicals, mildew and insects. It is non-biodegradable and is stable within a ph range of 2-13. Manufactured for ACF West Inc. The fabric meets the following minimum average roll values (MARV):

Property	Test Method	MARV (English)
Grab Tensile	ASTM D 4632	158.1 x 161.7 lbs
Grab Elongation	ASTM D 4632	20.7% x 21.3%
CBR Puncture	ASTM D 6241	620 lbs
Trapezoidal Tear	ASTM D 4533	90 x 85 lbs
UV Resistance	ASTM D 4355	80% @ 500hr
AOS	ASTM D 4751	70 sieve
Permittivity	ASTM D 4491	0.128 sec^{-1}

Support Mesh: Galvanized utility mesh, 4" x 2" opening, 36" height, 100' length

Separation Fabric
Specification 31-20-00
Paragraph 2.2A
Supplier ACF West

ACF WEST INC.
GEOSYNTHETIC PRODUCTS

ACF West Inc. is a D.B.A. name for Northwest Geosynthetics Inc.
8951 SE 76th Drive Portland, OR 97206 (503) 771-5115, (800) 878-5115, (503) 771-1161 fax

Product Data Sheet

WSF 250 (ACF 250) Woven Geotextile

WSF 250 is a woven slit film geotextile, and will meet the following physical properties when tested in accordance with the methods listed below. The individual slit films are woven together in such a manner as to provide dimensional stability relative to each other. The construction of the geotextile makes WSF 250 ideal for soil separation and stabilization. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

WSF 250 Woven Geotextile conforms to the following physical properties:

Property	Test Method	English (MARV)[1]
Typical Weight	ASTM D-5261	4.5 oz/yd
Grab Tensile Strength	ASTM D-4632	(MC/CD) 250 lbs / 250 lbs
Elongation	ASTM D-4632	>15%
Trapezoidal Tear	ASTM D-4533	90 lbs
UV Resistance	ASTM D-4355	80%
Apparent Opening Size (AOS)[2]	ASTM D-4751	50 US Std. Sieve
Permittivity	ASTM D-4491	0.10 Sec^{-1}
Roll Sizes		12.5’ x 360’ 15’ x 300’ 17.5’ x 258’

1. All values listed are Minimum Average Roll Value (MARV) unless otherwise noted, calculated as the typical minus two standard deviations Statistically, it yields 97.7% degree of confidence that any sample taken during quality assurance testing will exceed the value reported.
2. Values for Apparent Opening size are Maximum Average Roll Value (MaxARV), typical value plus two standard deviations.

Note: WSF 250 fabric is manufactured and imported for ACF West Inc. by Gia Loi Joint Stock Company. Phuoc Thai Hamlet, Tahi Hoa Tan Uyen District. Binh Duon Province, Vietnam. WSF 250 is a trade name of ACF West Inc. and any use of this name without the expressed written consent of ACF West Inc. is strictly prohibited. The property values listed above are effective 12-1-2014 and subject to change without notice.

TENCATE Mirafi

Landscape Cap / Marker Fabric
Plan Sheet C1 - Cross section BB & CC
Standard Specification 9-33 Table 3
Supplier ACF West

Drainage Separation

Mirafi® 160N/O

Mirafi® 160N/O is an orange nonwoven geotextile composed of polypropylene fibers, which are formed into a network such that the fibers retain their relative position. Mirafi® 160N/O is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Typical Roll Value	
			MD	CD
Grab Tensile Strength	ASTM D4632	lbs (N)	175 (779)	175 (779)
Grab Tensile Elongation	ASTM D4632	%	75	75
Trapezoid Tear Strength	ASTM D4533	lbs (N)	85 (378)	85 (378)
CBR Puncture Strength	ASTM D6241	lbs (N)	480 (2136)	
Apparent Opening Size (AOS)[1]	ASTM D4751	U.S. Sieve (mm)	100 (0.15)	
Permittivity	ASTM D4491	sec^{-1}	1.5	
Flow Rate	ASTM D4491	gal/min/ft^2 (l/min/m^2)	105 (4278)	
UV Resistance (at 500 hours)	ASTM D4355	% strength retained	80	

[1] ASTM D4751: AOS is a Maximum Opening Diameter Value

Physical Properties	Unit	Typical Value
Weight (ASTM D5161)	oz/yd^2 (g/m^2)	6.5 (220)
Thickness (ASTM D5199)	mils (mm)	65 (1.7)
Roll Dimensions (width x length)	ft (m)	15 x 300 (4.5 x 91)
Roll Area	yd^2 (m^2)	500 (418)
Estimated Roll Weight	lb (kg)	215 (97)

Made in USA

TENCATE
materials that make a difference

Erosion Control Blanket
Specification 31-25-00
Section 02540
Paragraph 2.02-A & B
Supplier ACF West

Rev 0111

Erosion Control
BLANKET

C32 BD

Specification Sheet

The ErosionControlBlanket C32 BD is a long-term 100% biodegradable double net 100% coconut fiber erosion control blanket designed for use on extreme slope and channel applications requiring erosion control for up to 36 months depending on moisture, light, and environmental conditions. The blanket is sewn together on 1.5 inch (38.1 mm) centers. The C32 BD meets all requirements established in the FHWA FP-03 as a Type 4 erosion control blanket for use on slopes with gradients not exceeding 1:1 (h:v) and has been tested by the National Transportation Product Evaluation Program (NTPEP). The C32 BD comes packaged in clear shrink-wrap with a purple band and includes installation instructions.

Product Nomenclature & Properties

C = 100% coconut fiber matrix
3 = coconut fiber matrix applied at a rate of 0.5 lbs/yd^2 (270 g/m^2)
2 = top and bottom leno woven biodegradable nets with a mesh size of 0.5 x 1.0 in (1.3 x 2.54 cm)
BD = 100% biodegradable leno woven net, thread, and matrix to ensure consistent functional longevity

Index & Bench Scale Testing

Test Description	Test Method	Test Results
Mass per Unit Area	ASTM D6475	9.19 oz/yd^2
Tensile Strength	ASTM D6818	19.9 lb/in @ 9.6% MD 11.9 lb/in @ 15.3% TD
Thickness	ASTM D6525	0.261 in
Light Penetration / Ground Cover	ASTM D6567	12.7% / 87.3%
Water Absorption	ASTM D 1117 & ECTCTASC 00197	271%
Unvegetated Bench-Scale Rain Splash and Runoff (not to be used as a design value)	ASTM D7101	Soil Loss Ratio* = 13.56 Soil Loss Ratio* = 15.10 Soil Loss Ratio* = 16.82
Unvegetated Bench-Scale Shear Stress (not to be used as design value)	ASTM D7207	2.90 lbs/ft^2 @ ½ in. soil loss
Seed Germination and Plant Growth Under Bench-Scale Conditions	ASTM D7322	412% Improvement (increased biomass)

*Soil Loss Ratio = Soil Loss Bare Soil / Soil Loss with RECP = 1 / C-Factor (Note: Soil loss is based on regression analysis)

Design Values

- "C" factor = 0.002
- Maximum Permissible Shear Stress = 2.25 lbs/ft^2 (108 Pa)
- Maximum Permissible Velocity = 10 ft/sec (3.05 m/s)
- Manning's "n" = 0.03

Standard Roll Details

Width	2.44m (8 ft)	4.88m (16 ft)
Standard Length	34.3m (112.5 ft)	34.3m (112.5 ft)
Area	83.61m^2 (100 yd^2)	167.22m^2 (200 yd^2)
Weight ± 10%	30.8 kg (68 lb)	61.6 kg (136 lb)

"Big Daddy" Roll Details

Width	2.44m (8 ft)	4.88m (16 ft)
Standard Length	137.2m (450ft)	137.2m (450ft)
Area	334.5m^2 (400 yd^2)	669m^2 (800 yd^2)
Weight ± 10%	92.5 kg (272 lb)	246.76kg (544lb)

PHONE: (866) 280-7327 • www.erosioncontrolblanket.com • FAX: (204) 378-2140

Construction Entrance Separation Fabric
Specification 31-25-00
Section 02540
Supplier ACF West

ACF WEST INC.
GEOSYNTHETIC PRODUCTS
ACF West Inc. is a D.B.A. name for Northwest Geosynthetics Inc.
8951 SE 76th Drive, Portland, OR 97206 (503) 771-5115, (800) 878-5115, (503)771-1161 fax

Product Data Sheet

WSF 200 (ACF 200) Woven Geotextile

WSF 200 is a woven slit film geotextile, and will meet the following physical properties when tested in accordance with the methods listed below. The individual slit films are woven together in such a manner as to provide dimensional stability relative to each other. The construction of the geotextile makes WSF 200 ideal for soil separation and stabilization. The geotextile is resistant to ultraviolet degradation and to biological and chemical environments normally found in soils.

WSF 200 Woven Geotextile conforms to the following physical properties:

Property	Test Method	English (MARV)[1]
Weight (Typical)	ASTM D-5261	4.0 oz./SY
Grab Tensile Strength	ASTM D-4632	200 lbs
CBR Puncture	ASTM D-6241	700 lbs
Trapezoidal Tear	ASTM D-4533	80 lbs
UV Resistance	ASTM D-4355	80%
Apparent Opening Size (AOS)[2]	ASTM D-4751	50 US Std. Sieve
Permittivity	ASTM D-4491	0.05 sec^{-1}
Roll Sizes		12.5' x 432' 15' x 360' 17.5'x 309'

1) All values listed are Minimum Average Roll Value (MARV) unless otherwise noted, calculated as the typical minus two standard deviations. Statistically, it yields 97.7% degree of confidence that any sample taken during quality assurance testing will exceed the value reported.
2) Values for Apparent Opening size are Maximum Average Roll Values (MaxARV), typical value plus two standard deviations.

Note: WSF 200 fabric is manufactured and imported for ACF West Inc. by Gia Loi Joint Stock Company. Phuoc Thai Hamlet, Tahi Hoa Tan Uyen District. Binh Duon Province, Vietnam. ACF 200 is a trade name of ACF West Inc. and any use of this name without the expressed written consent of ACF West Inc. is strictly prohibited. The property values listed above are effective 11-1-2010 and subject to change without notice.

CB Inlet Protection
Specification 31-25-00
Section 02540
Supplier ACF West

Ultra-DrainGuard®

Specifications

Minimum Average Fabric Values

Properties	ASTM Test	Value
Material: Non-woven, Polypropylene Geotextile		
Size Dimensions: 48” L x 36” W x 18” H		
Grab Tensile (lbs)	D 4632	215
Elongation (%)	D 4632	50
Trapezoid Tear (lbs)	D 4533	85
Puncture (lbs)	D 4833	115
Mullen Burst (psi)	D 3786	360
Permittivity (sec-1)	D 4491	0.9
Permeability (cm/sec)	D 4491	0.25
A.O.S. (U.S. sieve no.) / Microns	D 4751	80 / 180
UV Stability (strenght retained %) 500 hrs	D 4355	70
Weight (oz/yd2) (typical)	D 5261	9
Thickness (mils)	D 5199	85
Flow (through material gpm/ft2)	D 4491	65
Flow (including bypass gpm) *		770
Flow (including bypass cfs) *		1.7
* Larger bypass flow rate designs are available		

11542 Davis Creek Court   Jacksonville, FL 32256   800-353-1611

Website: www.stormwater- products.com

E-mail: info@stormwater- products.com

Wheel Wash System
Specification 31-25-00
Section 02540
Paragraph 2.04A
Supplier RAM Construction

OSW Equipment & Repair, Inc.

The Soaker HD-10 Wheel Wash

More nozzles

The HD-10 is 24' L x 10' W x 9'4" H and weighs 18,000lbs.

High Volume- Low Pressure

The Soaker HD-10 is equipped with 4 high volume pumps and more nozzles for larger truck volume projects.

Aluminum Construction

The all aluminum construction is environmentally friendly and easy to handle . The Soaker will not rust or flake paint.

APPENDIX B

Earthwork Construction Testing

Materials Testing & Consulting, Inc.
Geotechnical Engineering & Consulting ▪ Special Inspection ▪ Materials Testing ▪ Environmental Consulting
Engineered Assurance Since 1981

All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37329

CLIENT	Ram Construction	**DATE**	06/04/2016
PROJECT LOCATION	Dead end of Cornwall / near beach access Bellingham WA	**PERMIT #**	

Inspection Information:

Inspection Date: 06/04/2016 **Time Onsite:** 8:30 AM **Weather Conditions:** Sunny 70s

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location:	Landfill soil storage	**Gauge Standard MS:**	9845
Equipment ID & Serial #:	CPN MC-1, Ser. #MD20906738	**Gauge Standard DS:**	32853

Test Samples:

	Sample #:	Description:	Proctor Value(pcf):	Optimum Moisture and Oversize Rock Correction:
1.	B16-0536	gray silty sand w/ gravel	125.5	9.4% Uncorrected
2.	B16-0536	gray silty sand w/ gravel	135.9	6.7% (30% RC)

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	10"	S end, W side, +200'	13'	132.8	120.6	10.1	1	96.1	90
2	10"	S end, E side, +300'	15'	127.1	117	8.6	1	93.2	90
3	10"	S end, E side, +40'	15'	137.4	123.7	11.1	2	91	90
4	10"	N end, central, +220'	11'	139.5	127.2	9.7	2	93.6	90
5	10"	N end, central, +75'	12'	132.3	119.7	10.5	1	95.4	90
6	10"	N end, E side, +10'	12'	134.4	120.3	11.7	1	95.9	90
7	10"	N end, W side, +65'	12'	132.7	120.5	10.1	1	96	90
8	10"	N end, E side, +100	12'	128	116.7	9.7	1	93	90
9	10"	S end, Central, +250'	14'	147.2	134.1	9.8	2	98.7	90
10	10"	N end, Central, + 200	12'	126.9	115.3	10.1	1	91.9	90
11	10"	N end, w side, +25'	13'	139.5	123.9	12.6	1	98.7	90
12	10"	N end, w side, +115'	14'	136	119.8	13.5	1	95.5	90
13	10"	N end, central, +65	14'	130.2	116	12.2	1	92.4	90
14	10"	N end, e side, +125'	14'	137.4	123.8	11	2	91.1	90
15	10"	N end, e side, +305'	12'	124.9	114	9.6	1	90.8	90
16	10 "	N end, w side, +65'	15'	135.4	123.9	9.3	2	91.2	90
17	10	N end, e side, +15'	15'	130.6	119.4	9.4	1	95.1	90

☐ Native Soils
☒ Imported Fills

Soils consistent with Proctor ● Yes ○ No
Soils found to be firm and stable; and to the best of our knowledge, meet compaction ● Yes ○ No
Contractor notified of results ● Yes ○ No

Remarks:

MTC on site as requested for compaction testing of soils excavated at Hilton Harbor site and imported to Cornwall Ave Landfill site for storage. Port of Bellingham job. Contractor reports 90 percent compaction minimal.
Site is divided into two sections, north and south. Majority of fill today occurred on north section. Each individual section tested is divided into east, central and west. Locations are based on southernmost margin of each section named station 0+00 by MTC, numbers increase to north.
Ten Cowden double dump trucks placed soils, which were graded by dozer into lifts of 8 inches or less and compacted by Vibromax 1105 single drum vibrating roller.

Material variability on site has produced an almost 20 pcf difference in areas tested.

