Feasibility Study
Olympic View Sanitary Landfill
Port Orchard, WA

Prepared for

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List of Acronyms

ARAR	Applicable or Relevant and Appropriate Requirements
AS	air sparge
BKCHD	Bremerton-Kitsap County Health District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
cm/s	centimeter per second
cu yds	cubic yards
Ecology	Washington Department of Ecology
EMP	Environmental Monitoring Plan
EMSI	Engineering Management Support, Inc.
ERA	Ecological Risk Assessment
FS	Feasibility Study
ft/day	feet per day
ft^3/day	cubic feet per day
GAC	granular activated carbon
GP	gas probe
gph	gallons per hour
gpm	gallons per minute
GRA	General Response Action
HDPE	high density polyethylene
HHRA	Human Health Risk Assessment
HI	hazard index
IHS	indicator hazardous substance
KCHD	Kitsap County Health District
KCSL	Kitsap County Sanitary Landfill
LCS	leachate collection system
LEL	lower explosive limit
LES	leachate evaporator system
LEU	leachate evaporator unit
LR	leachate riser
MCL	maximum contaminant level
MFS	Minimum Functional Standards
mg/L	milligrams per liter
mS/cm	microSeimens per centimeter
MTCA	Model Toxics Control Act
NCP	National Contingency Plan
NMOC	non-methane organic compound
NPDES	National Pollutant Discharge Elimination System
OBWL	Old Barney White Landfill
O&M	operation and maintenance
OM&M	operation, maintenance and monitoring
OVSL	Olympic View Sanitary Landfill
%vol	percent by volume

List of Acronyms (cont.)

POTW	Publicly Owned Treatment Works
PSCAA	Puget Sound Clean Air Agency
RI	Remedial Investigation
ROI	radius of influence
S.U.	standard pH unit
SVE	soil vapor extraction
TBC	"to-be-considered" regulations
TCE	trichloroethene or trichloroethylene
ug/L	microgram per liter
VOC	volatile organic compound
UCL	upper confidence level
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VLDPE	very low density polyethylene
WAC	Washington Administrative Code
WWTF	wastewater treatment facility
ZOI	zone of influence

1 INTRODUCTION

This Feasibility Study (FS) has been prepared by Engineering Management Support, Inc. on behalf of Olympic View Sanitary Landfill, Inc. for the Olympic View Sanitary Landfill (OVSL) located in Port Orchard, Washington. This FS has been prepared to address the requirements of Task 4 of the Agreed Order for the Olympic View Landfill (No. DE 00SWFAPNR-1729) dated January 31, 2001. As required by the Agreed Order, this FS has been prepared in accordance with the requirements for feasibility studies set forth in the Model Toxics Control Act (MTCA) (WAC 173-340-350).

1.1 Purpose and Scope

The purpose of an FS under MTCA is to develop and evaluate cleanup action alternatives to enable a cleanup action to be selected for a site. This report addresses the MTCA requirements for an FS and presents various cleanup action alternatives that are intended to protect human health and the environment and reflect the conditions at the Site.
As discussed in Sections 2 and 3 of this report, the specific focus of this FS is on reducing the levels of groundwater contamination in order to meet the groundwater cleanup levels at the point of compliance.

1.2 Feasibility Study Report Organization

This report is organized as follows:

1 Introduction
2 Site History and Conditions
3 Cleanup Goal, ARARs, Cleanup Standards, and Point of Compliance
4 Identification and Screening of Technologies
5 Development and Description of Alternatives
6 Evaluation of Alternatives
7 Proposed Alternative
8 References

Appendix A includes Estimated Costs for Cleanup Alternatives.

2 SITE HISTORY AND CONDITIONS

This section of the FS presents a summary of the history of operations and regulatory activities at the Site and a brief description of geology, hydrogeology, and nature and extent of contamination at the Site. Summaries of the results of the risk assessments prepared for the Site are also included. Additional information on these topics is presented in the Remedial Investigation (Parametrix, 2007), Human Health Risk Assessment (AMEC GeoMatrix, 2008), and Ecological Risk Assessment (Arcadis BBL, 2007) that were previously prepared for the Site and accepted by the Washington Department of Ecology (Ecology) (2007, and 2009).

2.1 Site Location

OVSL is located at 10015 SW Old Barney White Road, Port Orchard, Washington in the Olympic View Industrial Park Complex. The Site, including the landfill, is located in the northeast quarter of Section 10, Township 23 North, Range 1 West (Figure 2-1). The Site consists of approximately 436 acres of which 65 acres were permitted for and used as a solid waste landfill. The landfill consists of three adjoining areas, the unlined Old Barney White Landfill (OBWL), a lined Phase I area located adjacent to the east side of the OBWL, and a lined Phase II area located adjacent to the north side of the Phase I area (Figure 2-2).

2.2 History of Site Operations

Solid waste disposal at the Landfill began in 1963 as a burning municipal garbage dump known as the Barney White Landfill. The Landfill area at that time was restricted to the southwestern portion of the Property and was unlined with a total area of approximately 25 acres. During the early operations at the Site, the landfill reportedly accepted U.S. Navy, industrial, putrescible, and self-hauled municipal wastes.

Brem Air Disposal, Inc. acquired the Site in 1970 (renaming it Brem Air Northwest Disposal) and expanded the landfilling operations to the northeast. Brem Air stopped burning at the Landfill and in 1975 developed the Landfill to comply with state regulations, the Minimum Functional Standards for Solid Waste Handling, and permit requirements imposed by the Bremerton-Kitsap County Health District (BKCHD). After 1975, the site accepted mixed municipal solid waste, industrial waste, demolition waste, and special waste, which included coal ash, asbestos, septage, and sewage sludge.

The Brem Air Disposal shareholders formed a new corporation in 1975, named the Kitsap County Sanitary Landfill, Inc. (KCSL) to own and operate landfills. Envirofil purchased KCSL and its assets in 1993. KCSL continued to operate the Landfill, although its name was changed in December 1995 to Olympic View Sanitary Landfill, Inc.

In 1985, the Landfill was expanded in accordance with the Development and Closure Plan (Parametrix, 1984). The expansion area included two 20-acre cells, Phases I and II (Figure 2-2). In 1984/1985 the OBWL was closed and covered with 12-inches of low permeability silt covered with 2-feet of native soil and top soil. A Phase III landfill area was designated and permitted in 1987 to receive dredged waste from U.S. Navy construction; however, naval construction waste (associated with the permit) was not disposed in the Landfill and the Phase III landfill was never constructed. In 1991/1992, the OBWL was recapped with a flexible membrane cover, geocomposite drainage layer, soil and hydroseeding that met Washington State Minimum Functional Standards (MFS) for Solid Waste Handling (WAC 173-304).

Pursuant to a Settlement Agreement approved by the Kitsap County Superior Court, the Landfill ceased accepting waste in 2002 and was capped before its permitted capacity was reached. A new waste transfer station was constructed on an area adjacent to the landfill in 2002.

From 1990 until it ceased accepting waste in 2002, the Landfill was the only operating solid waste landfill in Kitsap County, Washington. The permitted design volume is 4.3 million cubic yards (4,036,000 tons) in approximately 65 acres of the 500-acre site; however, the Landfill was closed prior to attaining full design capacity.

The Landfill property is currently owned and operated by Olympic View Sanitary Landfill, Inc. under the permits listed in Section 2.3.

2.3 Regulatory History

Disposal operations at the Landfill were not regulated by permit until 1965 when the BKCHD issued a permit to Bremsea, Inc., the operator of the Site at that time. In 1975 Brem Air Disposal improved the Landfill to comply with State regulations and BKCHD solid waste disposal permit requirements. Solid Waste Handling Permits were issued to the Landfill operators annually by BKCHD starting in 1975. These permits included provisions for monitoring potential impacts of the Landfill on the environment. The first monitoring wells were drilled at the Landfill in 1975, followed by additional wells in 1981, 1983, and 1984.

In 1985 Ecology adopted Minimum Functional Standards for Solid Waste Handling (Chapter 173-304 WAC) to regulate solid waste disposal and recycling. These regulations included provisions for reporting data from environmental monitoring to assess potential impacts of landfills on groundwater and surface water from runoff, leachate, and landfill gas. The monitoring system at the Landfill was enhanced with additional monitoring wells in 1986, 1987, and 1990 to meet these requirements, which were reflected in the annual BKCHD permits.

In response to new federal requirements enacted into law in 1991, mixed municipal solid waste landfill requirements for the State were rewritten under a separate rule as Chapter 173-351 WAC. In addition, the corrective action requirements of the WAC 173-351 regulations included provisions for triggering cleanup actions in the event of a release of contaminants to the environment per the State MTCA regulations (Chapter 173-340 WAC), which were enacted in 1989.

Based on their review of Landfill monitoring data and completion of a site hazard assessment process, Ecology added the Landfill to the Confirmed and Suspected Contaminated Sites list in 1993. Results of detection monitoring initiated under the solid waste regulations indicated a potential release to the environment and triggered the assessment monitoring process at the Landfill in 1994 (Parametrix, 1994). The Landfill was subsequently subject to regulation by both BKCHD and Ecology.

Various phases of investigation were subsequently conducted to evaluate the Landfill, including installation and testing of additional monitoring wells and monitoring of surface water, sediment, leachate, and landfill gas. A “Work Plan for Hydrogeologic Assessment and Evaluation of Extent of Groundwater Impact” and an associated addendum were prepared by Geomatrix (1996a and 1996b) to guide investigations at the Landfill.

In January 2001, the Landfill operator (Olympic View Sanitary Landfill, Inc.) signed an Agreed Order with Ecology. The purpose of the Agreed Order is to continue a phased approach to investigations that had been developed jointly among the Kitsap County Health District (KCHD; formally BKCHD), Ecology, and OVSL, Inc. The Agreed Order states that the Landfill has released products of solid waste decomposition into the environment, as confirmed by a report by Geomatrix (1997a) and quarterly and annual environmental monitoring reports between 1989 and 1998. For the duration of the Agreed Order, the Landfill is subject to dual regulation by Ecology and the KCHD. Ecology is responsible for ensuring compliance with the Agreed Order and enforcing MTCA. KCHD is responsible for permitting the Landfill during the closure and post-closure period.

Completion of a Remedial Investigation/Feasibility Study (RI/FS) of the Site (including the Landfill and adjacent impacted areas) is required by the Agreed Order, while the overall intent of the Agreed Order is to characterize the nature and extent of impacts through the completion of the RI/FS. Monitoring conducted pursuant to the Agreed Order also is required by the Solid Waste Landfill Post Closure Permit (KCHD, 2008) pursuant to the Solid Waste Regulations (WAC 173-351).

The Landfill continued operations as the investigations and studies associated with the Agreed Order proceeded. Pursuant to a Settlement Agreement approved by the Kitsap County Superior Court, the site ceased accepting waste in 2002, before its permitted capacity was reached. Quarterly environmental monitoring continues at the Landfill, in accordance with the Agreed Order and the Solid Waste Regulations.

An important component of the regulatory history of the OVSL is the implementation of cleanup actions associated with Landfill closure, as required by Ecology and KCHD regulations. Cleanup efforts began in the early 1990s and included re-capping the closed older "Barney White" portion of the Landfill with a flexible membrane liner, geocomposite drainage layer soil and hydroseeding in 1991/1992. Enhancements to the environmental protection systems at the Landfill have also been implemented including replacement of the 1991 temporary gas collection system with a permanent gas collection system in 1995, various improvements to the leachate collection system, replacement of two older leachate lagoons with a single double-lined lagoon in 1997, additional improvements to the landfill gas collection system and landfill cover completed in 2007 and 2008, improvements to the leachate pond completed in 2008, and improvements to the stormwater management system and landfill cover completed in 2008. Additional improvements to the stormwater management systems, landfill cover and gas extraction system were planned for and implemented in the summer of 2009 and are described further as part of Cleanup Alternative Action No. 2 in Section 5.2 of this report. These cleanup action efforts have resulted in demonstrated improvements to groundwater quality and reductions in landfill gas occurrences outside of the landfill, as documented in the quarterly monitoring reports and as further discussed in Sections 2.6 and 2.7 of this report.

The Landfill Property is owned and maintained by Olympic View Sanitary Landfill, Inc. The closed Landfill currently operates under several permits:

- State Waste Discharge Permit No. 7271;
- KCHD (formerly BKCHD) Solid Waste Landfill Post Closure Permit;
- Baseline General Stormwater Permit/Industrial Activities (No. S03-002538); and
- Puget Sound Clean Air Agency (PSCAA) Flare Permit (Registration Number 11042).

The Solid Waste Handling Permit is renewed on an annual frequency. The State Waste Discharge Permit and Baseline General Stormwater Permit are issued for 5-year terms and renewed upon expiration. The Agreed Order with Ecology also includes relevant monitoring requirements and requires compliance with the Solid Waste Handling Permit and Chapter 173-351 WAC.

2.4 Landfill Features and Systems

The Landfill consists of a closed, capped, unlined portion referred to as the OBWL and two additional closed areas known as Phases I and II (Figure 2-2). The landfill also includes a leachate management system, a landfill gas collection system, a stormwater management system, and an environmental monitoring program. The following sections briefly describe each of these areas or systems.

2.4.1 Old Barney White Landfill

The OBWL consists of approximately 20 acres and lies in the southwestern portion of the facility (Figure 2-2). The OBWL is unlined and was initially closed and covered with 12-inches of low permeability silt overlain by 2-feet of native soil and topsoil in 1984/1985. The OBWL landfill cover was upgraded in 1991/1992 with an engineered final cover system to meet Washington State MFS for Solid Waste Handling (WAC 173-304). The final cover system consists of a 50 mil very low density polyethylene (VLDPE) flexible geomembrane, geocomposite drainage layer, and topsoil (see Figure 2-3). As part of the final cover system construction, a leachate toe drain system was installed along the perimeter of the Landfill (see Section 2.4.3.2 for additional information).

2.4.2 Phase I and II Landfills

In 1985, the Landfill was expanded in accordance with the Development and Closure Plan (Parametrix 1984). The expansion area included two lined cells, Phases I and II, which are 25 and 20 acres, respectively (Figure 2-2).

Phase I Stage A (also referred to as Phase IA) has a bottom liner, but it was not constructed to MFS bottom liner requirements since the area was already constructed and filled before MFS standards were established. Therefore, Phase IA was closed in 1991 along with the OBWL.

Phase I Stage B (Phases IB) and Phase I Stage C (Phase IC) were designed to meet the requirements of WAC 173-304-460 with the following bottom liner system:

- Prepared subgrade;
- 24 inches low permeability soil (less than or equal to 1 x 10^{-6} cm/s);
- 60-mil high-density polyethylene (HDPE) geomembrane liner;
- Geotextile cushion; and
- 24 inches leachate collection system.

The promulgation of new landfill standards in 1993 resulted in a new bottom liner design for Phase II, in order to meet Washington State Criteria for Municipal Solid Waste Landfills (WAC 173-351). Phase II was designed to meet the requirements of WAC 173-351-300 with the following bottom liner system:

- Prepared subgrade;
- 24 inches low permeability soil (less than or equal to 1 x 10^{-7} cm/s);
- 60-mil HDPE geomembrane liner;
- Geotextile cushion; and
- 24 inches leachate collection system.

Phases IB and C, and Phase II were closed between 1994 and 2004, in accordance with WAC 173-351-500. Closure was performed in accordance with the Final Closure Plan and Post Closure Maintenance Plan (GeoSyntec, 2002). Closure of Phases I and II included construction of the final cover system consisting of the following layers (Figure 2-4):

- 6-inch thick, low permeability soil;
- 60-mil geomembrane;
- Geonet composite;
- 12-inch drainage layer;
- Geotextile fabric; and
- 12-inches of vegetative topsoil and cover soil.

2.4.3 Leachate Management System

This section describes the historic and current systems used to manage leachate at the Site.

2.4.3.1 Pre-2001 Leachate Lagoons

Prior to 1997, leachate was managed in three lined lagoons located to the west of the OBWL in an area where septic infiltration ponds were operated from 1971 through 1986 (Figure 2-5). Spray irrigation of treated leachate was also conducted in an area located to the south of the landfill (Figure 2-2), primarily during the summer months of 1988 through 1990.

The former lined lagoons received leachate from the Phase I and II area collection system via a leachate transmission system from 1986 to 1997 (Figure 2-5). Additional leachate was received after 1993 from the OBWL leachate toe seep collection system. The leachate transmission system consisted of non-perforated pipe and manholes (LM-1 through LM-5) located along the northern and western edges of the OBWL.

Leachate from the Landfill was treated to reduce the pollutant loading prior to disposal via tanker truck to a local wastewater treatment facility (WWTF). The truck fill station was located south of the lagoon area. Leachate was also pumped over to the leachate evaporator, located southeast of the lagoon area, to reduce leachate disposal to a WWTF. The onsite treatment system was an aerobic type system. The leachate flow from the Landfill entered the Aerator Lagoon No. 1 (2.7 million gallons) for biological treatment through aeration and nutrient addition. Storage Lagoon No. 2 (2.6 million gallons) and Storage Lagoon No. 3 (4.3 million gallons) provided storage and served as settling ponds for solids from the aeration lagoon.

Lagoons No. 1 and 2 were abandoned, excavated to near the groundwater surface, and subsequently replaced in the summer of 1997 with a double-lined geomembrane structure, which currently exists as part of general leachate system improvements. Lagoon No. 3 also was subsequently abandoned and excavated in 2001.

Two subsurface soil quality investigations were performed in the locations of existing and former lagoons to assess the potential impact of leachate on soils under the lagoon area (Geomatrix; 1996c, 1997b, c). During the abandonment of Lagoons 1 and 2, soil sampling indicated only limited evidence of site-related chemicals in the soil beneath the lagoons. Subsurface soil sampling was also performed beneath the former location of Lagoon 3 (Waste Management, 2001). The results were similar to the sampling under Lagoons 1 and 2, suggesting that the sporadic detection of elevated metals was associated with the imported soils used as fill materials. However, three feet of soils were removed at the lagoon area prior to construction of the new double-lined leachate pond.

2.4.3.2 OBWL Leachate Toe Drain

In 1993, as part of the OBWL closure, a leachate toe drain was installed along the perimeter of the OBWL. The toe seep collection system collected leachate that formerly broke out on the sideslopes of OBWL. The toe seep collection system consists of gravel blanket beneath the clay soil cap to intercept leachate. The gravel channels the leachate down the sideslopes of the old Landfill to perforated collection pipes that drain to the leachate transmission pipe. A compacted, keyed berm of low permeability soil was constructed all around the perimeter of the old Landfill to control potential breakout of leachate (Figures 2-3 and 2-5).

2.4.3.3 Phase I and II Leachate Collection Systems

The Phase I and II leachate collection system consists of a 2-foot layer of gravel placed over the composite bottom liner system, with a series of perforated pipes in gravel-filled trenches to assist in collection and removal of leachate from the Landfill. Leachate cleanouts were installed at the ends of the collection pipes for easy access and maintenance.

Until 1997, Phase I leachate was routed to the northwest corner of the Phase I area at leachate manhole LM-1, where it flowed by gravity to the lined lagoons via the leachate transmission pipe. Phase II leachate was routed to a leachate pump station at the northwest corner of Phase II. From there, leachate was pumped via an underground force main to LM-1, where it flowed by gravity to the lined lagoons via the leachate transmission pipe (Figure 2-5).

2.4.3.4 1997 Leachate System Improvements

A full upgrade of the leachate collection system was completed in 1997 (Emcon, 1997). The leachate system improvements included the following:

- Abandonment of the leachate transmission pipe and manholes LM-1 through LM-4;
- Replacement of the Phase II force main;
- Abandonment of the former leachate lined lagoons;
- Installation of the existing double-lined leachate aeration lagoon;
- Installation of new force main from Phase I to the leachate lagoon; and
- Reconfiguring toe seep system transmission pipe.

The leachate transmission pipe and manholes (LM-1 through LM-4) were abandoned and replaced with a HDPE force main that carries leachate from Phases I and II to the new doubled-lined leachate aeration lagoon (Figure 2-5). A 2-inch-diameter HDPE non-perforated transmission (gravity) pipe was inserted within the abandoned leachate transmission pipe and connected to the toe seep collection system. The leachate from the toe seep collection system is discharged into Leachate Manhole LM-5 and eventually into the leachate lagoon for treatment. A recent inspection of manhole LM-5 by Waste Management confirmed that the bottom of this manhole is composed of concrete. As stated above, leachate from the lagoon is either trucked to a local WWTF via the truckfill station for disposal or pumped to the leachate evaporator where it is evaporated.

2.4.4 Landfill Gas Collection System

An active landfill gas extraction and flaring system was originally installed at the Landfill as part of the OBWL closure area in 1991; however, the present system collects landfill gas from the old area as well as the Phase I and II areas. The gas system consists of five main components (Figure 2-6):

- Interior landfill gas extraction wells (installed in refuse);
- Gas extraction from the leachate cleanouts;
- Motor blower/flare facility to extract and combust the collected landfill gas;
- Condensate collection system; and
- Perimeter gas monitoring probes located near the Site boundary or adjacent to the disposal areas.

The system currently includes 90 gas collection points including 72 vertical wells, 7 horizontal wells, and 11 leachate risers from which landfill gas may be extracted.

Since the startup of the system in 1991, the system has been operated nearly (e.g., minor power outages) continuously, controlling landfill gas with the in-refuse wells.

The original in-refuse gas extraction system constructed in the OBWL and Phase I and II areas consisted of 68 vertical wells, 5 horizontal collectors, and 10 leachate cleanout connections (Figure 2-6). The system was designed to create a negative pressure (vacuum) within the Landfill and collect landfill gas that is generated by the decomposing refuse. The wells and other collectors were designed and spaced to collect and remove gas from all portions of the Landfill. The vertical gas extraction wells were typically installed to the depth of refuse in the OBWL and approximately 90 percent of the depth of refuse in Phases I and II, to ensure no contact with the composite bottom-liner system. All of the in-refuse wells were completed as single pipes in each borehole. Wells/other collectors were installed after normal landfill operations had deposited enough refuse to allow for installation of the wells and associated conveyance piping.

In 1997, the gas conveyance system piping was re-configured and the previously installed polyvinyl chloride (PVC) pipe was replaced by HDPE pipe. This helped reduce maintenance costs and air infiltration into the system, thus resulting in a more stable system operation.

All the active landfill gas extraction wells and other collectors are connected through a common piping network that routes the collected landfill gas to the motor blower/flare facility (Figure 2-6). Two blowers alternate in service to induce a vacuum on the system and draw landfill gas to the open flare where combustion takes place. The flare combusts the landfill gas (methane), thereby destroying other trace compounds in the landfill gas.

In 1997, the motor blower/flare facility and the landfill gas conveyance piping were upgraded, which included the addition of an enclosed flare. As part of these facility upgrades, a leachate evaporator was installed just to the north of the facility, which uses a portion of the landfill gas flow to reduce offsite leachate disposal. The leachate evaporator emissions are discharged to and controlled by the enclosed flare. The leachate evaporator has the design capability of processing up to 500 gallons of leachate per hour (gph). Evaporator solids are managed as solid wastes and are disposed of offsite.

As landfill gas is drawn to the surface, it begins cooling to ambient air temperatures and produces condensate. The condensate is removed from the gas conveyance pipe network to the leachate system via the main knockout located at the motor blower/flare or condensate driplegs at low points in the piping system.

A detailed assessment of the landfill gas system was performed in early 2006 (SCS, 2007 and 2008). The assessment identified design, construction and operations and maintenance issues that prevented optimal extraction of landfill gas at the Site. Improvements to the gas system were implemented in late 2007 and 2008 and included the following activities:

- Installation and modification of well head control assemblies;
- Video inspection of gas wells, riser piping, and conveyance piping;
- Repair of lateral and header junction piping;
- Replacement of existing PVC pipe tees with HDPE tees;
- Replacement of Condensate Trap No. 1;
- Repair of cover penetration seals;
- Installation of flow monitoring ports;
- Installation of sampling ports along the conveyance piping;
- Installation of new gas extraction wells and cover penetration seals;
- Abandonment of inoperable gas extraction wells,
- Perimeter probe monitoring;
- Surface emissions monitoring;
- Well field balancing; and
- Retaining wall installation.

2.4.5 Stormwater Management System

Stormwater management conforms to the requirements outlined in *Kitsap County Stormwater Drainage Ordinance, Ordinance No. 117, Section 1.05.080*, and WAC 173-351-200(7). The facility is operated under a National Pollutant Discharge Elimination System (NPDES) Stormwater Baseline General Permit for Industrial Activity (Permit No. SO3-002538). In addition to the operations plan and the NPDES Permit, water quality protection activities at the site are guided by a Stormwater Pollution Prevention Plan (Waste Management, 2008).

Surface water at the Landfill is segregated from waste areas, and is controlled by site grading, ditches, detention ponds, borrow areas, and multiple outfalls, all of which are within the Landfill property boundaries. Ultimately, clean surface water generated on the Landfill is discharged to the wetland areas to the north and west. It should be noted that the surface water system is designed to avoid adverse impacts to the wetland areas, and all drainage facilities at the Landfill have been engineered to accommodate a 25 year, 24 hour storm event. There are three detention ponds on-site (Stormwater Detention Ponds A, B/C and D) for the collection and controlled release of stormwater from the site (Figure 2-7).

Off-site run-on comes primarily from three discharges from the Port of Bremerton, Olympic View Industrial Park. Surface water from the Industrial Park flows underneath the U.S. Navy Railroad located east of the facility. Part of this flow is routed to an infiltration system, where the water percolates through the native soils and into the groundwater. Another portion of the flow discharges directly to the Tributary 575 running from east to west along the southern boundary of the facility. These diversions eliminated the need to design on-site controls for surface water flow volumes that do not originate at the facility.

2.4.6 2008 Stormwater Management, Landfill Cover and Leachate Management Improvements

Additional improvements to the stormwater management system and landfill cover were initiated in 2008. These improvements consisted of excavation of the perimeter drainage ditches and adjacent toe of the landfill in order to extend the VLDPE flexible membrane portion of the cover system beneath the perimeter drainage system. These ditch lining improvements were constructed along the south side of the Phase I portion (Stages B and C) of the landfill and also along the west side of Phase II (Stages A and B) of the landfill from approximately 250 ft east of leachate riser-01 (LR-01) around to the south past leachate risers LR-02 and LR-03 to the road intersections located immediately west of leachate riser LR-04. Areas where the ditch lining improvements were constructed in 2008 are shown on Figure 2-8. If based on monitoring of leachate flows during the 2008/2009 winter season, a reduction in leachate generation is observed, additional ditch lining may be performed in the summer of 2009.

Also in 2008, a floating, flexible-membrane, cover was installed over the leachate pond. Installation of the floating cover was conducted to eliminate precipitation entry and accumulation in the leachate pond thereby reducing the volume of water that needs to be treated by the leachate evaporator or hauled offsite for disposal at the WWTF.

2.5 Environmental Monitoring Systems

The Site includes numerous groundwater monitoring wells, leachate monitoring points, and landfill gas monitoring probes, the locations of which are shown on Figure 2-9.

2.5.1 Groundwater Monitoring

Historically, groundwater monitoring was conducted on the Landfill property in accordance with the Solid Waste Handling Permit and later in accordance with the requirements of the Agreed Order and the Post-Closure Permit for the Site. Samples from various monitoring wells have been collected pursuant to these requirements. The results of the groundwater monitoring activities have been submitted in quarterly and annual reports (i.e., SCS Engineers, 2009, 2008, 2007, and 2006). The results of the prior groundwater monitoring are also discussed in the RI report. The nature and extent of chemical occurrences in groundwater are briefly described in Section 2.6.2 below.

In accordance with the Agreed Order, a new Environmental Monitoring Plan (EMP) was recently prepared and submitted to Ecology and the KCHD for review and approval (EMSI, 2009). The EMP includes a new groundwater monitoring network, analyte lists, and sampling frequencies that were designed to evaluate the compliance of the facilities with the MTCA and Solid Waste Regulations and to assess the effectiveness of operational improvements and cleanup actions that may be implemented at the Site.

2.5.2 Leachate Monitoring

Historically, leachate discharge from the leachate force main into the lined leachate pond was monitored in accordance with the requirements of the Solid Waste Regulations and the Agreed Order. The results of the leachate monitoring have been submitted in quarterly and annual reports (i.e., SCS Engineers, 2009, 2008, 2007, and 2006). As part of the EMP, leachate discharge from the OBWL toe drain will also be monitored.

Operation of the leachate pond is subject to the surface impoundment regulations (WAC 173-350). As part of the EMP, monitoring of the volume of water withdrawn from the leak detection system, sampling of the quality of the water withdrawn from the leak detection system, and evaluation of the possible source(s) of the water withdrawn from the leak detection system is also being performed.

2.5.3 Stormwater Monitoring

Stormwater runoff monitoring is performed in accordance with the Industrial Stormwater General Permit SO3002538C and the Stormwater Pollution Prevention Plan (Waste Management, 2008) for the Site. In response to precipitation events, stormwater runoff samples are collected from the discharge from four stormwater outfall locations (Outfalls B, D, F and G) located on the west side of the landfill (Figure 2-7). The results of the stormwater monitoring activities have been submitted in quarterly to Ecology pursuant to the permit (in the form of Discharge Monitoring Reports, or DMRs), and in the annual reports (i.e., SCS Engineers, 2008, 2007, and 2006).

2.6 Groundwater Conditions

This section describes the geology and hydrogeology of the Site and the nature, extent, fate, and transport of chemical occurrences in groundwater at the Site.

2.6.1 Geology and Hydrogeology

The subsurface at the Site is dominated by poorly graded to well graded sands and gravels associated with coarse-grained Vashon recessional and advance outwash deposits and intervening lenses of silty sands, silts and clays associated with Vashon recessional lacustrine deposits. The outwash deposits and the interbedded recessional lacustrine deposits overlay thick deposits of silts and clays associated with the Vashon advance lacustrine deposits. Detailed information regarding the geologic conditions at the Site is presented in the RI report (Parametrix, 2007).

Groundwater is present in all of the units beneath the Site with the primary groundwater system composed of the Vashon recessional and advance outwash deposits which have been interpreted to act as one continuous unconfined aquifer extending from the water table to the underlying fine-grained deposits of the Vashon advance lacustrine deposits. This continuous unconfined aquifer is considered the regional aquifer. The regional aquifer overlies the Vashon advance lacustrine unit which has been interpreted to be present beneath the entire OVSL Site.

The groundwater flow direction of the regional aquifer is generally to the west or west-northwest extending from the highland areas along the eastern and southeastern portions of the Site to the wetlands and Union River valley to the west and west-northwest of the Site. Figure 2-10 presents a recent water level contour map of the groundwater elevations at the Site. Based on a horizontal hydraulic gradient of 0.014 ft/ft, a hydraulic conductivity of 160 ft/day, and an average aquifer thickness of 100 ft beneath the middle and western portions of the Site, (Parametrix, 2007), and a width of approximately 2000 ft across the landfill perpendicular to the direction of groundwater flow, the volume of groundwater flowing beneath the Landfill is approximately 450,000 ft^3/day which is equivalent to approximately 2,300 gallons per minute (gpm). The velocity of groundwater flow beneath the Site has been estimated to be between 6.4 and 6.9 ft/day beneath the western portion of the Site (SCS, 2007). Additional details regarding groundwater occurrence and flow can be found in the RI report (Parametrix, 2007) and in the annual monitoring reports (SCS, 2006, 2007, and 2008).