Compaction was attained for all locations tested. Contractor will receive notification with this report.

Elevations are based on feet above sea level.

MTC will return upon request for continued compaction testing.

Images:

UPLOADED: 06/04/2016 17:19:00

South area
Facing South

UPLOADED: 06/04/2016 17:20:00

North area
Facing East

REPORTED BY: Kurt Parker REVIEWED BY: Curtis Shear, Project Manager

Materials Testing & Consulting, Inc.

Geotechnical Engineering & Consulting ▪ Special Inspection ▪ Materials Testing ▪ Environmental Consulting

Engineered Assurance Since 1981

All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37337

CLIENT Ram Construction

DATE 06/06/2016

PROJECT LOCATION Dead end of Cornwall / near beach access
Bellingham WA

PERMIT #

Inspection Information:

Inspection Date: 06/06/2016 **Time Onsite:** 9:00 am **Weather Conditions:** Sunny 70s

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location: Landfill soil storage

Gauge Standard MS: 9845

Equipment ID & Serial #: CPN MC-1, Ser. #MD20906738

Gauge Standard DS: 32853

Test Samples:

	Sample #:	Description:	Proctor Value(pcf):	Optimum Moisture and Oversize Rock Correction:
1.	B16-0536	gray silty sand	125.5	9.4% Uncorrected

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	8"	175 N, 50 E	15	134.2	120.3	11.6	1	95.9	90
2	8"	200 N, 55 E	15	129.9	115.4	12.6	1	92	90
3	8"	230 N, 55 E	15	131.5	117.7	11.7	1	93.8	90
5	8"	30 N, 120 E	15	132.7	117.3	13.1	1	93.5	90
7	8"	300 N, 30 E	15	135.5	120.9	12.1	1	96.3	90
9	8"	290 N, 100 E	15	132.1	119.1	10.9	1	94.9	90
10	8"	285 N, 90 E	15	136.8	123	11.2	1	98	90
12	8"	130 N, 140 E	15	135.6	119.4	13.5	1	95.1	90
14	8"	50 N, 20 E	16	131.1	115.7	13.3	1	92.2	90
15	8"	60 N, 40 E	16	135	121.5	11.1	1	96.8	90
18	8"	250 N, 80 E	16	129.2	116.9	10.5	1	93.1	90
19	8"	30 N, 20 E	16	127.1	113.5	12	1	90.4	90
20	8"	20 N, 10 E	16	128.9	114.2	12.9	1	91	90
24	8"	270 N, 75 E	16	130.6	117.3	11.3	1	93.5	90
25	8"	140 N, 140 E	16	134.5	122.2	10.1	1	97.4	90
27	8"	10 N, 100 E	16	128.8	114.4	12.6	1	91.2	90
29	8"	20 N, 70 E	17	132.8	116.8	13.7	1	93.1	90
31	8"	160 N, 120 E	17	130.4	115.4	13	1	92	90
32	8"	280 N, 75 E	17	132.5	116.8	13.5	1	93.1	90
35	8"	130 N, 10 E	17	130.7	117.7	11	1	93.8	90

☐ Native Soils

☒ Imported Fills

Soils consistent with Proctor ● Yes ○ No

Soils found to be firm and stable; and to the best of our knowledge, meet compaction ● Yes ○ No

Contractor notified of results ● Yes ○ No

Remarks:

MTC on site as requested for compaction testing of soils excavated at Hilton Harbor site and imported to Cornwall Ave Landfill site for storage. Port of Bellingham job. Contractor reports 90 percent compaction minimal.
Site is divided into two sections, north and south. All fill today occurred on north section. Locations are based on southernmost and easternmost margins of each section and are located by number of feet north and east of those margins.

Double dump trucks placed soils, which were graded by a John Deere 850c dozer into lifts of 8 inches or less and compacted by Vibromax 1105 single drum vibrating roller.

Material variability on site has produced an approximate 10 pcf difference in areas tested.

Compaction was attained for all locations tested. Contractor will receive notification with this report.

Elevations are based on feet above sea level.

Images:

UPLOADED: 06/07/2016 07:20:00

North pad
Looking north from south boundary

REPORTED BY: Cass Dimitroff REVIEWED BY: Curtis Shear, Project Manager

Materials Testing & Consulting, Inc.

Geotechnical Engineering & Consulting ▪ Special Inspection ▪ Materials Testing ▪ Environmental Consulting

Engineered Assurance Since 1981

All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37343

CLIENT Ram Construction

DATE 06/07/2016

PROJECT LOCATION Dead end of Cornwall / near beach access
Bellingham WA

PERMIT #

Inspection Information:

Inspection Date: 06/07/2016 **Time Onsite:** 8:45 am **Weather Conditions:** Sunny 70s

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location: Landfill soil storage

Gauge Standard MS: 9845

Equipment ID & Serial #: CPN MC-1, Ser. #MD20906738

Gauge Standard DS: 32853

Test Samples:

	Sample #:	Description:	Proctor Value(pcf):	Optimum Moisture and Oversize Rock Correction:
1.	B16-0536	gray silty sand w/ gravel	125.5	9.4% Uncorrected
2.	B16-0536	gray silty sand w/ gravel	135.9	6.7% (30% RC)

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	10"	N end, E side, +350	15'	137.6	123.1	11.8	1	98.1	90
2	10"	N end, W side, +350'	15'	134.2	119.2	12.6	1	95	90
3	10"	N end, E side, +210'	17'	138.1	123.2	12.1	1	98.2	90
4	10"	N end, E side +100'	17'	137.9	120	14.9	1	95.6	90
5	10"	N end, central, +280'	16'	138.5	122.9	12.7	1	97.9	90
6	10"	N end, E side, +275'	16'	137.8	121.4	13.5	1	96.7	90
7	10"	N end, central, +340'	16'	134.7	119.3	12.9	1	95.1	90
8	10"	N end, W side, +290	16'	141.9	126.1	12.5	2	92.8	90
9	10"	N end, E side +140'	16'	137.6	121.7	13.1	1	97	90
10	10"	N end, E sidel, + 35'	17'	133.9	122.1	9.7	1	97.3	90
11	10"	N end, central, +175'	15'	135.1	121.3	11.4	1	96.7	90
12	10"	N end, central, +160'	15'	141.8	125.3	13.2	2	92.2	90
13	10"	N end, e side, +85	16'	137.2	122.5	12	1	97.6	90
14	10"	N end, central +110'	15'	134.6	120.3	11.9	1	95.9	90
15	10"	N end, W side, +175'	16'	136.8	119.5	14.5	1	95.2	90
16	10 "	N end, E side, +55'	16'	133.7	120.1	11.3	1	95.7	90
17	10	N end, e side, +310'	16'	143	123.9	15.4	1	98.7	90
18	10"	N end, W side, +315'	16.5'	137.9	121.2	13.8	1	96.6	90
19	10"	N end, E side, +145'	16'	136.6	118.7	15.1	1	94.6	90
20	10"	N end, E side, +190	16'	137.1	123.4	11.1	1	98.3	90

☐ Native Soils

☒ Imported Fills

Soils consistent with Proctor ● Yes ○ No

Soils found to be firm and stable; and to the best of our knowledge, meet compaction ● Yes ○ No

Contractor notified of results ● Yes ○ No

Remarks:

MTC was onsite as requested for compaction testing of imported soils for Cornwall Ave Landfill storage.
Locations for testing are based on the south end of each north and south sections starting at 0+00 and continuing to the north, in the west, central and eastern segments of the north and south fill areas.
Majority of work today was done on north section of project. Material variability was high and moisture was increasing throughout the day due to an increase in clay content.
Imported fills were placed by dump trucks, graded in lifts of 8 inches or less by dozer and compacted by Vibromax 1105 single drum vibrating roller.
Compaction was attained for all locations tested.

Images:

UPLOADED: 06/07/2016 16:05:00

South fill area
Facing south

REPORTED BY: Kurt Parker REVIEWED BY: Curtis Shear, Project Manager

Materials Testing & Consulting, Inc.

Geotechnical Engineering & Consulting ▪ Special Inspection ▪ Materials Testing ▪ Environmental Consulting

Engineered Assurance Since 1981

All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37350

CLIENT Ram Construction

PROJECT LOCATION Dead end of Cornwall / near beach access
Bellingham WA

DATE 06/08/2016

PERMIT #

Inspection Information:

Inspection Date: 06/08/2016 **Time Onsite:** 9:00 am **Weather Conditions:** cloudy, 57 deg

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location: Landfill soil storage (pre-load)

Gauge Standard MS: 9878

Equipment ID & Serial #: CPN MC-1, Ser. #MD20906738

Gauge Standard DS: 32947

Test Samples:

	Sample #:	Description:	Proctor Value(pcf):	Optimum Moisture and Oversize Rock Correction:
1.	B16-0536	Silty sand with gravel	125.5	9.4%, 0% oversize
2.	B16-0536	Silt sand with gravel	128.8	8.5%, 10% oversize

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	8	720 ft from center divider NW side	18	132.3	117.8	12.3	1	93.9	95
2	8	280 ft S of N-boundary center west	20	138.2	118.9	16.3	1	94.7	95
3	8	300 ft S of N-boundary east side	21	133.1	114	16.7	1	90.8	95
4	8	610 ft S of N-boundary east side	22	133.2	115.5	15.4	1	92	95
5	8	705 ft N of center NE side	17	133.2	116.2	14.6	1	92.6	95
6	8	690 ft N of center divide center	17	134.2	117.8	13.9	1	93.9	95
7	8	260 ft S of N-boundary center center (N end)	17	136.8	119.2	14.8	1	95	95
8	8	80 ft N of center divide (E side)	16	133.3	115.4	15.5	1	92	95
9	8	100 ft south of center east side (S end)	20	130.5	116.7	11.8	1	93	95
10	8	40 ft S of center west side	18	136.4	120.2	13.5	1	95.8	95
11	8	50 ft S of center divide east (S end)	18	126.8	119	6.5	1	94.8	95
12	8	50 ft S of center divide west (S end)	17	136.5	118.2	15.5	1	94.2	95
13	8	SW 20 ft N of southernmost portion	15	135	119.1	13.4	1	94.9	95
14	8	100 ft N of southernmost portion center	15	138.8	122.2	13.6	2	94.9	95
15	8	30 ft N of South end center center	15	127.8	115.4	10.8	1	92	95
16	8	30 ft S of center divide center (S end)	15	137.5	123.2	11.6	2	95.7	95
17	8	100 ft N of center divide (W side)	21	133.8	118.7	12.8	2	92.2	95
18	8	80 ft S of N-boundary center	23	136.8	120.8	13.3	2	93.8	95
19	8	80 ft S of N-boundary east side	21	134.9	121.1	11.4	1	96.5	95
20	8	100 ft N of center divide (center N side)	22	136.8	117.2	16.7	1	93.4	95
21	8	150 ft S of N-boundary center	20	140.9	124.3	13.4	2	96.5	95
22	8	80 ft N of center divide (E side)	18	137.4	120	14.5	2	93.2	95
23	8	40 ft S of N-boundary center	18	137.8	120.9	14	2	93.9	95

24	8	40 ft S of N-boundary east	18	137.7	119.1	15.6	1	94.9	95
25	8	40 ft S of N-boundary west	16	137.9	123.5	11.7	2	95.9	95
26	8	110 ft S of N-boundary center	17	140.5	121.5	15.6	2	94.3	95
27	8	110 ft S of N-boundary east	18	140.7	125.3	12.3	2	97.3	95
28	8	110 ft S of M-boundary west	16	137.5	120.7	13.9	2	93.7	95

☐ Native Soils
☒ Imported Fills

Soils consistent with Proctor ● Yes ○ No
Soils found to be firm and stable; and to the best of our knowledge, meet compaction ● Yes ○ No
Contractor notified of results ● Yes ○ No

Remarks:

MTC on-site for compaction testing of imported fill materials at the Cornwall Ave landfill storage area. Test locations based on distances from the ditch line dividing the north and south fill areas.

Images:

UPLOADED: 06/09/2016 05:36:00

Looking north across the north fill area

UPLOADED: 06/09/2016 05:37:00

Looking north from the drainage ditch dividing the fill areas

REPORTED BY: Ross Jorgensen REVIEWED BY: Curtis Shear, Project Manager

Materials Testing & Consulting, Inc.

Geotechnical Engineering & Consulting ▪ Special Inspection ▪ Materials Testing ▪ Environmental Consulting

Engineered Assurance Since 1981

All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37361

CLIENT	Ram Construction	**DATE**	06/09/2016
PROJECT LOCATION	Dead end of Cornwall / near beach access Bellingham WA	**PERMIT #**	

Inspection Information:

Inspection Date: 06/09/2016 **Time Onsite:** 8:45 AM **Weather Conditions:** cloudy, 57 deg

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location:	Landfill soil storage (pre-load)	**Gauge Standard MS:**	9834
Equipment ID & Serial #:	CPN MC-1, Ser. #MD20906738	**Gauge Standard DS:**	32997

Test Samples:

	Sample #:	Description:	Proctor Value(pcf):	Optimum Moisture and Oversize Rock Correction:
1.	B16-0536	Silty sand with gravel	125.5	9.4%, 0% oversize
2.	B16-0536	Silt sand with gravel	128.8	8.5%, 10% oversize

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	10	N end, W side, +150ft	17	140.6	124.4	13	1	99.1	90
2	10	N end, E side, +300 ft	18	126.9	114.7	10.7	1	91.4	90
3	10	N end, E side, +50 ft	18	134.3	120.9	11.1	1	96.3	90
4	10	N end, center, +75 ft	17	139.4	122.8	13.5	1	97.8	90
5	10	N end, W side, +100 ft	17	137.2	121.5	12.9	1	96.8	90
6	10	N end, E side, +150 ft	18	134.6	121.1	11.2	1	96.5	90
7	10	N end, W side, +165 ft	18	136.5	123.9	10.2	1	98.7	90
8	10	N end, center, +140 ft	18	140.4	122.4	14.7	1	97.5	90
9	10	N end, E side, +280 ft	18	139.7	124	12.7	1	98.8	90
10	10	N end, center, +250 ft	17	139.1	127.2	9.3	2	98.8	90
11	10	N end, center, +160 ft	17	139.8	123.4	13.3	1	98.3	90
12	10	N end, W side, +60 fr	16	135.2	120.6	12.1	1	96.1	90
13	10	N end, center, +170 ft	17	132.3	121.1	9.2	1	96.5	90
14	10	N end, W side, +220 ft	17	137.6	124.5	10.5	1	99.2	90
15	10	N end, E side, +290 ft	18	134.2	123	9.1	1	98	90
16	10	N end, E side, +300 ft	19	128.1	119.6	7.1	1	95.3	90
17	10	N end, E side, +150 ft	18	120.9	113.2	6.8	1	90.2	90
18	10	N end, center, +35 ft	16	138	126.9	8.8	2	98.5	90
19	10	N end, W side, +20 ft	16	138.3	127.1	8.8	2	98.7	90
21	10	S end, center, +300 ft	16	140.1	123	13.9	2	95.5	90
22	10	S end, E side, +350 ft	16	140.1	124.3	12.7	2	96.5	90
23	10	N end, E side, +200 ft	17	138.6	121.4	14.2	2	94.3	90
24	10	N end, E side, +265 ft	16	131.6	114.6	14.8	1	91.3	90

25	10	N end, E side, +110 ft	18	139.4	123	13.3	2	95.5	90
26	10	N end, center, +75 ft	17	135.2	118.2	14.4	2	91.8	90
27	10	N end, center, +225 ft	17	140.9	126.8	11.1	2	98.4	90

☐ Native Soils
☒ Imported Fills

Soils consistent with Proctor	● Yes	○ No
Soils found to be firm and stable; and to the best of our knowledge, meet compaction	● Yes	○ No
Contractor notified of results	● Yes	○ No

Remarks:

MTC arrived onsite per client's request to test for compaction of imported fill.

Location references are same as report on 6/7/16. Compaction was obtained for all locations tested. Contractor was notified of results.

Images:

UPLOADED: 06/09/2016 16:32:00

REPORTED BY: Greg Moran REVIEWED BY: Curtis Shear, Project Manager

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All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37367

CLIENT	Ram Construction	**DATE**	06/10/2016
PROJECT LOCATION	Dead end of Cornwall / near beach access Bellingham WA	**PERMIT #**	

Inspection Information:

Inspection Date: 06/10/2016 **Time Onsite:** 9:15 AM **Weather Conditions:** cloudy, 57 deg

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location:	Landfill soil storage (pre-load)	**Gauge Standard MS:**	9766
Equipment ID & Serial #:	CPN MC-1, Ser. #MD20906738	**Gauge Standard DS:**	32714

Test Samples:

	Sample #:	**Description:**	**Proctor Value(pcf):**	**Optimum Moisture and Oversize Rock Correction:**
1.	B16-0536	Silty sand with gravel	125.5	9.4%, 0% oversize
2.	B16-0536	Silty sand with gravel	128.8	8.5%, 10% oversize

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	10	N end, W side, +300 ft	17	138.9	120.7	15.1	1	96.2	90
2	10	N end, E side, +315 ft	17	139	125	11.2	1	99.6	90
3	10	N end, E side, +100 ft	17	137.4	124.8	10.1	1	99.4	90
4	10	N end, center, +20 ft	16	128.4	117.5	9.3	1	93.6	90
5	10	S end, W side, +350 ft	15	137.8	118.5	16.3	1	94.4	90
6	10	S end, W side, +200 ft	15	137.7	119.8	14.9	1	95.5	90
7	10	S end, W side, +20 ft	15	138.8	122.3	13.5	1	97.5	90
8	10	N end, E side, +120 ft	18	138.1	119.5	15.6	1	95.2	90
9	10	N end, W side, +150 ft	18	131.6	115.5	13.9	1	92	90
10	10	N end. E side, +330 ft	18	133.3	115.2	15.7	1	91.8	90
11	10	N end, E side, +300 ft	18	137.8	121.2	13.7	1	96.6	90
12	10	N end, W side, +160 ft	20	137.9	118.1	16.8	1	94.1	90
13	10	N end, central, +175 ft	18	140.1	124.6	12.4	1	99.3	90
14	10	N end, E side, +135 ft	18	134	119.5	12.1	1	95.2	90
15	10	N end, W side, +50 ft	18	133.1	117.5	13.3	1	93.6	90
16	10	S end, W side, +375 ft	16	129.7	114.6	13.2	1	91.3	90
17	10	S end, E side, +300ft	16	134.2	119.1	12.7	1	94.9	90
18	8	Center divide	16	138.9	125.4	10.8	1	99.9	90

☐ Native Soils
☒ Imported Fills

Soils consistent with Proctor	● Yes	○ No
Soils found to be firm and stable; and to the best of our knowledge, meet compaction	● Yes	○ No
Contractor notified of results	● Yes	○ No

Remarks:

MTC arrived onsite per client's request to test for compaction of imported fill.

All areas tested met compaction requirements. Contractor was notified of results.

Location descriptions are same as reported on 6/7/16.

Contractor reported compaction testing no longer needed after today.

Images:

UPLOADED: 06/10/2016 16:10:00

REPORTED BY: Greg Moran REVIEWED BY: Curtis Shear, Project Manager

Materials Testing & Consulting, Inc.

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All American - Cornwall - 16W002-01R - IPD-Soil Compaction: Report #D37514

CLIENT Ram Construction

PROJECT LOCATION Dead end of Cornwall / near beach access
Bellingham WA

DATE 07/08/2016

PERMIT #

Inspection Information:

Inspection Date: 07/08/2016 **Time Onsite:** 1215 **Weather Conditions:** Partly Sunny

Inspection Performed: IPD-Soil Compaction

Field Data:

Work / Location: Hilton Avenue - Building Pad

Gauge Standard MS: 0

Equipment ID & Serial #: Troxler 3430D, Ser. #19286

Gauge Standard DS: 0

Test Samples:

	Sample #:	Description:	Proctor Value(pcf):	Optimum Moisture and Oversize Rock Correction:
1.	B16-0536	Silty sand with gravel	125.5	9.4%, 0% oversize
2.	B16-0536	Silty sand with gravel	128.8	8.5%, 10% oversize
3.	B16-0536	Silty sand with gravel	134.1	7.1%, 25% OS

TEST METHOD ☒ ASTM D-1557 /AASHTO T-180

In Place Density Test Results (ASTM D-6938):

Test #	Mode / Depth	Location of Test	Elev.	Wet Dens.	Dry Dens.	Moist %	Sample #	% Comp.	% Reqd.
1	8"	gL A/10	AFG	139	133	4.5	3	99.2	95
2	8"	gL A/7	AFG	132	127	3.9	2	98.6	95
3	8"	gL A/5	AFG	134.7	129.5	4	3	96.6	95
4	6"	gL A/3	AFG	135.7	130.2	4.2	3	97.1	95

☐ Native Soils
☒ Imported Fills

Soils consistent with Proctor ● Yes ○ No
Soils found to be firm and stable; and to the best of our knowledge, meet compaction ● Yes ○ No
Contractor notified of results ● Yes ○ No

Remarks:

MTC onsite as requested to perform compaction testing of material placed at the proposed building site after installation of stone columns.
MTC observed upon arrival that material had been placed snd compacted prior to arrival
Upon arrival, MTC met with Bob from RAM construction who discussed the placement and location of tests.
MTC performed tests along the A line at gL 10, 7,5,3.
All tests met or exceeded the required 95% compaction. Contractor was notified of results.

Images:

UPLOADED: 07/08/2016 13:00:00

Project site
Photo looking south along A line shows location of compaction tests.

REPORTED BY: Meghan Hallam REVIEWED BY: Curtis Shear, Project Manager

APPENDIX C

Photographic Log

LANDAU ASSOCIATES

Construction Field Report

Project No.: 001037.070

Report No.: 1

Client/Owner: Port of Bellingham

Date: 5/30/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Sunny, 60’s F

Prepared By: Sean Gertz, E.I.T.

Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. No construction activities were observed today; this visit was simply to observe the current conditions on the site.

Observations and Recommendations

Upon arrival at the site, I observed the gates locked and no activity occurring due to the Memorial Day holiday. At the time of my visit, the asphalt had been pulverized in place and the vegetation on site had been mulched and spread around the areas of the proposed soil stockpiles. Ecology blocks had been placed around site features that are to be protected, though it was noted that one settlement monitoring point (SSM-5) had been destroyed beyond repair. A wheel wash was observed to be on site, but not yet operational.

Because the contractor (RAM Construction), had not received the most recent drainage improvements plan (5/25/16 revision), the storm drain at the south end of the site had not been plugged and the culvert along the southwestern edge of the work area had not been installed.

Equipment observed on-site: one (1) Hitachi excavator, one (1) John Deere bulldozer, and one (1) John Deere front-end loader

Visitors: -na-

Attachments: Site Photos 1-4

Distribution:

Signed:

1. Destroyed settlement survey monument SSM-5.

2. Looking north from southeast end of site.

3. Looking north from southwest end of site. Asphalt has been ripped and vegetation has been mulched and left in place.

4. Looking south from southwest end of site. Vegetation has been mulched and left in place.

Selected Site Photographs
May 30, 2016

Figure
C-2

Construction Field Report

Project No.: 001037.070 Report No.: 2

Client/Owner: Port of Bellingham Date: 5/31/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Sunny, 60's F

Prepared By: Sean Gertz, E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. I arrived on site after the conclusion of the 8:30 AM weekly construction meeting at the Port of Bellingham office, around 9:30 AM.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of constructing the wheel wash, near the entrance at the north end of the site. Throughout the day, trucks arrived with gravelly sand material for constructing the ramps leading up to the wheel wash. Construction of the wheel wash was not completed by the end of the day and the contractor expects it to be completed tomorrow, before beginning to import stockpile material from the Hilton Avenue site on Thursday.

While on site, I observed the contractor install a temporary culvert (approximately 50 L.F.) in the drainage ditch that runs between the two proposed stockpiles. The temporary culvert was installed at the approximate location of CP-7 (on page C-2). Based on conversations with the contractor, it is understood that this culvert will be used for the haul route through the site. I also observed the installation of a permanent culvert at the south end of the site. The contractor began installation of the silt fencing around the stockpile areas, and plans to have the silt fence installation completed by the time they begin transferring the stockpile material. The contractor also began consolidating the pulverized asphalt into an area approximately 10 ft smaller than the embankment footprint on all sides.

Because the contractor, had not received the most recent drainage improvements plan (5/25/16 revision), the storm drain at the south end of the site had not been plugged and the culvert along the southwestern edge of the work area had not been installed. Settlement monitoring point, SSM-5 has not been replaced.

Equipment observed on-site: one (1) Hitachi excavator, one (1) John Deere bulldozer, and one (1) John Deere front-end loader, one (1) Vibromax smooth drum roller

Visitors: -na-

Attachments: Attachment 1, Site Photo 5

Distribution:

Signed:

5. Temporary culvert installed between the two stockpiles.

Construction Field Report

Project No.: 001037.070

Report No.: 3

Client/Owner: Port of Bellingham

Date: 6/1/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Cloudy - Rain in Evening, 60’s F

Prepared By: Sean Gertz, E.I.T.

Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. I arrived on site at approximately 7:30 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of constructing the wheel wash, near the entrance at the north end of the site. Throughout the day, trucks arrived with gravelly sand material for constructing the ramps leading up to the wheel wash, which was completed by the end of the day. While on site, I observed the contractor install silt fencing around the southern stockpile and consolidate the pulverized asphalt in preparation of bringing in fill material.

The contractor has received the most recent drainage improvements plan (5/25/16 revision) as of this morning, and by the end of the day, a plug had been installed in the storm drain at the southern end of the site. The culvert added to the drainage plan in the most recent revision has not yet been installed, but the existing berm has been excavated so that groundwater flows freely through the area where the culvert is to be installed.

Throughout the day, the contractor made several requests for changes to the compacted fill plan. It was requested to move the edge of the embankment along the southeast edge of the site to the east approximately 10 ft so that it is not in the middle of the existing drainage ditch. After discussion with Dave Pischer, it was decided that it would be best to leave the edge of the embankment as is shown on the plans. Additionally, the contractor requested to move the edge of the embankment at the southern end of the site approximately 25 ft to the north to avoid filling around two telephone poles. This change was agreed to be reasonable. The contractor also requested to move the area of the proposed ramp that crosses over the culvert for use in the access road north to the area where the contractor actually constructed the culvert. This was also agreed to be a reasonable change. The stormwater outlet detail on page C-5 of the plan set instructed the contractor to place silt fencing around the stormwater outlet. The contractor pointed out that installing the silt fence around the outlet would cause quite a bit of ground disturbance and was not practical. The contractor instead opted to construct a quarry spall dam in the existing drainage ditch, just upstream from the stormwater outlet.

Equipment observed on-site: one (1) Hitachi excavator, one (1) John Deere bulldozer, and one (1) John Deere front-end loader, one (1) Vibromax smooth drum roller

Visitors: -na-

Attachments: Attachment 1, Site Photos 6-10

Distribution:

Signed:

6. Culvert installed at location of approach ramp to stockpile.

7. Ditches have been connected for stormwater flow. A culvert was installed here after this photo was taken.

Selected Site Photographs
June 1, 2016

Figure
C-4

8. Quarry spall check dam installed instead of silt fence.

9. Silt fence installed around perimeter of stockpile areas.

Selected Site Photographs
June 1, 2016

10. Silt fence installed north of planned area to avoid existing structures.

Selected Site Photographs
June 1, 2016

Figure
C-6

LANDAU ASSOCIATES

Construction Field Report

Project No.: 001037.070 Report No.: 4

Client/Owner: Port of Bellingham Date: 6/2/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Scattered showers in the AM, Partly Cloudy PM, 60's F

Prepared By: Sean Gertz, E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. I arrived on site at approximately 8:00 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of completing construction of the silt fence around the southern stockpile and began construction of the silt fence around the northern stockpile. At around 8:30 AM, truck and trailers and side-dump trucks began arriving with the stockpile fill material, which generally appeared to consist of a moist, gray-brown sand with silt and gravel to silty sand with gravel, with some intermittent chunks of clay. The trucks were arriving at approximately 30 trucks per hour. As the trucks dumped material, the contractor used a bulldozer to spread the material around the area of the southern stockpile, and began using a smooth drum vibratory roller to compact the material at around 10 AM.

The contractor's density testing subcontractor (MTC) arrived around noon to begin testing the density of the material for compaction. After conversations with MTC's representative (Victor), I learned that they will not have proctor results for the fill material until Monday. I requested that Victor take frequent density readings at approximately 150 ft spacing.

By the end of the day, the contractor claims to have placed and compacted approximately 5,100 cubic yards of fill material in the southern stockpile. According to Victor, the dry density results ranged from 106 to 121 pcf, with water content ranging from 7% to 12%. The presence of organics, construction debris, and intermittent clay in the fill material is likely causing inconsistent density readings. Throughout the day, I observed the embankment material to perform well under the heavy truck traffic, showing only minimal (1-2 inches) of pumping, and minor rutting. No material was placed in the north stockpile today.

Equipment observed on-site: one (1) Hitachi excavator, one (1) John Deere bulldozer, and one (1) John Deere front-end loader, one (1) Vibromax smooth drum roller

Visitors: -na-

Attachments: Attachment 1, Site Photo 11

Distribution:

Signed:

11. Looking from existing stockpile toward the southern new stockpile.

Early Action Completion Report
Cornwall Avenue Landfill

Selected Site Photographs
June 2, 2016

Figure
C-7

LANDAU ASSOCIATES

Construction Field Report

Project No.: 001037.070 Report No.: 5
Client/Owner: Port of Bellingham Date: 6/6/16
Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer
Location: Cornwall Avenue Landfill, Bellingham, Washington
Weather Conditions: Partly cloudy, 70's F
Prepared By: Sean Gertz, E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. I arrived on site at approximately 11:30 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of hauling, placing, and compacting the fill material in the location of the north stockpile, which generally appeared to consist of a moist, gray-brown sand with silt and gravel to silty sand with gravel, with some intermittent chunks of clay and some organics. As the trucks dumped material, the contractor used a bulldozer to spread the material around and a smooth drum vibratory roller to compact the material in lifts.