2.6.2 Nature and Extent of Groundwater Contamination

Based on the results of the RI and past and ongoing groundwater monitoring activities, groundwater contamination at the Site has been characterized as consisting of low levels of volatile organic compounds (VOCs) and trace metals present within the regional aquifer. Specifically, comparison of the results of the 2005 through 2008 groundwater monitoring data to the *Water Quality Standards for Groundwater of the State of Washington* (Chapter 173-200 WAC), State/Federal primary and secondary Maximum Contaminant Levels (MCLs), and the MTCA Method B values has identified six analytes that exceed one of these standards in at least one well. These six analytes include arsenic, iron, manganese, 1,1-dichloroethane, trichloroethene (TCE), and vinyl chloride. The monitoring wells where these chemicals were detected during the period from 2005 through 2008 at concentrations greater than standards or the MTCA Method B risk-based values are shown on Figure 2-11. Vinyl chloride results for selected groundwater monitoring wells over time are displayed on Figure 2-12.

Specific conductivity was detected once in one well (MW-2B1 in June 2007) at a level slightly above the secondary MCL of 0.7 microSeimens per centimeter (mS/cm). As this result was not confirmed by prior or subsequent sampling and the secondary MCL is based on taste considerations and not health effects, specific conductivity was not selected as an indicator hazardous substance. pH has been detected in numerous wells numerous times at levels below the secondary MCL of 6.5 to 8.5 standard units (S.U.). As the secondary MCL is based on taste considerations and not health effects, and the lowest values of pH (less than 6 S.U.) were found to occur in the upgradient (background) wells, pH was not selected as an indicator hazardous substance.

Other trace metals that have been detected in groundwater include barium, chromium, cobalt, copper, nickel, vanadium and zinc although with the exception of barium, occurrences of these metals are isolated and infrequent. Where and when they have been detected, the levels of all of these metals have been below the State and Federal standards and the MTCA Method B Cleanup Levels for Groundwater. The compound cis-1,2-dichloroethene has also been detected in groundwater beneath the Site but at levels below the State and Federal standards and MTCA Method B Levels. Freon compounds, ethyl ether, benzene, toluene, and dichlorobenzene have also been detected in groundwater samples. These detections have only been reported in isolated wells and have generally occurred infrequently over time and in every case have been reported at concentrations below the State and Federal standards and the MTCA Method B Levels.

Additional information regarding groundwater quality and the results of past groundwater monitoring can be found in the RI report (Parametrix, 2007) and the various annual monitoring reports (SCS, 2006, 2007, 2008, 2009, and 2010). Additional information regarding how these monitoring results compare to groundwater standards and health-based criteria can be found in the Human Health Risk Assessment (AMEC Arcadis, 2008).

The waste materials disposed at the landfill are the source of the contaminant occurrences in groundwater. Based on the nature of the contaminants and general correlation between areas of past landfill gas occurrences and occurrences of groundwater contamination, it appears that the primary mechanism for contaminant migration from the landfill is landfill gas. Specifically, the presence of VOCs, in particular vinyl chloride which is a gas at ambient pressures and temperatures, and the trace metals suggests that migration of VOCs has occurred in conjunction with migration of landfill gas. As discussed further in this report and in more detail in the most recent annual report (SCS, 2010), reductions in the concentrations of VOCs have recently occurred in groundwater monitoring wells located near the landfill. These reductions in VOCs levels appear to correlate with reductions in the magnitude and extent of landfill gas occurrences outside of the landfill as a result of recent improvements to the landfill gas extraction system components and operations, further supporting the conclusion that migration with landfill gas is a primary mechanism for contaminant transport from the landfill. The solubility of arsenic, iron and manganese in groundwater increases under reducing conditions which can also be caused by landfill gas generation (and consequent reduction in oxygen levels) within the landfill and/or in response to prior migration of landfill gas from the landfill. Generation of leachate within the landfill may also contribute to groundwater contamination. Leachate generation can be the result of release of moisture contained in the refuse and infiltration of precipitation and/or stormwater into the landfill. Groundwater entering into the base of the landfill is also a possible mechanism for leachate generation, although at OVSL, this is unlikely given the presence of an impermeable liner beneath most of the landfill and the elevation of the refuse mass relative to the groundwater levels.

2.6.3 Contaminant Fate and Transport

Site related chemicals that are present in groundwater will be transported along with the bulk of shallow groundwater flow to the west or west-northwest of the Site. Ultimately, the concentrations of the site-related chemicals in groundwater are decreased by the processes of dilution, dispersion, volatilization and microbial degradation in the case of VOCs, and precipitation and adsorption in the case of the trace metals.

Dilution is caused by infiltration of rainwater downgradient of the site that infiltrates to the saturated zone and mixes with the groundwater flowing beneath the Site. Dispersion is a mixing process caused by heterogeneities in the subsurface that cause groundwater flow paths to spread out with distance. It is analogous to turbulence in surface water flow. Volatilization is the process whereby volatile compounds preferentially partition from the dissolved phase to the vapor phase. VOCs are also subject to microbial degradation which can breakdown organic chemicals to their basic elements of carbon, oxygen, and hydrogen. Precipitation is a process that causes dissolved phase constituents to be deposited as solids. Precipitation primarily occurs in response to changes in oxidation-reduction (redox) conditions. Adsorption is a process whereby compounds preferentially partition from the dissolved phase to the solid phase.

All of these processes act to reduce the concentrations of site-related chemicals in groundwater as they flow downgradient away from the landfill. Review of the groundwater monitoring data shows that the VOC concentrations in groundwater generally decline with distance from the landfill and are non-detect in wells located along or near the property boundary. For example, TCE and vinyl chloride are present in well MW-19C located at the toe of OBWL but are non-detect in downgradient wells MW-21, the MW-29 well cluster and MW-38 located approximately 800 to 1100 ft downgradient of well MW-19C and are also non-detect in wells MW-30A, MW-37 and the MW-33A located along the downgradient boundary of the landfill property. Similarly, vinyl chloride is present in wells MW-23A and MW-24 located adjacent to the toe of the Phase II landfill but declines by approximately an order of magnitude (factor of ten) by the time this groundwater reaches well MW-15R. Vinyl chloride was not detected during the first two quarterly monitoring events of 2009 in recently installed shallow monitoring well MW-36A located further downgradient of wells MW-23A, MW-24 and MW-15R. Vinyl chloride has been detected in downgradient well MW-34C, which is located downgradient of well MW-2B1 in the general area between wells MW-15R and MW-36A and wells MW-33A, MW-37 and MW-38. Manganese occurs in groundwater at well MW-24 at approximately 2 to 3 milligrams per liter (mg/L) but declines to less than 0.01 mg/L downgradient at well MW-15R and to even lower levels further downgradient at well MW-36. Ultimately, only iron and manganese (and possibly arsenic once the final cleanup level is established for arsenic) have been detected at concentrations greater than the cleanup levels in wells located along the downgradient property boundary (e.g., wells MW-33A and MW-37) and the presence of these metals at these locations may be due to the presence of reducing conditions within the wetlands that enhance dissolution and solubility of naturally occurring metals

2.7 Landfill Gas Occurrences

Landfill gas consisting of methane and carbon dioxide and possibly VOCs is present within the landfill mass. Accumulation and migration of landfill gas is controlled through operation of the landfill gas extraction and treatment (evaporator and flare) system. Migration of landfill gas from the landfill mass has been and continues to be monitored using landfill gas probes, some of which include probe clusters completed at varying depths, installed outside of but generally near the perimeter of the landfill (Figure 2-9).

Monitoring of the landfill gas probes previously detected the presence of methane in gas probes GP-15 located along the western boundary of the Phase II landfill and in the middle and deeper landfill gas monitoring probes (GP-13m and GP-13d) installed at the northeast corner of the Phase II portion of the landfill (Figure 2-13). Gas probe GP-15 contained methane levels ranging from 5% to 19% prior to December 2008 at which time the levels dropped to 1.4% (Figure 2-13). In 2009, methane levels continued to decline to 0.9% in March 2009 and to 0% in June 2009 (Figure 2-13). Methane levels in the GP-13 probes initially ranged as high as 10.5% in GP-13m and 6.1% in GP-13d but declined significantly in both wells and have been at 0% in GP-13m since September 2006 and in GP-13d since March 2007 (Figure 2-13). These declines presumably occurred in response to changes in operation and repairs/replacements made to the landfill gas extraction system beginning in 2006 and continuing through today. Low to very low levels of methane were also measured once in gas probes GP-7 (0.10% in March 2006) located approximately 1500 ft to the west of the OBWL and GP-16 (1.6% in March 2007) located adjacent to the OBWL (Figure 2-13). Occurrences of methane were not reported in any of the prior or subsequent monitoring events at these locations (Figure 2-13).

In addition to the occurrence of methane, migration of landfill gas from the landfill can also be reflected by occurrences of elevated levels of carbon dioxide and depressed levels of oxygen in soil gas. Carbon dioxide levels in gas probe GP-15 (the probe with the highest and most consistent occurrences of methane) initially were 20% in September 2005 but declined to less than 3% by December 2008 and in the first half of 2009 (Figure 2-14) presumably again as a result of the changes in operations and repairs/replacements made to the landfill gas extraction system. 0% oxygen was reported for this probe prior to the most recent observation in June 2009 when oxygen was reported to be 6.2% (Figure 2-15). Similar conditions were found in the GP-13 gas probes where carbon dioxide levels initially ranged as high as 14% in 2005 but have declined to 4% by early 2009 (Figure 2-14) again presumably in response to changes in operations and repairs/replacements made to the landfill gas extraction system. There has been a commensurate increase in oxygen levels in these probes over this same period from less than 1% in 2005 to approximately 13% in 2009 (Figure 2-15).

Gas probes that do not appear to have detected landfill gas migration include the GP-9, GP-10, and GP-11 gas probe clusters where carbon dioxide levels are generally on the order of 1.5 to 3% and oxygen levels generally range from 15 to 20% (Figures 2-14 and 2-15). These probes are located outside the southern boundary of the OBWL and the Phase I landfill. With the exception of the March 2007 results when carbon dioxide was measured at 20% (as noted above methane was detected at 1.6% at this location during this event), carbon dioxide levels have remained fairly constant between 1 and 2% at gas probe GP-16 (Figure 2-14). Oxygen levels have ranged between 18.8 and 20.3% at this location (Figure 2-15). These data suggest that with the exception of the March 2007 event, landfill gas has not been present at the GP-16 location which is located adjacent to northwestern boundary of the OBWL. The gas probes in the GP-12 cluster (located adjacent to the eastern boundary of the Phase I landfill) initially displayed higher carbon dioxide levels and lower oxygen content; however, over time the carbon dioxide levels have declined to approximately 2% and the oxygen levels have increase to between 15 and 20% at this location (Figures 2-14 and 2-15) indicating that currently there does not appear to be any landfill gas occurrences at this location.

Gas probe GP-8 is located near the western boundary of the OBWL. This probe has displayed elevated and variable carbon dioxide levels ranging from approximately 1 to 8.5% and depressed oxygen levels ranging from 1 to 13.6% (Figures 2-14 and 2-15). Although methane has never been reported at this location, these data suggest possible landfill gas occurrences in this area.

Gas monitoring results from the remaining two gas probe locations (GP-7 and GP-14) are more ambiguous. At GP-7, the carbon dioxide levels have been elevated but highly variable, initially ranging between 3.3 and 13.5% and more recently between 4.9 and 10.3% (Figure 2-14). Oxygen levels at this location are depressed ranging from approximately 4 to 7% prior to December 2008 when they declined to between 1.4 to

2.9% (Figure 2-15). The presence of elevated carbon dioxide and depressed oxygen levels in this probe suggests the possibility of landfill gas occurrences at this location; however, this probe is located approximately 1500 ft to the west of the OBWL. The levels of carbon dioxide reported in this probe are greater and the oxygen levels in this probe are less than those observed in GP-8 which is located much closer to the landfill (Figures 2-14 and 2-15). Gas quality at GP-7 may reflect landfill gas migration from the landfill or may result in part or in whole from the presence of bog-like conditions and decaying vegetation in the vicinity of this probe.

Gas probe GP-14 is located approximately 450 ft to the northwest of the Phase II landfill. Methane has never been reported at this location; however, carbon dioxide levels have ranged from 5.7 to 11.2% and the oxygen levels have ranged from 1.0 to 5.5% at this location (Figures 2-14 and 2-15) suggesting a possible impact from landfill gas. However, this probe is located in close proximity (approximately 100 ft) to the wetlands area where bog-like conditions are present. Occurrence of decaying vegetation within the wetlands likely result in production of carbon dioxide and consumption of oxygen and therefore could contribute to the elevated carbon dioxide and depressed oxygen observed in this gas probe.

In summary, it appears clear that soil gas quality at the GP-8, GP-13 and GP-15 probe locations has been affected by past migration of landfill gas from the landfill whereas gas quality at the GP-9, GP-10, GP-11 and more recently GP-12 and GP-16 locations do not indicate the presence of landfill gas. Gas quality at the GP-7 and GP-14 locations may reflect landfill gas migration and/or result from local conditions in the vicinity of these probes.

2.8 Risk Assessment

A Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA) were prepared to evaluate the potential risks that the Site may poses to human health and the environment.

2.8.1 Human Health Risk Assessment

The HHRA (AMEC GeoMatrix, 2008) evaluated risks to various off-site human receptors using guidance provided by both Ecology and U.S. EPA. For human health risks, potential noncarcinogenic hazard indices and cumulative excess lifetime cancer risks were estimated for off-site recreational users and off-site residents.

The estimated non-cancer hazard indices are below the acceptable level (a hazard index of 1) for this project for all receptors. The theoretical excess cancer risks are below the acceptable target risk level ($1x10^{-6}$) for this project for recreational users. In addition, the theoretical excess cancer risk for an off-site resident is $5.4x10^{-5}$, which is within the risk range considered acceptable by U.S. EPA. The primary risk-driving exposure pathway and chemical is ingestion of arsenic in groundwater. A review of the analytical results indicates that concentrations of arsenic in groundwater from the deeper water-bearing zone are either at or below the drinking water MCL of 10 micrograms per liter (µg/L). The estimated arsenic 95% UCLs of 1.7 ug/L for deep groundwater and 2.6 ug/L for shallow groundwater are lower than the drinking water MCL. Thus, the potential health risks associated with arsenic in groundwater at this site would be less than a municipal drinking water well containing an allowable level of arsenic.

Excluding arsenic, the estimated cumulative lifetime cancer risk for the Indicator Hazardous Substances (IHSs) is $2x10^{-5}$ based on TCE and vinyl chloride. This conservative risk estimate is greater than the target acceptable risk level of $1x10^{-6}$. However, this lifetime excess cancer risk estimate does not take into account chemical degradation or attenuation that occurs in the groundwater environment. An example of this mechanism is that these VOCs were primarily detected in well MW-19C but were not detected above the laboratory sample quantitation limits in groundwater samples collected downgradient from MW-19C, suggesting that off-site migration of VOCs is negligible. This conclusion is further supported by the fact that VOCs were not detected in offsite wells sampled in 2006 during the RI (Parametrix, 2007).

2.8.2 Ecological Risk Assessment

The ERA (Arcadis BBL, 2007) was conducted to determine the potential for adverse effects to the ecological communities in the vicinity of the site associated with exposure to chemicals at the Site. The ERA estimated that the hazard index due to direct ingestion and dermal contact with shallow groundwater containing IHSs by the indicator species (muskrat) was 0.015. A hazard index of less than 1.0 indicates the exposures evaluated pose a negligible risk of adverse effects to the receptor species. This assessment of risk is considered protective of other ecological receptors that reside in the wetland and terrestrial habitats adjacent to the landfill area because they are expected to have an equivalent (e.g., beaver) or less extensive potential for contact with the emergent shallow groundwater at the site.

The results of the ERA indicate that IHSs in the shallow emergent groundwater at the OVSL site pose a negligible risk of adverse effects to ecological receptors in the aquatic and terrestrial habitat downgradient of the OBWL, the lined Phase I and II landfill cells, and the current and former leachate collection system (LCS).

3 CLEANUP GOAL, ARARS, CLEANUP STANDARDS, AND POINT OF COMPLIANCE

The cleanup goal, requirements of other regulations that may be applicable or relevant and appropriate to any cleanup actions that may be taken at the Site, cleanup standards, and point of compliance for the cleanup standards are discussed in this Section.

3.1 Cleanup Goal

As discussed in Section 2, concentrations of site-related chemicals in groundwater at levels greater than the groundwater protection standards established pursuant to the Solid Waste Regulations, the State Groundwater Standards and MTCA Method B Levels have been detected in monitoring wells at the Site. No site-related chemicals have been detected in stormwater or surface waters at or near the Site. Although prior landfill gas monitoring indicated the presence of methane in one monitoring probe (GP-15) at levels above those allowed by the Solid Waste Regulations, recent monitoring data (SCS, 2008, 2009a and 2009b) have shown that the levels of methane in this probe have declined in response to repairs and improvements to the landfill gas collection system and landfill cover system implemented in 2007 and 2008. Therefore, the evaluation of potential cleanup actions for the Site will be focused on further increasing source control and containment to reduce concentrations of site-related chemicals in groundwater. Specifically, the cleanup goal for the Site is to reduce the concentrations of site-related chemicals in groundwater along and downgradient of the point of compliance to below applicable standards or risk-based levels.

3.2 Applicable or Relevant and Appropriate Requirements

This Section presents the proposed applicable or relevant and appropriate requirements (ARARs) and the "to-be-considered" regulations (TBCs) that are identified for cleanup of the Site. The intent is to identify potential ARARs to be used to evaluate cleanup action alternatives.

WAC 173-340-710 (1) specifies that site cleanup actions shall comply with "applicable state and federal laws." This term includes legally applicable requirements and those requirements determined by Ecology to be relevant and appropriate. Legally applicable requirements include those cleanup standards, standards of control, and other environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, contaminant, remedial or cleanup action, location, or other situation at a site. Relevant and appropriate requirements are those promulgated under federal and state law that are not directly applicable, but still address concerns or situations sufficiently similar to those encountered at the site that their use is well suited to the particular site.

ARARs are determined on a case-by-case basis for each site. Ecology makes the final interpretation as to whether ARARs are correctly identified and are legally applicable or relevant and appropriate. TBCs are advisory or guidance documents that are not legally binding and do not have the same status as ARARs. However, TBCs may be used in evaluating the cleanup alternatives and are included in the evaluation of ARARs.

The MTCA cleanup regulation identifies three categories of potential ARARs: chemical-specific, location-specific, and action-specific. These potential ARARs are presented in Tables 3-1, 3-2, and 3-3, respectively.

- Chemical-specific ARARs include those laws and regulations governing the release to the environment of materials possessing certain chemical or physical characteristics, or containing specific chemical compounds. These requirements include groundwater cleanup standards and surface water quality criteria;

- Location-specific ARARs are those requirements that relate solely to the geographical location or physical position of the site; and

- Action-specific ARARs are requirements that define acceptable containment, treatment, storage, and disposal procedures. These requirements are triggered by the particular activities that are selected to accomplish a cleanup.

3.3 Cleanup Standards

Cleanup standards are established in accordance with WAC 173-340-700 through -760. As previously discussed (Section 2.6.2), six chemicals have been found to be present in groundwater at the Site at concentrations greater than regulatory standards or risk-based levels. These include arsenic, iron, manganese, 1,1-dichloroethane, TCE, and vinyl chloride. Four additional compounds (1,4-dichlorobenzene, cis-1,2-dichloroethene, ethyl ether and ammonia) detected in groundwater were also evaluated as part of the HHRA prepared for the Site (AMEC, GeoMatrix, 2008). Together these 10 chemicals are considered to be the indicator hazardous substances for the Site.

Table 3-4 presents a summary of various groundwater quality standards or risk-based levels derived from potential ARARs or other regulations for the ten indicator hazardous substances. This table summarizes the Federal and State drinking water standards, the MTCA Method B Levels; and for inorganics, the background prediction limits for groundwater for the ten indicator hazardous substances. To address potential discharge of groundwater to surface water, this table also includes various Federal and State surface water quality standards. Preliminary cleanup levels for the Site were identified by following procedures outlined in WAC 173-340-720. Final cleanup levels will be selected by Ecology as part of the cleanup plan for the Site.

3.4 Point of Compliance

The point of compliance is defined as the points where groundwater cleanup levels must be attained for a site to be in compliance with the cleanup standards. The standard point of compliance under MTCA is established throughout the site from the uppermost level of the saturated zone extending vertically to the lowest most depth which could potentially be affected by the site. The presence of waste materials and associated containment systems (e.g., liner and leachate collection system) that will remain on site strongly controls both the types of cleanup actions to be considered and the identification of a point of compliance. Monitoring cannot be conducted beneath the landfill to demonstrate compliance with cleanup standards pursuant to the standard point of compliance. Drilling and installation of monitoring wells through the waste materials would not only destroy the integrity of the containment systems but could provide a direct conduit for migration of site-related chemicals directly into the groundwater.

Where it can be demonstrated under WAC 173-340-350 through 173-340-390 that it is not practicable to meet the cleanup level throughout the site within a reasonable restoration time frame, a conditional point of compliance can be approved by Ecology. A conditional point of compliance shall be established as close as practicable to the source of hazardous substances and, except under certain conditions (WAC 173-340-720(8)(d)), shall be located within the property boundary of the site.

Although achievement of cleanup standards throughout the Site may occur in the future, the presence of the waste materials and containment systems will prevent collection of monitoring data to demonstrate that the cleanup standards have been achieved throughout the Site. Therefore, a conditional point of compliance located downgradient of the landfill within the property boundary needs to be established. This conditional point of compliance also needs to meet the requirements of a point of compliance established under the Solid Waste Regulations; that is the point of compliance needs to be located no more than 150 meters [492 feet] from the waste management unit boundary (WAC 173-351-100 and -300(2)(c)). As implementation of any cleanup actions will need to be conducted outside (presumably outside the downgradient edge) of the waste management unit, the conditional point of compliance needs to be placed at a distance sufficiently far enough downgradient to allow for implementation of cleanup actions.

Based on the above considerations, a conditional point of compliance located near to but no more than 492 feet downgradient of the landfill is proposed. The location of the conditional point of compliance is shown on Figure 3-1. As a conditional point of compliance is proposed, all practical methods of treatment need to be considered in the evaluation of cleanup action alternatives, as required by MTCA (WAC 173-340-720(8)(c)).

4 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section includes discussions of the General Response Actions (GRAs), and a wide range of cleanup technologies that are identified and screened in order to select technologies that could potentially be appropriate to achieve the cleanup goal listed in Section 3.1 of reducing the concentrations of site-related chemicals in groundwater along and downgradient of the point of compliance to below applicable standards or risk-based levels. Technologies that are retained after applying the selected screening criteria will provide the basis for developing cleanup action alternatives. Technologies that are rejected will not be considered further. Briefly, the major elements of this Section are intended to:

- Identify cleanup action technologies;

- Evaluate (screen) the technologies based on the criteria of technical feasibility (effectiveness), implementability, and relative cost; and

- Select potentially feasible technologies for further analysis as components of cleanup action alternatives.

4.1 Identification of General Response Actions and Technologies

After cleanup goals are established for a site, media-specific GRAs that have the ability to satisfy the cleanup goals for the exposure area are determined. Once GRAs are determined, potential technologies are identified in the context of the GRAs. The GRAs and technologies will be used as the basis for development of a series of cleanup action alternatives that could be applied to meet the cleanup goals. Several GRAs were identified for the OVSL FS including:

- Containment of Refuse;

- Containment of Leachate;

- Containment of Landfill Gas;

- Protection of Groundwater; and

- Maintain compliance with the Post-Closure permit.

These GRAs are consistent with the U.S. Environmental Protection Agency (USEPA) Presumptive Remedy for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Municipal Landfill Sites (USEPA, 1993). While the OVSL is not a CERCLA municipal landfill site, USEPA's presumptive remedy approach includes GRAs and technologies that would be applicable to cleanup action alternatives for OVSL. USEPA's Presumptive Remedy Approach for CERCLA Municipal Landfills can be briefly summarized as follows:

- Section 300.430(a)(iii)(B) of the National Contingency Plan (NCP) contains the expectation that engineering controls, such as containment, will be used for waste that poses a relatively low long-term threat or where treatment is impracticable. The preamble to the NCP identifies municipal landfills as a type of site where treatment of the waste may be impracticable because of the size and heterogeneity of the contents (55 FR 8704). Waste in landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with other waste. Because treatment is usually impracticable, EPA generally considers containment to be the appropriate response action, or the "presumptive remedy" for the source areas of municipal landfill sites.

- Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The objective of the presumptive remedy approach is to use past experience at other sites to streamline site investigation and accelerate selection of cleanup actions. The presumptive remedy for municipal landfill sites relates primarily to containment of the landfill mass and collection and/or treatment of landfill gas. In addition, measures to control landfill leachate, affected groundwater at the perimeter of the landfill, and/or upgradient groundwater that are causing saturation of the landfill mass may be implemented as part of the presumptive remedy.

- Based upon their experience, USEPA has identified the following components for consideration in applying the presumptive remedy approach for source area containment at municipal landfills: landfill cap; source area groundwater control to contain plume; leachate collection and treatment; landfill gas collection and treatment; and/or institutional controls to supplement engineering controls.

Technologies that are considered effective and implementable for the GRAs identified within the context of USEPA's presumptive remedy for municipal landfill are described on Table 4-1 and listed below.

4.1.1 Containment of Refuse

Potential technologies include:

- Institutional controls;

- Engineered controls;

- Impermeable bottom liner installation at OBWL;
- Excavation and re-disposal of OBWL contents in an engineered landfill; and
- Landfill cover enhancements.

4.1.2 Containment of Leachate

Technologies include:

- Leachate flow monitoring;
- Inspection and repair of the existing leachate collection system, and
- Extraction or interception of leachate generated from OBWL.

4.1.3 Containment of Landfill Gas

Potential applicable technologies include:

- Landfill gas monitoring;
- Landfill gas system assessment and optimization;
- Landfill gas system improvements; and
- Installation of new landfill gas wells.

4.1.4 Protection of Groundwater

Technologies include:

- Institutional controls;
- Groundwater monitoring;
- Natural attenuation;
- Soil vapor extraction;

- Containment of groundwater, including physical barriers and hydraulic containment;

- Various aboveground treatment technologies if groundwater is extracted via hydraulic containment, including VOCs removal via air stripping or granular activated carbon (GAC) and/or metals removal via precipitation/settling; and

- In-situ groundwater treatment technologies including in-situ oxidation, air sparging, and in-situ biological treatment.

4.1.5 Maintaining Compliance with the Post-Closure Permit

The "technology" that would be applicable would include Post-Closure care of the Site pursuant to the Solid Waste Regulations (WAC 173-351-500(2)) and in accordance with the Post-Closure Permit and as further detailed in the Final Closure Plan and Post-Closure Maintenance Plan (GeoSyntec, 2002). Because the activities associated with maintaining compliance with the Post-Closure Permit are too numerous to include on Table 4-1, a brief summary of the specific requirements is provided below. These summaries are only intended to describe the requirements for purposes of this Feasibility Study report and do not replace, supersede or modify these requirements in any way.

Post-Closure care requirements of the Solid Waste Regulations include:

1. Maintaining the integrity and effectiveness of the final cover;

2. Maintaining and operating the leachate collection system;

3. Environmental monitoring; and

4. Maintaining and operating the gas extraction, treatment and monitoring system.

The Post-Closure Permit was issued by Kitsap County Health District and is renewed annually. This Permit requires the following post-closure activities:

1. Minimum Standards of Performance:

    a. Compliance with the groundwater and surface water performance standards set by Ecology in the Cleanup Action Plan pursuant to WAC 173-340-380;

    b. Not allow discharges of pollutants into waters of the state that violate state law and regulations from point or non-point sources in accordance with the approved Plan of Operations and Maintenance and the approved engineering plans;

    c. Control explosive gases to ensure that concentrations of methane do not exceed standards set forth in WAC 173-351-200(4);

    d. Follow all applicable regulations and permitting requirements established by the Puget Sound Clean Air Agency for the leachate collection/evaporation system and the landfill gas collection system;

2. Access Restrictions – control unauthorized access to the facility;

3. Stormwater Run-on/Run-off Control Systems – maintain run-on/run-off control systems for the Site in accordance with the approved Post-Closure Plan, Stormwater Permit, and SWPPP, as amended, and requirements set for by the Kitsap County Department of Public Works;

4. Equipment Storage – take precautions to ensure that reserve operation equipment stored on site does not leak fluids that would contaminate the surface soil and/or stormwater run-off;

5. Record Keeping – keep records required by the Final Closure and Post-Closure Maintenance Plan;

6. Other Post-Closure Requirements:

    a. Maintain all monitoring wells and gas probes as required by the Agreed Order, the Environmental Monitoring Plan, the Post-Closure Monitoring and Maintenance Plan, or the Cleanup Action Plan issued by Ecology, which is then in effect; and

    b. Monitor and control the occurrences of intrusive vegetation capable of puncturing the cover liner system.

The Post-Closure Permit also requires continued environmental monitoring until such time as a new Environmental Monitoring Plan is approved for the Site. Existing environmental monitoring programs include:

1. Groundwater Monitoring – in accordance with the agreed MTCA Order;

2. Stormwater Monitoring – in accordance with the Stormwater Permit and approved Stormwater Pollution Prevention Plan;

3. Leachate Monitoring:

    a. As required by the State Discharge Permit No. 7271 and as required by the Agreed MTCA Order;

    b. Maintain and operate the leachate collection system in accordance with the requirements in WAC 173-351-300, as applicable;

    c. Operate and maintain the Leachate Evaporator System (LES) in accordance with the approved LES Operations and Maintenance Plan;

4. Landfill Gas – meet the explosive gas control requirements in WAC 173-351-200(4) and assess compliance with these requirements by conducting landfill gas monitoring as follows:

    a. Quarterly monitoring of landfill gas probes GP-1 through GP-16 and around the leachate pumphouse as described in the Closure Plan and Post-Closure Maintenance Plan and at other locations as recommended by Ecology (Note: As part of the Remedial Investigation, the gas probe monitoring program was revised to include only gas probes GP-7 through GP-16 and gas probes GP-1 through GP-6 were either abandoned or are no longer monitored). The Post-Closure permit also required monitoring of facility structures for the potential presence of landfill gas. This monitoring has been performed in the past; however, these structures were recently demolished and therefore this type of monitoring will not be required in the future.;

    b. All gas monitoring wells shall be constructed, maintained, and decommissioned to ensure protection of the ground water and to prevent groundwater contamination in accordance with WAC 173-160;

    c. Field measurements of methane (%LEL), oxygen (%vol), and barometric pressure;

    d. Record on a daily and summarize on a monthly basis any problems with the gas collection system and leachate evaporator system and a corrective actions taken;

    e. Perform landfill gas monitoring as described in the Final Closure and Post-Closure Maintenance Plan until such time as the new Environmental Monitoring Plan is approved; and

5. Weather Monitoring – collect and maintain weather data from the weather station at the Bremerton National Airport.

The Final Closure and Post-Closure Maintenance Plan (GeoSyntec, 2002) sets forth the inspection and maintenance schedules and procedures for the post-closure inspection and maintenance program for the Site. Specifically, this Plan describes the schedules, procedures, and equipment, labor and material requirements to inspect and maintain the following systems at the Site:

- Final cover;
- Surface water management system including channels and attenuation basins;
- Vegetative erosion control layer;
- Leachate collection system;
- Landfill gas collector network;
- Survey control monuments;
- Site security, and;
- Environmental monitoring systems.

This Plan also describes the post-closure land use as non-irrigated open space vegetated with native vegetation. As changes have been made to some of the systems addressed in this Plan, the Plan needs to be updated. Updating of the Plan is included as part of the cleanup action alternatives for the Site.

4.2 Technology Screening

The following criteria were used to screen the potential cleanup action technologies identified for the Site. These include (in order of application):

- Technical Feasibility - Engineering factors related to the ability of the technology to function effectively and achieve meaningful progress toward the cleanup action objectives, based on site-specific characteristics, including: the nature and extent of site-related chemicals, waste/source type and locations, site hydrogeology, and time required to achieve cleanup levels.

- Implementability – Technical feasibility, resource availability, and administrative issues related to the technology, including government regulatory approvals, construction schedule, constructability, access, monitoring, operation and maintenance, and community concerns.

- Cost - The relative cost of the technology, including initial capital and future annual operating, maintenance, and monitoring costs, compared to other similarly applied technologies.

The goal of the screening process is to select the most practicable technology from among each category of similar technologies. The results of the technology screening evaluation are summarized in Table 4-1. The following technologies will be used as the basis for development of a series of cleanup action alternatives that could be applied to meet the cleanup goal.

Containment of Refuse

- Institutional controls;
- Engineered controls;
- Excavation and re-disposal of OBWL contents in an engineered landfill; and
- Landfill cover enhancements.

Containment of Leachate

- Leachate flow monitoring; and
- Inspection and repair of the existing leachate collection system.

Containment of Landfill Gas

- Landfill gas monitoring;
- Landfill gas system assessment and optimization;
- Landfill gas system improvements; and
- Installation of new landfill gas wells.

Protection of Groundwater

- Institutional controls;
- Groundwater monitoring;
- Natural attenuation;
- Soil vapor extraction; and
- Air sparging in-situ groundwater treatment.

Maintaining compliance with the Post-Closure permit

- Post-Closure care of the Site pursuant to the Solid Waste Regulations (WAC 173-351-500(2)) and in accordance with the Post-Closure Permit and as further detailed in the Final Closure Plan and Post-Closure Maintenance Plan.

5 DEVELOPMENT AND DESCRIPTION OF ALTERNATIVES

This section describes the cleanup action alternatives developed for the OVSL Site from the technologies that were retained by the screening process described in the previous section of this report. All of the retained technologies were included in at least one alternative and most of the alternatives include multiple technologies. Table 5-1 lists the remedial technologies included as part of each of the cleanup action alternatives developed for the Site.

The intent of developing cleanup action alternatives for the Site is to provide for a range of containment and source control actions from no additional action to complete removal of waste materials to reduce the concentrations of site-related chemicals in groundwater along and downgradient of the point of compliance. Each alternative was developed as an independent action, with additional technologies or process options added to each successive alternative, as appropriate, to increase the level of containment or source control. The overall purpose of the cleanup action alternatives is to prevent or reduce the amount of landfill gas and/or leachate migration from the landfill and to reduce the levels of existing site-related chemicals in groundwater located on-site downgradient of the landfill.

The cleanup action alternatives include the following:

Alternative 1 - Increased Inspection, Repair and Operational Improvements

Alternative 2 - Landfill Gas Collection System Upgrades

Alternative 3 - Vadose Zone Gas Investigation and Extraction

Alternative 4 - Air Sparge Wall

Alternative 5 - Excavation and Offsite Re-Disposal of OBWL

As shown on Figure 5-1, each of the cleanup action alternatives would include continuation of Post-Closure care. The components of Post-Closure care are discussed in the following section. Descriptions of Alternatives 1 through 5 are provided in subsequent sections.

5.1 Continued Post-Closure Care

Post-Closure care includes continued operation and maintenance of the existing landfill source control and containment systems and environmental monitoring programs as well as continued compliance with requirements of State and Local regulations for landfill post-closure (WAC 173-351; KCHD Landfill Post Closure Permit). Existing institutional controls on use of the landfill and restrictions on installation of water supply wells near the landfill would be maintained as required by the Solid Waste Regulations, the Post Closure Permit, and the Post Closure Plan. Natural attenuation of site-related chemicals in groundwater is also a component of Post-Closure care.

5.1.1 Source Control and Containment Systems

The existing source control and containment systems at the Site include:

- Impermeable cap over the Phase I and II landfill cells and the Old Barney White Landfill to reduce precipitation infiltration and thereby reduce leachate generation;
- Stormwater runoff diversion and control structures to reduce precipitation infiltration and leachate generation;
- Impermeable liner beneath Phases I and II to contain leachate;
- Leachate collection system from the Phase I and II landfill cells;
- OBWL toe drain leachate collection system;
- Leachate treatment and disposal systems;
- Landfill gas extraction and treatment system; and
- Gates and berms on the landfill property to control vehicle trespass.

The general locations of the gates and berms used to reduce trespass are shown on Figure 5-1.

5.1.2 Operation, Maintenance, and Monitoring Activities

Operation, maintenance, and monitoring activities associated with the existing source control and containment systems include:

- Inspection and maintenance of the landfill cover;
- Control of growth of weeds and intrusive vegetation to reduce root penetration into and resultant damage to the cover;
- Inspection and maintenance of stormwater runoff and control structures;

- Extraction and collection of leachate from the collection system associated with the Phase I and II landfills and from the OBWL toe drain systems;

- Storage and treatment of the collected leachate in the double lined and covered leachate pond pursuant to the requirements of the surface impoundment regulations (WAC 173-350) and monitoring requirements set forth in the EMP;

- Disposal of leachate through the leachate evaporator unit (LEU) or through offsite disposal at the Publicly Owned Treatment Works (POTW) pursuant to the terms of the NPDES permit;

- Inspection, maintenance, and repair of the leachate collection system pumps, piping, flow meters, transfer and truck load out pumps and the leachate pond liner and cover;

- Operation of the landfill gas vacuum blowers, landfill gas extraction wells, lateral and header piping to extract and collect landfill gas from the Phase I and II landfills and OBWL;

- Destruction of the landfill gas in the LEU and/or landfill gas flare;

- Operation of the landfill gas condensate traps to collect landfill gas condensate and disposal of the condensate in conjunction with leachate disposal;

- Inspection, maintenance, and repair of the landfill gas wells, lateral and header pipes, vacuum blowers, condensate traps, LEU, and landfill gas flare;

- Inspection and maintenance of the perimeter fencing and maintenance of existing berms and construction of additional berms across roads or trails to limit trespass potential;

- Performance of environmental monitoring of leachate, groundwater, stormwater, and soil gas; and

- Inspection, repair and maintenance of the environmental monitoring points and systems.

Post-Closure care also includes performance of all of the activities required by the Post-Closure Plan (GeoSyntec) and Post-Closure Permit (KCHD, 2008) pursuant to the closure and post-closure requirements of the Solid Waste Regulations (WAC 173-351). As previously indicated, the Post-Closure Plan needs to be updated to reflect recent changes and improvements made at the landfill (e.g., installation of the floating cover over and new aerators in the leachate collection pond and the new EMP, among others).

Updating the Post-Closure Plan and Post-Closure Permit to reflect these changes is included as part of all of the alternatives.

5.1.3 Institutional Controls

Institutional controls consist of restrictions on use of the landfill surface, signage and deed restrictions regarding the presence of the landfill, and existing regulatory prohibitions on installation of water supply wells on land within 1,000 ft of the waste management unit boundaries of a solid waste landfill. Specifically, subsection (3) (b)(vi) of WAC 173-160-171 (Construction and Maintenance of Wells) prohibits water supply wells from being located within 1,000 ft of the waste management unit boundary of a solid waste landfill.

5.1.4 Monitored Natural Attenuation

In conjunction with operation of the existing source control and containment measures, natural attenuation processes (within the context of controlled and monitored Site conditions) are relied upon to achieve groundwater cleanup adjacent to (performance monitoring wells) and downgradient of the landfill (compliance and downgradient monitoring wells). Natural attenuation is the process by which concentrations of chemicals introduced into the environment are reduced over time by natural physical, biological, and chemical processes. Natural attenuation has been shown to effectively reduce the concentrations of inorganic and organic site-related chemicals in groundwater.

As discussed further below, the primary processes acting to reduce the concentrations of VOCs in groundwater adjacent to and downgradient of the landfill are volatilization, dispersion, and dilution. The primary processes acting to reduce the concentrations of inorganic compounds are oxidation, precipitation, co-precipitation, dispersion, and dilution.

Natural attenuation is most appropriate for sites with the following characteristics (WAC 173-340-370(7)):

- Source control is concurrently and effectively applied;
- Human health and the environment are protected;
- Site-specific cleanup goals can be achieved in a reasonable time frame;
- Migration of groundwater is limited;
- Transformation of site-related chemicals into more mobile or more toxic substances is unlikely;

- Transformation processes are irreversible;
- Effectiveness of attenuation processes can be supported with site-specific data;
- Methods to monitor cleanup action progress are available; and
- Backup or contingency plans are available.

A summary of the evaluation of the OVSL site characteristics relative to natural attenuation is presented on Table 5-2.

Landfills typically follow a pattern of activity with age. Initially, biological activity is intense, but as moisture declines following capping of the waste and the most readily degradable wastes are consumed, biological activity declines. Leachate and gas generation rates also decline with time after closure. Biological activity has been and is continuing to decompose waste materials in the disposal areas at the Landfill. Because of the Landfill cap and the age of the waste, it is anticipated that gas and leachate generation rates would continue to decline with time.

As discussed in Section 2, the site-related chemicals at the Site include vinyl chloride, TCE, 1,1-dichloroethane, iron, manganese and arsenic. TCE was a common solvent found in commercial cleaning products and therefore can be present in municipal refuse. Microbial degradation of TCE (through reductive dechlorination) results in production of cis-1,2-dichloroethene and vinyl chloride. Therefore, TCE is a potential source of the vinyl chloride present in landfill gas and leachate. Other potential sources of vinyl chloride include refrigerants, floor tiles, plastics, drugs, and cosmetics. Vinyl chloride is also subject to microbial degradation. Most of the vinyl chloride precursors originally present in the Landfill are completely decomposed, as indicated by the very low concentrations of TCE and cis-1,2-dichloroethene in the leachate and groundwater at the Site. Given the low levels of vinyl chloride precursors in the landfill combined with microbial degradation, concentrations of vinyl chloride in landfill gas, leachate, and groundwater beneath the Landfill should decline with time. In addition to microbial degradation of TCE and vinyl chloride, other natural attenuation processes at the Site that may reduce TCE and vinyl chloride concentrations in groundwater are dispersion and volatilization.

Natural processes at the Site that may reduce iron, manganese and arsenic concentrations in the groundwater include dispersion and geochemical precipitation/fixation as a result of oxidation reactions. Arsenic, iron and manganese are more soluble in their reduced states. Biological activity within the landfill results in consumption of oxygen and creation of anaerobic (reducing) conditions that reduce the valence state of arsenic, iron and manganese and thereby increase the solubility of these metals. The presence of reducing conditions increases the amount of arsenic, iron and manganese that leaches from the solid wastes and/or from natural occurrences of these metals in soil. The increased solubility of these metals under reducing conditions also increases the rate of transport of these metals in groundwater. As groundwater moves away from the landfill and becomes mixed with meteoric water, oxygen levels in the groundwater increase, the solubility of these metals is reduced resulting in precipitation and immobilization of the metals. Arsenic is known to also co-precipitate with and adsorb to iron and manganese, and this may be the mechanism responsible for its removal.

Review of the variations in the dissolved oxygen levels in groundwater as a function of distance from the landfill support the presence of changes in oxidation–reduction (redox) conditions. Dissolved oxygen levels in upgradient monitoring wells (e.g., MW-13, -13A, -13B and -35) are generally on the order of 7 to 8 mg/L and as high as 20 to 24 mg/L during the high precipitation winter months. In contrast, dissolved oxygen levels in shallow groundwater located immediately downgradient of the landfill (e.g., MW-2B1, -19C, -20 and -24) are generally less than 1 mg/L. Further downgradient, the dissolved oxygen levels begin to increase (e.g. MW-34A, -34B and -36); however, the presence of decaying vegetation in the wetlands also results in consumption of oxygen and creation of reducing conditions that can increase leaching and transport of naturally occurring arsenic, iron, and manganese as well as extending the areal extent of reducing conditions downgradient of the landfill.

The effectiveness of natural attenuation or any of the successive alternatives would be evaluated based on the results of the groundwater monitoring program described in the EMP. The effectiveness of the source control measures in conjunction with natural attenuation of downgradient groundwater quality provided for under continued Post-Closure care and each of the successive alternatives would be demonstrated by the presence of decreasing concentrations of site-related chemicals in the performance, compliance and downgradient monitoring wells over time. This demonstration would include statistical evaluation of potential trends using the procedures presented in the EMP.

As part of the design and/or implementation of cleanup actions at the Site, a contingency plan will be developed. The contingency plan will describe what, if any, additional actions may be taken beyond the source control measures previously or currently being implemented at the Site and the additional actions that Ecology may select in the Cleanup Action Plan for the Site, in the event that the levels of contamination in groundwater do not decline below the cleanup standards. Implementation of contingent actions can be performed on a voluntary basis by Waste Management at any time, or in response to a directive from Ecology pursuant to the terms of the Consent Decree or Compliance Order for implementation of the selected cleanup action at the Site. Implementation of the contingency plan could be triggered by a statistically significant exceedance of one or more of the groundwater cleanup standards in one of the compliance monitoring wells coupled with a statistically significant increasing trend in the concentration(s) of the parameter(s) determined to be present in excess of the cleanup standards. Contingent actions could include additional or more frequent groundwater sampling, modifications to the operation or components of the landfill gas extraction and/or leachate collection systems, and/or implementation of additional corrective actions such as soil vapor extraction and/or air sparging. The exact nature and scope of any contingent actions that may be implemented cannot be predicted in advance of their occurrence at they depend upon numerous factors. Factors affecting the selection of additional actions, if any, would include the nature of the chemical constituent(s) determined to exceed the cleanup standards, the concentration of the chemical relative to the cleanup standard, the location and depth of the exceedance(s) relative to the landfill mass, the conditions and operation of the landfill gas extraction and/or leachate collection systems at and just prior to the occurrence of any exceedance, among other factors.

5.2 Alternative 1 - Increased Inspection, Repair and Operational Improvements

This alternative includes increased inspection, repair and operational enhancements in conjunction with the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as continued Post-Closure care in Section 5.1. Specifically, Alternative 1 includes the following additional elements. The locations and descriptions of these elements are provided on Figure 5-2.

- Repair/modification of the landfill cover system along the landfill toe to reduce potential for stormwater infiltration and resultant leachate generation and to reduce potential for atmospheric air intrusion and resultant increased oxygen levels and loss of vacuum applied by the landfill gas system;

- Inspection, and repair if necessary, of penetrations to cover system to reduce potential for atmospheric air intrusion and resultant increased oxygen levels and loss of vacuum applied by the landfill gas system;

- Repair/replacement of landfill gas extraction wells containing blockages that restrict gas extraction and flow;

- Repair/replacement of landfill gas extraction system conveyance piping as needed to eliminate blockages that restrict gas extraction and flow;

- Repair/replacement of condensate collection equipment as needed to reduce condensate accumulation in the piping that causes blockages, thereby restricting gas extraction and flow;

- Maintenance/repair of landfill gas system vacuum blowers to optimize gas extraction and flow;

- A program of optimization of the landfill gas collection system (wellfield balancing) to insure that all portions of the landfill are subject to vacuum thereby minimizing the potential for gas migration from the landfill;

- Increased inspection, maintenance and adjustment of the leachate collection system pumps to insure optimum performance of the leachate extraction system;

- Repair and improvement of the perimeter stormwater drainage diversion and control system to minimize the potential for stormwater infiltration into the landfill and resultant leachate generation;

- Installation of a floating cover to eliminate rainwater accumulation in the leachate pond to reduce the amount of leachate requiring treatment or disposal; and

- Permitting of alternate leachate disposal facilities to insure sufficient capacity for leachate collection and disposal.

The focus of these improvements/enhancements is to reduce potential leachate generation, increase leachate capture, optimize gas collection, and prevent migration of landfill gas from the landfill. It should be noted that, as discussed in Section 2, nearly all of these operation enhancements, repairs and improvements have recently been implemented by Waste Management.

5.3 Alternative 2 - Landfill Gas Collection System Upgrades

Prior monitoring of landfill gas occurrences in soils (soil gas) detected the presence of methane in gas probes GP-13 and GP-15; however, recent enhancements made to the gas extraction system operations and the landfill cover have eliminated methane occurrences in these probes. Monitoring of soil gas adjacent to (e.g., gas probes GP-8, and GP-16) and further away from the OBWL (e.g., GP-7) has not identified any areas of methane migration from OBWL. All of the gas monitoring data obtained from gas monitoring probes located around OBWL have been in compliance with the landfill gas performance standards contained in the Solid Waste Regulations (WAC 173-351-200(4)). Low levels of methane (0.1% and 1.6% in probes GP-7 and GP-16, respectively) have only been detected once in gas probes GP-7 and GP-16 over the last four years. Elevated carbon dioxide and reduced oxygen levels have been seasonally observed in gas probes GP-7, GP-8 and GP-16 which may be suggestive of landfill gas migration from OBWL; however, similar conditions have been observed in gas probe GP-14 which is not located near the landfill but is located near the wetlands suggesting that these conditions may result from biological activity in the wetlands areas. Given the lack of methane occurrences outside the landfill, the focus of this alternative is not to contain gas that may otherwise be migrating from the landfill. The purpose of this alternative would be to reduce the amount of gas within OBWL that may be contributing to groundwater contamination beneath and subsequently downgradient of OBWL. To the extent that gas migration has or is occurring from the OBWL, this alternative will also address this condition.

This alternative includes installation of additional landfill gas collection wells along with the increased inspection, repair and operational enhancements of Alternative 1 and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care. Under Alternative 2, approximately ten additional landfill gas extraction wells would be installed and connected to the landfill gas extraction system. The additional wells include nine more gas extraction wells in the OBWL and one additional gas extraction well in the Phase II Stage B portion of the landfill.

Figure 5-3 shows the locations of the existing and recently installed replacement landfill gas extraction wells. Details of the construction of the replacement wells and repair of the cover around the new wells are provided on Figure 5-4. Also shown on Figure 5-3 are 100-foot radius (200-ft diameter) areas of influence around each well. As can be seen on this figure, there are several locations within the OBWL that are not included within the radius of influence of any of the existing gas collection wells. There is also one location in the Phase II Stage B area, between existing gas wells GW-42 and -58 that is not within the radius of influence of any of the gas extraction wells located in this portion of the landfill. Under Alternative 2, additional gas extraction wells would be installed in these areas. Approximate northings and eastings for additional well locations within the OBWL and the Phase II Stage B area are included on Figure 5-4.

Waste Management recently made improvements to the landfill gas extraction and treatment system. These improvements included replacement of 35 existing gas wells that were plugged or otherwise inefficient with new gas wells, abandonment or the 35 old gas wells, and termination of operation of the leachate evaporation unit. In conjunction with these modifications, Waste Management also implemented a program of more frequent adjustment of the applied vacuum and gas flow rates at individual gas extraction wells in response to vacuum and gas quality monitoring results at the individual gas extraction wells. Due to the presence of leaks of atmospheric air into the 35 abandoned gas wells, these wells were recently re-abandoned. Consequently, the effects of these recent improvements to the landfill gas extraction system components and operations are still being evaluated. In addition, Waste Management recently began pumping condensate from landfill gas extraction wells that were determined to be watered in to improve gas flow from these wells. Waste Management is also planning on replacing the existing enclosed flare operation with a candlestick flare that includes variable frequency drives. This modification will provide for flexibility in application of vacuum to the gas extraction wells, allow landfill gas extraction to occur at lower flow rates that occur with the aging of the refuse, and will also allow for extraction and treatment of landfill gas with a lower methane content.

Although recent improvements to the landfill gas extraction system components and operation have reduced the levels of landfill gas that previously occurred outside but near the margins of the landfill, the existing landfill gas extraction system may still be allowing accumulations of landfill gas within portions of the body of the landfill mass which could be affecting the quality of groundwater located beneath or immediately downgradient of the landfill mass. This may be particularly true in the area of the Old Barney White Landfill which does not contain a liner system and in which previous landfill gas extraction efforts were limited due to the poor quality (low methane content) of the landfill gas produced by this older portion of the landfill.

Alternative 3 is intended to expand the landfill gas collection system to collect landfill gas from all portions of the landfill, in particular OBWL, so as to reduce the potential for gas-to-water impacts. The conceptual design of Alternative 3 is predicated on an assumption that the landfill gas wells have a radius of influence of 100-feet. Based on this assumption, Alternative 3 includes installation and operation of approximately 10 landfill gas extraction wells to address areas where the existing gas extraction system may not be actively removing landfill gas from the landfill mass. The exact locations and number of additional landfill gas extractions wells included in this alternative are considered to be preliminary as adjustments and enhancements to the landfill gas extraction system are ongoing. Although the exact locations and number of additional landfill gas extraction wells that may be installed under this alternative is only conceptual, the magnitude of the proposed enhancements is considered reasonable and sufficient for purposes of evaluating this alternative. The design of any additional landfill gas collection wells will be based on measurements of the performance of the landfill gas extraction system, if and when this alternative were to be implemented. In addition, the additional landfill gas extraction wells included in this alternative may be implemented using an observation engineering approach. Specifically, the additional landfill gas extraction wells may be installed in a phased manner over time so as to allow the effects of the improvements achieved from installation of a few initial wells to guide the need for, placement, design and operation of subsequent landfill gas extraction wells that may be installed.

5.4 Alternative 3 - Vadose Zone Gas Investigation and Extraction

Alternative 3 includes investigation of landfill gas and VOC occurrences in soil gas outside of the landfill followed by installation and operation of soil vapor extraction (SVE) wells to remove significant occurrences of landfill gas and/or VOCs present outside of the landfill mass that may be contributing to groundwater contamination downgradient of the landfill. Alternative 3 also includes installation of ten additional gas collection wells described under Alternative 2; the increased inspection, repair and operational enhancements of Alternative 1; and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

Prior soil gas monitoring data identified the presence of methane in two gas probes (GP-13 and GP-15) at levels above the numeric landfill gas performance standards; however, more recent monitoring data indicate that the levels of methane in these probes are below the numeric standards. Occurrences of methane in gas probes GP-13 and GP-15 did not and do not represent non-compliance with the landfill standards as these gas probes are not located at the property boundary which is where the standards are applicable. None of the gas probes located at or near the property boundary have ever contained methane, or methane levels above the gas standards. In addition to the past occurrences of methane in probes GP-13 and GP-15, elevated levels of carbon dioxide, indicative of the presence of landfill gas, have been detected in a number of the gas probes. The presence of methane and carbon dioxide along with decreased levels of oxygen in soil gas may reflect the presence of landfill gas; however, biological activity within the wetland areas adjacent to the landfill may also cause elevated carbon dioxide and depressed oxygen levels. The presence of these conditions in gas probes such as GP-7 and GP-14 which are located close to the wetland areas but several hundred to over one thousand feet from the landfill and in which methane has never been detected supports this observation. Regardless, occurrences of landfill gas, which could contain VOCs such as TCE and VC, outside of the landfill mass could act as a source of groundwater contamination downgradient of the landfill. This alternative would address such occurrences.

Under Alternative 3, a soil gas investigation consisting of geoprobe drilling and gas sampling, would be performed outside of the landfill mass to identify the presence and define the extent of VOC occurrences, if any, in soil gas outside of the landfill. The soil gas investigation would be conducted using a phased approach which may consist of one or more of the following activities:

- Collection of samples from the existing gas probes for VOC analyses;

- Geoprobe® direct-push drilling and soil gas sampling near the perimeter of the landfill to identify areas where landfill gas and/or VOC migration may be occurring in soil gas; and/or

- Geoprobe® drilling and soil gas sampling in the vicinity of groundwater monitoring wells at which VOCs have been detected above groundwater cleanup levels.

The specifics of the investigations would be described in a work plan describing the scope and phasing of the investigations which would be submitted to Ecology and KCHD for review and approval.

If occurrences of VOCs in soil gas at levels that could act as a source for groundwater contamination are identified outside of the landfill, an SVE system would be installed and operated to contain and collect any landfill gas located outside of the landfill. For purposes of preparing cost estimates for this FS, it is assumed that a system of 54 SVE wells with a radius of influence (ROI) of 50 feet would be installed along the downgradient portion of the landfill (Figure 5-5). These wells would be connected to a vacuum blower located at the landfill flare/evaporator stations, which would be used to create a vacuum in these wells to extract any landfill gas that may be present outside of the landfill. The extracted gas would either be discharged to the atmosphere, possibly after treatment using vapor phase granular activated carbon as required by the terms of an air quality permit for this activity, or possibly treated within the landfill gas flare depending upon the volume and quality of the extracted soil gas.

For purposes of preparing a cost estimate, the following design criteria were considered:

- A pilot test would be conducted during cleanup action design to confirm design criteria;
- SVE well depth of 10 feet constructed in the vadose zone;
- A 5 foot screen length in the bottom 5 feet of the SVE well;
- Vapor flow rate of 2 cubic feet per minute (cfm) per foot of well screen, which equates to 10 cfm per SVE well;
- ROI of 50 feet per SVE well;
- 44 of the SVE wells could be constructed to the west of the access road and served by aboveground piping (Figure 5-5);
- 10 of the SVE wells would need to be constructed in the access road located to the east of the leachate pond (Figure 5-5) and would need to be housed in vaults, buried piping would be needed to serve these wells;
- A 540 cfm positive displacement blower would be located at the existing flare/evaporator station; sound insulation would be hung on a new chain-link fence constructed around the blower;
- Offgas treatment would not be needed; and
- The SVE system would be operated for 5 years as it is assumed that the landfill gas collection system will prevent further migration of landfill gas from the landfill and therefore the SVE system is only considered necessary to remove landfill gas that previously migrated outside of the landfill.

5.5 Alternative 4 – Air Sparge Wall

Alternative 4 includes installation and operation of a line of air sparge (AS) points downgradient of the landfill to reduce the concentrations of chemicals in groundwater migrating downgradient of the landfill area. Alternative 4 also includes installation of ten additional gas collection wells described under Alternative 2; the increased inspection, repair and operational enhancements of Alternative 1; and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

Under Alternative 4, a line or system of AS points would be installed and operated downgradient of the landfill. Air sparging consists of injection of air into the saturated (groundwater) zone. The injected air would volatilize VOC compounds present in the groundwater and would also increase the oxygen levels thereby decreasing the solubility of the trace metals. Given the low levels of VOCs in the groundwater (less than 1 ug/L for the IHSs), operation of an SVE system to remove the VOCs should not be required as part of this system. Existing, or possibly additional, soil vapor probes would be used to verify that the levels of VOCs in soil gas near the AS points are sufficiently low to negate the need for installation and operation of a companion SVE system.

A conceptual layout of an AS system downgradient of the landfill along with the conceptual design of the AS points are provided in Figure 5-6. For purposes of preparing a cost estimate, the following design criteria were considered:

- A pilot test would be conducted during cleanup action design to confirm design criteria;

- Air sparge point well depth of 100 feet, constructed below levels where site-related chemicals were detected;

- A 2 foot screen length in the bottom of the air sparge point well;

- Oil-free compressed air flow rate of 5 cfm per air sparge point;

- Zone of influence (ZOI) of 75 feet per air sparge point (literature indicates range of 1:1 to 2:1 width to depth ratio for ZOI, depending on geologic conditions);

- 30 of the air sparge points would be constructed to the west of the access road and served by aboveground piping (Figure 5-6);

- Seven of the air sparge points would be constructed in the access road located to the east of the leachate pond (Figure 5-6) and would be housed in vaults; buried piping would be needed to serve these wells;

- A 270 cfm oil-free rotary screw compressor would be located at the existing flare/evaporator station; the compressor would be housed in an insulated sound enclosure; and

- The air sparge wall system would be operated for 30 years because it is assumed for purposes of this alternative that the existing source control and containment measures do not effectively limit migration from the landfill and therefore the air sparge wall is intended to treat impacted groundwater as it migrates downgradient from the landfill area.

5.6 Alternative 5 - Excavation and Offsite Re-Disposal of OBWL

Under Alternative 5, the majority of the solid waste materials contained within OBWL would be excavated and transported offsite for disposal. Alternative 5 also includes installation of one additional gas collection well in the Phase II landfill as described under Alternative 2; the increased inspection, repair and operational enhancements of Alternative 1; and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

Under Alternative 5, trackhoes, front-end loaders, and bulldozers would be used to remove and stockpile the OBWL soil cover materials (vegetative topsoil, drainage and low permeability soil layers) and excavate the refuse contained within OBWL. The geosynthetics cover materials (geomembrane, geonet, and geotextiles) would be cut to a width to fit in a roll-off container, rolled-up using a backhoe, and rolls placed in roll-off containers for subsequent transfer to the adjacent solid waste transfer station and loading onto gondola railcars. The excavated refuse would be loaded into trucks or rolloff containers and transported to the adjacent solid waste transfer facility for subsequent transportation to and disposal at the Waste Management facility in Arlington, Oregon. Upon completion of the refuse excavation, the excavated area would be filled with the stockpiled soil cover materials and regraded to achieve drainage and support the adjacent Phase I and II landfill facilities. The regraded area would be revegetated with native grasses and allowed to return to a natural state; that is, the area would not be mowed or otherwise maintained except if and as necessary to protect the integrity of the adjacent landfill areas or leachate or landfill gas collection systems or the environmental monitoring points. Lined drainage ditches would be constructed to direct stormwater from the regraded area to existing stormwater outfall G. Also, removal of OBWL refuse will necessitate installation of new re-routed landfill gas piping in the northeast corner and along the southern edge of the OBWL footprint.

A portion of the solid waste materials in OBWL provide the foundation for the liner and leachate collection system beneath the Phase I Stage A portion of the landfill. Consequently, removal of all of the waste materials within OBWL cannot be conducted without undermining the integrity of the liner and leachate collection system of the Phase I landfill. Therefore, a portion of the OBWL waste materials would need to be left in place. Figure 5-7 shows the approximate extent of waste removal activities that may be conducted under this alternative. It is estimated that a total of approximately 2.1 million cubic yards of in-place waste materials would be removed under this alternative and that approximately 200,000 in-place cubic yards of the existing wastes in OBWL would remain in place. The waste materials that would be left in-place would be recovered and revegetated to restore the integrity of the existing landfill cover over these areas.

6 EVALUATION OF ALTERNATIVES

The alternatives described in Section 5 are evaluated in this section. Descriptions of the MTCA cleanup action alternative evaluation criteria are provided in Section 6.1, followed by evaluation of each of the five alternatives in Section 6.2. Section 6.3 provides a comparative evaluation of the alternatives.

6.1 Evaluation Criteria

MTCA, as implemented by Chapter 173-340-360 WAC, specifies criteria for evaluating and selecting cleanup action alternatives. Minimum requirements for cleanup actions applicable to the Site include Threshold Requirements and Other Requirements specified in WAC 173-340-360 (2) (a) and (b). With respect to Threshold Requirements, the cleanup action shall:

- Protect human health and the environment;
- Comply with cleanup standards;
- Comply with applicable State and federal laws; and
- Provide for compliance monitoring.

For cleanup action alternatives that fulfill the Threshold Requirements, the Other Requirements include:

- Use permanent solutions to the maximum extent practicable;
- Provide for a reasonable restoration timeframe; and
- Consider public concerns.

Detailed descriptions of the MTCA cleanup action alternative evaluation criteria are included in the remainder of this Section.

6.1.1 Threshold Requirements

The Threshold Requirements require that the cleanup action alternative protect human health and the environment, comply with cleanup standards, comply with applicable State and federal laws, and provide for compliance monitoring.