The contractor's density testing subcontractor (MTC) was on site when I arrived, and had been testing the density of the material for compaction. Comparing with the proctor results that MTC had received today, the material the contractor has placed so far does not pass 90% compaction using the rock corrected max density value. After conversations with MTC's representative, it was decided that because the material being brought to the site didn't appear to be very gravelly, it would be appropriate to use the original max density value of approximately 125 pcf instead of the rock corrected value of 132 pcf.

By the end of the day, the contractor claims to have placed and compacted a total of approximately 22,000 cubic yards of fill material between the two stockpiles to date. According to MTC, the density tests have all shown the material to be passing 90% compaction, based on the uncorrected max density value. Throughout the day, I observed the embankment material to perform well under the heavy truck traffic, showing only minimal (2 inches) of pumping, and minor rutting. At one point in the afternoon, I observed the contractor placing material in lifts up to 2 ft thick, at which point, I recommended that the contractor make their lifts thinner in order to achieve better compaction. Despite the excessive lift thickness in this area, the material still managed to achieve 90% compaction, and when proof-rolled with a fully loaded dump truck, only minimal deformation was observed. With the exception of a small amount of material placed to improve the haul road, stockpile material was only placed in the north stockpile today.

It was also observed that a truck going around the haul road had cut a corner too sharply and tore through the plastic stockpile cover in the northern corner of the site.

Equipment observed on-site: one (1) Hitachi excavator, one (1) John Deere bulldozer, and one (1) John Deere front-end loader, one (1) Vibromax smooth drum roller

Visitors: -na-
Attachments: Site Photos 12-13
Distribution:

A preliminary copy of the Field Report may be provided solely as evidence that field observation was performed. Observations and/or conclusions and/or recommendations conveyed in the Field Report are subject to review and revision by Landau Associates' project manager or designee. A reviewed Field Report shall take precedence over a preliminary report.

Signed:

12. Area where cap material was damaged by truck traffic.

13. Looking south from top of north existing stockpile.

Selected Site Photographs
June 6, 2016

Figure
C-8

Construction Field Report

Project No.: 001037.070
Report No.: 6
Client/Owner: Port of Bellingham
Date: 6/7/16
Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer
Location: Cornwall Avenue Landfill, Bellingham, Washington
Weather Conditions: Partly Cloudy, 60's F
Prepared By: Sean Gertz, E.I.T.
Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. We arrived on site at approximately 10:00 am, after the conclusion of the 8:30 am weekly construction meeting at the Port of Bellingham office, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of filling with truck and trailers and side-dump trucks on-site with the stockpile fill material from the Hilton Avenue borrow site. The materials consisted of a moist to wet, gray-brown sand with silt and gravel to silty sand with gravel, with some intermittent chunks of clay. By late morning the majority of the import soil consisted of a wet, gray brown, sandy silt/clay with gravel. As the trucks dumped material, the contractor used a bulldozer to spread the material around the area of the northern stockpile, and used a smooth drum vibratory roller to compact the material.

After walking the site and observing that the drainage berm had not been constructed and that installation of the silt fence had not been completed around the northern stockpile, we discussed the issue with the contractor, and he agreed to complete these tasks before the next rain.

The contractor's density testing subcontractor (MTC) was on site when I arrived, and claimed to have been on site since 9:00 am to conduct fill density testing of the material for compaction. According to MTC, the dry density results all exceeded 90% of the max dry density, based on their proctor results. Most of tests were above optimum moisture content. Borrow soil import included the presence of sod and other fine organics along with some wood, and construction debris consisting of plastic pipe, plastic tarps, metal pipes, etc.

We observed the embankment material generally to perform well under the heavy truck traffic, some areas of rutting and subgrade pumping occurred in the upper lifts of the embankment fill where the wet sandy silt/clay soils were placed and compacted. The previously damaged settlement monitoring point, SSM-5 was replaced today by Wilson Engineering.

Equipment observed on-site: one (1) Hitachi excavator (not working), two (2) John Deere bulldozer, and one (1) John Deere front-end loader (not working), one (1) Vibromax smooth drum roller.

Visitors: -na-

Attachments: Site Photo 14

Distribution:

Signed:

14. Destroyed settlement survey monument SSM-5 has been replaced.

Landau Associates

Early Action Completion Report
Cornwall Avenue Landfill

Selected Site Photographs
June 7, 2016

Figure
C-9

Landau Associates

Construction Field Report

Project No.: 001037.070 Report No.: 7

Client/Owner: Port of Bellingham Date: 6/8/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Partly Cloudy, Rain Beginning at 3 PM, 60's F

Prepared By: Sean Gertz, E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. We arrived on site at approximately 8:30 am and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of filling with truck and trailers and side-dump trucks on-site with the stockpile fill material from the Hilton Avenue borrow site. The material placed today consisted of a wet, gray brown, sandy silt/clay with gravel. As the trucks dumped material, the contractor used a bulldozer to spread the material around the area of the northern stockpile, and used a smooth drum vibratory roller to compact the material.

The contractor's density testing subcontractor (MTC) arrived on site around 9:00 am to conduct fill density testing of the material for compaction. According to MTC, the dry density results all exceeded 90% of the max dry density, based on their proctor results today. Most of tests were above optimum moisture content. Borrow soil import included the presence of sod and other fine organics along with some wood, and construction debris consisting of plastic pipe, plastic tarps, metal pipes, etc.

We observed the embankment material generally to perform poorly under the heavy truck traffic, many areas of rutting and subgrade pumping occurred in the embankment fill where the wet sandy silt/clay soils were placed and compacted. During the time between 7 and 9 am, we observed three trucks get stuck and need the help of the bulldozer to get free. After discussing performance of the material with the contractor, they began placing material in the southern stockpile in order to give the northern stockpile time to stabilize. Around noon, the contractor switched back to placing material on the northern stockpile because the surface of the southern stockpile was also not performing well under the heavy truck traffic.

The drainage berm and silt fencing around the northern stockpile was still not completed by the end of the day.

Equipment observed on-site: one (1) Hitachi excavator (not working), two (2) John Deere bulldozer, and one (1) John Deere front-end loader (not working), one (1) Vibromax smooth drum roller.

Visitors: -na-

Attachments: Site Photos 15-18

Distribution:

Signed:

15. A stuck truck being pulled out by bulldozer.

16. Construction of southern stockpile. Note oversized piece in foreground.

17. Silt fence has fallen down. MTC technician in background.

18. Trucks getting stuck in compacted fill material.

LANDAU ASSOCIATES

Construction Field Report

Project No.: 001037.070 Report No.: 8

Client/Owner: Port of Bellingham Date: 6/9/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Partly Cloudy, Rain Beginning at 3 PM, 60's F

Prepared By: Sean Gertz, E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. We arrived on site at approximately 8:15 am and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of filling with truck and trailers and side-dump trucks on-site with the stockpile fill material from the Hilton Avenue borrow site. The materials consisted of a wet, gray brown, sandy silt/clay with gravel. By late morning the majority of the import soil consisted of a moist to wet, gray-brown sand with silt and gravel to silty sand with gravel, with some intermittent chunks of clay. As the trucks dumped material, the contractor used a bulldozer to spread the material around the area of the southern stockpile, and began using a smooth drum vibratory roller to compact the material.

The contractor's density testing subcontractor (MTC) arrived on site around 9:00 am to conduct fill density testing of the material for compaction. According to MTC, the dry density results all exceeded 90% of the max dry density, based on their proctor results. Most of tests were above optimum moisture content. Borrow soil import included the presence of sod and other fine organics along with some wood, and construction debris consisting of plastic pipe, plastic tarps, metal pipes, etc. MTC collected a sample of the sandy silt/clay material in order to run a new proctor test since the material is clearly different than the sand with silt to silty sand material.

We observed the embankment material generally to perform better than the previous day under the heavy truck traffic, some areas of rutting and subgrade pumping occurred in the embankment fill where the wet sandy silt/clay soils were placed and compacted. Ram requested a meeting with Port of Bellingham representatives to discuss the difficulties of working with the sandy silt/clay material and the Port agreed to support the contractor if a change of tactics is needed to continue working with the material due to poor weather. During this meeting, the contractor also said they would remove a piece of existing stem wall that crosses one of the drainage ditches and affects the flow of stormwater.

Equipment observed on-site: one (1) Hitachi excavator (not working), two (2) John Deere bulldozer, and one (1) John Deere front-end loader (not working), one (1) Vibromax smooth drum roller.

Visitors: -na-

Attachments: None

Distribution:

Signed:

Construction Field Report

Project No.: 001037.070 Report No.: 9

Client/Owner: Port of Bellingham Date: 6/10/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Scattered showers in the AM, Partly Cloudy PM, 60's F

Prepared By: Brian Christianson Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. We arrived on site at approximately 8:00 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of filling with truck and trailers and side-dump trucks on-site with the stockpile fill material from the Hilton Avenue borrow site. The materials consisted of a moist to wet, gray-brown sand with silt and gravel to silty sand with gravel, with some intermittent chunks of clay. By late morning the majority of the import soil consisted of a wet, gray brown, sandy silt/clay with gravel. As the trucks dumped material, the contractor used a bulldozer to spread the material around the area of the southern stockpile, and began using a smooth drum vibratory roller to compact the material.

Two visits were made to the borrow site at Hilton Avenue. It was estimated that the majority of the remaining borrow material will mostly be the wet, gray brown, sandy silt/clay soils. The majority of the site subgrade following the removal of the off haul is noted to be a gravelly sand to a sandy gravel with silt.

By late morning the south and north embankment(s) fill had been completed to approximately the designed compaction height. The exception is the north end of the south embankment and the south end of the north embankment where the haul road crosses over the temporary culvert along the central drainage ditch. These areas are within about 2 feet of final grade. The remainder of the day the mostly gray, wet, sandy clay soils was stockpiled on the east (side dumps) and west (truck and trailers) sides of the embankments to allow through haul down the center of the embankments of the haul trucks on the compacted stable soils. The contractor noted these soil will be grade into the design slopes following soil import.

The contractor will likely be close to finishing the soil hauling from Hilton Avenue from by the end of the day Saturday or next Monday. Final embankment grading will be done next week to shape the final fill slopes. Additionally, silt fencing, soil berms, and other storm water control structures will be completed.

The contractor's density testing subcontractor (MTC) arrived around 10:00 am to begin testing the fill density of the material for compaction. They left the site about mid-day for about two hours to cover another project. According to Victor, the dry density results were above 92% today. Most of tests were above optimum moisture content. Samples collected last week for proctor tests were delayed being run by the contractor according to MTC Victor. Borrow soil import included the presence of sod and other fine organics along with some wood, and construction debris consisting of plastic pipe, plastic tarps, metal pipes, etc.

We observed the embankment material generally to perform well under the heavy truck traffic, some areas of rutting and subgrade pumping occurred in the upper lifts of the embankment fill where the wet sandy silt/clay soils were placed and compacted.

See site photographs taken today at both Cornwall site and the Hilton Avenue borrow area for construction details.

Equipment observed on-site: one (1) Hitachi excavator (not working), two (2) John Deere bulldozer, and one (1) John Deere front-end loader (not working), one (1) Vibromax smooth drum roller.

LANDAU ASSOCIATES

DRAFT Construction Field Report

Project No.: 001037.070

Report No.: 9

Client/Owner: Port of Bellingham

Date: 6/10/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Visitors: -na-

Attachments: Site Photos 19-22

Distribution:

Landau Associates' representatives are onsite solely to observe operations of the contractor identified, to form opinions about the adequacy of those operations, and report those opinions to our client. The presence and activities of our field representative do not relieve the contractor from its obligation to meet contractual requirements. The contractor retains sole responsibility for site safety and the methods, operations, and sequences of construction.

A preliminary copy of the Field Report may be provided solely as evidence that field observation was performed. Observations and/or conclusions and/or recommendations conveyed in the Field Report are subject to review and revision by Landau Associates' project manager or designee. A reviewed Field Report shall take precedence over a preliminary report.

Signed:

19. Both stockpiles viewed from top of north existing stockpile.

20. Construction of southern stockpile.

LANDAU ASSOCIATES

Early Action Completion Report
Cornwall Avenue Landfill

Selected Site Photographs
June 10, 2016

Figure
C-12

21. Looking south from top of north stockpile.

22. Looking west between the two stockpiles. Note silt fence has been repaired.

LANDAU ASSOCIATES

Construction Field Report

Project No.: 001037.070 Report No.: 10

Client/Owner: Port of Bellingham Date: 6/21/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Partly Cloudy, 60's F

Prepared By: Sean Gertz E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe placement of fill material to be imported from the All American Marine - Hilton Avenue site. We arrived on site at approximately 11:00 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) had finished shaping the stockpiles and was in the process of installing erosion control blanket on the southern stockpile. At the time of my arrival, approximately a quarter of the southern stockpile had been covered, and no erosion control had been installed on the northern stockpile or the drainage berm. The erosion control blankets came in rolls and the contractor installed them so that there was a 3 to 4 inch overlap between each blanket, with staples approximately every 6 ft along the overlapping areas.

Since the last visit, the contractor had installed the drainage berm along the eastern edge of the project site and had stockpiled material to be used in filling in the low areas at the north end of the site to promote drainage to the stormwater pond on the eastern side of the site. The culvert that had been left incomplete was still incomplete, though the contractor informed me that it would be completed by the end of the day. I also noted the silt fence was falling down/missing in several areas around the site, and the contractor told me he would address this as well.

See site photographs taken today at the Cornwall site for construction details.

Equipment observed on-site: two (2) Hitachi excavators (not working), one (1) John Deere bulldozer (not working), one (1) John Deere front-end loader (not working), and one (1) Vibromax smooth drum roller (not working).

Visitors: -na-

Attachments: Site Photos 23-26

Distribution:

Signed:

23. Erosion control matting being installed on southern stockpile.

24. Incomplete culvert. Looking to the south.

25. Looking north toward northern stockpile from middle of south stockpile. Erosion control matting being placed.

26. Repairs made to damaged stockpile cover.

LANDAU ASSOCIATES

Construction Field Report

Project No.: 001037.070 Report No.: 11

Client/Owner: Port of Bellingham Date: 6/28/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Partly Cloudy, 60's F

Prepared By: Sean Gertz E.I.T. Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe installation of drainage and erosion control features at the Cornwall Avenue site. We arrived on site at approximately 10:30 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, the contractor (RAM Construction) was in the process of installing erosion control blanket on the northern stockpile. At the time of my arrival, all but approximately a quarter of the northern stockpile had been covered, and the drainage berm had been nearly completely covered with erosion control as well. The erosion control blankets came in rolls and the contractor installed them so that there was a 3 to 4 inch overlap between each blanket, with staples approximately every 6 ft along the overlapping areas.

Since the last visit, the contractor had filled in the low areas at the north end of the site to promote drainage to the stormwater pond on the eastern side of the site. The contractor brought attention to the fact that there would still be a low area that would cause ponding at the north end of the site unless some of the existing asphalt was removed. The contractor said they would take this up with the Port. The culvert that had previously been left incomplete was now completed and covered with erosion control blanket. I noted that silt fence was still missing along the east and north edges of the northern stockpile. I discussed this with the contractor and told him that all areas of silt fencing need to be constructed per the approved plans.

While on-site, I observed Wilson Engineering install six settlement monuments on the top of the stockpiles, approximately in the planned locations.

See site photographs taken today at the Cornwall site for construction details.