6.1.1.1 Protection of Human Health and the Environment

The MTCA criteria comprise three elements:

- Degree of reduction of existing risk - Future risks can be minimized by achieving cleanup levels and by implementing appropriate institutional controls;

- Time required to reduce risks and attain cleanup standards (or other applicable cleanup action levels) - The time required to achieve cleanup levels would be estimated; and

- On-site/off-site risks due to cleanup actions - Cleanup activities may create risks that previously did not exist. An example is toxic dusts and vapors that might occur from excavation activities if waste at the Landfill is excavated and the waste materials are moved to an off-site location.

6.1.1.2 Compliance with Cleanup Standards and Applicable State and Federal Laws

Each cleanup action alternative is assessed for its compliance with cleanup standards as well as applicable State and federal laws. Cleanup standards were discussed in Section 3 and preliminary standards are listed on Table 3-4. Applicable State and federal laws were discussed in Section 3.2 (ARARs). Compliance factors include the consistency of Federal, State, and local requirements, the activities necessary to coordinate with government agencies, and the ability and time required to obtain any necessary authorization from government agencies. ARARs are tabulated in Tables 3-1 through 3-3. Compliance with three types of ARARs are evaluated:

- Chemical-specific ARARs -Chemical-specific ARARs include:

    - Compliance with cleanup standards: The capability to reduce concentrations of each site-related chemical to its respective cleanup standard at each point of compliance.

    - Compliance with other chemical-specific ARARs.

- Location-specific ARARS - Location-specific ARARs are those requirements that apply solely to the geographic location or physical position of the Site.

- Action-specific ARARs - Action-specific ARARs define requirements applicable to a specific activity that may or may not occur as part of the cleanup action.

6.1.1.3 Provide for Compliance Monitoring

Compliance monitoring is required to demonstrate:

- Protection of human health and the environment;
- Performance of the cleanup action towards achieving cleanup standards; and
- Confirmation that cleanup standards have been achieved.

6.1.2 Other Requirements

The Other Requirements require that permanent solutions be used to the maximum extent practicable, a reasonable restoration timeframe is provided for; and public concerns are considered.

6.1.2.1 Use of Permanent Solutions to the Maximum Extent Practicable

For a cleanup action to be selected, WAC 173-340-360 (3) requires that a disproportionate cost analysis be used to determine whether a cleanup action uses permanent solutions to the maximum extent practicable. The criteria to be used to evaluate and compare each cleanup action alternative when conducting a disproportionate cost analysis are described in WAC 173-340-360 (3) (f) and include:

- Protectiveness;
- Permanence;
- Cost;
- Effectiveness over the long term;
- Management of short-term risks;
- Technical and administrative implementability; and
- Consideration of public concerns.

Protectiveness. The protectiveness criteria include:

- Overall protectiveness of human health and the environment, including the degree to which existing risks are reduced;
- The time required to reduce risk at the facility and attain cleanup standards;
- On-site and off-site risks resulting from implementing the alternative; and
- Improvement of the overall environmental quality.

Permanence. Each cleanup action alternative is assessed for its degree of permanently reducing the toxicity, mobility, and volume of waste through treatment and the permanence of the treatment in achieving cleanup standards by considering the following:

- Treatment capability - The adequacy to which the waste is destroyed.
- Reduction or elimination of releases - The effectiveness of measures to control the source of releases or reduce the magnitude of releases.
- Reduction of future releases (source control) - The adequacy of controls to manage the risk posed by site-related chemicals remaining at the Site following the cleanup action. This criterion also applies to off-site treatment, storage, or disposal facilities used for management of contaminated material from the Site.
- Degree of irreversibility of treatment - The permanence of the treatment technology as evidenced by the chemical and/or physical transformation of the site-related chemicals during the treatment process.
- Quantity/quality of wastes - The quantity and toxicity of the residuals generated by the treatment technology compared to the amount of material processed and the amount of original site-related chemical present.

Cost. The costs for each cleanup action alternative are assessed through consideration of estimated present capital; operation, maintenance, and monitoring (OM&M), net present worth, and incremental costs, as described below. The estimated costs are presented within the +50/-30 percent accuracy range as stated in USEPA's RI/FS guidance (USEPA, 1988). Capital and OM&M costs were prepared using late 2008 dollars. In preparing the capital and OM&M cost estimates, contingency allowances of 25 and 10 percent, respectively, were included to address unforeseen circumstances such as the ability to estimate the scope of any cleanup action alternative at this stage of the FS, uncertainties with respect to unit costs, and the ability to predict the schedule for implementation of any cleanup action.

- Present capital cost: The present capital cost includes all costs for materials and equipment purchases and installation, construction labor, Site improvements, utility connections, contractor fees, engineering design fees, Agency oversight fees, permitting fees, and sales tax.

- Operation, maintenance, and monitoring (OM&M) costs:

  - Operating costs include expenses for labor; electricity, fuel, and other utilities; chemical treatment additives; and waste disposal.

  - Maintenance costs include expenses for routine equipment maintenance, emergency repairs, and scheduled equipment replacement.

  - Monitoring costs include labor, expenses, and equipment to assess progress towards achieving cleanup standards, verify treatment equipment performance, monitor treatment equipment emissions (i.e., to air or water), and sampling and analysis costs for landfill gas, soil gas, soil vapor, stormwater and groundwater media.

- Net present worth of capital and OM&M costs: Net present worth represents the total estimated cleanup action project cost in today's dollars. It is calculated from present capital cost and annual OM&M costs based on the expected project duration and an assumed future interest rate. For this FS, present worth cost estimates for all of the alternatives are based on a 30 year project duration and a Waste Management guidance criteria 3 percent discount rate. OM&M may be required beyond 30 years; however, the present value of future costs beyond 30 years are low. The estimated value of the future OM&M costs is a function of the discount rate used with lower discount rates increasing the present value of future costs and higher discount rates decreasing the present value of future costs.

- Incremental costs - The cost differences of cleanup action alternatives compared to the differences in their capability to achieve the Site cleanup standards, per application of MTCA's disproportionate cost analysis (WAC 173-340-360[3][e]).

<u>Effectiveness over the long term</u>. Each cleanup action alternative will be assessed for its long-term effectiveness in achieving cleanup standards by considering the following:

- Degree of certainty of the cleanup process - The potential success of an alternative based on the existence of a fully developed theoretical basis, available design data, existing successfully operating facilities for similar applications, and availability of commercial vendors.

- Long-term reliability - The nature, degree, and certainties or uncertainties of any long-term management.

- Magnitude of residual risk and degree of reduction in risk - The risk associated with any sources or areas of contamination remaining after achievement of cleanup standards, less any risk reduction achieved through management of the exposure pathways. The characteristics of the residual site-related chemicals are considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, propensity to bioaccumulate, and propensity to degrade.

- Management of treatment residues - The benefits or problems resulting from recycling, destroying, detoxifying, transporting, or containing on-site or off-site site-related chemicals extracted, processed, or accumulated during the treatment processes used for the cleanup action.

- Management of wastes remaining untreated - The effectiveness of the containment strategies, such as engineering or institutional controls, used to manage risks from areas containing residual site-related chemicals.

<u>Management of short-term risks.</u> Each cleanup action alternative will be assessed for:

- The risk to human health and the environment during implementation of the cleanup action, including the potential impacts to on-site workers and adjacent communities during construction of the cleanup action; and

- The effectiveness and reliability of protective or mitigation measures that will be taken to manage such risks.

<u>Technical and administrative implementability</u>. The implementability of each cleanup action alternative will be assessed by considering the following:

- Technical Feasibility:

    - Ability to achieve cleanup standards - The ability of the cleanup action alternative to achieve the cleanup standards identified for each site-related chemical and medium.

    - Constructability - The practical, technical, legal difficulties, and unknowns associated with the construction and implementation of a technology, engineering control, or institutional control, including potential schedule delays.

- Availability of necessary off-site support facilities - The availability of off-site transport, storage, treatment, and disposal services with the required capacities, based on the anticipated nature and quantities of materials to be managed.

- Availability of necessary services and materials - The availability of necessary services, material, equipment, and specialists to implement the cleanup action technology.

- Administrative requirements:

  - Regulatory and permitting requirements - The difficulty and time required to comply with ARARs, coordinate with government agencies, obtain the necessary authorizations, and comply with the substantive requirements of permit programs to implement the cleanup action.

  - Schedule requirements - The time necessary to plan, design, construct, operate, and monitor the cleanup action, including time to obtain authorizations from adjacent property owners and government agencies.

  - Monitoring requirements - The monitoring necessary to ensure effective progress of the cleanup action toward achievement of cleanup standards and to ensure proper operation of the treatment equipment.

  - Construction access - The physical, legal, and contractual barriers to installing and operating the facilities for the cleanup action and to perform short- and long-term monitoring.

  - Operation and maintenance requirements - The level-of-effort and relative costs associated with operation and maintenance, including the need for trained and experienced personnel and equipment complexity and potential downtime.

  - Integration with current Site operations – There are no current operations at the Site. Alternatives will be evaluated for any possible conflicts with existing uses adjacent to the Site such as those associated with the solid waste transfer station and other existing industrial uses in the surrounding areas.

  - Integration with other cleanup actions - The possible conflicts between constructing and operating separate treatment systems necessary to address individual site-related chemicals or contaminated areas.

<u>Consideration of public concerns.</u> See Section 6.1.2.3 below.

6.1.2.2 Provide for Reasonable Restoration Timeframe

To determine whether a cleanup action provides for a reasonable restoration timeframe, the factors to be considered include the following [WAC 173-340-360 (4) (b)]:

- Potential risks posed by the Site to human health and the environments;

- Practicability of achieving a shorter restoration time frame;

- Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

- Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site;

- Availability of alternative water supplies;

- Likely effectiveness and reliability of institutional controls;

- Ability to control and monitor migration of hazardous substances from the site;

- Toxicity of the hazardous substances at the site; and

- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions.

6.1.2.3 Consideration of Public Concerns

Each cleanup action alternative is assessed for its ability to address community concerns. MTCA requires evaluating community concerns in advance of the public involvement process. Therefore, the following potential community concerns have been identified:

- Protection of human health - The results achieved by the cleanup action to reduce actual or potential threats to human health in the areas surrounding the Landfill.

- Control of further releases - The ability of the cleanup action to permanently "fix" the problem and to eliminate the Landfill as a concern for the community.

- Community impacts - The impacts to the community from construction and operation of the cleanup action, including air pollution, odors, noise, vehicle traffic, and other concerns.

The specific concerns of the community around the Site were solicited in 2000 during the public comment period on the MTCA Agreed Order. These concerns included the following:

1. All state and federal laws should be followed and standards met;

2. The aquifer flow should be known;

3. Domestic water supply wells should be protected; and

4. Occurrences of methane gas should be addressed.

The first of these comments will be addressed through the evaluation of the compliance with cleanup standards and applicable State and federal laws section of the FS as well as identification of ARARs made by Ecology in the Cleanup Action Plan. Characterization of the groundwater flow directions was performed as part of the RI report. Protection of domestic wells is being address through the sampling of the domestic wells as part of the RI and through development and implementation of the new EMP for the Site. Occurrences of methane gas are being addressed by the various corrective action alternatives developed and evaluated in this FS and ultimately by the cleanup action selected by Ecology for the Site. Neighboring landowners also complained about noise and odor issues during the period of time the landfill was operated and these concerns may also apply to some of the potential cleanup action alternatives for the Site.

Interested persons from the community will also have an opportunity to communicate their thoughts about the project during the public comment period for the draft RI and FS reports. Public comments submitted during the comment period will be compiled and addressed by Ecology in a Responsiveness Summary.

6.2 Evaluation of Individual Alternatives

Each of the five potential cleanup action alternatives was evaluated against the minimum requirements for cleanup actions required by WAC 173-340-360 (2) (a) and (b). The results of the evaluation are provided in Table 6-1 and indicate that all of the alternatives satisfy both the Threshold and Other Requirements.

A disproportionate cost analysis was then used to determine whether a cleanup action uses permanent solutions to the maximum extent practicable. The analysis compares the costs and benefits of the cleanup action alternatives. As provided for in WAC 173-340-360 (3) (e) (i): “Costs are disproportionate to benefits if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of the other lower cost alternative.” A presentation of the evaluation and benefit scores of the potential cleanup action alternatives using the criteria for the disproportionate cost analysis is included as Table 6-2.

The basis for the benefit scoring and the disproportionate cost analysis are included in Section 6.3. Narrative discussions of the threshold/other requirements and disproportionate cost analysis evaluation criteria with respect to each of the cleanup action alternatives are provided in the rest of this Section 6.2.

6.2.1 Alternative 1 – Increased Inspection, Repair, and Operational Improvements

Alternative 1 includes the continued Post-Closure care activities of operation and maintenance of the existing landfill source control and containment systems, institutional controls, environmental monitoring programs, and reliance on natural attenuation to reduce the levels of existing groundwater contamination located downgradient of the landfill. Alternative 1 also includes enhanced operations and maintenance activities. These additional operations and maintenance activities include more frequent monitoring and balancing of the landfill gas extraction system and extension of the landfill cover geomembrane beneath additional portions of the perimeter drainage ditch system.

Protectiveness

There are no current or anticipated future exposures to wastes. There is no exposure to groundwater at the Site and existing groundwater contamination does not extend to offsite groundwater users. No adverse impacts have been identified to any potential ecological receptors. Consequently, there are no current risks to human health and the environment. Continuation of existing source control and containment actions, Site access controls, and regulatory controls on installation of water supply wells in the area of a solid waste landfill should insure that potential risks to human health and the environment continue to remain low in the future. Therefore, Alternative 1 is protective of human health and the environment.

Based on aquifer property values presented in the RI (Parametrix, 2007) including a value for the hydraulic conductivity for the advance outwash deposits of approximately 150 ft/day, a hydraulic gradient of approximately 0.014 ft/ft, and a saturated thickness of approximately 100 ft, and assuming an aquifer porosity of 25% and a groundwater flow path length of approximately 2000 ft beneath and downgradient of the Phase II area, it will take approximately 250 days (assume one year) to flush one groundwater pore volume from the area beneath and downgradient of the Phase II area. As the flow path beneath the Phase 1 and OBWL area is approximately twice as long, it will take approximately two years to flush one pore volume of groundwater from beneath the Phase I and OBWL area. Therefore, once the additional source control actions have been implemented, it will take a minimum of one to two years for demonstrable improvements in groundwater quality to occur. As improvements in groundwater quality will be identified based on the results of statistical evaluations of potential decreases in chemical concentrations and statistical comparisons of water quality results to cleanup standards, it will take an additional one to two years to obtain sufficient data to document improvements in groundwater quality. As there is variability in the aquifer properties, improvements in groundwater quality may occur slower in some areas, such as in areas where monitoring wells are completed in the lower permeability silt and clay materials associated with the recessional lacustrine deposits. In summary, initial improvements in water quality should be identified within approximately one to three years time. Statistical data analysis documenting water quality improvements at locations near the landfill will take approximately three to five years. Achievement of cleanup standards in wells located in lower permeability materials or at greater distances from the landfill are more uncertain and may take as much as five to ten years to occur.

The levels of vinyl chloride and other site-related chemicals in groundwater are beginning to decline in response to prior actions to improve the effectiveness of the existing source control and containment systems at the Site. Methane levels have declined in probe GP-15 to below the standards established by the Solid Waste Regulations (which are applicable at the Site property boundary) in response to improvements made within the last year to the landfill gas system operation. As shown on Figure 2-12, the levels of vinyl chloride in groundwater in some areas immediately adjacent to or near the landfill (e.g., wells MW-24 and MW-15R) are also beginning to decline in responses to improvements made to the landfill gas system operation. Continuation of the recently implemented improvements in the operation of the source control and containment systems is expected to result in continued decline in the levels of vinyl chloride and other site-related chemicals in groundwater downgradient of the Phase I and II landfills. These improvements combined with the effects of natural attenuation should result in reductions in the concentrations of site-related chemicals in the compliance and downgradient monitoring wells located downgradient of the Phase I and II landfills. As the only additional actions to be implemented at OBWL under Alternative 1 are limited modifications to the landfill gas extraction system operation, improvements in groundwater quality downgradient of the OBWL under Alternative 1 are primarily expected to occur as a result of improvements in the landfill gas extraction operations in the Phase I area located upgradient of OBWL.

No additional risks are expected to be created through operation of this alternative. All emissions and discharges are subject to permitting requirements and engineering controls and treatment as necessary to insure that discharges from the Site do not pose any risk.

Compliance with Cleanup Standards/Applicable State and Federal Laws

As stated above and as displayed on Figure 2-12, reductions in the levels of site-related chemicals are already occurring in response to recently implemented improvements in the operations of the existing source control and containment measures. Continued reductions in the levels of site-related chemicals are expected such that levels of site-related chemicals should decline below the cleanup standards. Therefore, this alternative is expected to meet the chemical-specific ARARs; however, there is some uncertainty as to the magnitude of the improvements that will be realized from the recently implemented operational improvements. The benefits of the recent operational improvements can only be determined through continued operation of the source control and containment systems combined with continued environmental monitoring to determine the expected magnitude of improvements in groundwater quality downgradient of the landfill. This alternative complies with the location- and action-specific ARARs.

Permanence

The Site is a solid waste landfill and therefore waste materials will remain on site. No active treatment of the waste materials will be conducted as part of this or any of the alternatives. Active treatment is performed on the landfill gas and leachate extracted from the landfill that is treated in the evaporator and such treatment completely and permanently destroys any site-related chemicals present in the landfill gas or leachate. Any leachate that is trucked offsite to the WWTP for disposal is treated in conjunction with other waste streams as necessary to meet the POTW NPDES discharge limits. Sludge produced by treatment of leachate in the evaporator is not treated but is disposed of at an off-site permitted landfill.

As discussed above, recently implemented enhancements to the operation of the source control and containment systems have resulted in reduced levels of landfill gas outside of the landfill and have begun to reduce the levels of vinyl chloride in groundwater adjacent to or near the landfill (e.g. MW-24 and MW-15R) and therefore appear to be effective in controlling releases from the landfill.

Costs

The estimated capital costs for Alternative 1 are $0.78 million. Estimated annual costs for operation and maintenance of the source control and containment systems and performance of environmental monitoring range from $0.42 to 1.2 million. Based on a 30-year O&M period and a 3% discount rate, the net present worth for Alternative 1 is estimated to be $11.1 million. The detailed cost estimates for Alternative 1 are included in Table A-1 in Appendix A (Estimated Costs for Cleanup Action Alternatives).

Effectiveness over the Long Term

As stated above and as displayed on Figure 2-12, reductions in the levels of site-related chemicals are already occurring near the landfill in response to recently implemented improvements in the operations of the existing source control and containment measures. There is some uncertainty as to magnitude of the improvements that will be realized from the recently implemented operational improvements. This can only be determined through continued operation of the source control and containment systems combined with continued environmental monitoring to determine the expected magnitude of improvements in groundwater quality downgradient of the landfill.

There are no uncertainties associated with the long-term operation and management activities to be conducted under this alternative and therefore this alternative is considered to be reliable. As the Site is a solid waste landfill that will remain in place after implementation of this or any of the alternatives, the source materials will remain in place. Reduction of risk will be achieved through reduction in migration of chemicals from the source area. Iron and manganese and possibly arsenic, which may be due to natural occurrences, are the only residual site-related chemicals that may remain in the downgradient groundwater after implementation of this alternative. Arsenic, a known carcinogen, poses a potential risk; however, some of the arsenic occurrences appear to be due to natural conditions. Iron and manganese affect the color, appearance and possibly the taste of groundwater but do not pose adverse health risks.

Leachate extracted from the landfill will continue to be treated in the LEU and as necessary through trucking to and disposal at a POTW facility pursuant to the requirements of the NPDES permit. The Site is currently permitted to dispose of leachate at either the Bremerton POTW or the West Sound POTW and therefore sufficient capacity should exist for offsite disposal of leachate. In addition, installation of a cover over the leachate pond, extension of the impermeable geomembrane beneath the perimeter drainage ditches, and other improvements were recently made to decrease the amount of leachate generated by the Site. Improvements were also made to the landfill gas system to increase the quantity and quality of gas extracted from the landfill and thereby increase the amount of leachate that can be destroyed in the LEU.

As stated above, solid wastes will remain in place after implementation of this or any other alternative that may be selected for the Site. The existing source control and containment measures, institutional controls, and environmental monitoring programs are required not only as part of the selection of any cleanup action alternative for the Site but also in accordance with the requirements of the Solid Waste Regulations and the Post-Closure Permit for the Site. The existing source control and containment measures have limited migration of site-related chemicals from the landfill to property owned by the landfill. Recently implemented enhancements to these systems have reduced the levels of landfill gas outside of the landfill and have begun to reduce the levels of vinyl chloride in groundwater adjacent to the landfill (at the locations of performance monitoring well MW-24 and compliance monitoring well MW-15R) and therefore appear to be effective in further controlling risks that may be posed by the residual waste materials.

Management of Short-Term Risks

As stated above, the Site does not currently pose a risk to human health or the environment and implementation of this alternative is not expected to cause any additional or increased risks. No impacts to onsite workers or adjacent communities are expected to occur as a result of the actions taken under this alternative. Existing risks are low and there is no expectation that risks will increase during design, construction or operation and maintenance of this alternative.

Technical and Administrative Implementability

The levels of landfill gas (methane and carbon dioxide) in gas monitoring probe GP-15 have already declined significantly in response to recently implemented improvements in the operation of the landfill gas collection system (Figures 2-13 and 2-14). As displayed on Figure 2-12, reductions in the levels of site-related chemicals in groundwater near the landfill have also been observed. There is some uncertainty as to magnitude of the improvements that will be realized from the recently implemented operational improvements. The benefits of the recent operational improvements can only be determined through continued operation of the source control and containment systems combined with continued environmental monitoring to determine the magnitude of improvements in groundwater quality downgradient of the landfill.

All of the landfill gas treatment and the majority of leachate treatment is performed onsite. As discussed above, the Site utilizes two POTWs for treatment and disposal of any leachate generated in excess of the amounts that can be stored and treated onsite. Prior to installation of the floating cover over the leachate pond, disposal of any leachate generated in excess of the amounts that can be stored and treated onsite generally occurs in the winter months. All of the services and materials necessary for operation and maintenance of the existing source control and containment systems are available onsite or in the immediate area. All permits necessary for continued operation and maintenance of the existing systems are in place and no other administrative requirements are anticipated.

Consideration of Public Concerns

Community concerns specific to the RI/FS have not yet been identified but this alternative is expected to meet the anticipated community concerns described above in Section 6.1.2.3.

6.2.2 Alternative 2 – Landfill Gas Collection System Upgrades

Alternative 2 includes the continued operation of the existing source control and containment systems, institutional controls and environmental monitoring programs described under continued Post-Closure care, the enhanced operations and maintenance activities included under Alternative 1, plus installation and operation of ten additional landfill gas extraction wells. As with Alternative 2 and all of other alternatives, natural attenuation will be relied on to reduce the levels of existing groundwater contamination located downgradient of the landfill.

As this alternative includes the same components and activities as Alternative 1, the results of the detail evaluation of this alternative are essentially the same as those described for Alternative 1. The only difference is that Alternative 2 includes additional gas extraction in conjunction with the operational improvements recently implemented at the Site and those proposed as part of Alternative 1. The goal of Alternative 2 is to further improve landfill gas collection and thereby further reduce the potential for gas to water transfer of VOCs. This alternative also includes the additional perimeter ditch lining improvements described under Alternative 1 to further reduce the amount of leachate generated at the Site.

Given the similarity between Alternative 2 and Alternative 1, the results of the detailed evaluation of Alternative 2 are for the most part the same as the results described above for Alternative 1. Specifically, given the low level of risk posed by the Site, Alternative

2, as well as any of the other alternatives, is protective of human health and the environment. Differences in the evaluation criteria that may occur under implementation of Alternative 2 are discussed below.

The only difference in the evaluation is that by installing additional landfill gas extraction wells and implementing the additional operational enhancements described under Alternative 1, Alternative 2 is anticipated to have a slightly higher degree of certainty of achieving the cleanup goal and maintaining containment of the waste materials. In particular, Alternative 2 includes additional landfill gas extraction from the OBWL and therefore, to the extent that impacts to groundwater quality downgradient of OBWL are a result of gas to water migration, this alternative may result in potentially greater and slightly more rapid improvements in groundwater quality downgradient of OBWL. Alternative 2 would also include a slightly greater amount of extraction and treatment of landfill gas compared to Alternative 1; however, the quality of the additional gas that would be extracted under Alternative 2 is expected to be poor which raises several operational and implementability concerns. Nine of the ten new gas wells will be installed within the OBWL. The waste materials in the OBWL are older and consequently methane production from this portion of the landfill is lower. During the latter half of 2007 and through 2008, methane content of the ten existing gas extraction wells located in OBWL averaged between 11 and 27% compared to a normal operating range of 48 to 52%. Consequently, extraction of additional low methane content gas from OBWL could reduce the heating value of the gas provided to the LEU and potentially reduce the amount of leachate that can be evaporated.

Extraction of lower methane content landfill gas may nonetheless be necessary if OBWL is a source of non-methane organic compounds (NMOCs). The presence of NMOCs such as VOCs within landfill gas in OBWL may be impacting groundwater that flows beneath the OBWL. Alternatively, migration of landfill gas from OBWL, if it is occurring, could impact groundwater quality downgradient of the landfill. Under either of these scenarios, increased extraction of landfill gas from OBWL, even with its lower methane content, should act to reduce impacts to groundwater if OBWL is a source of NMOCs. If it is determined that additional gas extraction from OBWL is necessary, extraction and collection of low-methane content landfill gas from OBWL may need to be separated from extraction and collection of landfill gas from the other portions of the landfill in order to maintain the gas content necessary for operation of the leachate evaporator and landfill gas flare. A separate smaller landfill gas flare that may be augmented with gas collected from other portions of the landfill or possibly through addition of propane or natural gas may need to be constructed and operated in conjunction with the OBWL landfill gas extraction system.

The estimated costs for Alternative 2 include $1.21 million in capital costs, annual OM&M costs ranging from $0.42 to 1.2 million, for a net present worth of $11.6 million. The detailed cost estimates for Alternative 2 are included in Table A-2 in Appendix A.

6.2.3 Alternative 3 – Vadose Zone Gas Investigation and Extraction

Alternative 3 includes investigation of the nature and extent of landfill gas occurrences in soil (soil gas) outside of the landfill and installation of SVE wells to remove any gas occurrences that may be present outside of the landfill. This alternative also includes installation and operation of the ten additional landfill gas extraction wells included under Alternative 2, the enhanced operations and maintenance activities included under Alternative 1, and continued operation of the existing source control and containment systems, institutional controls and environmental monitoring programs as described under continued Post-Closure care. As with the other alternatives, natural attenuation will be relied on to reduce the levels of existing groundwater contamination located downgradient of the landfill under Alternative 3.

As this alternative includes the same components and activities as Alternatives 1 and 2, the results of the detail evaluation of this alternative are essentially the same as those described for Alternatives 1 and 2. The only difference is that Alternative 4 includes a system to capture landfill gas that may have previously migrated from the landfill that may be acting as a source of site-related chemicals in groundwater downgradient of the landfill.

It should be noted that Alternative 3 was identified as a possible alternative based on prior soil gas monitoring data which previously indicated the presence of methane, elevated levels carbon dioxide, and reduced oxygen in gas probes GP-13 and GP-15 and elevated levels of carbon dioxide and reduce oxygen in gas probes GP-7 and GP-8. Gas probe GP-15 is located near monitoring wells MW-23A, MW-24 and MW-15R, all of which contain vinyl chloride at concentrations above the groundwater standards. Well MW-24 also contained 1,1,-dichloroethane and wells MW-23A and MW-24 also contain iron and manganese at concentrations above the groundwater standards. Gas probe GP-8 is located near groundwater monitoring wells MW-4, MW-9 and MW-19C all of which contain vinyl chloride and either iron or manganese at concentrations above the groundwater standards. Gas probe GP-7 is located near the western boundary of the landfill property near groundwater monitoring wells MW-29A, MW-37 and MW-38 where iron and manganese have been detected at levels above the groundwater standards.

As vinyl chloride and 1,1-dichloroethane are volatile constituents that can migrate in the gas phase and iron and manganese solubility are increased under reducing conditions which are likely caused by the presence of landfill gas, it was thought that migration of landfill gas in these areas was a possible cause, in whole or in part, of the groundwater contamination observed in these areas. Therefore, evaluation of an out-of-landfill system for removal of gas occurrences in this area was identified during scoping of the FS as a possible alternative. However, it must be noted that the most recent soil gas monitoring data from GP-15 shows that the methane and carbon dioxide levels declined significantly and the oxygen level increased in this area during the latter part of 2008 and early part of 2009 (Figures 2-13, 2-14 and 2-15). Corresponding declines were observed in vinyl chloride concentrations in groundwater samples obtained from monitoring wells MW-15R and MW-24 in this area. Similar improvements in soil gas quality have not been observed in gas probes GP-7 or GP-8 and may reflect the fact that improvements to the landfill gas extraction system and perimeter ditch system were made in the Phase I and Phase II areas and not in the OBWL area. Improvements in soil gas quality and possibly groundwater quality observed in the GP-15, MW-24 and MW-15R area presumably occurred in response to the improvements in the operation of the landfill gas collection system described in Section 2.4.4 and the extension of the landfill cover geomembrane beneath the perimeter stormwater drainage ditches described in Section 2.4.6 of this FS that were implemented during 2007 and 2008. These improvements are part of the actions included under continued Post-Closure care. Additional improvements to the Phase I and II area landfill gas extraction system operation and performance are included as part of Alternative 1.

Additional time and monitoring are necessary to further verify the effects of the recent improvements to the landfill gas extraction system and to assess the benefits of the additional improvements that may be made in the near future to the Phase I and II area landfill gas extraction system. Therefore, this alternative is considered to be a contingent action in the event that sufficient improvements in groundwater quality are not observed adjacent to and downgradient of the Phase I and II Landfills over the next few years.

The results of the detailed evaluation of Alternative 3 are for the most part the same as the results described above for Alternative 1. Given the low level of risk posed by the Site, Alternative 3, or any of the other alternatives, is protective of human health and the environment. Differences in the evaluation criteria that may occur under implementation of Alternative 3 are discussed below.

Methane levels in gas probe GP-15 declined significantly during the latter portion of 2008 such that the need for installation and operation of an out-of-landfill vapor extraction system no longer appears warranted. Consequently, the potential effectiveness of this alternative in reducing a presumed source of downgradient groundwater contamination may be low if the previously implemented actions or the additional actions described under Alternative 1, which are also included in Alternative 3, prove effective at improving groundwater quality downgradient of the Phase I and II landfills or if the additional gas extraction activities described under Alternative 2 prove effective in reducing groundwater impacts downgradient of the OBWL.

Operation of an out-of-landfill vapor extraction system also poses significant issues for the effectiveness and operation of the existing source control and containment systems, most notably the landfill gas extraction system. Application of vacuum to the subsurface immediately outside of the landfill has a potential for pulling gas out of and increasing gas migration from the landfill.

The estimated costs for Alternative 3 include $1.94 million in capital costs, annual OM&M costs ranging from $0.42 to 1.3 million for a net present worth cost of $12.8 million. The present worth of the costs for Alternative 3 is based on assumed project duration of 5 years for the soil vapor extraction system operation and 30 years of operation for all of the other source control and containment measures and environmental monitoring. The detailed cost estimates for Alternative 3 are included in Table A-3 in Appendix A.

6.2.4 Alternative 4 – Air Sparge Wall

Alternative 4 includes installation and operation of a line of air sparge wells along the downgradient boundary of the landfill to remove VOCs from the groundwater and to increase the dissolved oxygen content and oxidation state of the groundwater and thereby reduce the solubility of arsenic, iron and manganese. This alternative also includes installation and operation of the ten additional landfill gas extraction wells included under Alternative 2, the enhanced operations and maintenance activities included under Alternative 1, and continued operation of the existing source control and containment systems, institutional controls and environmental monitoring programs as described under continued Post-Closure care. As with the other alternatives, natural attenuation will be relied on to reduce the levels of existing groundwater contamination located downgradient of the landfill under Alternative 4.

As this alternative includes the same components and activities as Alternatives 1 and 2, the results of the detail evaluation of this alternative are essentially the same as those described for Alternative 1. The only difference is that Alternative 4 includes in-situ treatment of groundwater immediately downgradient of the landfill to reduce the levels of site-related chemicals in the groundwater.

The results of the detailed evaluation of Alternative 4 are for the most part the same as the results described above for Alternative 2. Given the low level of risk posed by the Site, Alternative 4, or any of the other alternatives, is protective of human health and the environment. Differences in the evaluation criteria that may occur under implementation of Alternative 4 are discussed below.

It is expected that air sparging will quickly result in significant improvement in groundwater quality immediately downgradient of the landfill. Therefore this alternative is expected to achieve cleanup standards relatively quickly. However, as discussed above under continued Post-Closure care, groundwater quality downgradient of the landfill is already beginning to improve in response to the recently implemented improvements demonstrated by declines in the concentrations of vinyl chloride in wells immediately adjacent to or near the landfill such as at performance monitoring well MW-24 and compliance monitoring well MW-15R (Figure 2-12). However, decreases in arsenic, iron, or manganese concentrations have not been observed in conjunction with the decreases in vinyl chloride concentrations. Implementation of Alternative 4 has the potential for improvements in arsenic, iron, and manganese concentrations beyond those seen and expected from implementation of Alternative 1 and 2; however, at this time the magnitude of the water quality improvements that may occur as a result of implementation of Alternative 1 cannot be fully determined. Additional time and monitoring results are necessary to allow for any improvements that may occur as a result of the actions previously taken or the additional actions that may be taken as part of

Alternative 1 can be defined. Therefore, the additional improvements that may be gained through implementation of Alternative 4 at this time are uncertain.

Alternative 4 is the only alternative that includes active treatment of groundwater, although, like the other alternatives, Alternative 4 relies on natural attenuation to reduce the levels of site-related chemicals in groundwater located further downgradient from the landfill. If the actions previously taken or that may be implemented as part of Alternative 1 prove insufficient to achieve the required improvements in groundwater quality, then the magnitude of additional improvements that may be achieve by Alternative 4 could be significant. For this reason, Alternative 4 more closely approximates a contingent action that may be implemented in the future in the event that one of Alternatives 1 through 3 are selected and prove ineffective at achieving the desire level of water quality improvement. As Alternative 4 would be expected to directly and quickly improve the quality of groundwater along downgradient boundary of the landfill, it is expected to achieve the desired level of groundwater quality improvement in wells located immediately downgradient of the landfill one to two years more quickly than the other alternatives which rely on reduction in landfill gas contributions to groundwater contamination. Similar to the other alternatives, Alternative 4 would be expected to take 5 to 10 years to improve groundwater quality downgradient of the point of compliance.

Air sparging could create mounding in the groundwater surface causing divergence of groundwater flow paths around the outer boundaries of the air sparge system. This could result in migration of impacted groundwater around the system. However, this potential has been addressed by extending the system to the northernmost and southernmost portions of the landfill. Operation of the system would need to include monitoring of water levels in the wells to insure that significant groundwater mounding and resultant divergence in groundwater flow is not created.

Air sparging could alter the existing redox state of the groundwater and create more oxidizing conditions which could affect the chemistry of the wetland soils situated near and downgradient of the air sparge array. There are no implementability or other concerns associated with Alternative 4.

The estimated costs for Alternative 4 include $2.64 million in capital costs, annual OM&M costs ranging from $0.53 to 1.31 million for a net present worth of $15.3 million. The present worth of the costs for Alternative 4 is based on assumed project duration of 30 years for the air sparge system and for all of the other source control and containment measures and environmental monitoring. The detailed cost estimates for Alternative 4 are included in Table A-4 in Appendix A.

6.2.5 Alternative 5 – Excavation and Offsite Re-Disposal of OBWL

Alternative 5 includes excavation and offsite re-disposal of the waste materials in OBWL to reduce or eliminate any landfill gas or leachate migration from this area. This alternative also includes installation and operation of one of the additional landfill gas extraction wells included under Alternative 2, the enhanced operations and maintenance activities included under Alternative 1 and continued operation of the existing source control and containment systems, institutional controls and environmental monitoring programs as described under continued Post-Closure care. As with the other alternatives, natural attenuation will be relied on to reduce the levels of existing groundwater contamination located downgradient of the landfill under Alternative 5.

As this alternative includes the same components and activities as Alternative 1, the results of the detail evaluation of this alternative are essentially the same as those described for Alternative 1. The only difference is that Alternative 5 includes source reduction through excavation and offsite re-disposal of the OBWL contents.

The results of the detailed evaluation of Alternative 5 are in part the same as the results described above for Alternative 1. However, this alternative introduces considerable short-term risk to worker health and safety during excavation of the landfill, and additional safety risk to the public along the transportation corridor between the site and Arlington, Oregon where the material will be re-disposed. Therefore, short-term effectiveness will be lower than the other alternatives. Other differences in the evaluation criteria are discussed below.

It is anticipated that excavation and offsite disposal of the OBWL contents would eliminate source materials located in the unlined portion of the landfill; however, complete removal of OBWL is not feasible. The liner and leachate collection system for the Phase IA landfill were constructed over refuse that had previously been disposed in the eastern portion of the OBWL. Removal of this refuse would undermine the integrity of these systems; therefore, a portion (approximately 10 %) of the OBWL cannot be removed in order to protect these systems. Even leaving a portion of the refuse behind to support the Phase I liner and leachate collection system is no guarantee that the excavation will not result in a slope failure or other adverse impact on the Phase I systems.

Although removal of the OBWL should eliminate a potential source of contamination, data are not available and cannot be readily obtained to assess what, if any, contribution OBWL has contributed or is contributing to the presence of site-related chemicals in groundwater downgradient of the landfill. Therefore, although excavation and offsite re-disposal is an effective means of removing a source or possible source of contamination, the effectiveness of removing OBWL in terms of reducing the overall site contribution to groundwater contamination cannot be determined with any degree of certainty.

Solely due to the volume of material and the constraints associated with unloading the excavated waste at the transfer station and subsequently loading it into rail cars, removal of OBWL will require several years to complete. Implementation of this alternative would require increased truck and rail traffic in the area along with significant increases in noise and odors which may be concerns for the surrounding community.

The estimated costs for Alternative 5 include $168 million in capital costs, annual OM&M costs ranging from $0.42 to 1.2 million for a net present worth of $178 million. The present worth of the costs for Alternative 5 is based on assumed project duration of 5 years for the waste excavation and 30 years for all of the other source control and containment measures and environmental monitoring. The detailed cost estimates for Alternative 5 are included in Table A-5 in Appendix A.

6.3 Comparative Evaluation of Alternatives

As discussed below, cleanup action alternatives are comparatively-evaluated in terms of the disproportionate cost analysis evaluation criteria described previously. The alternatives were compared against one another using the disproportionate cost analysis approach. Alternative 1 – Increased Inspection, Repair, and Operational Improvements is considered to be the base alternative because it represents a viable cleanup action with the lowest cost. The benefits and costs of all other alternatives are compared to the base alternative to determine if their higher costs are in proportion to their expected increased benefit. This procedure is termed the "disproportionate cost analysis" and is one of the evaluation steps referenced under MTCA.

For the disproportionate cost analysis conducted in this FS, benefit is defined in terms of these six evaluation criteria: protectiveness, permanence, effectiveness over the long term, management of short-term risks, technical and administrative implementability, and consideration of public concerns. The analysis presented in this FS weights each of six criteria equally. Each cleanup action alternative receives a benefit score from 1 to 3 under each criterion. A benefit score of 1 indicates the alternative satisfies the MTCA criterion the least, while a benefit score of 3 indicates the best performance. A minimum benefit score of 6 and a total maximum benefit score of 18 is possible.

The basis for benefit scoring under each criterion is described below. As discussed previously, cleanup action alternatives are evaluated and benefit-scored in Table 6-2.

6.3.1 Basis for Benefit Scoring

This section indicates the specific factors for each of the MTCA criteria used to assign a benefit score between 1 and 3 to the alternatives.

<u>Protectiveness</u>

1. Protection of human health and the environment is uncertain.

2. Achieves cleanup goals for preventing exposure to site-related chemicals. Provides limited control of future releases to groundwater. Cleanup standards achieved over a long period of time.

3. Prevents exposure to site-related chemicals. Eliminates future releases to groundwater. Cleanup standards are achieved relatively quickly.

Permanence

1. Other than through existing source controls, such as the multi-layer geomembrane cap, leachate collection system, and landfill gas extraction system; site-related chemicals are not permanently reduced in toxicity, mobility, or volume, nor are they irreversibly immobilized or destroyed.

2. Some site-related chemicals would likely be permanently reduced in toxicity, mobility, or volume.

3. Most site-related chemicals would be permanently reduced in toxicity, mobility, or volume.

Effectiveness over the Long Term

1. Cleanup success and long-term reliability are uncertain. Management of treatment wastes and untreated site-related chemicals is uncertain.

2. Moderate probability of cleanup success and long-term reliability. Management approaches for site-related chemicals are moderately certain to succeed.

3. High probability of cleanup success and long-term reliability. Management approaches for site-related chemicals are highly likely to succeed.

Management of Short-Term Risks

1. Protection of human health and the environment is uncertain. May not reduce risks prior to attainment of cleanup standards.

2. Protects human health and the environment. Moderately reduces risks prior to attainment of cleanup standards.

3. Protects human health and the environment. Greatly reduces risks prior to attainment of cleanup standards. Note that because the risk of exposure is low, the overall risks posed by the OVSL site are low and therefore human health and the environment are protected. Consequently, this score can be applied to most of the alternatives unless a specific alternative results in increased short-term risks.

Technical and Administrative Implementability

1. Technology has technical or administrative constraints.

2. Technology that may have some technical or administrative constraints.

3. Conventional and readily-available technology with no expected technical or administrative constraints.

Consideration of Public Concerns

Public concerns are not known at this time. Therefore, potential public concerns were identified and used as the basis for alternative scoring. The list of public concerns will be updated to reflect actual issues brought forth during the public comment period for the draft FS.

1. Does not address public concerns.

2. Partially addresses public concerns, such as reducing long-term releases to groundwater and protection of downgradient groundwater supplies.

3. Addresses public concerns, such as eliminating future releases to groundwater quality relatively quickly.

6.3.2 Cost Basis

Present worth costs for each cleanup action alternative are listed on Table 6-2 and included in Appendix A. A present worth cost is one in which all future costs have been adjusted to the present (using an assumed interest rate to reflect the anticipated time value of money), to account for the fact that funds expended in the future have a lesser value (in today's dollars) than funds expended today. The lesser value of future expenses is due to several factors, including inflation, ability to invest unspent funds, anticipation of greater income in the future, and anticipation that future events may alter the need to expend funds.

6.3.3 Disproportionate Cost Analysis

As an aid to selecting a preferred cleanup action alternative, costs versus benefits were assessed for each alternative, as shown in Table 6-3. The key result of the cost versus benefit evaluation is the cost/benefit ratio, shown in the far right column. This ratio indicates how the cost and benefit of each alternative varies relative to the base alternative. Alternative 1 - Increased Inspection, Repair and Operational Improvements was used as the base cost alternative because it is a viable alternative and estimated to have the lowest present worth cost. Benefit ratios were determined relative to the base case of Alternative 4 – Air Sparge Wall, because it has the highest alternative benefit score of 16 (Table 6-3).

A cost-benefit ratio of 1 indicates that the benefits of an alternative are in proportion to its cost. If the ratio is greater than 1, it indicates that the cost is disproportionate to the benefit. As shown in Table 6-3, all alternatives were judged to have costs that are disproportionate to benefits. Alternative 1 has a cost-benefit ratio of 1.1, indicating that its cost only slightly exceeds its benefit. All of the other alternatives have higher cost-benefit ratios than Alternative 1, ranging from 1.3 to 29, indicating their costs exceed their benefits to a greater degree than for Alternative 1. Figure 6-1 provides a graphical illustration of cost and benefit scores.

Please be aware that although the cost-benefit ratios of many of the potential cleanup action alternatives are relatively similar, the cost-benefit analysis does not fully reflect fundamental issues regarding the potential effectiveness and/or short-term impacts associated with some of the alternatives. For example, although additional gas wells can be installed in the OBWL, collection of poor quality (low methane content) gas from OBWL may affect the operating characteristics of the overall gas collection system and the effectiveness of the LES. Similarly, although it was developed as an alternative during the scoping of the FS, installation and operation of SVE wells outside of the Phase I and II landfill mass may no longer be required as the levels of methane gas and carbon dioxide in gas probe GP-15 have declined and oxygen levels have increased in response to recent changes made to the gas collection system in this area. A contemporaneous reduction in the levels of vinyl chloride in groundwater has also been observed in this area. Operation of SVE wells outside of other portions of the landfill such as OBWL, where landfill gas occurrences and associated impacts to groundwater quality remain, may still be appropriate.

7 PROPOSED ALTERNATIVE

Based on the detailed evaluation of alternatives presented in Section 6, Alternative 1 - Increased Inspection, Repair and Operational Improvements, is the preferred cleanup action alternative. Alternative 1 includes the following components:

- Existing source control and containment systems including:
    - Impermeable cap over the Phase I and II landfill cells and the Old Barney White Landfill to reduce precipitation infiltration and thereby reduce leachate generation;
    - Stormwater runoff diversion and control structures to reduce precipitation infiltration and leachate generation;
    - Impermeable liner beneath Phases I and II to contain leachate;
    - Leachate collection system from the Phase I and II landfill cells;
    - OBWL toe drain leachate collection system;
    - Leachate treatment and disposal systems;
    - Landfill gas extraction and treatment system; and
    - Fencing of the landfill property to control trespass.
- Operations, maintenance, and monitoring activities including:
    - Inspection and maintenance of the landfill cover;
    - Control of growth of weeds and intrusive vegetation to reduce root penetration into and resultant damage to the cover;
    - Inspection and maintenance of stormwater runoff and control structures;
    - Extraction and collection of leachate from the collection system associated with the Phase I and II landfills and from the OBWL toe drain systems;
    - Storage and treatment of the collected leachate in the double lined and covered leachate pond;
    - Disposal of leachate through the LEU or through offsite disposal at the POTW pursuant to the terms of the NPDES permit;

    - Inspection, maintenance, and any required repair of the leachate collection system pumps, piping, transfer and truck load out pumps and the leachate pond liner and cover;

    - Operation and maintenance of the landfill gas vacuum blowers, landfill gas extraction wells, and lateral and header piping to extract and collect landfill gas from the Phase I and II landfills and OBWL;

    - Destruction of the landfill gas in the LEU and/or landfill gas flare;

    - Operation of the landfill gas condensate traps to collect landfill gas condensate and disposal of the condensate in conjunction with leachate disposal;

    - Inspection, maintenance, and any required repair of the landfill gas extraction wells, lateral and header pipes, vacuum blowers, condensate traps, LEU, and landfill gas flare;

    - Inspection and maintenance of the perimeter fencing to limit trespass potential;

    - Inspection and maintenance of existing berms and, if necessary, construction of additional berms across roads or trails to limit trespass potential;

    - Performance of environmental monitoring of leachate, groundwater, stormwater, and soil gas; and

    - Inspection, repair and maintenance of the environmental monitoring points and systems.

- Institutional Controls including:

    - Restrictions on use of the landfill surface;

    - Signage and deed restrictions regarding the presence of the landfill; and

    - Existing regulatory prohibitions on installation of water supply wells on land within 1,000 ft of the waste management unit boundaries of a solid waste landfill.

- Monitored Natural Attenuation:
    - Natural attenuation processes within the context of controlled and monitored Site conditions to achieve the groundwater cleanup standards in downgradient groundwater.

Alternative 1 also includes the following additional improvements/enhancements to reduce potential leachate generation, increase leachate capture, optimize gas collection, and prevent migration of landfill gas from the landfill. As discussed in Section 2, nearly all of these operation enhancements, repairs and improvements have recently been implemented by Waste Management. The locations and descriptions of these elements are provided on Figure 5-2.

- Repair/modification of the landfill cover system along the landfill toe to reduce potential for stormwater infiltration and resultant leachate generation and to reduce potential for atmospheric air intrusion and resultant increased oxygen levels and loss of vacuum applied by the landfill gas system;

- Inspection, and repair if necessary, of penetrations to cover system to reduce potential for atmospheric air intrusion and resultant increased oxygen levels and loss of vacuum applied by the landfill gas system;

- Repair/replacement of landfill gas extraction wells containing blockages that restrict gas extraction and flow;

- Repair/replacement of landfill gas extraction system conveyance piping as needed to eliminate blockages that restrict gas extraction and flow;

- Repair/replacement of condensate collection equipment as needed to reduce condensate accumulation in the piping that causes blockages, thereby restricting gas extraction and flow;

- Maintenance/repair of landfill gas system vacuum blowers to optimize gas extraction and flow;

- A program of optimization of the landfill gas collection system (wellfield balancing) to insure that all portions of the landfill are subject to vacuum thereby minimizing the potential for gas migration from the landfill;

- Increased inspection, maintenance and adjustment of the leachate collection system pumps to insure optimum performance of the leachate extraction system;

- Repair and improvement of the perimeter stormwater drainage diversion and control system to minimize the potential for stormwater infiltration into the landfill and resultant leachate generation;

- Installation of a floating cover to eliminate rainwater accumulation in the leachate pond to reduce the amount of leachate requiring treatment or disposal; and

- Permitting of alternate leachate disposal facilities to insure sufficient capacity for leachate collection and disposal.

This preferred cleanup action alternative includes performance of all of the activities required by the Post-Closure Maintenance Plan (GeoSyntec, 2002) and Post-Closure Permit (KCHD, 2008) pursuant to the closure and post-closure requirements of the Solid Waste Regulations (WAC 173-351). This alternative provides a practical cleanup action at a reasonable cost while reducing the potential for landfill gas or leachate migration from the landfill and resultant impacts to downgradient groundwater.

Alternative 1 best satisfies the six disproportionate cost analysis evaluation criteria of protectiveness, permanence, effectiveness over the long term, management of short-term risks, technical and administrative implementability, and consideration of public concerns. This preferred cleanup action alternative also provides the best balance of costs and benefits. The cost/benefit ratio for Alternative 1 is 1.1 whereas the cost/benefit ratios for the other alternatives are higher, ranging from 1.3 to 29.

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Tables

Table 3-1 - Potential Chemical-Specific ARARs

Statute/Regulation	Status	Requirements
Federal ARARs		
Federal Safe Drinking Water Act Citation: 42 USC 300f et seq. 40 CFR 141,143	Relevant and Appropriate	Defines Maximum Contaminant Levels (MCLs) for drinking water
Pertaining to Groundwater Discharge to Surface Water: National Recommended Water Quality Criteria Citation: 2002 table (EPA-822-R-02-047) last updated November 9, 2009	Relevant and Appropriate	Contains ambient water quality criteria for aquatic life and human health
Citation: 40 CFR 131.36		
State of Washington ARARs		
Model Toxics Control Act Citation: RCW 70.105D Chapter 173-340 WAC	Applicable	Identifies procedures for establishing cleanup levels for groundwater, surface water, sediments, and soil
State Group A Public Water Systems Citation: Chapter 246-290 WAC	Relevant and Appropriate	Defines MCLs for drinking water
Pertaining to Groundwater Discharge to Surface Water: Water Quality Standards for Surface Water Citation: Chapter 173-201A WAC	Relevant and Appropriate	Eatablishes water quality standards for surface waters; all surface waters protected by narrative criteria, designated uses and an antidegradation policy.

Table 3-2 - Potential Location-Specific ARARs

Statute/Regulation	Status	Requirements	Notes
State of Washington and County ARARs			
Water Well Construction Citation: RCW 18.104 WAC 173-160-171 Kitsap County Board of Health Ordinance 2004-2	Applicable	No water wells to be located within 1,000 ft of the waste management boundary of a solid waste landfill.	No wells in upper aquifer are within the restricted area.
Kitsap County Board of Health Citation: Ordinance 2004-2	Applicable	Requires methane testing for buildings within 1,000 ft of the active area of an active, closed, or abandoned landfill.	Applies to new buildings added as part of remediation (no existing buildings are within affected area).
Kitsap County Board of Health Citation: Ordinance 2004-2	Applicable	Adopts Chapter 173-351, Criteria for Municipal Solid Waste Landfills and Chapter 173-350 for surface impoundments by reference.	Chapter 173-351 includes provisions for quarterly groundwater monitoring, until trends are clearly established.
Kitsap County Local Development Ordinances Citation: KCC Title 12	Relevant and Appropriate	Local codes provide standards for all construction activities, including stormwater management and grading.	Plans review and building permit not required, but planned facilities must meet substantive requirements of applicable codes for stormwater, grading, and other factors.

Table 3-3 - Potential Action-Specific ARARs

Statute/Regulation	Status	Requirements	Notes
Federal ARARs			
Federal Resource Conservation and Recovery Act (RCRA) Citation: 42 USC 6902 et seq. and RCRA, HWMA Citations: 40 CFR 261, 262, 264	Applicable	Defines hazardous waste management requirements.	Applies to management of hazardous/ dangerous waste. If wastes are removed from the disposal areas, the wastes will be managed in accordance with these requirements.
RCRA, HWMA, and DOT Citation: 40 CFR 263 49 CFR 171, 172, 173, 177	Applicable	Defines requirements for off-site transportation of waste.	Applies to transportation of waste off-site. Actions will comply with these requirements.
RCRA, HWMA Citation: 40 CFR 268	Applicable	Defines pre-treatment and land disposal restrictions for certain wastes.	Applies to disposal of hazardous/dangerous wastes off-site. Wastes from OVSL probably will not require additional treatment or be subject to restrictions.
RCRA, HWMA Citation: 40 CFR 257, 258	Applicable	Defines requirements for solid waste management and disposal facilities.	Applies to closure of solid waste landfills including capping, installation of gas systems, and environmental monitoring. Future site actions will comply with these regulations regardless of cleanup action alternative selected (including No Additional Actions).

Table 3-3 - Potential Action-Specific ARARs (continued)

Statute/Regulation	Status	Requirements	Notes
Federal Water Pollution Control Act (a.k.a. Clean Water Act) National Pollutant Discharge Elimination System (NPDES) Citation: 33 USC Sec. 303, 304 40 CFR Part 122, 125	Relevant and Appropriate	Establishes State permit program for discharge of pollutants and wastewater to surface waters. Requires all known, available, and reasonable methods of treatment.	Applies to discharge of extracted treated groundwater to surface water. Discharges to surface waters will comply with substantive requirements of these regulations; however, permit not required per MTCA exemption.
Federal Clean Air Act: New Source Performance Standards, National Emission Standards for Hazardous Air Pollutants, National Ambient Air Quality Standards Citation: 42 USC 7401-7642 40 CFR Subpart 50, 60, 61, 63	Relevant and Appropriate	Establishes program for source registration and fee payment to restrict emissions, use Best Available Control Technology (BACT), and ensure compliance with air quality standards.	Applies to installing or operating source having emissions to atmosphere. Alternatives emitting contaminants to atmosphere will comply with substantive requirements of these regulations; however, source registration not required per MTCA exemption.

Table 3-3 - Potential Action-Specific ARARs (continued)

Statute/Regulation	Status	Requirements	Notes
		State of Washington ARARs	
Model Toxics Control Act Citation: RCW 70.105D.090	Applicable	Defines hazardous waste cleanup policies. Actions conducted under consent decree are exempt from the procedural requirements of RCW 70.94, 70.95, 70.105, 75.20, 90.48, and 90.58 and the procedural requirements of any laws requiring or authorizing government permits or approvals for cleanup actions. Actions shall comply with substantive requirements adopted pursuant to such laws and shall consult with government agencies charged with implementing such laws.	Performing cleanup under Consent Decree. Cleanup action activities will comply with substantive requirements of ARARs.
Model Toxics Control Act Regulations WAC 173-340	Applicable	Establishes administrative processes and standards to identify, investigate, and clean up facilities where hazardous substances have come to be located.	Applies to any facility (including landfills) where hazardous substance releases to the environment have been confirmed. Also specifies application of cleanup levels.
Chapter 173-351 WAC Criteria for Municipal Solid Waste Landfills	Applicable	Defines requirements for solid waste management and disposal facilities.	Applies to disposal at new landfill of solid waste/soil excavated from site. These regulations apply if new landfill is in Washington; however, disposal will likely occur at a landfill in Oregon. If so, these regulations do not apply, but Oregon regulations would apply.
State Hazardous Waste Management Act (HWMA) Citation: RCW 70.105: Definition/generation of hazardous/dangerous waste	Applicable	Defines threshold levels and criteria to determine whether materials are hazardous/dangerous wastes.	Applies to designation, handling, and disposal of wastes. Treatment residuals meeting these criteria will be handled and disposed of in accordance with regulatory requirements.

Table 3-3 - Potential Action-Specific ARARs (continued)

Statute/Regulation	Status	Requirements	Notes
Chapter 173-303-140 WAC Disposal Requirements and Land Disposal Restrictions Solid Waste Disposal Facilities	Applicable	Defines pre-treatment and land disposal restrictions for certain wastes.	Applies to disposal of hazardous/dangerous wastes off-site. Wastes probably will not require additional treatment or be subject to restrictions.
WAC 446-50 Transportation of hazardous/ dangerous waste	Applicable	Defines requirements for offsite transportation of waste.	Applies to transportation of waste off-site. Actions will comply with these requirements.
State Environmental Policy Act (SEPA) Citation: RCW 43.21 C Chapter 197-11 WAC	Applicable	Defines requirements for evaluating environmental impacts of a governmental action, such as Department of Ecology selecting a cleanup action.	Applies to the evaluation of environmental impacts of various cleanup activities. Cleanup activities will require submittal of a checklist describing the environmental impacts of the proposed project, public notice, and possibly additional project analyses and public involvement. All alternatives are anticipated to receive a Determination of Non-Significance, except possibly Alternative 7 may require an environmental impact statement.
State Water Pollution Control Act, NPDES Regulations Citation: RCW 90.48 Chapter 173-220 WAC	Relevant and Appropriate	Establishes program for permitting discharges to surface waters.	Applies to discharge of treated groundwater to surface water.
State Clean Air Act: Source Registration Emissions Limits, Air Quality Standards Citation: RCW 70.94 Chapter 173-400 WAC	Relevant and Appropriate	Establishes state approved program for source registration and fee payment to restrict emissions, use of BACT, and ensures compliance with air quality standards.	Applies to installing or operating source having emissions to atmosphere. Alternatives emitting contaminants to atmosphere will comply with substantive requirements of these regulations.

Table 3-3 - Potential Action-Specific ARARs (continued)

Statute/Regulation	Status	Requirements	Notes
Puget Sound Clean Air Agency (PSCAA), Source Registration, Emission Limits, Air Quality Standards Citation: Regulation I, III	Relevant and Appropriate	Establishes local approved program for source registration and fee payment to restrict emissions, use of BACT, and ensures compliance with air quality standards.	Applies to installing or operating source having emissions to atmosphere. Alternatives emitting contaminants to atmosphere will comply with substantive requirements of these regulations.
Puget Sound Clean Air Agency (PSCAA) Citation: Regulation III	Relevant and Appropriate	Local air quality standards for toxics.	Applies to installing source emitting regulated toxic air pollutants to the atmosphere.
State Clean Air Laws: Controls for Air Toxics (Air Quality Standards) Citation: RCW 70.94 Chapter 173-460 WAC	Relevant and Appropriate	Air quality standards for toxics: Vinyl chloride: 0.012 ug/m3, annual average	Applies to installing source emitting regulated toxic air pollutant to atmosphere. Alternatives emitting vinyl chloride to atmosphere may require off-gas treatment. No iron, arsenic or manganese emisisons to the atmosphere anticipated.

Table 3-4 - Preliminary Groundwater Cleanup Levels

Indicator Hazardous Substance	**Units**	Groundwater Standards & Criteria			Protection of Surface Water										Background	Cleanup Level	Basis
			MTCA Method B CLARC Database Levels		WA Surface Water Quality Standards (b)		National Toxics Rule (c)				National Recommended Water Quality Criteria (d)						
		Federal/State MCL (a)	Carcinogen $1x10^{-6}$ risk	Noncarcinogen	Freshwater Max Conc.	Freshwater Continuous Conc.	Freshwater Max Conc.	Freshwater Continuous Conc.	HH water + organism	HH organism only	Freshwater Max Conc.	Freshwater Continuous Conc.	HH water + organism	HH organism only	Prediction Limit (e)		
Arsenic	mg/l	0.01	0.000058	0.0048	0.36	0.19	0.36	0.19	0.000018	0.00014	0.34	0.15	0.000018	0.00014	0.000462	**0.000462 mg/l**	prediction limit
Iron	mg/l	0.3	NE	NE	NE	NE	NE	NE	NE	NE	NE	1000	300	NE	0.23	**0.3 mg/l**	lowest value
Manganese	mg/l	0.05	NE	2.2	NE	NE	NE	NE	NE	NE	NE	NE	50	100	0.031	**0.05 mg/l**	lowest value
1,4-Dichlorobenzene	µg/l	75	1.8	NE	NE	NE	NE	NE	400	2,600	NE	NE	63	190	NA	**18 µg/l**	other (g)
1,1-Dichloroethane	µg/l	NE	NE	1,600	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	**1,600 µg/l**	lowest value
cis-1,2-Dichloroethene	µg/l	70	NE	80	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	**70 µg/l**	lowest value
Ethyl ether	µg/l	NE	NE	1,600	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NA	**1,600 µg/l**	lowest value
Trichloroethene	µg/l	5	0.49	2.4	NE	NE	NE	NE	2.7	81	NE	NE	2.5	30	NA	**2.4 µg/l**	other (h)
Vinyl Chloride	µg/l	2	0.029	24	NE	NE	NE	NE	2	525	NE	NE	0.025	2.4	NA	**0.29 µg/l**	other (i)
Ammonia	mg/l	NE	NE	NE	36.7 (f)	0.00057 (f)	NE	NE	NE	NE	NE	NE	NE	NE	0.19	**0.19 mg/l**	prediction limit

(a) MCL = maximum contaminant level as either a federal or state primary or secondary drinking water standard

(b) from WAC 173-201A-240

(c) 40 CFR Part 131

(d) Section 304 of the Clean Water Act

(e) Background prediction limits based on 99% upper tolerance limit

(f) assumes pH of 6 and temperature of 12 degrees C

(g) MCL adjusted downward to $1x10^{-5}$ cancer risk in accordance with WAC 173-340-720(7)(b)

(h) Noncarcinogen value associated with a Hazard Index of 1, because it is lower than the MCL adjusted downward to $1x10^{-5}$ cancer risk in accordance with WAC 173-340-720(7)(b)

(i) MCL adjusted downward to $1x10^{-5}$ cancer risk in accordance with WAC 173-340-720(7)(b). Lower value from National Recommended Water Quality Criteria for human health ingestion of water and organisms not applicable because WA has established drinking water standards for vinyl chloride.

NE = Not established

NA = Not applicable; background for volatile organics is assume to be zero, therefore no prediction limits are calculated.