Equipment observed on-site: two (2) Hitachi excavators (not working), one (1) John Deere bulldozer (not working), one (1) John Deere front-end loader (not working), and one (1) Vibromax smooth drum roller (not working).

Visitors: -na-

Attachments: Site Photos 27-31

Distribution:

Signed:

27. Drainage berm has been constructed and covered with erosion control matting.

28. Looking north from top of northern stockpile. Low area is barely visible left of pavement.

Selected Site Photographs
June 28, 2016

29. Previously incomplete culvert has been completed.

30. Settlement survey monument installed on top of stockpile.

31. Temporary culvert has been removed and area has been covered with erosion control.

Selected Site Photographs
June 28, 2016

Construction Field Report

Project No.: 001037.070 Report No.: 12

Client/Owner: Port of Bellingham Date: 8/22/16

Project Name: Cornwall Avenue Landfill , Hilton Avenue Soil Stockpile Transfer

Location: Cornwall Avenue Landfill, Bellingham, Washington

Weather Conditions: Partly Cloudy, 60's F

Prepared By: Jeremy Davis, PE Reviewed By:

General

Landau Associates was on-site today at the request of the Port of Bellingham, to observe conditions of drainage and erosion control features at the Cornwall Avenue site. Landau Associates visited the site with Ben Howard (Port of Bellingham) and Bob Carbee (Ram Construction) after reviewing a brief punch list of tasks and items documenting completion of the stockpile transfer project. We arrived at the Cornwall Site together at approximately 10:30 AM, and made the following observations.

Observations and Recommendations

Upon arrival at the site, we walked together to visually observe the following:

- Jute matting covering the soil stockpiles to provide erosion control
    - Appeared to be in-place and secure over all areas of the soil stockpile
- Grass growth on the stockpiles to provide erosion control
    - Grass growth was insufficient.
    - Established growth estimated at approximately 10% of the stockpile area
    - Significant growth noted only along the western portions of the stockpile area
- Silt fence at the bottom of the stockpiles to protect the stormwater control conveyance ditches from fine particulates
    - Silt fence was present and appeared to be functioning well along the toe of the stockpile
- Construction access road
    - The road appeared clean; free of soil or debris

No work was occurring onsite during the visit. No equipment was observed onsite during the visit.

See attached photographs documenting vegetation conditions.

Visitors: Ben Howard (Port of Bellingham); Bob Carbee (Ram Construction)

Attachments: Site Photos 32-37

Distribution:

Signed:

32. Looking down the west side of the northern stockpile

33. Looking north from top of northern stockpile.

34. Looking northwest from top of northern stockpile.

35. Looking south along the west edge of the northern stockpile.

LANDAU ASSOCIATES

Early Action Completion Report
Cornwall Avenue Landfill

Selected Site Photographs
August 22, 2016

Figure
C-20

36. Looking south from top of northern stockpile. Grass seed has not been successful.

37. Looking west from top of northern stockpile.

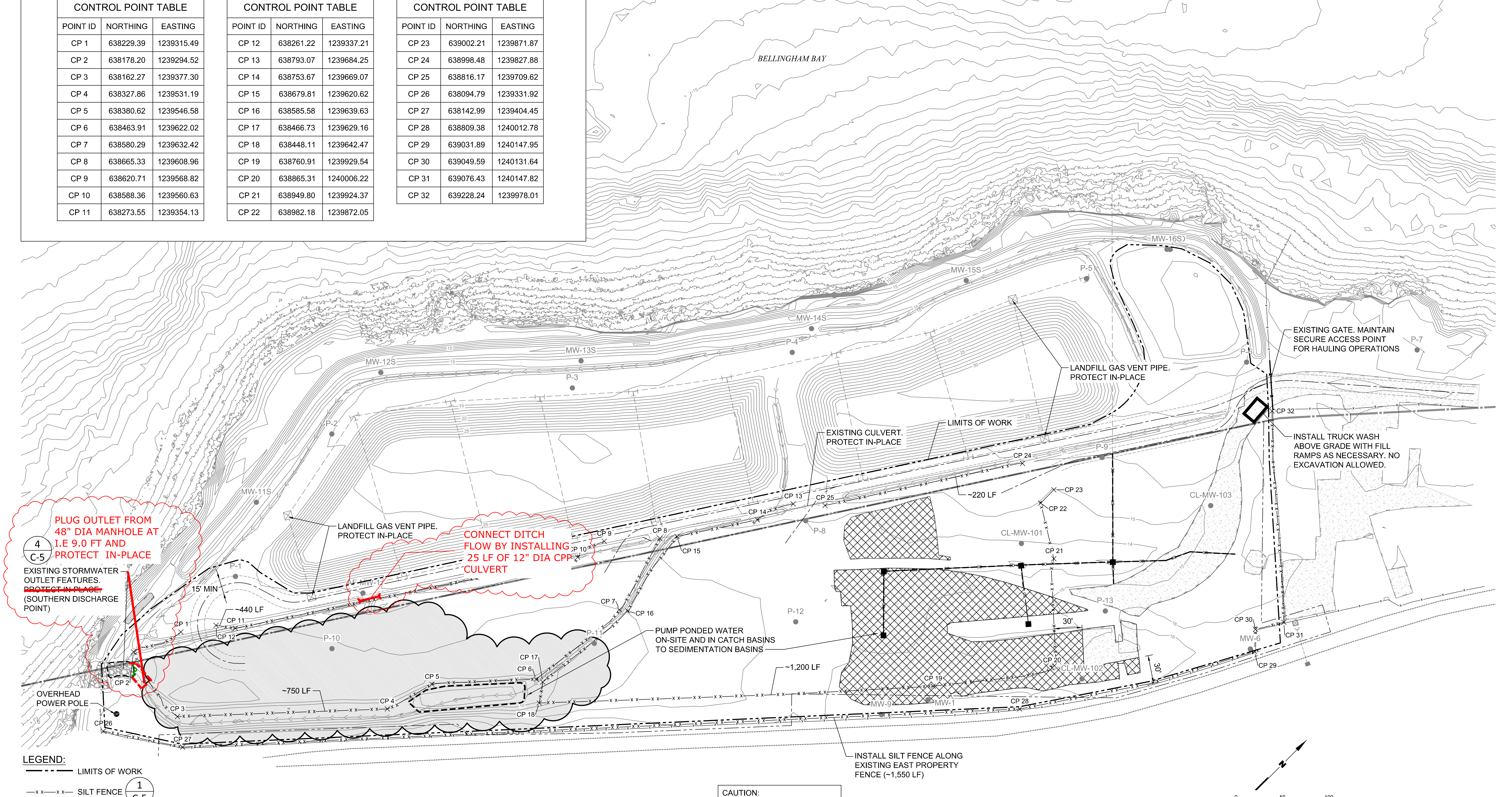
APPENDIX D

Revised Plans and Specifications

CONTROL POINT TABLE		
POINT ID	NORTHING	EASTING
CP 1	638229.39	1239315.49
CP 2	638178.20	1239294.52
CP 3	638162.27	1239377.30
CP 4	638327.86	1239531.19
CP 5	638380.62	1239546.58
CP 6	638463.91	1239622.02
CP 7	638580.29	1239632.42
CP 8	638665.33	1239608.96
CP 9	638620.71	1239568.82
CP 10	638588.36	1239560.63
CP 11	638273.55	1239354.13

CONTROL POINT TABLE		
POINT ID	NORTHING	EASTING
CP 12	638261.22	1239337.21
CP 13	638793.07	1239684.25
CP 14	638753.67	1239669.07
CP 15	638679.81	1239620.62
CP 16	638585.58	1239639.63
CP 17	638466.73	1239629.16
CP 18	638448.11	1239642.47
CP 19	638760.91	1239929.54
CP 20	638865.31	1240006.22
CP 21	638949.80	1239924.37
CP 22	638982.18	1239872.05

CONTROL POINT TABLE		
POINT ID	NORTHING	EASTING
CP 23	639002.21	1239871.87
CP 24	638998.48	1239827.88
CP 25	638816.17	1239709.62
CP 26	638094.79	1239331.92
CP 27	638142.99	1239404.45
CP 28	638809.38	1240012.78
CP 29	639031.89	1240147.95
CP 30	639049.59	1240131.64
CP 31	639076.43	1240147.82
CP 32	639228.24	1239978.01



LEGEND:

- LIMITS OF WORK
- —x—x— SILT FENCE (1/C-5)
- EXISTING STORMWATER CONVEYANCE
- APPROXIMATE CENTERLINE OF HAUL ROAD
- —SD— EXISTING STORM DRAIN LINES (8" DIA PVC, TYP)
- ■ EXISTING CATCH BASIN. CLEAN AND BACKFILL WITH CONTROLLED DENSITY FILL
- P-10 ● EXISTING WELL LOCATIONS ABANDONED IN PLACE (NIC)
- APPROXIMATE LIMITS OF EXISTING VEGETATION TO BE CLEARED, CHIPPED & EVENLY REDISTRIBUTED IN FUTURE PILE LOCATIONS
- ▨ EXISTING PAVEMENT TO BE RUBBLIZED & LEFT IN-PLACE OR MOVED TO INSIDE OF FILL FOOTPRINT 10' MIN.
- APPROXIMATE LIMITS OF EXISTING SEDIMENTATION PONDS

NOTE

ALL DEBRIS ASSOCIATED WITH DEMOLITION AND CLEARING VEGETATION TO BE PLACED IN FOOTPRINT OF NEW STOCKPILES (SEE DWG NO. C-3).

CAUTION:
OVERHEAD POWER EXISTS ON-SITE IN PROPOSED WORK AREAS. CONTRACTOR TO VERIFY EXACT LOCATIONS

Know what's **below.**
Call before you dig.

KENT W. WIKEN
34524
5/25/16

NO.	DATE	REVISIONS	DESIGNED	REVIEWED	APPROVED
0.	2/1/2016	ISSUED FOR CITY & PORT REVIEW			
1.	2/11/2016	ISSUED FOR ECOLOGY REVIEW			
2.	3/4/2016	POB REVIEW SET			
3.	5/25/16	DRAINAGE IMPROVEMENTS			

		INITIAL	DATE
DRAFTED BY:	E.ZICK	ESZ	2/1/2016
DESIGNED BY:	A.BERGSENG	ALB	2/1/2016
REVIEWED BY:	D.PISCHER	DAP	2/1/2016
APPROVED BY:	K.WIKEN	KWW	2/1/2016
STATUS:	POB REVIEW SET		

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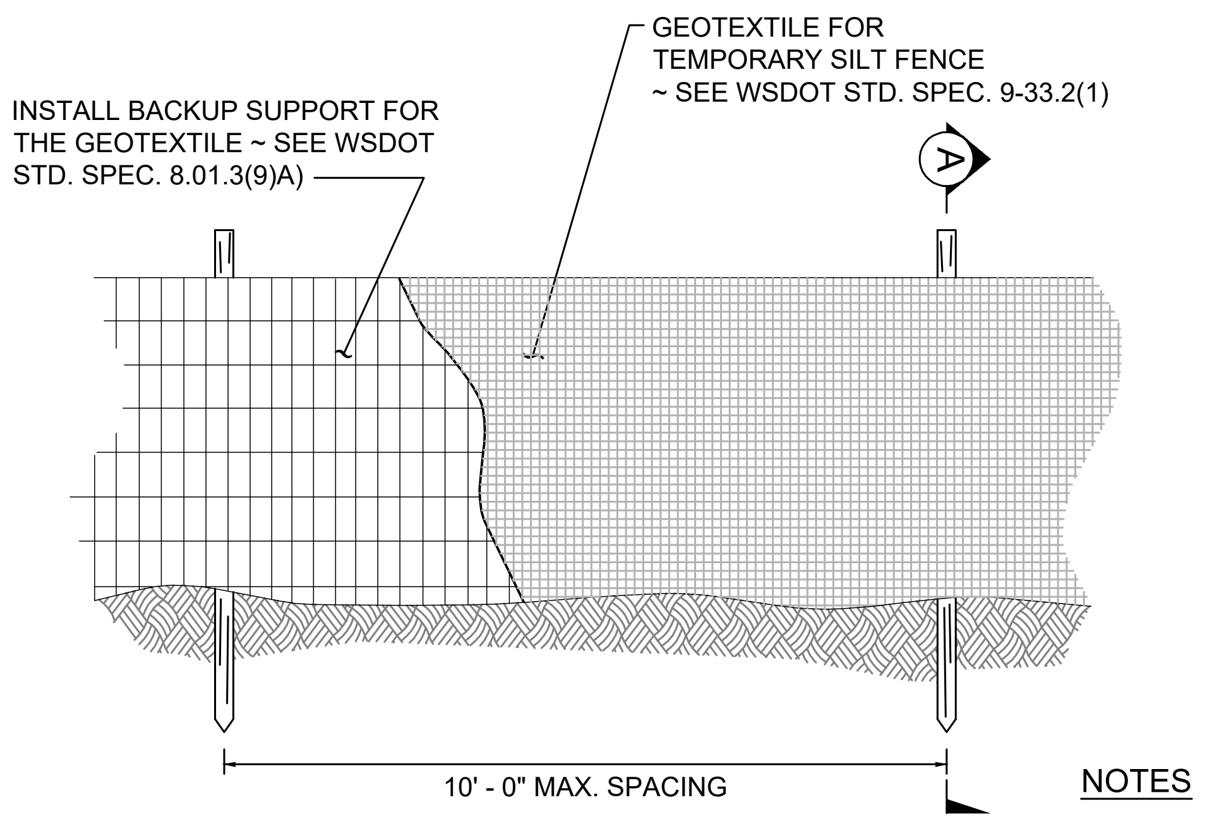
130 2ND AVENUE S.
EDMONDS, WASHINGTON 98020
(425) 778-0907, FAX (425) 778-6409