Table 4-1: Screening of Technologies

General Response Action/Technology	Description of Technology	Technical Feasibility (Effectiveness)	Implementability	Cost	Retained or Rejected
Containment of Refuse					
Institutional Controls	Legal methods such as land use, access, and deed restrictions or other non-engineered practices to reduce human contact with and possible health effects occurring for contacting waste. Can be used to prevent inappropriate future land use and activities such as building on the site that could damage engineered landfill structures (e.g., landfill cover, LFG extraction, and leachate collection facilities). Current institutional controls include restrictions on the use of the landfill surface, signage, and deed restrictions regarding the presence of the landfill.	Effective if monitored and maintained.	Readily implemented.	Very low	Retained
Engineered controls	Fencing of the landfill property.	Effective at preventing unauthorized access.	Readily implemented. Site is fenced with locked gate. Berms are maintained that were constructed of fallen tree limbs and brush located just inside of the fence prevent trespassers.	Low	Retained.
Impermeable bottom liner installation at OBWL	Excavate/replace waste. Remove and stockpile existing cover, excavate and stockpile waste material, install engineered impermeable lining and leachate collection systems in accordance with State regulations, refill and re-cover landfill.	Would be effective at containing any leachate. In the short term, would cause significant odor and safety concerns associated with removing the existing waste. Temporary stockpile area would require engineered liner and collection of any leachate and stormwater.	Presents significant technical and administrative implementability concerns. Insufficient suitable space on-site to temporarily stockpile cover materials and waste during construction of new liner. Need to assure there are no slope stability issues associated with the adjacent Phase II landfill during waste excavation and replacement. Will require multiple years to execute during which waste will be exposed to precipitation.	Very high	Rejected
Impermeable bottom liner installation at OBWL	Pressure grouting. Inject impermeable grout at high pressure into soil beneath the OBWL to provide seal to prevent leachate drainage to groundwater.	Cannot necessarily install complete impervious seal after waste material has been placed in the landfill. Any unsealed area would continue to release leachate.	Would be difficult to construct continuous liner. Hundreds of grout injection points would require penetration and subsequent resealing of geosynthetics in cover system.	Very high	Rejected
Excavation and re-disposal of OBWL contents in engineered landfill	Would involve removal and stockpiling or disposal of low permeability, drainage, and vegetative cover layers; removal and disposal of geosynthetic cover layers; excavation of waste; transport of waste to an existing off-site permitted landfill; regrading of excavated area to control stormwater runoff; and assure there are no slope stability issues associated with adjacent Phase II landfill.	Removal of wastes from a landfill provides effective source control by eliminating any potential contribution of site-related chemicals to groundwater from leachate and landfill gas from the OBWL.	Presents significant technical and administrative implementability concerns including coordination of truck hauling, transfer station operation, and rail hauling of waste to another landfill over multiple-year duration; and environmental impact concerns including fugitive dust, odor, blowing litter, surface water control. May require considerable worker protection measures.	Very high	Retained
Landfill cover enhancements	Activities to prevent infiltration of precipitation or stormwater runoff from entering the landfill through or around the base of the cover, including improving seals between geomembrane layer of cover and penetrations (landfill gas wells and piping) and modifications to base of cover to prevent introduction of stormwater from perimeter drainage ditches.	Effective at reducing leachate flow. Secondary effect of increasing landfill gas flow.	Readily implemented. Improvements to the stormwater management system and cover were initiated in 2008, including excavation of the perimeter drainage ditches and adjacent toe of the landfill to extend the flexible membrane portion of the cover system beneath the perimeter drainage system. If monitoring of leachate flows show a reduction in leachate generation, additional ditch lining may be performed in 2009.	Low	Retained

Table 4-1: Screening of Technologies

General Response Action/Technology	Description of Technology	Technical Feasibility (Effectiveness)	Implementability	Cost	Retained or Rejected
Containment of Leachate					
Leachate flow monitoring	Monitor leachate flow from leachate force main and discharge from OBWL toe drain.	Provides data to evaluate trends in flow and to assess effectiveness of any cover system improvements.	Readily implemented. Flow from leachate force main into lined leachate pond has been monitored. As part of the EMP, OBWL leachate flow from the OBWL toe drain, if any, is monitored and a sample is collected.	Very low	Retained
Inspect and repair leachate collection systems	Periodically inspect aboveground components of leachate collection system: leachate risers, manholes, cleanouts, influent monitoring station and flowmeter, covered lagoon components, and evaporator. If necessary, conduct video inspection of collection piping and jet cleaning through cleanouts.	Effective at determining whether collection systems are operating properly.	Readily implemented. May be difficult to clean north-south aligned leachate collection piping in Phase I Stage A area.	Low	Retained
Extract leachate from OBWL	In addition to existing toe drain, construct new vertical or horizontal leachate collection wells at bottom of OBWL.	It is not known how much, if any, that leachate generated within OBWL is contributing to the site-related chemicals observed downgradient of the landfill. Therefore, effectiveness of additional leachate collection facilities within the landfill is unknown. Construction of vertical leachate collection wells may provide conduits for leachate migration through any daily or intermediate cover layers within the landfill and accumulation of leachate at the bottom of the landfill. Leachate collection facilities constructed after a landfill has been filled are not anticipated to effectively recover the majority, if any, of leachate present.	It is difficult to install wells in a heterogeneous unit such as an old landfill, especially where there is little construction documentation.	High	Rejected
Containment of Landfill Gas					
LFG monitoring	Monitor for presence of LFG in perimeter gas monitoring probes adjacent to disposal areas and near site boundaries. Measure vacuum and flow. Assess gas composition. Record condensate volumes.	Effective at assessing performance of landfill gas collection system and trends in gas production.	Readily implemented.	Very low	Retained
LFG system assessment, optimization	Conduct video inspection of LFG wells, riser piping, and conveyance piping to assess structural or condensate blockages. Install flow monitoring and sampling ports in conveyance piping. Perform wellfield balancing to assure that all portions of the landfill are subject to vacuum thereby minimizing the potential for gas migration. Evaluate blower and flare operation and efficiency. Assess quality of LFG from wells.	Effective at increasing flow of landfill gas and decreasing/minimizing potential for gas migration from landfill. Methane levels in gas probe GP-15 have declined significantly since late 2008.	Readily implemented.	Low	Retained

Table 4-1: Screening of Technologies

General Response Action/Technology	Description of Technology	Technical Feasibility (Effectiveness)	Implementability	Cost	Retained or Rejected
Containment of Landfill Gas (cont'd)					
LFG system improvements	Modify wellhead control assemblies; repair lateral and header junction piping; replace brittle piping materials with HDPE materials; repair LFG wells, gas conveyance piping, and condensate collection equipment that contain blockages and restrict gas flow; repair/replace condensate traps; repair cover penetration seals at existing, new, and abandoned wells; install new gas monitoring probes; increase blower capacity.	Effective at increasing flow of landfill gas and decreasing/minimizing potential for gas migration from landfill. Methane levels in gas probe GP-15 have declined significantly since late 2008.	Readily implemented.	Low	Retained
New LFG wells	Installation of new LFG extraction wells in areas outside of radii of influence (ROI) of existing wells or to replace existing blocked or ineffective wells. Includes abandonment of inoperable wells. (Note: 35 existing LFG extraction wells were replaced in 2008.)	May increase flow of landfill gas from those areas outside of ROI of existing wells. May decrease or minimize potential for gas migration from landfill.	Requires removal of cover where wells would be constructed and lateral piping trenched and subsequent patching of cover geomembrane and associated sealing of patches above piping trenches and at wellheads.	Moderate.	Retained.
Protection of Groundwater					
Institutional controls	Prohibitions on installation of water supply wells on land within 1,000 ft from the solid waste within a solid waste landfill. Specifically, subsection (3) (b)(vi) of WAC 173-160-171 (Construction and Maintenance of Wells) prohibits water supply wells from being located within 1,000 ft of the solid waste within a solid waste landfill.	Effective if monitored and maintained.	Readily implemented.	Very low	Retained
Groundwater monitoring	Collect groundwater samples from wells in the groundwater monitoring network at the frequencies specified in the EMP; analyze samples for parameters specified in the EMP; evaluate results with respect to presence of site-related chemicals and compliance with MTCA and Solid Waste Regs; use monitoring data to assess effectiveness of any operational improvements and/or implemented cleanup action(s).	Effective at assessing performance of natural attenuation and other technologies.	Readily implemented.	Low	Retained
Natural attenuation	Toxicity and mobility of chemicals introduced to the environment are decreased by natural physical, chemical, and/or biological processes such as dilution, dispersion, volatilization, and biodegradation in the case of VOCs and by oxidation, precipitation, and adsorption in the case of trace metals. Relies on natural processes, within the context of a controlled and monitored cleanup action approach, to achieve cleanup goals within a reasonable timeframe. Natural processes at the Site that may reduce arsenic, iron, and manganese concentrations in groundwater are oxidation and geochemical fixation/precipitation. Long-term groundwater monitoring program required to evaluate effectiveness.	Natural attenuation is most appropriate (WAC 173-340-370(7)) for sites where source control is concurrently and effectively applied; human health and the environment are protected; site-specific cleanup goals can be achieved in a reasonable time frame; migration of groundwater is limited; transformation of site-related chemicals into more mobile or more toxic substances is unlikely; transformation processes are irreversible; effectiveness of attenuation processes can be supported with site-specific data; methods to monitor cleanup action progress are available; and backup or contingency plans are available.	Readily implemented. Natural attenuation is occurring at the Site, as evidenced by the low levels of vinyl chloride precursors and variations in dissolved oxygen levels supporting the presence of changes in redox conditions. Concentrations of vinyl chloride are decreasing in monitoring wells. Also, biodegradation of wastes in the landfill is reducing the quantities of leachate and landfill gas produced over time.	Low	Retained

Table 4-1: Screening of Technologies

General Response Action/Technology	Description of Technology	Technical Feasibility (Effectiveness)	Implementability	Cost	Retained or Rejected
Protection of Groundwater (cont'd)					
Soil vapor extraction (SVE)	Would be designed to capture any landfill gas in the vadose zone that may have previously migrated from the landfill and may be acting as a source of site-related chemicals in groundwater downgradient of the landfill. EPA Presumptive Remedy for VOC's in soil. Vacuum is applied to soil using vertical extraction wells or horizontal vents (installed in trenches or horizontal borings) to create a pressure/concentration gradient to induce the controlled flow of air and remove volatile and some semivolatile chemicals from impacted soil. Depending on concentration of chemicals, offgas from system may have to be treated to recover or destroy the contaminants.	Could be effective at reducing concentrations of VOCs in vadose zone. (Note: Since methane levels in gas probe GP-15 declined significantly during the latter portion of 2008, the need for installation and operation of an out-of-landfill SVE system may not be warranted in this area.)	Operation of out-of-landfill SVE system may pose concern with operation of the existing landfill gas extraction system. Application of vacuum to the subsurface immediately outside of the landfill has potential for increasing gas migration from the landfill.	Moderate capital and OM&M costs.	Retained
Containment of groundwater	<u>Physical barriers.</u> A slurry wall (impermeable wall of bentonite/soil mixture trenched from ground surface to level below location of site-related chemicals, forming a barrier to groundwater flow) or cutoff wall (metal sheet pilings driven into the ground to form barrier to groundwater flow) would be constructed to level below location of site-related chemicals.	Could create increase in groundwater surface upgradient of barrier causing divergence of groundwater flow paths around the outer boundaries of the barrier and migration of impacted groundwater around the system.	Site-related chemicals are at depths below where cost-effective to implement with conventional equipment.	High capital, low O&M	Rejected,
Containment of groundwater (cont'd)	<u>Hydraulic containment</u>. Groundwater extraction wells or infiltration trenches would be completed to a level below location of site-related chemicals. Groundwater would be pumped from the wells or trenches at the minimum flowrate necessary to achieve hydraulic containment. Would also require above-ground treatment of extracted groundwater.	Proving achievement of hydraulic containment with very low concentrations of site-related chemicals may be difficult.	Achieving hydraulic containment would likely require high groundwater flowrates and resultant sizeable aboveground treatment equipment to remove very dilute concentrations of vinyl chloride. Would require aboveground VOCs and metals removal treatment processes and subsequent discharge of treated groundwater.	Moderate capital, very high O&M	Rejected,
Above-ground treatment of groundwater (if groundwater is extracted via hydraulic containment)	<u>VOCs removal:</u> *Air stripping* is the physical transfer of a volatile compound from the groundwater to the air, usually in a counter-current tower where water is introduced at the top of the tower and air is blown in at the bottom. Once in the vapor phase, the compound may be emitted to the atmosphere without treatment or treated via additional technologies prior to discharge to the atmosphere.	*Air stripping* is an effective technology for VOCs removal. Vinyl chloride is very volatile and readily transfers to air. Metals and other inorganics are not removed in this process.	Pretreatment of groundwater may be required to prevent scaling on the media in the air stripping tower. Would also require discharge of treated groundwater to receiving water body or recharge to groundwater.	Moderate capital, high O&M	Rejected, as hydraulic containment is rejected.
	<u>VOCs removal:</u> *Granular activated carbon* (GAC) is a specially manufactured carbon with a high surface area capable of sorbing a large variety of primarily organic substances. Groundwater is pumped through contactors filled with GAC and subsequently discharged to a receiving water body or recharged. GAC is not compound-specific and simultaneously adsorbs multiple compounds at different rates. After the GAC has adsorbed to its full capacity, it is typically shipped off-site for regeneration.	*GAC:* Vinyl chloride adsorbs poorly to GAC in the water phase, thus requiring extremely large quantities of carbon and very frequent replacement.	Metals and other inorganics are not typically removed in this process. Pretreatment of groundwater may be required to prevent scaling on the media. Would also require discharge of treated groundwater to receiving water body or recharge to groundwater.	Low capital, very high O&M	Rejected, as hydraulic containment is rejected.

Table 4-1: Screening of Technologies

General Response Action/Technology	Description of Technology	Technical Feasibility (Effectiveness)	Implementability	Cost	Retained or Rejected
Protection of Groundwater (cont'd)					
Above-ground treatment of groundwater (if groundwater is extracted via hydraulic containment) [cont'd]	Metals removal. Precipitation/settling is an aboveground treatment process used to remove dissolved metals by adjusting the pH to alkaline using lime, caustic, ferric chloride, or other agents in a stirred tank reactor to cause the metals to precipitate. Alum or other coagulation/flocculation agents are added to agglomerate the precipitated metal particles and the flocs settled in a clarifier. Most metals have solubilities in water that reach a minimum at a pH between 8 and 10, depending on the specific metal. Precipitation of metals with minimum solubilities at different pH values requires multiple treatment stages.	Precipitation/settling is feasible technology for removing arsenic, iron, and manganese from groundwater. Arsenic can exist in any of several chemical states that affect the type of treatment required and the resultant removal efficiencies.	Lime addition to pH 12 for arsenic removal is reportedly effective, but the large quantities of lime required would generate large sludge volumes that require dewatering and disposal. Would also require discharge to stream of treated groundwater.	Low capital, very high O&M	Rejected, as hydraulic containment is rejected.
In-Situ groundwater treatment	In-situ oxidation. In-situ chemical oxidation (ISCO) involves injecting strong chemical oxidants into the vadose zone and/or groundwater to oxidize organic contaminants. The common oxidants are hydrogen peroxide-based Fenton's reagent, and potassium permanganate (KMnO4). Ozone can also oxidize organic contaminants in-situ, but it has been used less frequently. Complete mineralization to carbon dioxide and water is the desired endpoint of an ISCO process.	The effectiveness of oxidation is contingent primarily upon the geology, the residence time of the oxidant, the amount of oxidant used, and the effective contact the oxidant has with the contaminant. Will be difficult to "target" vinyl chloride.	Matching the oxidant and in situ delivery system to the contaminants is critical to successful implementation and achieving performance goals. Can be large oxidant demand for native organic matter in the formation. Difficult to implement at depths of site-related chemicals at OVSL. Field pilot study must be performed to determine injection parameters and injection well spacing.	High	Rejected
In-Situ groundwater treatment (cont'd)	Air sparging (AS). In-situ AS is commonly used for removal of gasoline and volatile chlorinated organic compounds. AS involves of injecting clean air into the aquifer below the water table to induce the transfer of volatile organics to the vapor phase, which are then transported with the rising air into the vadose zone. The movement of air through the aquifer and the vadose zone transfers oxygen into the groundwater and soil pore spaces. The presence of oxygen changes the redox conditions in the groundwater, potentially establishing aerobic conditions and increasing the potential for biodegradation of organic contaminants. Introduced dissolved oxygen may also chemically oxidize many metals and inorganics present in the groundwater, causing them to precipitate.	Expected that AS would result in improvement in groundwater quality immediately downgradient of the landfill through volatilization of VC and increasing DO content, thereby reducing solubility of iron, manganese, and arsenic. Groundwater quality downgradient of the landfill with respect to organics has improved in response to recently implemented improvements; therefore additional improvements through AS are uncertain. AS could affect improvement in groundwater quality with respect to metals more quickly. Relies on natural attenuation to reduce the levels of site-related chemicals in groundwater located further downgradient from the landfill.	Typical sparging depths at other sites are around 30 feet. Pilot testing would be required to confirm adequate distribution of oxygen at 100 foot depths and 75 foot zone of influence estimated for OVSL site. Air sparging could create mounding in groundwater surface causing divergence of groundwater flow paths around the outer boundaries of the air sparge system and migration of impacted groundwater around the system. Air sparging could alter the existing redox state of the groundwater creating more oxidizing conditions and affecting the chemistry of the wetland soils downgradient.	Moderate	Retained
In-Situ groundwater treatment (cont'd)	In-situ biological treatment. To encourage biological action and to break down organic compounds, bioremediation involves the planned in situ introduction of one or more of the following: nutrients, oxygen, or microbes. Active bioremediation is most commonly used to degrade petroleum hydrocarbons, although chlorinated organic compounds have been degraded in-situ. Technology is best suited to sites with a single or a few organic contaminants in a uniform and homogeneous soil structure. Metals and complex organic compounds, including many chlorinated organic compounds, cannot readily be biodegraded.	Active bioremediation is not effective technology for OVSL. Vinyl chloride concentrations are extremely low and biodegradation rate of vinyl chloride is extremely low. Vinyl chloride as a site-related chemical from landfills is common; often the end result of the natural biological degradation of other chlorinated organic compounds.	Difficult to deliver to ensure uniform distribution of oxygen or electron donor to groundwater at depths required and heterogeneous geologic conditions.	High	Rejected.

Table 4-1: Screening of Technologies

General Response Action/Technology	Description of Technology	Technical Feasibility (Effectiveness)	Implementability	Cost	Retained or Rejected
<u>Maintain Compliance with Post-Closure Permit</u>					
Continued compliance with State Landfill Regulations, Chapters 173-350 WAC and 173-351 WAC	Standard and proven landfill closure technologies. Maintenance of the landfill property and surface cover; control growth of weeds and intrusive vegetation; operation of the gas extraction, leachate collection, and stormwater management systems; and conducting environmental monitoring in accordance with State regulations will continue as required.	Effective. Existing cover and landfill gas extraction system meet State regulation requirements and are effective in minimizing surface water infiltration, leachate generation, and gas migration.	Readily implemented.	Low	Retained.

Table 5-1: List of Technologies Associated with Each Alternative

Technology	Alternative				
	1	2	3	4	5
	Increased Inspection, Repair, and Operational Improvements	Landfill Gas Collection System Upgrades	Vadose Zone Gas Investigation and Extraction	Air Sparge Wall	Excavation and Offsite Re-Disposal of OBWL
Continued Post-Closure Care:					
O&M of existing landfill source control and containment systems	●	●	●	●	●
Existing environmental monitoring	●	●	●	●	●
Compliance with State and Local regulations for landfill post-closure (WAC 173-351; KCHD Landfill Post Closure Permit)	●	●	●	●	●
Institutional controls: use of the landfill and restrictions on installation of water supply wells near the landfill	●	●	●	●	●
Natural attenuation of site-related chemicals in groundwater	●	●	●	●	●
Repair/modification of landfill cover system along landfill toe	●	●	●	●	●
Inspect (and repair if necessary) penetrations to cover system	●	●	●	●	●
Repair/replace landfill gas extraction wells containing blockages	●	●	●	●	●
Repair/replace landfill gas extraction system conveyance piping	●	●	●	●	●
Repair/replace condensate collection equipment	●	●	●	●	●
Maintenance/repair of landfill gas system vacuum blowers	●	●	●	●	●
Optimize operation of landfill gas collection system	●	●	●	●	●
Leachate collection system pumps: increased inspection, maintenance and adjustment	●	●	●	●	●
Repair/improve perimeter stormwater drainage diversion and control system	●	●	●	●	●
Install floating cover on leachate pond to eliminate rainwater accumulation	●	●	●	●	●
Permit alternate leachate disposal facilities	●	●	●	●	●
Install additional landfill gas collection wells		●	●	●	See Note
Investige landfill gas and VOC occurrences in soil gas outside of landfill			●		
Installation and operate Soil Vapor Extraction wells			●		
Install/operate line of Air Sparge (AS) points downgradient				●	
Excavate OBWL and transport offsite for disposal					●

Note: Would only include the installation of one additional gas collection well in the Phase II landfill.

Table 5-2: Application of Natural Attenuation Criteria to OVSL

Natural Attenuation Site Criteria	OVSL Site
Source control is concurrently and effectively applied.	The existing landfill cap, landfill gas control system and leachate collection and treatment and disposal systems provide source control resulting in declining concentrations of indicator hazardous substances in groundwater over time.
Human health and the environment are protected.	Currently, exposures to site-related chemicals do not exist and are not expected to occur in the future and therefore risks to human health and the environment are low. Existing and additional institutional controls will limit use and exposure to contaminated groundwater beneath the landfill and adjacent OVSL-owned property.
Cleanup standards can be achieved in a reasonable time.	The time required to meet cleanup standards is expected to be between 5 and 15 years depending upon aquifer properties and the distance of the monitoring point from the landfill. Releases of indicator chemicals may initially continue but are expected to decline over time such that cleanup standards are met within approximately 15 years.
Migration to groundwater is limited.	Chemical migration to groundwater appears to primarily result from impacts associated with landfill gas (gas-to-water migration of VOCs and landfill-gas caused reducing conditions resulting in increased metals solubility). Improvements to landfill gas controls should reduce the impacts caused by landfill gas occurrences. In the event that landfill gas is not the primary source of groundwater contamination, additional, contingent source control actions may be required to reduce the levels of chemical migration from the landfill.
Transformation of contaminants into more mobile or more toxic substances is unlikely.	Vinyl chloride degrades to ethene which is not considered hazardous. Mobility of vinyl chloride and ethene are not expected to change over time. Oxidation and precipitation processes for arsenic, iron and manganese result in less mobile and less toxic substances, and hence lower concentrations.
Transformation processes are irreversible.	Attenuation processes for vinyl chloride are irreversible. Attenuation processes for arsenic, iron and manganese are potentially reversible; however, oxidizing conditions in the aquifer downgradient and offsite of the landfill favor irreversibility.
Effectiveness of attenuation processes can be thoroughly and adequately supported with site-specific data.	Effectiveness of existing source controls and natural attenuation are evident from the recent groundwater monitoring results that show declining concentrations of vinyl chloride in response to recently made improvements to the landfill gas collection system components, operations and performance.
Methods to monitor remediation progress are available.	An Environmental Monitoring Program for monitoring landfill gas, leachate, groundwater, and stormwater is being established separately from this Feasibility Study.
Backup or contingency plans are available.	Possible backup plans and contingent actions include using active systems such as soil vapor extraction or air sparging to further improve groundwater quality along the downgradient boundary of the waste management unit if necessary.

Table 6-1: Evaluation of Alternatives Against Minimum Requirements for Cleanup Actions

	Threshold Requirements				Other Requirements		
Alternative	Protect Human Health and Environment	Compliance with Cleanup Standards	Compliance with Applicable State and Federal Laws	Provide for Compliance Monitoring	Use Permanent Solutions	Provide for Reasonable Restoration Timeframe	Consider Public Concerns
Description of Evaluation Criteria from WAC 173-340-360 (2) (a) and (b)	• Degree of reduction of existing risk • Time required to reduce risk and attain cleanup standards • Onsite/offsite risks due to remedial actions • Improvement of overall environmental quality	• Compliance with cleanup standards. • Ability and time required to obtained necessary authorization.	• All cleanup actions shall comply with applicable state and federal laws.	• Monitoring is required to demonstrate: 1. Protection of human health and the environment; 2. Performance of the cleanup action towards achieving cleanup standards; and 3. Confirmation that cleanup standards have been achieved.	• Degree of permanently reducing toxicity, mobility, or volume of wastes • Adequacy in destroying wastes • Reduction or elimination of releases and sources of releases • Degree of irreversibility of treatment • Quality/quantity of treatment wastes	Factors to be considered: • Potential risks posed by site • Practicability of achieving shorter restoration timeframe • Current use of site and surrounding areas affected by releases • Potential future uses of site and surrounding areas • Likely effectiveness/reliability of Institutional Controls • Ability to control and monitor migration of wastes • Toxicity of wastes at site • Natural processes that reduce concentration of wastes	• Protection of human health • Control of further releases • Community impacts Specific concerns previously raised by the public include: • Compliance with state and federal laws; • Characterization of groundwater flow directions; • Protection of domestic supply wells in the area • Control of landfill gas Concerns raised by the public during the period of active operations included: • Noise and odor issues • Traffic
Alternative 1 Increased Inspection, Repair, and Operational Improvements	• Existing risks are already low • Expected to achieve cleanup standards within 3 to 5 years for wells located adjacent to the landfill and approximately 5 to 10 years for wells located at a distance from the landfill or in lower permeability portions of the aquifer. • No onsite/offsite risks anticipated due to remedial actions.	• Expected to comply with cleanup standards over the time period described under Protect Human Health and Environment. • Necessary authorizations should be obtained quickly.	• Complies with all applicable State and Federal laws.	• Compliance monitoring is included as part of the Environmental Monitoring Plan (EMP) for the Site.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release and should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Existing risks are already low. • It is not practicable to achieve a shorter restoration timeframe. • Current use of site and surrounding areas are unaffected by releases. • Future uses of site and surrounding areas will remain the same. • Effectiveness/reliability of Institutional Controls is high. • Ability to control and monitor migration of wastes is high because of the Environmental Monitoring Plan (EMP) for the Site. • Toxicity of wastes at the site is low. • Natural attenuation processes of volatilization, dispersion, dilution, and precipitation that reduce concentration of wastes are on-going.	• This alternative will continue to provide protection of human health and the environment • This alternative will control further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic

Table 6-1: Evaluation of Alternatives Against Minimum Requirements for Cleanup Actions

	Threshold Requirements				Other Requirements		
Alternative	Protect Human Health and Environment	Compliance with Cleanup Standards	Compliance with Applicable State and Federal Laws	Provide for Compliance Monitoring	Use Permanent Solutions	Provide for Reasonable Restoration Timeframe	Consider Public Concerns
Alternative 2 Landfill Gas Collection System Upgrades	• Existing risks are already low • Expected to achieve cleanup standards within 3 to 5 years for wells located adjacent to the landfill and approximately 5 to 10 years for wells located at a distance from the landfill or in lower permeability portions of the aquifer. • No onsite/offsite risks anticipated due to remedial actions.	• Expected to comply with cleanup standards over the time period described under Protect Human Health and Environment for Alternative 1. • Necessary authorizations should be obtained quickly.	• Complies with all applicable State and Federal laws.	• Compliance monitoring is included as part of the EMP for the Site.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release and should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Existing risks are already low. • It is not practicable to achieve a shorter restoration timeframe. • Current use of site and surrounding areas are unaffected by releases. • Future uses of site and surrounding areas will remain the same. • Effectiveness/reliability of Institutional Controls is high. • Ability to control and monitor migration of wastes is high because of the EMP for the Site. • Toxicity of wastes at the site is low. • Natural attenuation processes of volatilization, dispersion, dilution, and precipitation that reduce concentration of wastes are on-going.	• This alternative will continue to provide protection of human health and the environment • This alternative will control further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic
Alternative 3 Vadose Zone Gas Investigation and Extraction	• Existing risks are already low. As there are no methane occurrences outside of the landfill, this alternative will not further reduce potential risks. • Cleanup standards are expected to be achieved in the timeframes indicated under Alternative 1 without implementation of this alternative. • No onsite/offsite risks anticipated due to remedial actions.	• Expected to comply with cleanup standards over the time period described under Protect Human Health and Environment for Alternative 1. • Necessary authorizations should be obtained quickly.	• Complies with all applicable State and Federal laws.	• Compliance monitoring is included as part of the EMP for the Site.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release and should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Existing risks are already low. • It is not practicable to achieve a shorter restoration timeframe. • Current use of site and surrounding areas are unaffected by releases. • Future uses of site and surrounding areas will remain the same. • Effectiveness/reliability of Institutional Controls is high. • Ability to control and monitor migration of wastes is high because of the EMP for the Site. • Toxicity of wastes at the site is low. • Natural attenuation processes of volatilization, dispersion, dilution, and precipitation that reduce concentration of wastes are on-going.	• This alternative will continue to provide protection of human health and the environment • This alternative is not expected to enhance control of further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic

Table 6-1: Evaluation of Alternatives Against Minimum Requirements for Cleanup Actions

	Threshold Requirements				Other Requirements		
Alternative	Protect Human Health and Environment	Compliance with Cleanup Standards	Compliance with Applicable State and Federal Laws	Provide for Compliance Monitoring	Use Permanent Solutions	Provide for Reasonable Restoration Timeframe	Consider Public Concerns
Alternative 4 Air Sparge Wall	• Existing risks are already low. • Cleanup standards are expected to be achieved in the timeframes indicated under Alternative 1 without implementation of this alternative. Addition of an air sparge wall could accelerate timeframes 1 to 2 years over those under Alternative 1. • No onsite/offsite risks anticipated due to remedial actions.	• Expected to comply with cleanup standards over the time period described under Protect Human Health and Environment for Alternative 1. • Necessary authorizations should be obtained quickly.	• Complies with all applicable State and Federal laws.	• Compliance monitoring is included as part of the EMP for the Site.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release and should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Existing risks are already low. • It is not practicable to achieve a shorter restoration timeframe. • Current use of site and surrounding areas are unaffected by releases. • Future uses of site and surrounding areas will remain the same. • Effectiveness/reliability of Institutional Controls is high. • Ability to control and monitor migration of wastes is high because of the EMP for the Site. • Toxicity of wastes at the site is low. • Natural attenuation processes of volatilization, dispersion, dilution, and precipitation that reduce concentration of wastes are on-going.	• This alternative will continue to provide protection of human health and the environment • This alternative will control further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic
Alternative 5 Excavation and Offsite Re-Disposal of OBWL	• Existing risks are already low. • Expected to achieve cleanup standards within 3 to 5 years for wells located adjacent to the landfill and approximately 5 to 10 years for wells located at a distance from the landfill or in lower permeability portions of the aquifer. • No onsite/offsite risks anticipated due to remedial actions.	• Expected to comply with cleanup standards over the time period described under Overall Protection of Human Health and the Environment for Alternative 1. • Necessary authorizations should be obtained quickly.	• Complies with all applicable State and Federal laws.	• Compliance monitoring is included as part of the EMP for the Site.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU/POTW disposal capable of treating expected leachate volumes. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release and should reduce the potential for further releases. • Refuse disposed offsite would be a permanent solution. • Quantity/quality of treatment wastes will greatly increase through offsite disposal of excavated refuse and treatment of excavation contact water.	• Existing risks are already low. • It is not practicable to achieve a shorter restoration timeframe. • Current use of site and surrounding areas are unaffected by releases. • Future uses of site and surrounding areas will remain the same. • Effectiveness/reliability of Institutional Controls is high. • Ability to control and monitor migration of wastes is high because of the EMP for the Site. • Toxicity of wastes at the site is low. • Natural attenuation processes of volatilization, dispersion, dilution, and precipitation that reduce concentration of wastes are on-going.	• This alternative will continue to provide protection of human health and the environment. • This alternative will control further releases from the Site. • Groundwater contamination will remain downgradient (onsite) of the landfill for some time. • Excavation and offsite re-disposal of OBWL will result in an increase in noise and possibly odors from the Site. • Significant additional traffic will result during implementation of this alternative.