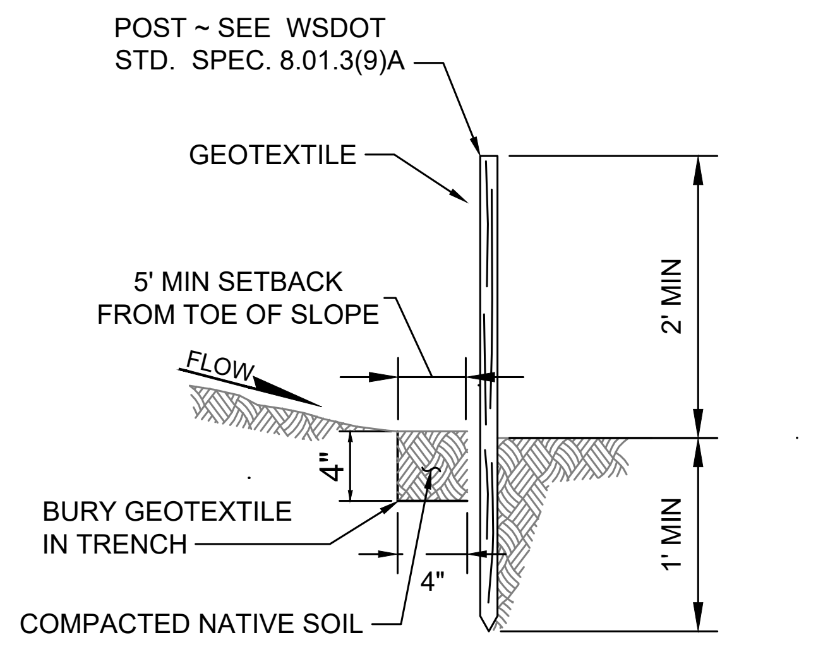
CORNWALL AVENUE LANDFILL
BELLINGHAM, WASHINGTON

SITE CLEARING & SELECTIVE DEMOLITION PLAN

PROJECT NO. 001037.060
DATE 3/4/2016
SHEET 2 OF 5
DRAWING NO. C-2

LANDAU ASSOCIATES INC. | G:\PROJECTS\001\037\060\PLANSET_HILTONTRANSFER\P SITECLEARING-PREP.DWG | 3/3/2016





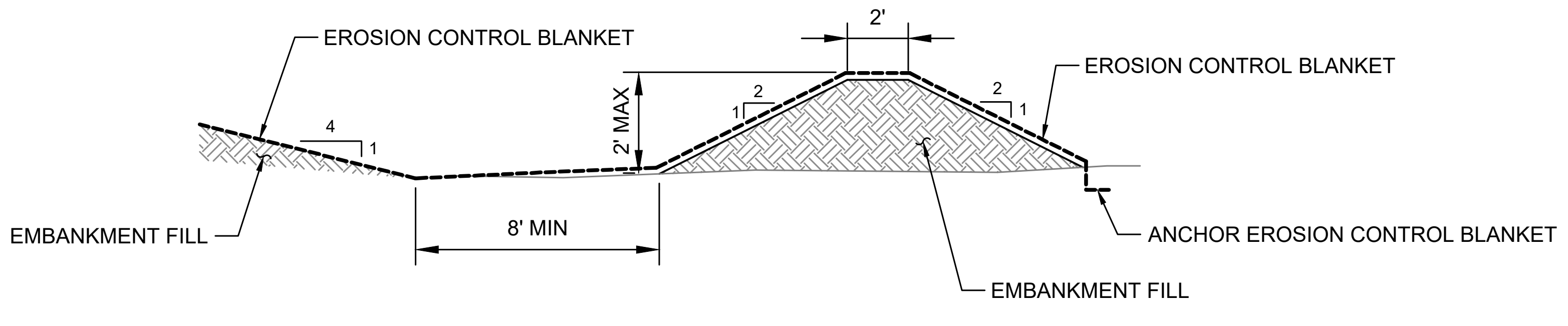
Ⓐ SECTION OF SILT FENCE
N.T.S.

NOTES

1. INSTALL SILT FENCING ALONG CONTOURS WHENEVER POSSIBLE.
2. INSTALL THE ENDS OF THE SILT FENCE TO POINT SLIGHTLY UP-SLOPE TO PREVENT SEDIMENT FROM FLOWING AROUND THE ENDS OF THE FENCE.
3. PERFORM MAINTENANCE IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATIONS 8.01.3(9)A AND 8.01.3(15).

1 / C-2 SILT FENCE DETAIL

SOURCE: WSDOT STANDARDS PLAN SILT FENCE DETAIL I-30.10-00
N.T.S.

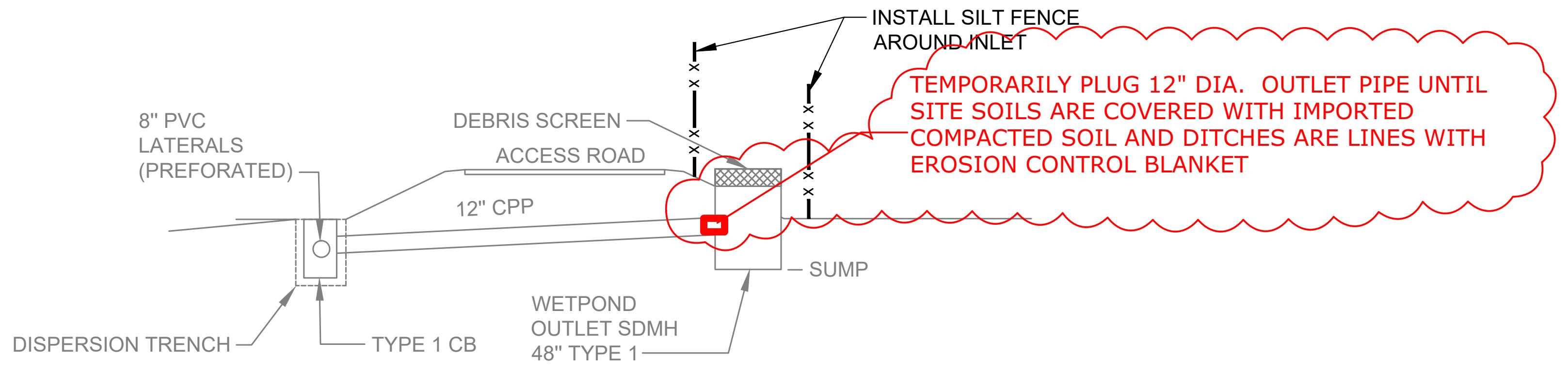


NOTES

1. EROSION CONTROL BLANKET SHALL BE U.S. EROSION CONTROL PRODUCTS, INC. 2S-NN8/2S-NN16 OR ENGINEER APPROVED EQUIVALENT.
2. STAKES SHALL BE SPACED ON 3' X 3' GRID PATTERN.

0 5 10
SCALE IN FEET

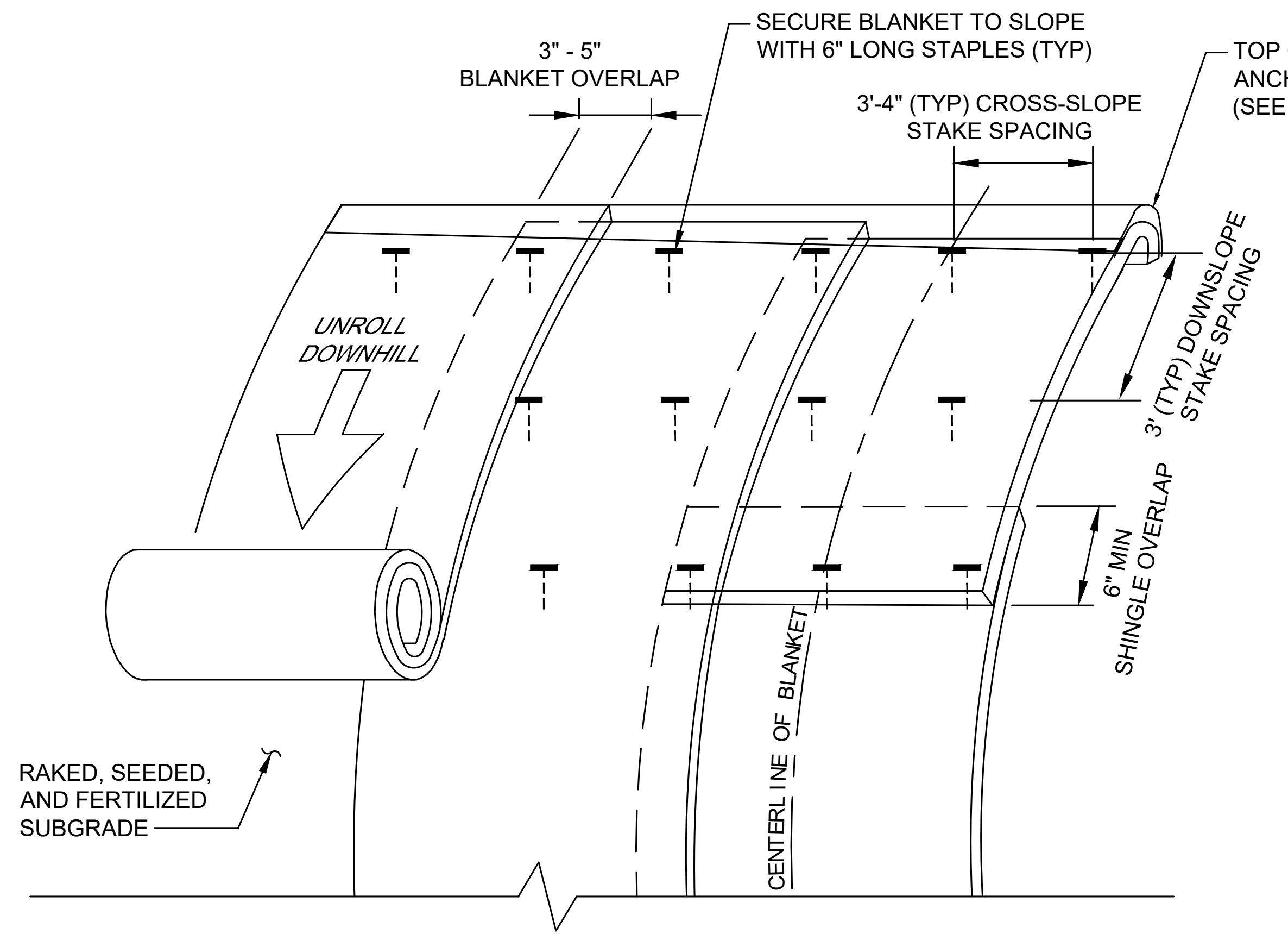
3 / C-3 EAST SIDE BERM (TYP)

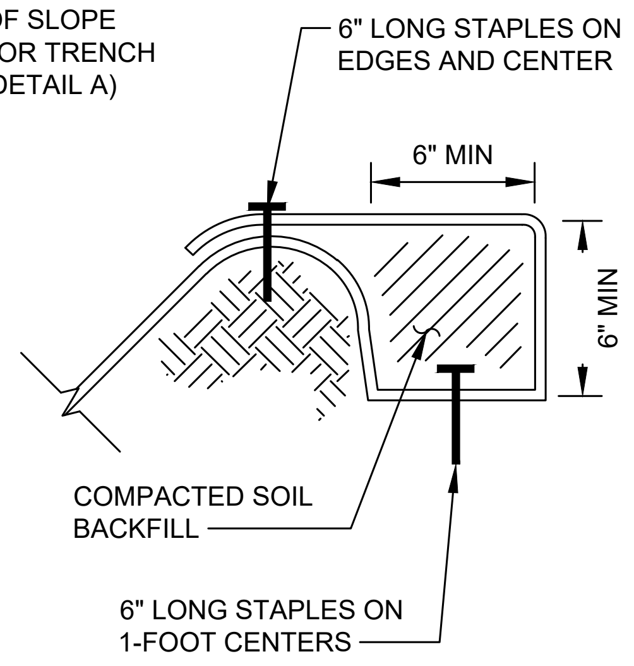


TEMPORARILY PLUG 12" DIA. OUTLET PIPE UNTIL SITE SOILS ARE COVERED WITH IMPORTED COMPACTED SOIL AND DITCHES ARE LINES WITH EROSION CONTROL BLANKET

4 / C-2 EXISTING STORMWATER OUTLET PROTECTION DETAIL

N.T.S.





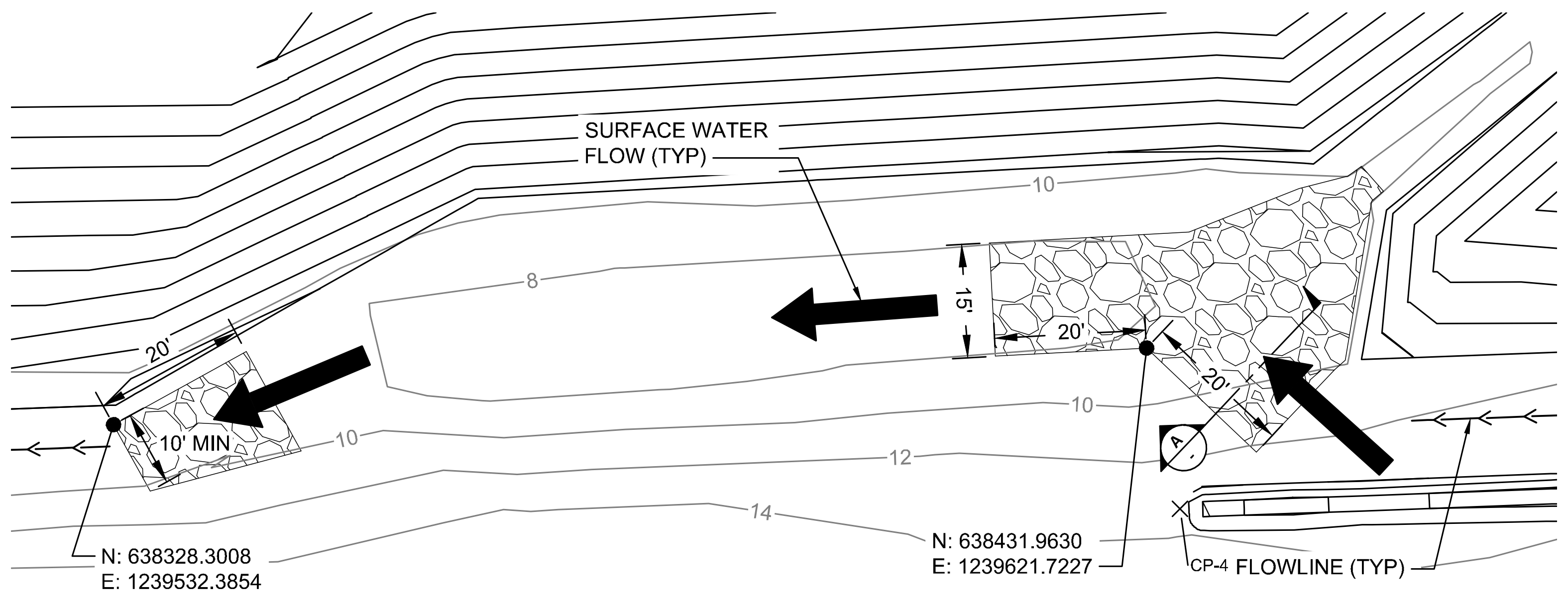
Ⓐ EROSION CONTROL BLANKET ANCHOR TRENCH
N.T.S.

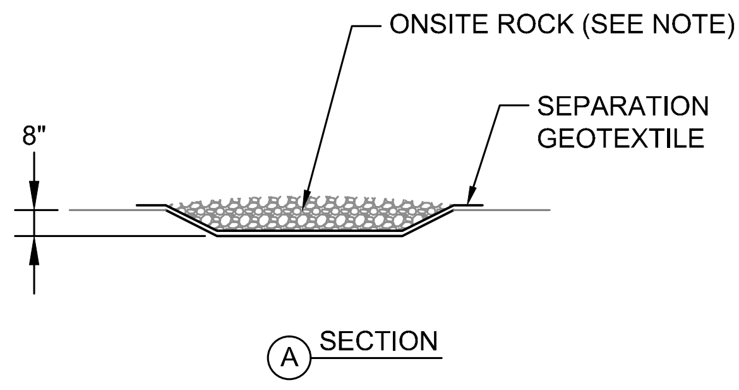
NOTE

1. USE U.S. EROSION CONTROL PRODUCTS, INC. 2S-NN8/2S-NN16 OR ENGINEER APPROVED EQUIVALENT.

2 / C-3 EROSION CONTROL BLANKET - FILL SLOPE PROTECTION

N.T.S.





Ⓐ SECTION

NOTE
PRESERVE AND USE ONSITE ROCK STOCKPILED NEAR EXISTING SEDIMENTATION POND.

5 / C-3 DITCH REINFORCEMENT DETAIL

0 20 40
Scale in Feet

Know what's **below.**
Call before you dig.

KENT W. WIKEN
34524
5/25/16

NO.	DATE	REVISIONS	DESIGNED	REVIEWED	APPROVED
0.	2/1/2016	ISSUED FOR CITY & PORT REVIEW			
1.	2/11/2016	ISSUED FOR ECOLOGY REVIEW			
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3.	5/25/16	DRAINAGE PROTECTION			

		INITIAL	DATE
DRAFTED BY:	E.ZICK	ESZ	2/1/2016
DESIGNED BY:	A.BERGSENG	ALB	2/1/2016
REVIEWED BY:	D.PISCHER	DAP	2/1/2016
APPROVED BY:	K.WIKEN	KWW	2/1/2016
STATUS:	POB REVIEW SET		

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CORNWALL AVENUE LANDFILL
BELLINGHAM, WASHINGTON

DETAILS

PROJECT NO. 001037.060
DATE 3/4/2016
SHEET 5 OF 5
DRAWING NO. C-5

LANDAU ASSOCIATES INC. | G:\PROJECTS\001037\060\PLANSET_HILTONTRANSFERP DETAILS.DWG | 3/4/2016

APPENDIX E

LAI Final Site Punchlist Review

Technical Memorandum

TO: Jon Gibson, EIT
Port of Bellingham

FROM: Kent Wiken, PE

DATE: August 24, 2016

RE: **Punchlist Review of Soil Transfer from Hilton Avenue Site**
Cornwall Avenue Landfill
Bellingham, Washington
Project No. 0001037.070 Task 071

Introduction

Ram Construction (Contractor) began transferring fill from the All American Marine (AAM) construction site on Hilton Avenue to the Cornwall Avenue Landfill (Site) on June 1, 2016 and continued through June 28, 2016. This fill transfer was to be completed in accordance with the plans and specifications prepared by Landau Associates, Inc. (LAI) and was as observed by LAI's field engineers during site preparation and fill placement.

On August 22, 2016, Jeremy Davis from LAI met with the Contractor superintendent, Bob Carbee, and Ben Howard with the Port of Bellingham (Port) to review the punchlist for completion of the transfer of fill from the Hilton Avenue site to the Site. On August 24, 2016, the Port provided the as-built surveys of both the AAM excavation site and the Cornwall Fill Areas. This technical memorandum outlines the observations made during that site visit and lists the outstanding items that remain to be completed.

Punchlist Items

The following punchlist items are provided in order of bid item requirements:

Item No 1. Temporary Facilities and Required Plans – The temporary facilities have been removed.

Item No. 2 Construction Survey – On August 24, 2015 the Port provided LAI the as-built survey information that they received from the Contractor.

Item No. 3 Site Clearing and Demolition – LAI verified that the asphalt pavement had been ripped and left in place and the catch basins had been backfilled with controlled density fill (CDF) as required by the specifications and shown on the drawing.

Item No. 4 Embankment Fill – The Contractor provided the Port with their calculation of the quantity of embankment fill placed. On August 24, 2016, the Port provided LAI this quantity calculation. The Contractor estimated the fill placed on the Site to be 41,355 cubic yards of compacted embankment fill. This quantity will be verified by LAI once we receive the requested CAD file from the Contractor's Surveyor (Pacific Surveying & Engineering, Inc.). It is understood, from discussions with the Port, that the Contractor requested that all the fill brought to the Site be compacted. This was approved by the Port on the condition that since the Contractor did not provide an intermediate survey once the embankment fill reached the design height, the compacted fill above the estimated 32,100 cubic yards for embankment fill would be billed as "Stockpile Fill Soil" (see Item 5).

Item No. 5 Stockpile Fill Soil – As noted in Item 4 above, the quantity of compacted fill over 32,100 cubic yards would be billed as stockpile fill soil. Subtracting 32,100 cubic from 41,355 cubic yards placed (quantity to be verified by LAI) yields 9,255 in-place cubic yards of additional compacted soil.

Item No. 6 Temporary Erosion and Sediment Control (TESC) – See attached photos. In summary:

1. Silt Fence – the silt fence remains on the Site and should remain in place and in good condition until vegetation growth has been established on the piles and ditches.
2. Erosion Control Blankets – has been placed and anchored on the stockpiles and the channel with seeding underneath it. The jute matting is in good condition but vegetation growth is not adequate for Site stabilization.
3. Seeding – LAI estimates that only 10% of the surface area has established vegetation. Vegetation appears limited to the northern and western slopes of the piles.
4. Grading and drainage –
    a. Because of the additional compacted fill (as discussed in Item 4 above), the finished grades are approximately 2 feet higher in elevation on the south pile and 4 feet higher in elevation on the north pile. The crown grades, however, parallel those shown on the plans to provide adequate drainage. The higher elevation piles are therefore acceptable.
    b. According to the as-built survey provided, there is a depression on the north end of the piles. The construction plans require that the area northwest of the northern stockpile be graded in a way to promote overland sheet flow in the area leading to the engineered channel on the eastern boundary. The comparison of the as-built grades to the required plan grades is attached as Figure 1.

Item No. 7 Excavate Borrow Soil, Load and Haul to Cornwall Avenue Landfill Site – the haul route was left in good condition, there are no signs of tracked soil off the property.

Remaining Items to be Completed by Contractor

Based on the Site walkover and review of the as-built plans provided, it is recommended the Contractor:

1. Provide additional non-contaminated compacted fill to the north end of the piles to be consistent with the plans. Transporting additional soil from the AAM site should not be allowed to avoid possible transport of contaminated soil that exists below the AAM site. After review of the AAM excavation as-built drawing, the excavation was close to the target elevations shown on Sheet C5 of the Construction Plans, and therefore any additional soil from the AAM site as a result of building earthwork should not be transported to the Site. Loose soil that has accumulated on the inside of the silt fences may be used as fill, but may

not be enough soil. It is important to eliminate depressions and provide adequate drainage on the north side to the eastern drainage ditch before the fall and winter rains. The Contractor should provide a plan to the Port for this work for approval prior to proceeding.

2. The loose soil accumulated on the upstream side of the silt fences (see photos 4 and 5 attached) must be removed or graded and vegetated before the silt fences can be removed.
3. Field design and implement additional seeding measures. Per Washington State Department of Ecology (Ecology) requirements (as outlined in the Construction Stormwater General permit [CSWGP]) and City of Bellingham requirements, the Site must have 80 percent coverage of established vegetation on the embankment fill and all disturbed ground, and 100 percent coverage of established vegetation in the ditches (areas not covered by rip rap). These requirements were included in the specifications:
    a. The Specifications Section 31 25 00 includes:
        i. Paragraph 1.01.C “Provide and install seeding and fertilizer for all areas disturbed by construction.”
        ii. Paragraph 1.01.E. “If the Owner, Engineer, or any governmental agency determines that Contractor's TESC measures are inadequate to meet the intent of applicable regulatory programs or the Contract Documents with regard to the control of surface water runoff or erosion or the prevention of environmental degradation as a result surface water runoff or erosion, Contractor shall field design and implement additional surface water runoff or erosion control measures that address the deficiencies at no additional cost to the Port.”
        iii. Paragraph 1.03.A requires the Contractor to comply with City of Bellingham Standards (specifically BMC 15.42.060.F.2.iv and v [Element 4 and Element 5] apply here),
        iv. Paragraph 1.03.B requires the Contractor to have a Certified Erosion and Sediment Control Lead (CESCL) who shall oversee all elements of this specification including compliance with the CSWGP.
    b. Section S10.A.1 of the CSWGP requires that the site undergo final stabilization. Final stabilization is defined as establishment of vegetative cover that prevents erosion. Ecology Stormwater Management Manual for Western Washington, Section 4-19, requires reseeding of any seeded areas that fail to establish at least 80 percent cover (100 percent cover for areas that receive sheet or concentrated flows).

    Per the above requirements, the Contractor should provide a plan on how to establish the required grass growth to the Port for approval prior to proceeding. The Contractor also needs to provide documentation on the seed mix and fertilizer used.
4. Once the seeding is established and all other erosion and sediment control elements are complete and satisfactory to the Port, the Contractor should apply for a Notice of Termination (NOT) for their CSWGP. Once the NOT is obtained, the Contractor should remove the silt fence from the Site.

Upon receipt of the construction closeout items listed herein, LAI will prepare a construction report for the project which will include in progress photos, field reports, compaction testing, and documentation of as-built conditions.

This concludes our review of the work completed to date on the Site. Please contact me at (425) 329-0285 or kwiken@landauinc.com if you have any questions or concerns.

LANDAU ASSOCIATES, INC.

Kent Wiken, PE
Senior Associate Engineer

KWW/kes
[P:\001\037\R\MOVE HILTON AVENUE SOIL\CONSTRUCTION COMPLETION\LAI FINAL SITE WALKOVER 082216.DOCX]

Attachments: Figure 1 – TESC Photos (3 pages)
Figure 2 – North Area Grade Comparison

1. Top of pile, looking west toward IPAs. Jute matting and grass coverage is typical of 90% of the pile.

2. Top of pile looking southwest. Southern IPA in background.

3. Top of pile looking north. Rail tracks on right

4. Top of pile showing western slope, silt fence visible, grass visible. Loose soil along upstream side of silt fence needs to be graded out and stabilized with grass or some other means.

LANDAU ASSOCIATES

Cornwall Avenue Landfill
Bellingham, Washington

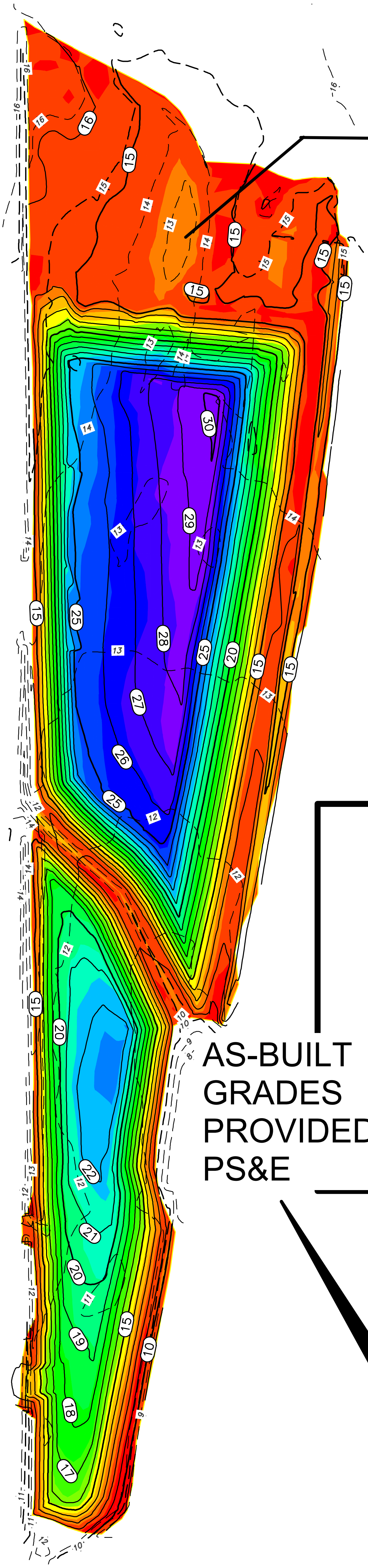
Selected Site Photographs

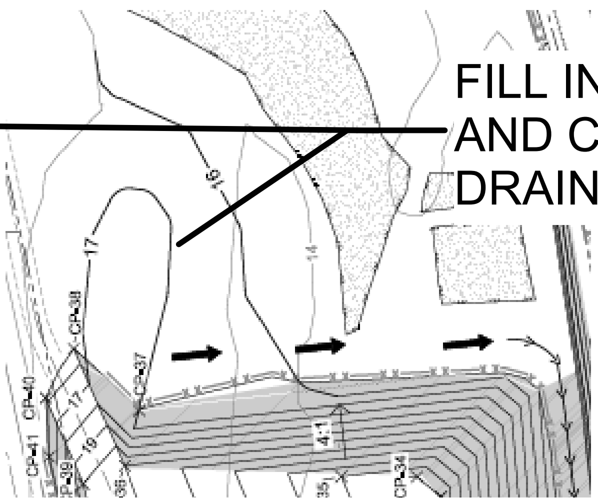
Figure
1-B

5. Top of pile looking west, down the western slope, silt fence visible, grass visible.

6. Top of pile looking northwest, silt fence visible, some grass visible on northern slope. Per survey, fill needs to be added to areas north of pile to facilitate drainage.

Selected Site Photographs





FILL IN DEPRESSION
AND CREATE
DRAINAGE TO EAST

PLAN REQUIRED GRADING
(NORTH END)