Table 6-2: Evaluation and Benefit Summary of Alternatives Using Criteria for Disproportionate Cost Analysis

Alternative	Protectiveness	Permanence	Cost	Effectiveness Over the Long Term	Management of Short-Term Risks	Technical and Administrative Implementability	Consideration of Public Concerns
Description of Disproportionate Cost Analysis Evaluation Criteria from WAC 173-340-360 (3) (f)]	• Degree of reduction of existing risk. • Time required to reduce risk and attain cleanup standards. • Onsite/offsite risks due to cleanup actions. • Improvement of overall environmental quality.	• Degree of permanently reducing toxicity, mobility, or volume of wastes. • Adequacy in destroying wastes. • Reduction or elimination of releases and sources of releases. • Degree of irreversibility of treatment. • Quality/quantity of treatment wastes.	• Capital costs. • Annual operation, maintenance, and monitoring (OM&M) costs. • Present Worth costs.	• Degree of certainty of cleanup success. • Long-term reliability. • Magnitude of residual risk. • Management of treatment residues. • Management of wastes remaining untreated.	• Risk to human health and the environment during implementation. • Effectiveness of measures to manage risk.	• Technical feasibility. • Availability of necessary off-site facilities, services, and materials. • Administrative and regulatory requirements. • Scheduling, size, complexity. • Monitoring requirements. • Access for construction operations and monitoring. • Integration with existing facility operations and other current or potential cleanup actions.	• Protection of human health • Control of further releases • Community impacts Specific concerns previously raised by the Public include: • Compliance with state and federal laws; • Characterization of groundwater flow directions; • Protection of domestic supply wells in the area • Control of landfill gas Concerns raised by the Public during the period of active operations included: • Noise and odor issues • Traffic
Alternative 1 Increased Inspection, Repair, and Operational Improvements	• Existing risks are already low. • Expected to achieve cleanup standards within 3 to 5 years for wells located adjacent to the landfill and approximately 5 to 10 years for wells located at a distance from the landfill or in lower permeability portions of the aquifer. • No onsite/offsite risks anticipated due to cleanup actions.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release and should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Capital: $0.78 M • OM&M: $0.42-1.20 M/yr • Present Worth: $11.1 M	• Based on declines in contaminant levels already observed, it is expected that this alternative should be successful in achieving cleanup standards adjacent to the landfill. • This alternative is considered to be reliable. • Existing risks posed by the site are low and the magnitude of residual risk should be further reduced over time.	• Human health and environment will not be impacted during implementation. • Existing degree of risk is low and should remain so prior to attainment of cleanup standards.	• Offsite facilities including POTW and offsite solid waste disposal facilities are available. • Services and materials necessary for implementation of this alternative are available. • There are no administrative requirements that affect implementation of this alternative.	• This alternative will continue to provide protection of human health and the environment. • This alternative will control further releases from the Site. • Groundwater contamination will remain downgradient (onsite) of the landfill for some time. • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic.
Benefit Score = 15	2	3		2	3	3	2

Table 6-2: Evaluation and Benefit Summary of Alternatives Using Criteria for Disproportionate Cost Analysis

Alternative	Protectiveness	Permanence	Cost	Effectiveness Over the Long Term	Management of Short-Term Risks	Technical and Administrative Implementability	Consideration of Public Concerns
Alternative 2 Landfill Gas Collection System Upgrades	• Existing risks are already low. • Expected to achieve cleanup standards within 3 to 5 years for wells located adjacent to the landfill and approximately 5 to 10 years for wells located at a distance from the landfill or in lower permeability portions of the aquifer. • No onsite/offsite risks anticipated due to cleanup actions.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release; should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Capital: $1.21 M • OM&M: $0.42-1.20 M/yr • Present Worth: $11.6 M	• Based on declines in contaminant levels already observed, it is expected that this alternative should be successful in achieving cleanup standards adjacent to the landfill. • This alternative is considered to be reliable. • Existing risks posed by the site are low and the magnitude of residual risk should be further reduced over time.	• Human health and environment will not be impacted during implementation. • Existing degree of risk is low and should remain so prior to attainment of cleanup standards.	• Offsite facilities including POTW and offsite solid waste disposal facilities are available. • Services and materials necessary for implementation of this alternative are available. • There are no administrative requirements that affect implementation of this alternative. • Gas collection from OBWL will result in addition of gas with low methane content to the gas stream affecting operation of the remainder of the gas system and the LEU and flare operations.	• This alternative will continue to provide protection of human health and the environment • This alternative will control further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic
Benefit Score = 13	2	3		2	3	1	2
Alternative 3 Vadose Zone Gas Investigation and Extraction	• Existing risks are already low. As there are no methane occurrences outside of the landfill, this alternative will not further reduce potential risks. • Cleanup standards are expected to be achieved in the timeframes indicated under Alternative 1 without implementation of this alternative. • No onsite/offsite risks anticipated due to cleanup actions.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release; should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Capital: $1.94 M • OM&M: $0.42-1.30 M/yr • Present Worth: $12.8 M	• This alternative is expected to be as effective as Alternative 1. • Although no gas occurrences above standards currently exist outside of the landfill, soil vapor in concentrations less than standards may be affecting groundwater quality and vadose zone gas extraction might be effective at improving groundwater quality. • Existing risks posed by the site are low and the magnitude of residual risk should be further reduced over time with or without implementation of this alternative.	• Human health and environment will not be impacted during implementation. • Existing degree of risk is low and should remain so prior to attainment of cleanup standards. • Operation of an SVE system outside of the landfill could pull landfill gas out from the landfill and thereby increase contaminant migration from the landfill.	• Installation of SVE system is feasible but topographic conditions may limit the ability to install SVE wells immediately adjacent to the landfill. • Offsite facilities including POTW and offsite solid waste disposal facilities are available. • The services and materials necessary for implementation of this alternative are available. • Operation of an SVE system outside of the landfill could pull landfill gas out from the landfill and thereby increase contaminant migration from the landfill. Operation of an SVE system outside the landfill could interfere with operation of the landfill gas extraction system.	• This alternative will continue to provide protection of human health and the environment • This alternative is not expected to enhance control of further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic
Benefit Score = 12	2	3		2	2	1	2

Table 6-2: Evaluation and Benefit Summary of Alternatives Using Criteria for Disproportionate Cost Analysis

Alternative	Protectiveness	Permanence	Cost	Effectiveness Over the Long Term	Management of Short-Term Risks	Technical and Administrative Implementability	Consideration of Public Concerns
Alternative 4 Air Sparge Wall	• Existing risks are already low. • Cleanup standards are expected to be achieved in the timeframes indicated under Alternative 1 without implementation of this alternative. Addition of an air sparge wall could accelerate timeframes 1 to 2 years over those under Alternative 1. • No onsite/offsite risks anticipated due to cleanup actions.	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining onsite will be contained. • LEU and POTW disposal are capable of treating expected volumes of leachate. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release; should reduce the potential for further releases. • Quantity/quality of treatment wastes will remain unchanged.	• Capital: $2.64 M • OM&M: $0.53-1.31 M/yr • Present Worth: $15.3 M	• Based on declines in contaminant levels already observed, Alt 4 should be successful in achieving cleanup standards adjacent to the landfill. Achievement of standards further downgradient is expected over time. Downgradient sparge wall may be effective in reducing levels downgradient of areas where improvement in organics have not occurred and in all areas where metals are an issue. Would increase certainty of achieving cleanup goals. • This alternative is considered to be reliable. • Existing risks posed by site are low; magnitude of residual risk should be further reduced over time.	• Human health and environment will not be impacted during implementation. • Existing degree of risk is low and should remain so prior to attainment of cleanup standards. • By raising oxygen levels in the groundwater that discharges to the wetlands, this alternative could affect water quality in the wetlands.	• Installation of a sparge wall is feasible but topographic conditions may limit the ability to install injection points immediately adjacent to the landfill. • Offsite facilities including POTW and offsite solid waste disposal facilities are available. • The services and materials necessary for implementation of this alternative are available. • There are no administrative requirements that affect implementation of this alternative.	• This alternative will continue to provide protection of human health and the environment • This alternative will control further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will not result in any increase in noise or odors from the Site. • This alternative will not result in any additional traffic
Benefit Score = 16	3	3		3	2	3	2
Alternative 5 Excavation and Offsite Re-Disposal of OBWL	• Existing risks are already low • Expected to achieve cleanup standards within 3 to 5 years for wells located adjacent to the landfill and approximately 5 to 10 years for wells located at a distance from the landfill or in lower permeability portions of the aquifer. • No onsite/offsite risks anticipated due to cleanup actions	• Treatment wastes will continue to be destroyed by the LEU or disposed at a POTW or offsite landfill. • Wastes remaining will be contained. • LEU/POTW disposal capable of treating expected leachate volumes. LEU and flare are capable of treating expected flow of LFG. • Based on declines in contaminant levels already observed, additional actions have already reduced potential for release; should reduce the potential for further releases. • Refuse disposed offsite would be a permanent solution. • Quantity/quality of treatment wastes will greatly increase with offsite disposal of excavated refuse and treatment of excavation contact water.	• Capital: $168 M • OM&M: $0.42-1.20 M/yr • Present Worth: $178 M	• Based on declines in contaminant levels already observed, it is expected that Alt 5 should be successful in achieving cleanup standards adjacent to the landfill. Achievement of cleanup standards further downgradient is expected over time. Excavation of portion of OBWL not likely to result in improvement in groundwater quality. • Considered to be reliable. • Existing risks posed by site are low; magnitude of residual risk should be further reduced over time.	• Human health and environment may be impacted during implementation as a result of odor emissions and vehicle traffic. • Existing degree of risk is low and should remain so prior to attainment of cleanup standards.	• Offsite facilities including POTW and offsite solid waste disposal facilities are available. • The services and materials necessary for implementation of this alternative are available; however, capacity limits at the transfer station and rail haul may limit the amount of refuse that can be processed each day and extend the time for completion of this alternative. • Implementation of this alternative may be limited by capacity restrictions at the transfer station and could affect transfer station operations.	• This alternative will continue to provide protection of human health and the environment • This alternative will control further releases from the Site • Groundwater contamination will remain downgradient (onsite) of the landfill for some time • This alternative will result in any increase in noise and possibly odors from the Site. • This alternative will result in additional traffic
Benefit Score = 9	2	3		1	1	1	1

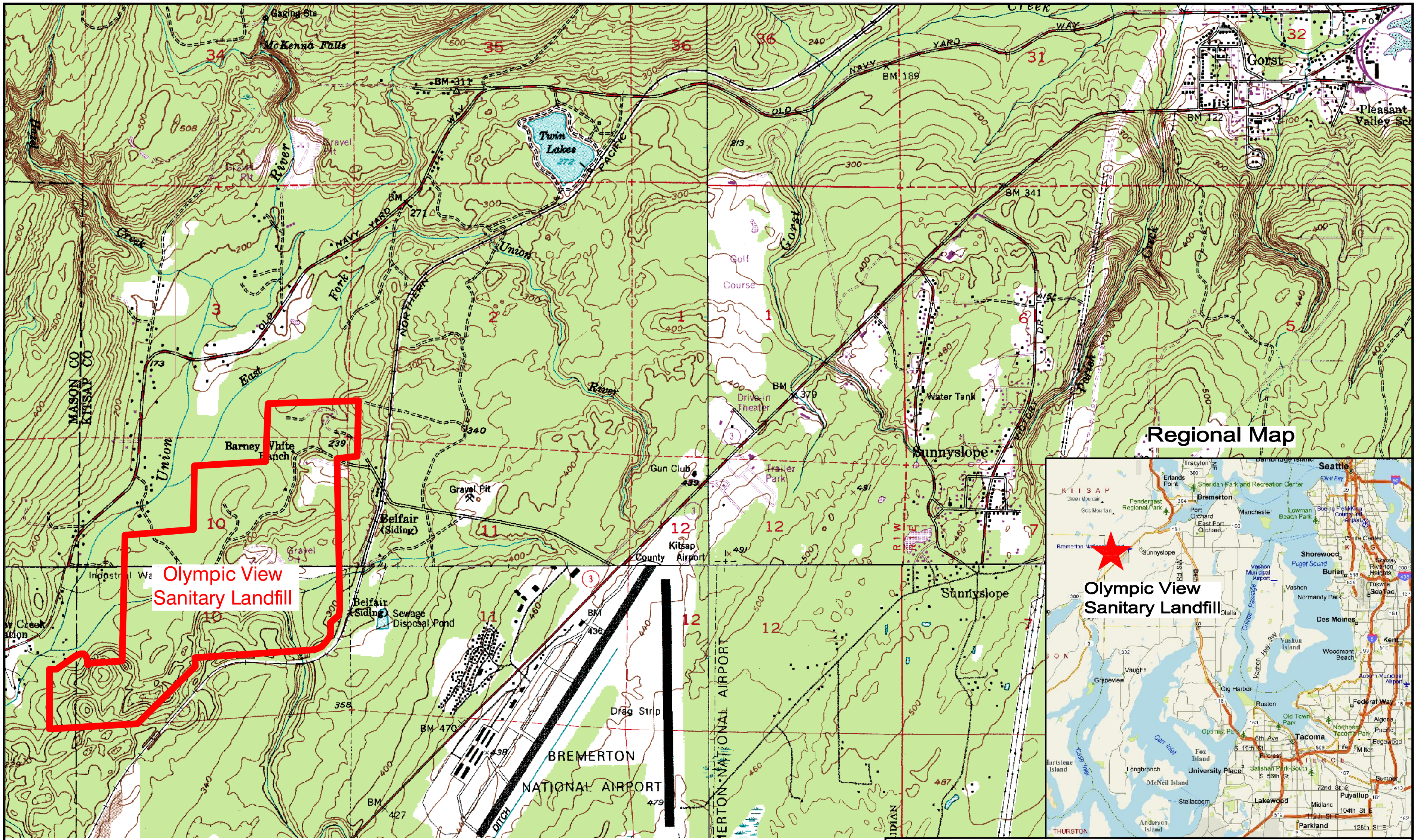
Table 6-3: Cost/Benefit Analysis

Potential Cleanup Action Alternative	Alternative Benefit Score	Base Benefit Score	Benefit Ratio	Estimated Present Worth Cost ($M)	Cost Ratio *	Cost/Benefit Ratio
Alternative 1 - Increased Inspection, Repair and Operational Improvements	15	16	0.94	11.1	1.00	1.1
Alternative 2 - Landfill Gas Collection System Upgrades	13	16	0.81	11.6	1.05	1.3
Alternative 3 - Vadose Zone Gas Investigation and Extraction	12	16	0.75	12.8	1.15	1.5
Alternative 4 - Air Sparge Wall	16	16	1.00	15.3	1.38	1.4
Alternative 5 - Excavation and Offsite Re-Disposal of OBWL	9	16	0.56	178	16	29

* The Cost Ratio for an Alternative is calculated by dividing the Present Worth Cost of the Alternative by the Present Worth Cost of the Alternative with the least Present Worth Cost (Alternative 1).

Figures

M:\clients\EMSI\Waste-Man-OVSL\Parametrix\BL2982003P06T04F2-1 11-9-07\OVSL-Fig-2-1.dwg plotted: 07/31/2009



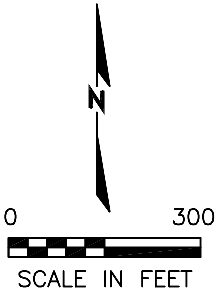
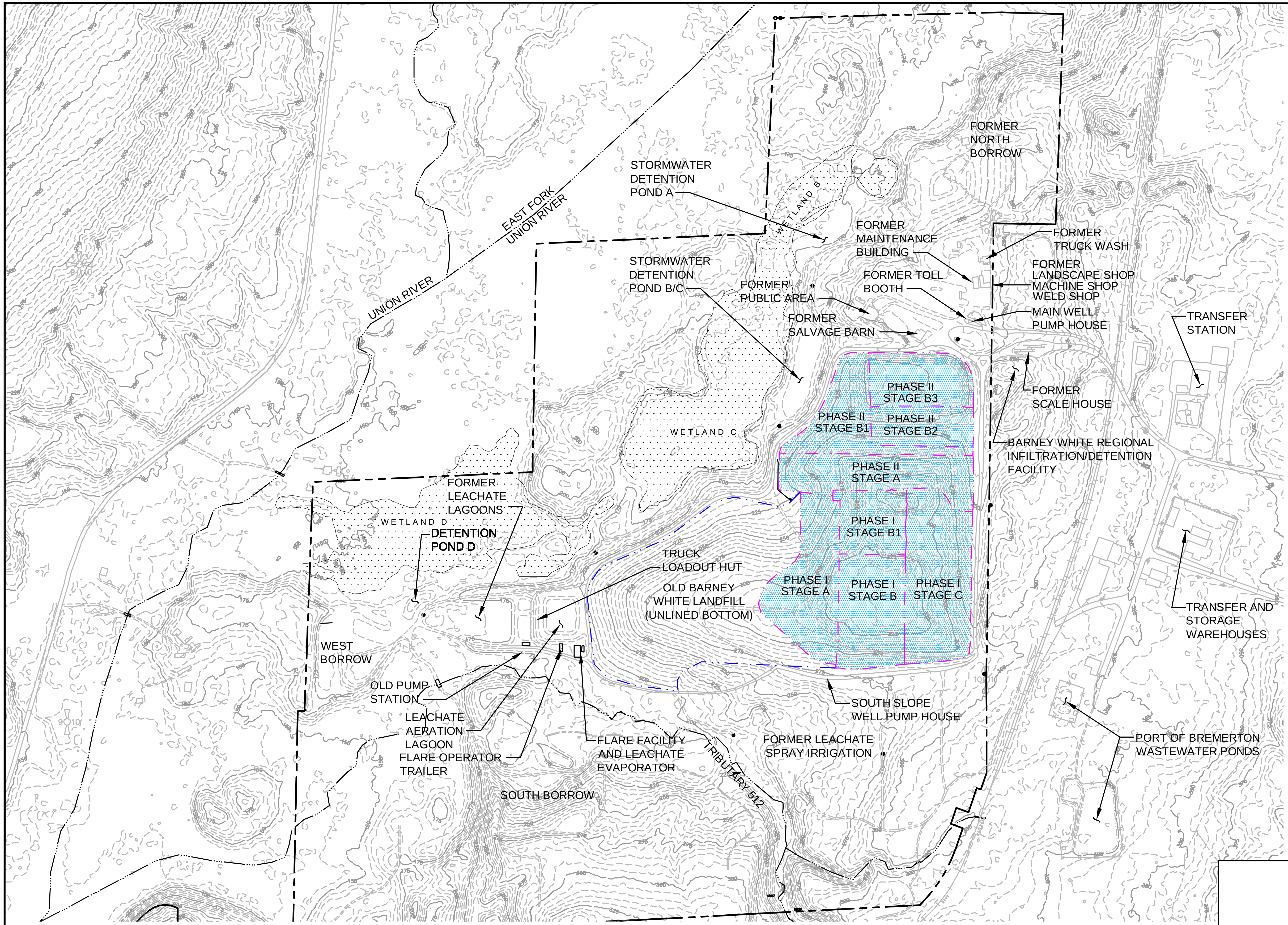


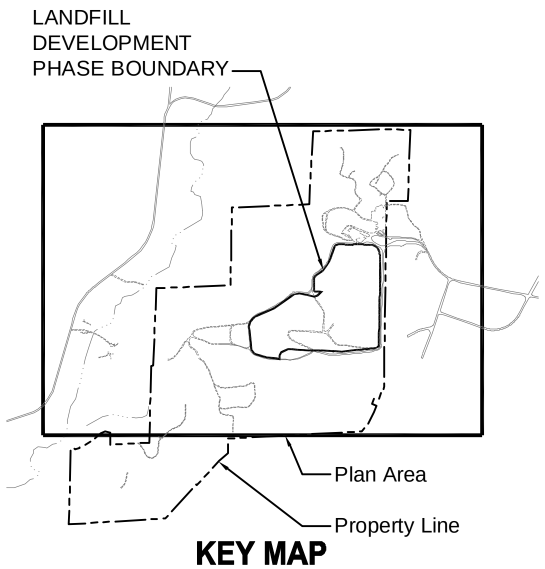
Figure 2-1

Site Location Map
Kitsap County, Washington

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.





KEY MAP

NO SCALE

NOTES:

1. Contour data based on topographic survey data supplied by Space Imaging LLC & Kitsap County GIS Aerial Imagery, June 2001.
2. Additional property to south (see Key Map).

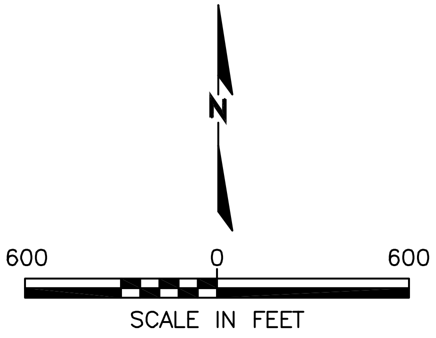


Figure 2-2

Overall Site Plan

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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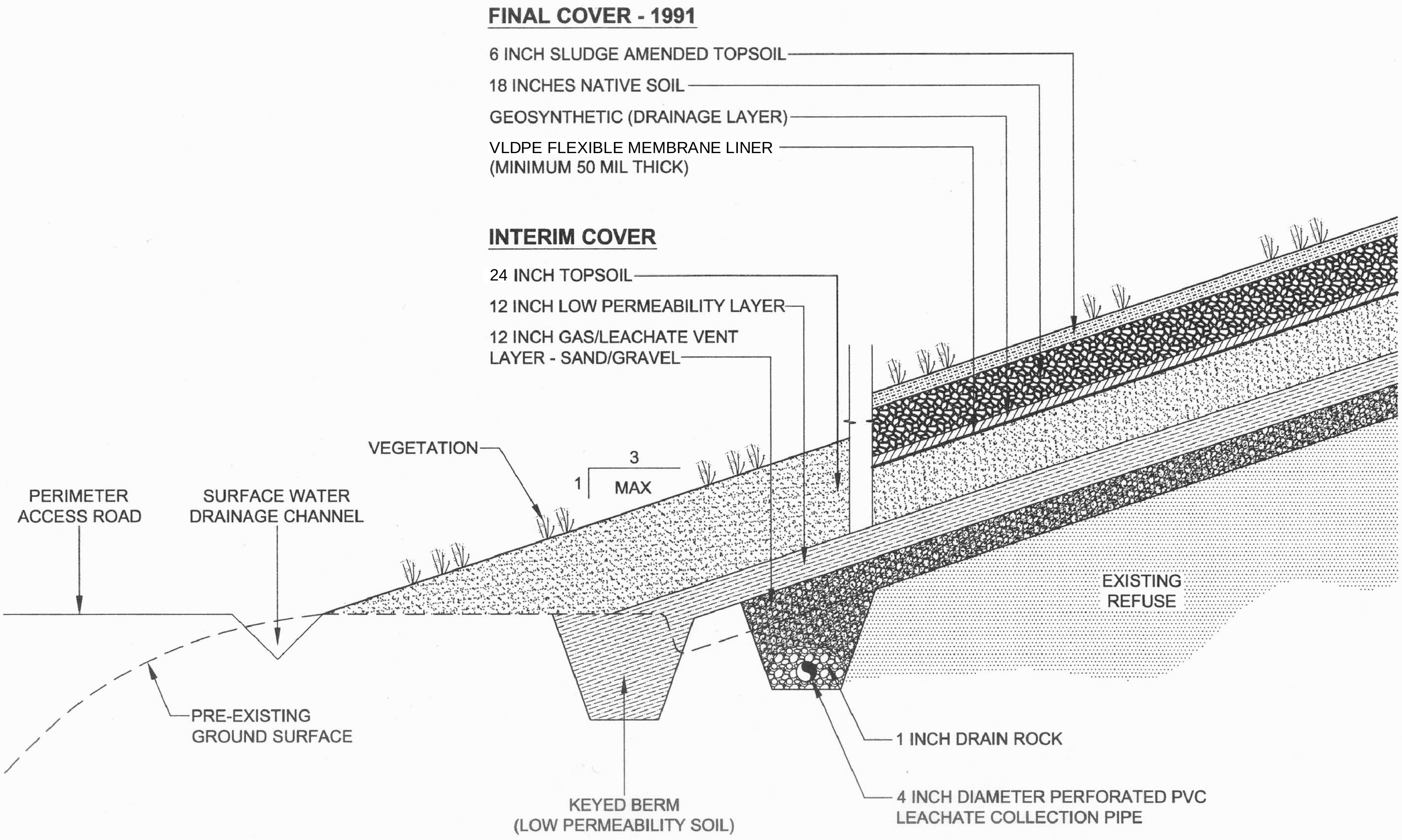


Figure 2-3

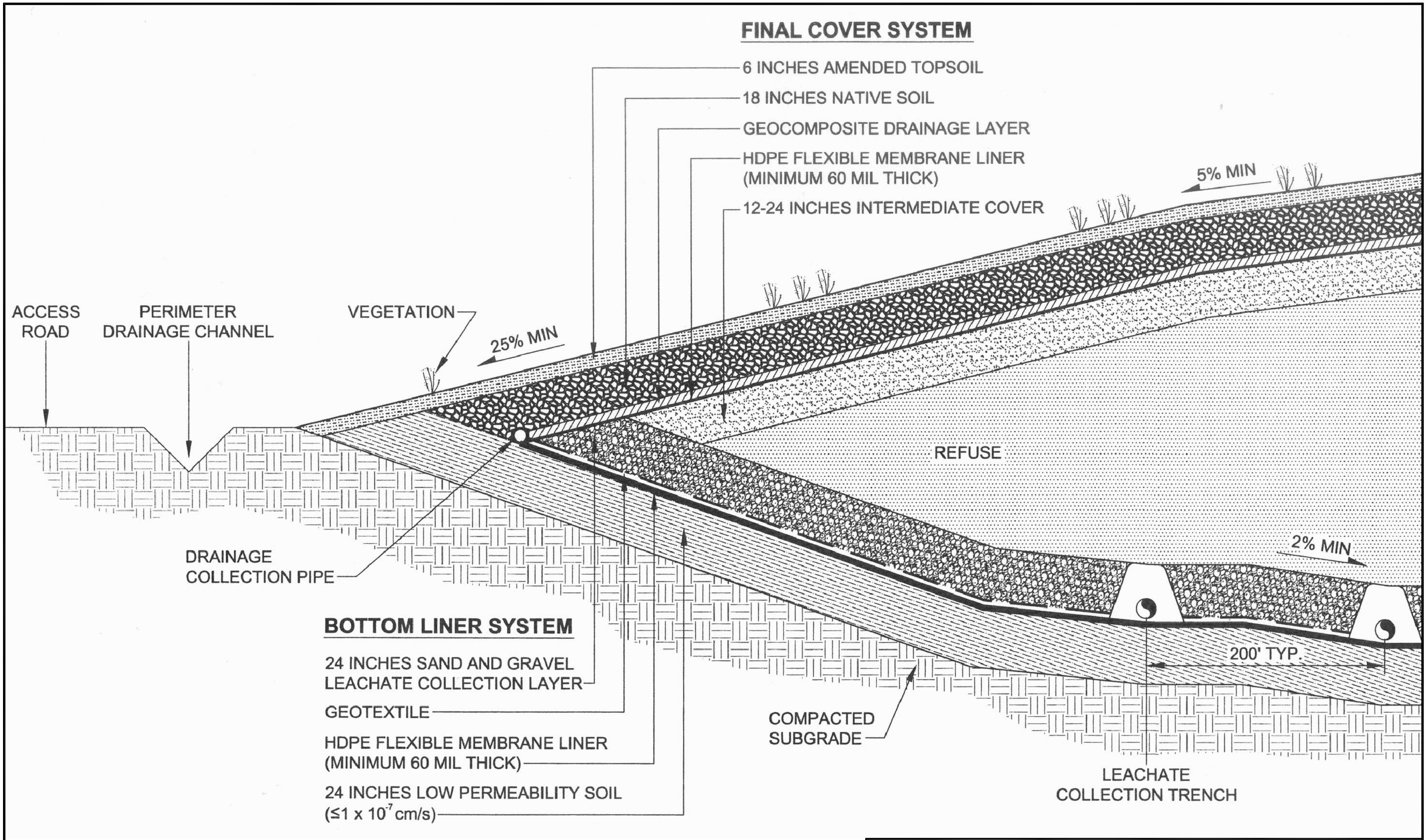
Old Barney White Area
Toe Seep Collection and Final Cover Sytems

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

Modified from: Parametrix 2007

NOT TO SCALE



Modified from: Parametrix 2007

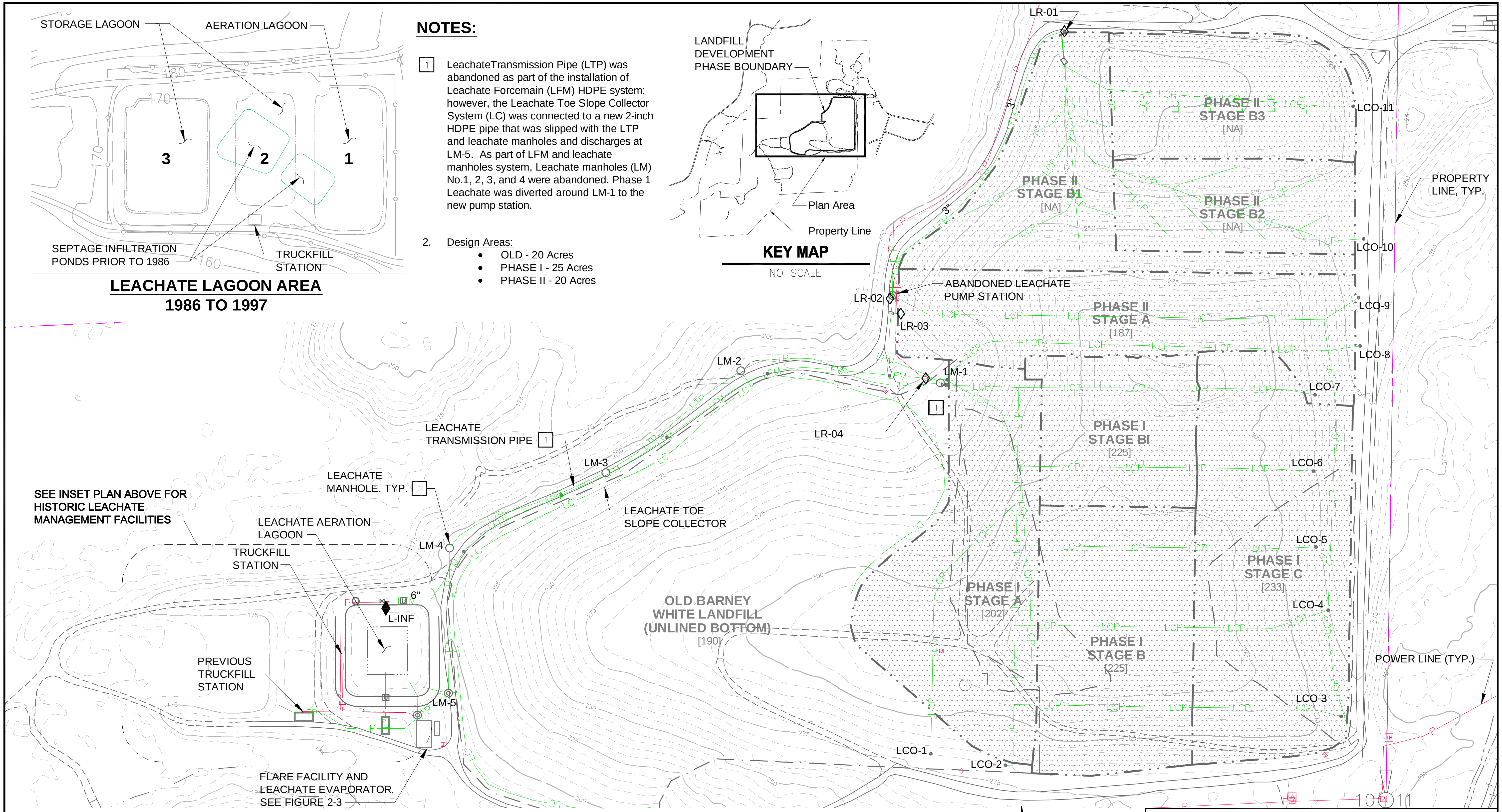
NOT TO SCALE

Figure 2-4

Typical Section of Phase I and II Final Cover, Bottom Liner, and Leachate Collection System

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.