AS-BUILT
GRADES
PROVIDED BY
PS&E

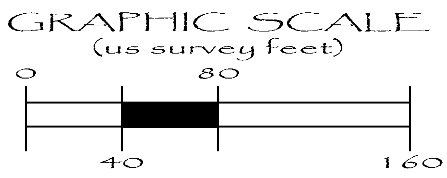


FIGURE 2 - North Area
Grade Comparison

APPENDIX F.3

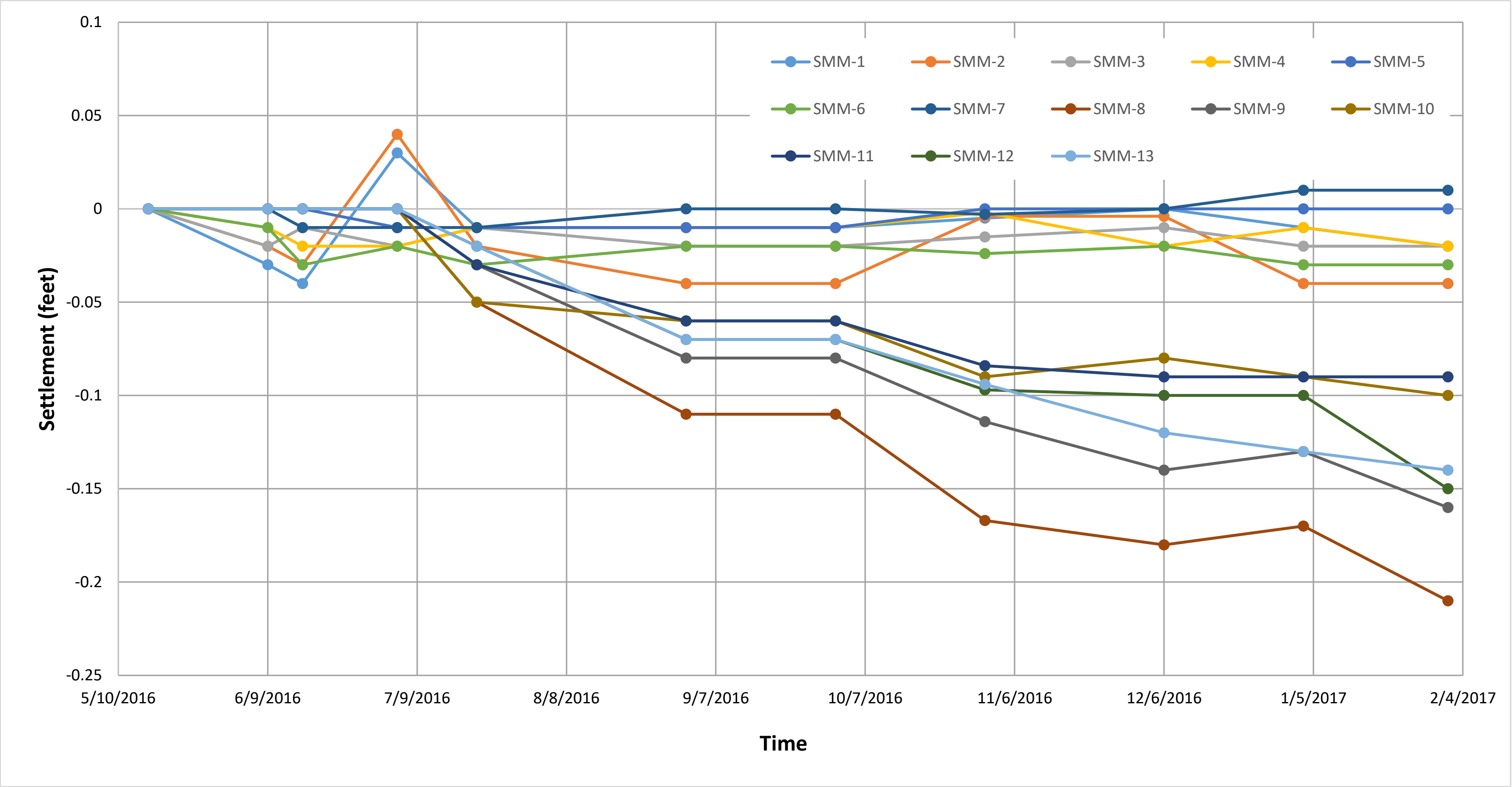
Preload Settlement Monitoring Results

Appendix F.3

Settlement v. Time

Eastside Preloading

Cornwall Avenue Landfill



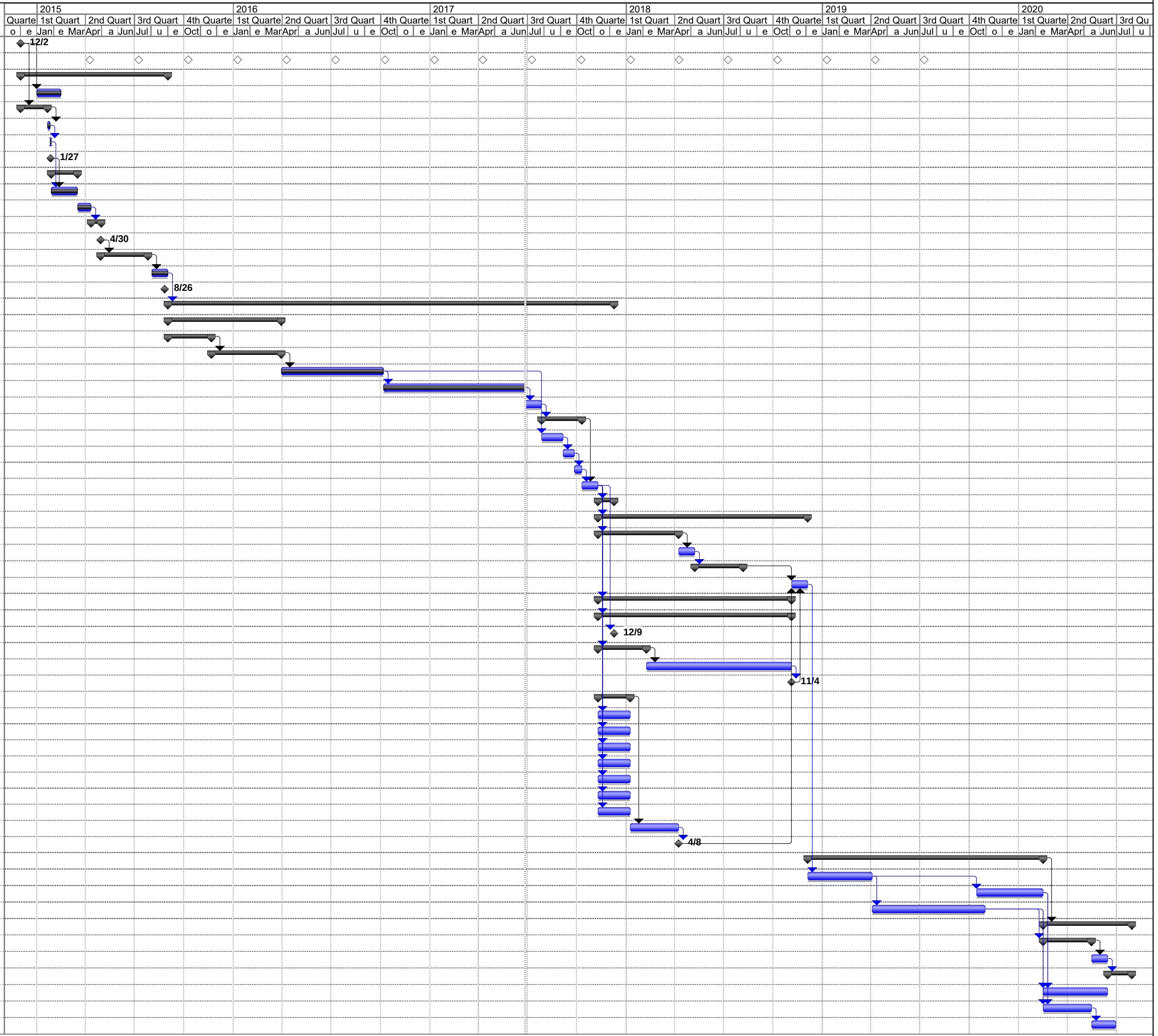
APPENDIX G

Project Schedule

ECOLOGY REVIEW DRAFT

CORNWALL AVENUE LANDFILL FINAL CLEANUP ACTION
DETAILED PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Effective Date of Consent Decree**	0 days	Tue 12/2/14	Tue 12/2/14	
2	**Quarterly Progress Report to Ecology**	**1552 days**	**Fri 4/10/15**	**Wed 7/10/19**	
21	**A. Pre-design Activities**	**274 days**	**Tue 12/2/14**	**Tue 9/1/15**	
22	Marine Survey (Wilson during high tide, calm waters) - Early Action Item	45 days	Thu 1/1/15	Sat 2/14/15	1FS+30 days
23	**A.1 Prepare Detailed Project Schedule (within 90 days of CD)**	**50 days**	**Tue 12/2/14**	**Tue 1/20/15**	**1**
29	**Ecology Review and Comment on Draft Schedule**	**5 days**	**Wed 1/21/15**	**Sun 1/25/15**	28,23
30	**Revise and Finalize Detailed Project Schedule**	**2 days**	**Mon 1/26/15**	**Tue 1/27/15**	29
31	Meet with Ecology to Discuss Scope for EDS Work Plan/SAP	0 days	Tue 1/27/15	Tue 1/27/15	
32	**A.2 Prepare Draft Engineering Design Studies (EDS) Work Plan/SAP (Within 120 days of schedule approval)**	**49 days**	**Tue 1/27/15**	**Tue 3/17/15**	
39	Coordinate Access for Surveying on BNSF Property	49 days	Wed 1/28/15	Tue 3/17/15	30,31
40	**Ecology Review of Draft EDS Work Plan/SAP and Issues Comments**	**25 days**	**Wed 3/18/15**	**Sat 4/11/15**	**38**
41	**A.3 Revise and Submit Final EDS Work Plan/SAP (within 45 days comments on draft Work Plan)**	**19 days**	**Sun 4/12/15**	**Thu 4/30/15**	**40**
44	**Ecology Review of Final Work Plan/SAP and Issues Approval Letter**	**0 days**	**Thu 4/30/15**	**Thu 4/30/15**	
45	**A.4 Complete Pre-design Field Investigation (within 90 days of Final WP)**	**88 days**	**Thu 4/30/15**	**Sun 7/26/15**	**44**
54	30 day extension granted by Ecology for additonal LFG Monitoring	30 days	Mon 8/3/15	Tue 9/1/15	45FS+7 days
55	Ecology and Project Team meeting to Review Results of Pre-design Field Investigation	0 days	Wed 8/26/15	Wed 8/26/15	
56	**B. Engineering Design Report (EDR)**	**830 days**	**Wed 9/2/15**	**Sat 12/9/17**	**54**
57	**B.1 Submit Draft EDR to Ecology for Review (within 180 days of completing field Investigations)**	**211 days**	**Wed 9/2/15**	**Wed 3/30/16**	
58	**Pre-Design Engineering and Analysis**	81 days	Wed 9/2/15	Sat 11/21/15	
61	**Draft EDR Preparation and Submittal**	**130 days**	**Sun 11/22/15**	**Wed 3/30/16**	**58**
67	**Ecology Reviews Draft EDR and Issues Informal Comments**	**190 days**	**Thu 3/31/16**	**Thu 10/6/16**	**66,61**
68	**LAI prepares responses to Ecology informal and City and Stakeholder review**	264 days	Fri 10/7/16	Tue 6/27/17	67
69	**Ecology Reviews Second Draft of EDR and Issues Formal Comments**	30 days	Wed 6/28/17	Thu 7/27/17	68
70	**B.2 Revise and Submit Draft Final EDR to Ecology (within 75 days of Ecology comments on Draft EDR)**	**75 days**	**Fri 7/28/17**	**Tue 10/10/17**	**69**
71	LAI Team Reviews Ecology Comments and Prepares Responses/ EDR Edits	40 days	Fri 7/28/17	Tue 9/5/17	67
72	Port and Stakeholders Concurrent Reviews Responses and Changes to EDR	21 days	Wed 9/6/17	Tue 9/26/17	71
73	LAI Team Addresses Port Comments; Prepares Draft Final EDR; and Submits to Ecology	14 days	Wed 9/27/17	Tue 10/10/17	72
74	**Ecology Review of Draft Final EDR and issues final comments**	**30 days**	**Wed 10/11/17**	**Thu 11/9/17**	**73,70**
75	**B.3 Submit Final EDR to Ecology (within 30 days of Ecology comments on the Draft Final EDR)**	**30 days**	**Fri 11/10/17**	**Sat 12/9/17**	**74**
79	**C. Preparation of Construction Plans/Specifications**	**390 days**	**Fri 11/10/17**	**Tue 12/4/18**	**74**
80	**C.1 Submit 90% Plans and Specifications (within 150 days of Ecology Comments on Draft Final EDR)**	**150 days**	**Fri 11/10/17**	**Sun 4/8/18**	**74**
86	**Ecology Reviews 90% Plans and Specs and Issues Comments**	**30 days**	**Mon 4/9/18**	**Tue 5/8/18**	**85,80**
87	**C.2 Submit 100% Plans and Specifications to Ecology (within 90 days of Ecology comments on 90%)**	**90 days**	**Wed 5/9/18**	**Mon 8/6/18**	**86**
91	LAI Team finalizes 100 % Design for Bidding Following Receipt of all Permits and Approvals	30 days	Mon 11/5/18	Tue 12/4/18	99,109,87
92	**Construction Permitting**	**360 days**	**Fri 11/10/17**	**Sun 11/4/18**	**74**
93	**In-Water Permitting (JARPA)**	**360 days**	**Fri 11/10/17**	**Sun 11/4/18**	**74**
94	Pre-Application Meeting with the US Army Corps of Engineers (USCOE)	0 days	Sat 12/9/17	Sat 12/9/17	74FS+30 days
95	Prepare and Submit Joint Aquatic Resources Protection Application (JARPA) to USACE	90 days	Fri 11/10/17	Wed 2/7/18	**74**
98	Coordination/Consultation with USACE and Services	270 days	Thu 2/8/18	Sun 11/4/18	95,97
99	Obtain Nationwide Permit 38, HPA, DNR Aquatic Land Use Authorization and Related Approvals	0 days	Sun 11/4/18	Sun 11/4/18	98
100	**Upland Permitting and Substantive Requirements**	**60 days**	**Fri 11/10/17**	**Mon 1/8/18**	
101	Comply with Substantive Requirements of City Critical Areas Ordinance	60 days	Fri 11/10/17	Mon 1/8/18	74
102	Comply with Substantive Requirements of City Land Disturbing Activity (i.e. Grading Permit)	60 days	Fri 11/10/17	Mon 1/8/18	74
103	Prepare and Submit NPDES Construction Stormwater General Permit Application	60 days	Fri 11/10/17	Mon 1/8/18	74
104	Comply with Substantive Requirements of City of Bellingham Construction Stormwater Permit	60 days	Fri 11/10/17	Mon 1/8/18	74
105	Comply with Substantive Requirements oft City of Bellingham Substantial Development Permit	60 days	Fri 11/10/17	Mon 1/8/18	74
106	Comply with Substantive Requirements of Northwest Clean Air Agency Operating Permit, if applicable	60 days	Fri 11/10/17	Mon 1/8/18	74
107	Obtain BNSF Approval for Stormwater Improvements on BNSF Property	60 days	Fri 11/10/17	Mon 1/8/18	74
108	Coordination to Obtain Permits/Approvals for Upland Work	90 days	Tue 1/9/18	Sun 4/8/18	100
109	Obtain All Permits/Approvals for Upland Work	0 days	Sun 4/8/18	Sun 4/8/18	108
110	**D. Field Construction**	**438 days**	**Wed 12/5/18**	**Sat 2/15/20**	
111	**D.1 Construction Procurement (within 120 days of 100% Plan and Specs or 90 days of permits)**	120 days	Wed 12/5/18	Wed 4/3/19	91
112	**D.2 Complete Marine Construction (during period authorized by NWP 38 Sept 15 to Feb 15)**	124 days	Tue 10/15/19	Sat 2/15/20	111FS+194 days
113	**D.3 Complete Upland Construction (during one construction season April-October)**	210 days	Thu 4/4/19	Wed 10/30/19	111
114	**E. Post Construction Activities**	**165 days**	**Sun 2/16/20**	**Wed 7/29/20**	**110**
115	**E.1 Submit Draft Institutional Control (IC) Plan (within 90 days of completing upland cleanup)**	**90 days**	**Sun 2/16/20**	**Fri 5/15/20**	**113**
119	**Ecology Review of Draft IC Plan**	**30 days**	**Sat 5/16/20**	**Sun 6/14/20**	**118,115**
120	**E.2 Submit Final IC Plan (within 45 days of Ecology comments on Draft IC plan)**	**45 days**	**Mon 6/15/20**	**Wed 7/29/20**	**119**
124	**E.3 Submit Construction Report to Ecology (within 120 days of construction both areas)**	120 days	Sun 2/16/20	Sun 6/14/20	112,113
125	**E.4 Prepare Draft Long-term Compliance Monitoring Plan to Ecology**	90 days	Sun 2/16/20	Fri 5/15/20	112,113
126	**E.5 Prepare Final Long-term Compliance Monitoring Plan to Ecology**	45 days	Sat 5/16/20	Mon 6/29/20	125



Project: Cornwall Ave LF Engr Service
Date: Mon 6/26/17

Task	▬	Split	┈┈┈
Progress	▬	Milestone	◆
Summary	▬	Project Summary	▬
External Tasks	▬	External Milestone	◆
Deadline	⇩		