LEACHATE LAGOON AREA
1986 TO 1997

KEY MAP

NO SCALE

NOTES:

1. LeachateTransmission Pipe (LTP) was abandoned as part of the installation of Leachate Forcemain (LFM) HDPE system; however, the Leachate Toe Slope Collector System (LC) was connected to a new 2-inch HDPE pipe that was slipped with the LTP and leachate manholes and discharges at LM-5. As part of LFM and leachate manholes system, Leachate manholes (LM) No.1, 2, 3, and 4 were abandoned. Phase 1 Leachate was diverted around LM-1 to the new pump station.

2. Design Areas:
   - OLD - 20 Acres
   - PHASE I - 25 Acres
   - PHASE II - 20 Acres

LEGEND:

◎LM-5	Leachate Manhole
○LM-2	Decommissioned Leachate Manhole
• LCO-1	Leachate Cleanout
[202]	Approximate Bottom Elevation
—▢—	Power Utility Vault
——LC——	Leachate Toe Slope Collection Pipe
——LCP——	Leachate Collection Pipe
——LTP——	Leachate Transmission Pipe (Decommissioned-In-Place)
——LFM——	Leachate Force Main Pipe
——P——	Underground Power Line
◆ L-INF	Leachate Influent Monitoring Station and Flow Meter
◇ LR	Leachate Riser
— · —	Landfill Development Phase Boundary
▨	Bottom Liner System

N

240 0 240

SCALE IN FEET

Figure 2-5

Leachate Management Systems

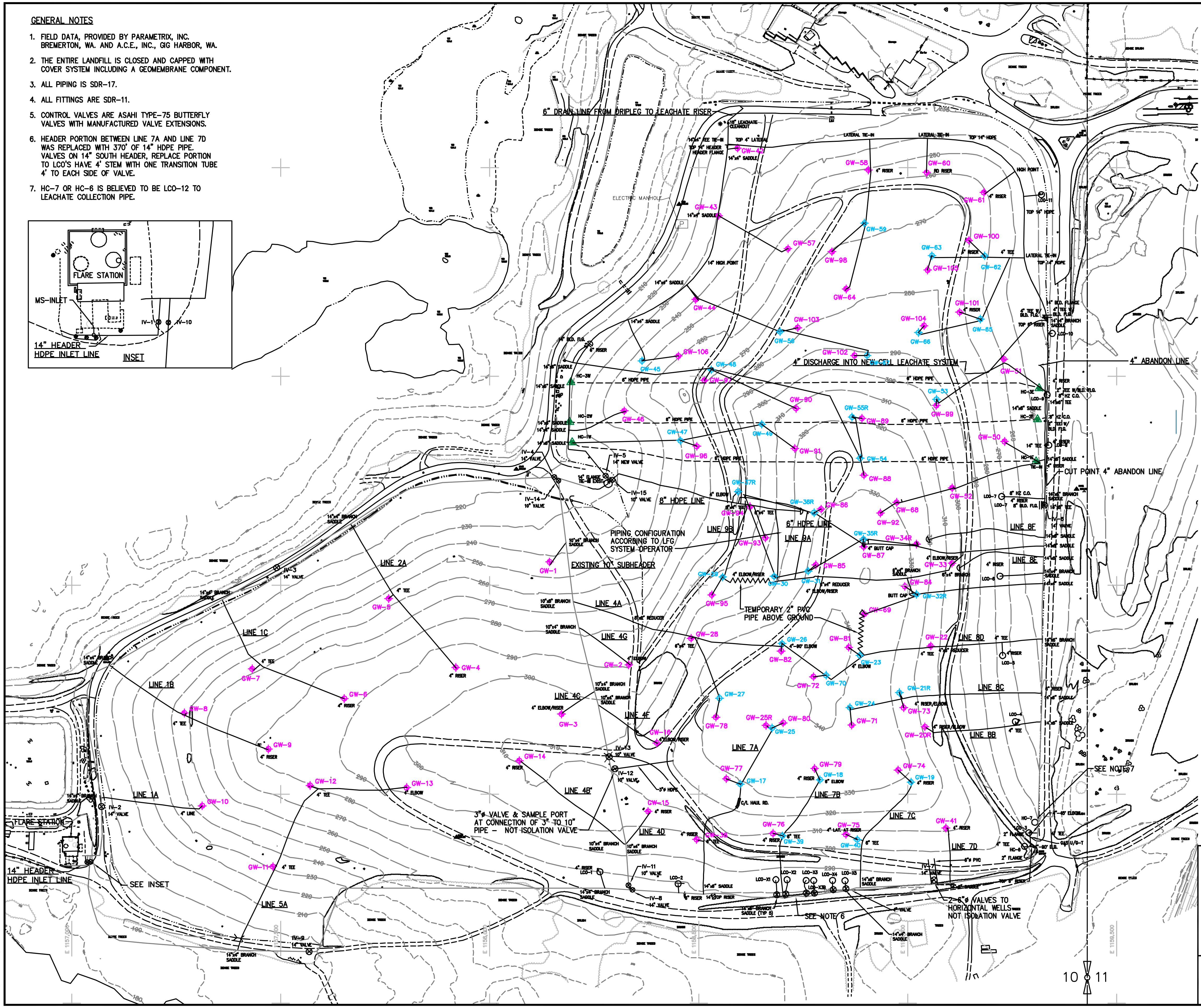
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-2-5.DWG-LAYOUT1 07/31/2009 3:08PM

GENERAL NOTES

1. FIELD DATA, PROVIDED BY PARAMETRIX, INC. BREMERTON, WA. AND A.C.E., INC., GIG HARBOR, WA.
2. THE ENTIRE LANDFILL IS CLOSED AND CAPPED WITH COVER SYSTEM INCLUDING A GEOMEMBRANE COMPONENT.
3. ALL PIPING IS SDR-17.
4. ALL FITTINGS ARE SDR-11.
5. CONTROL VALVES ARE ASAHI TYPE-75 BUTTERFLY VALVES WITH MANUFACTURED VALVE EXTENSIONS.
6. HEADER PORTION BETWEEN LINE 7A AND LINE 7D WAS REPLACED WITH 370' OF 14" HDPE PIPE. VALVES ON 14" SOUTH HEADER, REPLACE PORTION TO LCO'S HAVE 4' STEM WITH ONE TRANSITION TUBE 4' TO EACH SIDE OF VALVE.
7. HC-7 OR HC-6 IS BELIEVED TO BE LCO-12 TO LEACHATE COLLECTION PIPE.



LEGEND

- ⌖ Gas Extraction Well
- ⌖ Abandoned Gas Extraction Well
- ▲ Horizontal Gas Collection Well
- ○ Leachate Cleanout

N

240 0 240

SCALE IN FEET

Figure 2-6

Landfill Gas Collection Systems

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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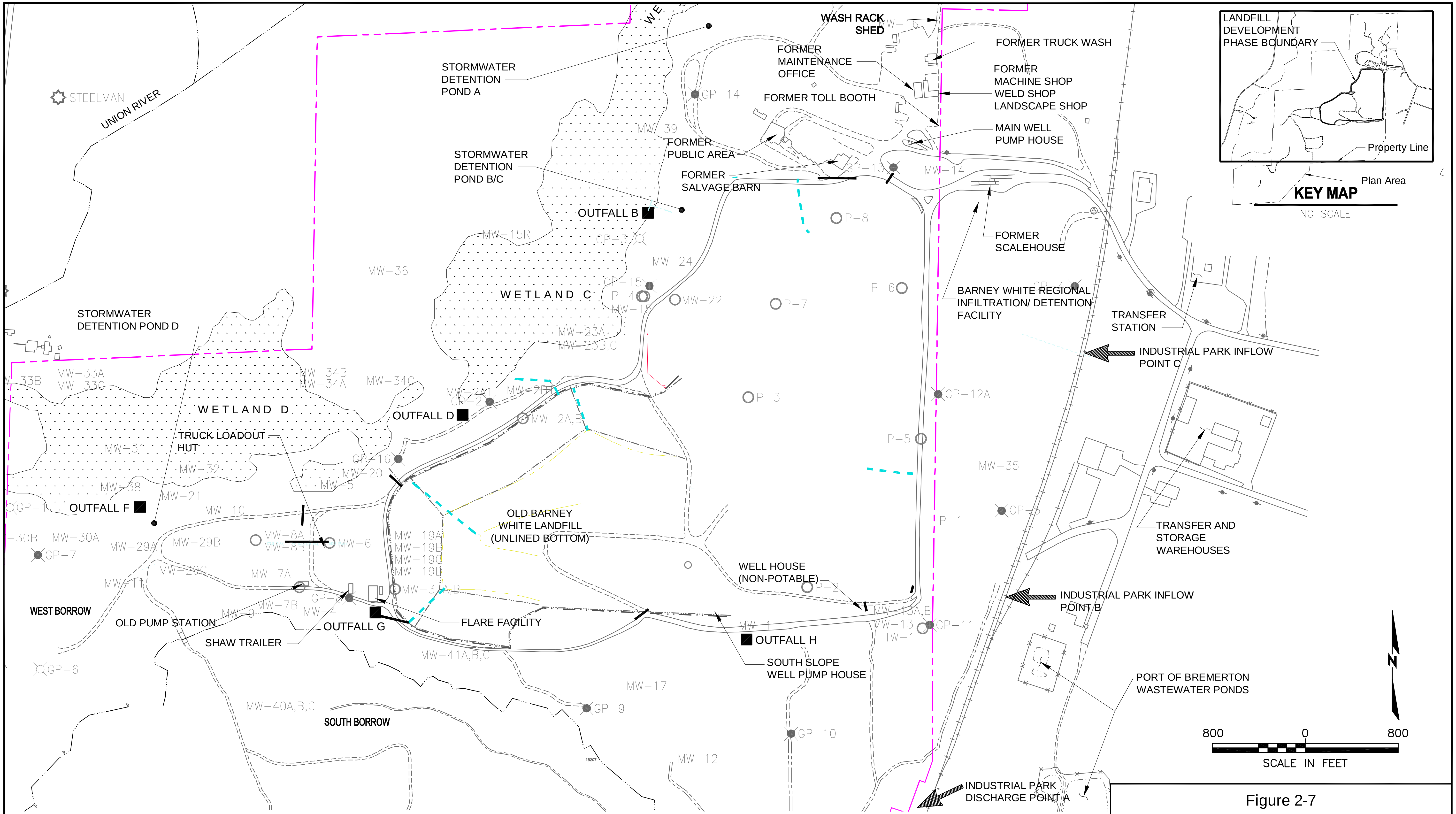


LEGEND:

◉ MW-32 Monitoring Well or Piezometer
○ MW-15 Decommissioned Monitoring Well or Piezometer
✪ SCOTT Offsite Private Well
● GP-15 Gas Probe
⌧ GP-6 Decommissioned Gas Probe

■ OUTFALL B Stormwater Monitoring Outfall
➨ Off-Site Point Discharge
Downchutes
Ditch
Conveyance Channels
Culverts

Property Line
Landfill Development Phase Boundary
Stream
Access Road
Railroad

NOTES:

1. Contour data based on topographic survey data supplied by Space Imaging LLC & Kitsap County GIS Aerial Imagery, June 2001.
2. Additional property to south (see Key Map).

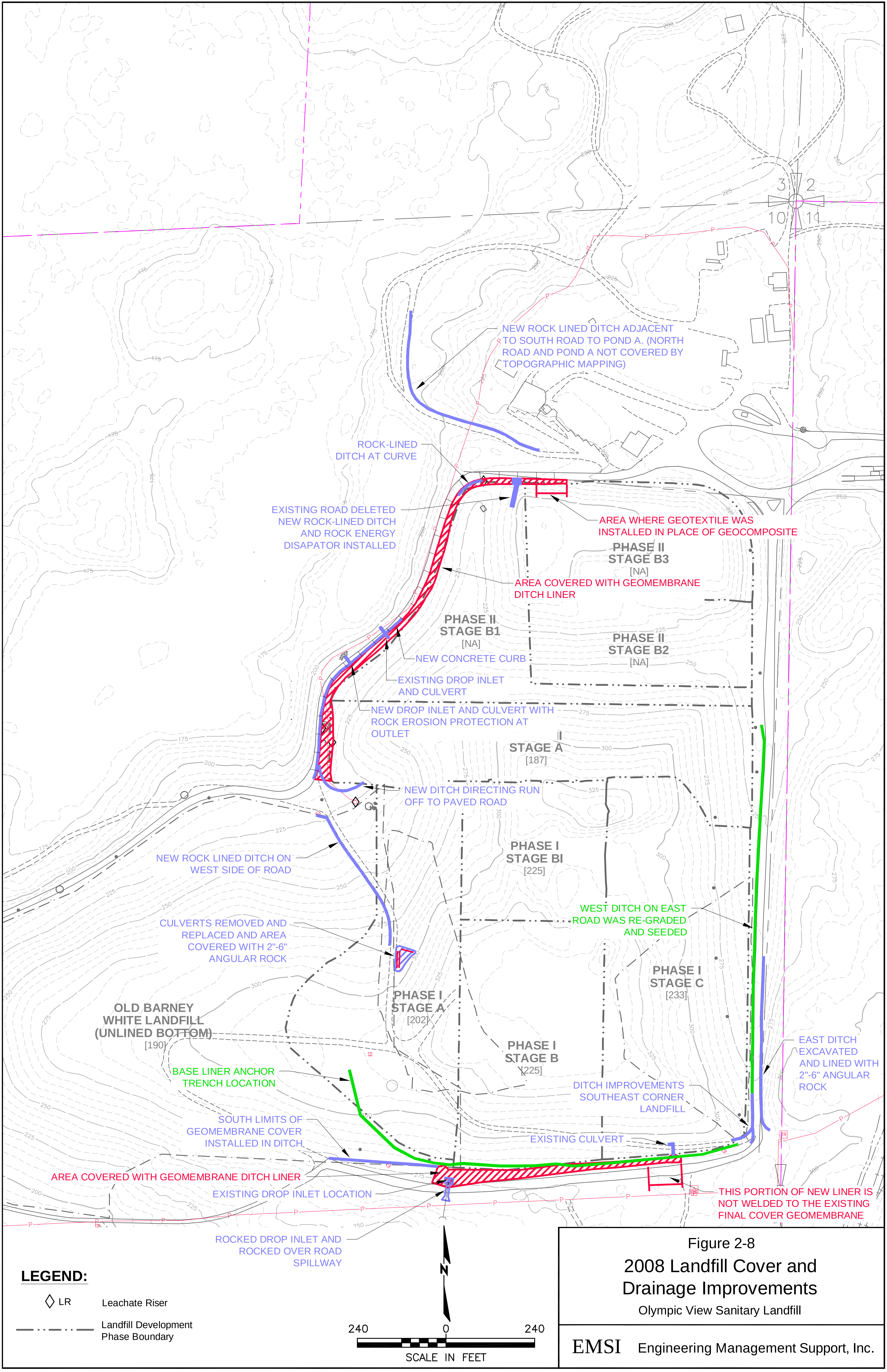
Figure 2-7

Stormwater Management Systems

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-2-7.DWG-11X17 FIGURE 07/31/2009 3:10PM



LEGEND:

◇ LR Leachate Riser

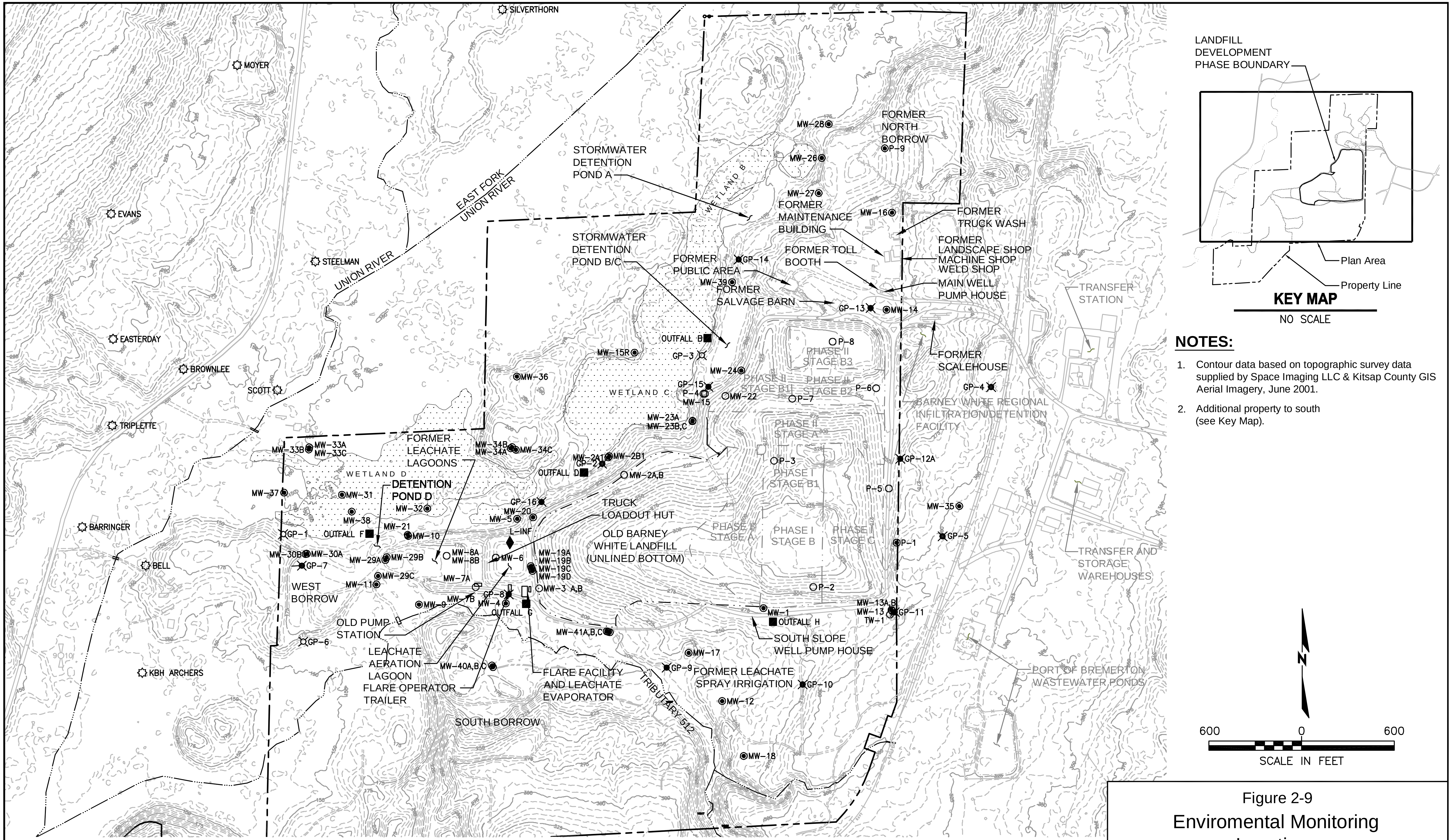
—·—··— Landfill Development Phase Boundary

Figure 2-8

2008 Landfill Cover and Drainage Improvements

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.



NOTES:

1. Contour data based on topographic survey data supplied by Space Imaging LLC & Kitsap County GIS Aerial Imagery, June 2001.
2. Additional property to south (see Key Map).

LEGEND:

◉ MW-32	Monitoring Well or Piezometer
✪ SCOTT	Offsite Private Well
○ MW-15	Decommissioned Monitoring Well or Piezometer
◆ L-INF	Leachate Influent Monitoring Station
⊗ GP-15	Gas Probe
■ OUTFALL B	Stormwater Monitoring Outfall
——— — — ———	Property Line
—·—·—·—	Landfill Development Phase Boundary
⋯⋯	Stream
══════	Access Road
—+—+—+—	Railroad

Figure 2-9

Enviromental Monitoring Locations

Olympic View Sanitary Landfill

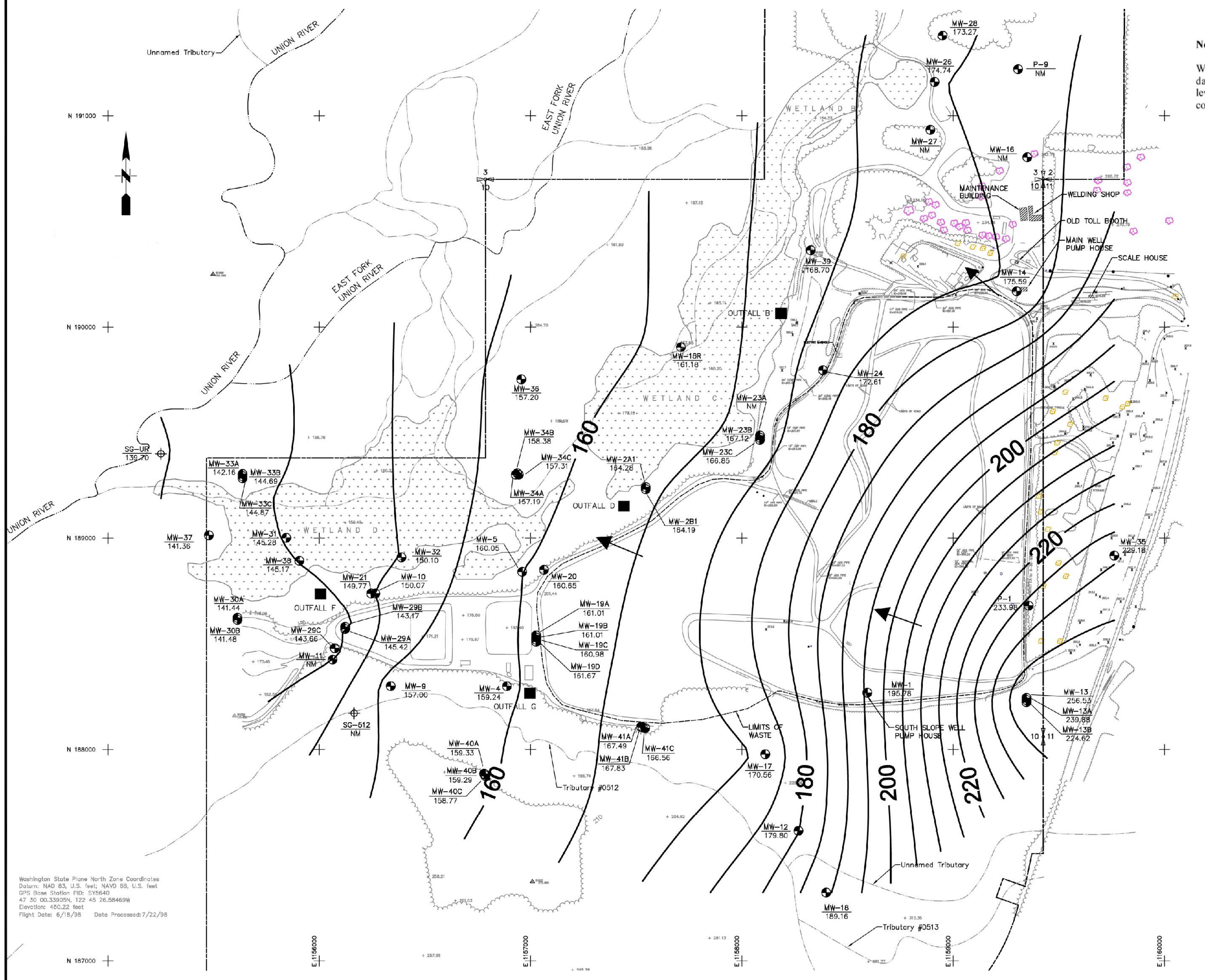
EMSI Engineering Management Support, Inc.

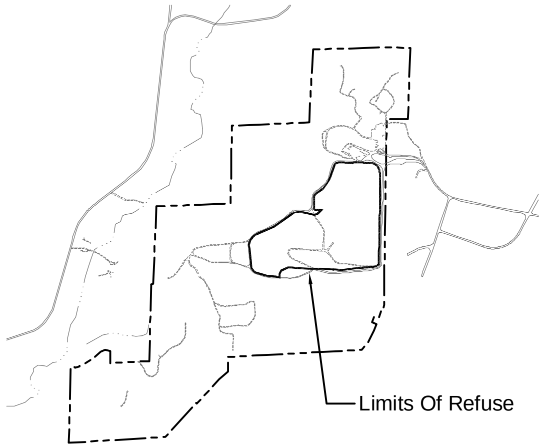
M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-2-9.DWG-11X17 FIGURE 07/31/2009 3:13PM

Note:

Water level contours were generated using depth to water and measuring point elevation data from wells screened between 89 and 200 ft-msl and one stream gauge. The water level elevations for fourteen wells and one stream gauge have not been used to generate contours for the following reasons:

- Wells MW-13, MW-13B, MW-19D, MW-23C, MW-30B, MW-33C, MW-34B, MW-40C, MW-41C, and P-1 have screen elevations outside the 89 to 200 ft-msl range.
- Tributary 512 was flowing, but not under the gauge.
- Water levels were omitted for MW-11, MW-12, MW-16, MW-18, MW-27, and P-9.





KEY MAP

NO SCALE

Figure 2-10

Water Level Contour Map
December 2008

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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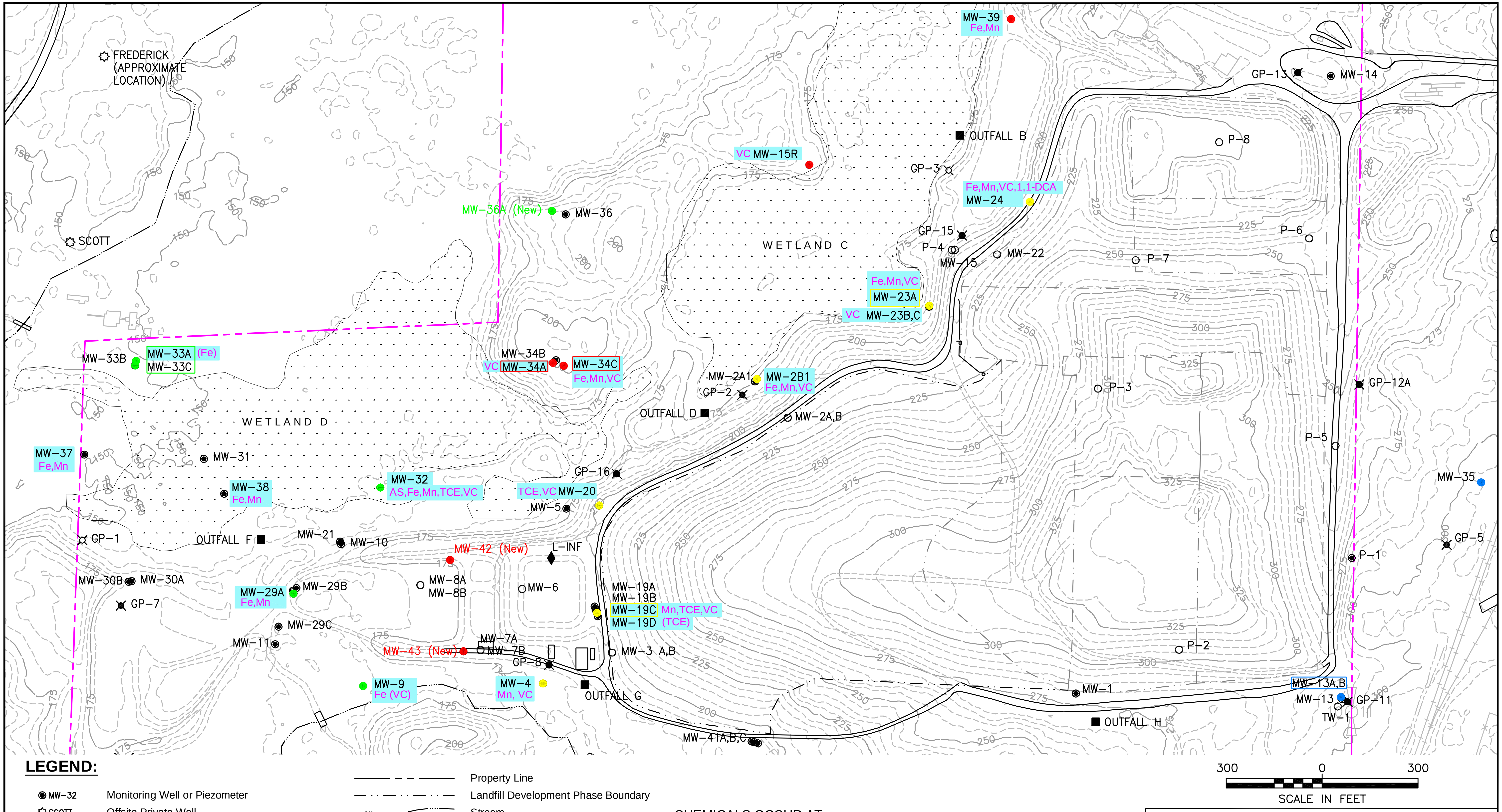

LEGEND:

◉ MW-32	Monitoring Well or Piezometer
✪ SCOTT	Offsite Private Well
○ MW-15	Decommissioned Monitoring Well or Piezometer
◆ L-INF	Leachate Influent Monitoring Station
⊗ GP-15	Gas Probe
¤ GP-6	Decommissioned Gas Probe
△ GP-7B	Decommissioned Gas Probe Boring
■ OUTFALL B	Stormwater Monitoring Outfall
—— – – ——	Property Line
— · · — · · —	Landfill Development Phase Boundary
～	Stream
═	Access Road
┼┼┼	Railroad

MONITORING WELL KEY

🔴	Compliance Monitoring Well
🟡	Performance Monitoring Well
🟢	Downgradient Monitoring Well
🔵	Upgradient (background) Monitoring Well

CHEMICALS OCCUR AT CONCENTRATIONS GREATER THAN STANDARDS OR RISK BASED LEVELS

As = Arsenic
Fe = Iron
Mn = Manganese
TCE = Trichloroethylene
VC = Vinyl Chloride
1,1-DCE = 1,1-Dichloroethane
( ) = One Time Occurance

Figure 2-11

Groundwater Quality Exceedances of Standards or Risk-Based Levels

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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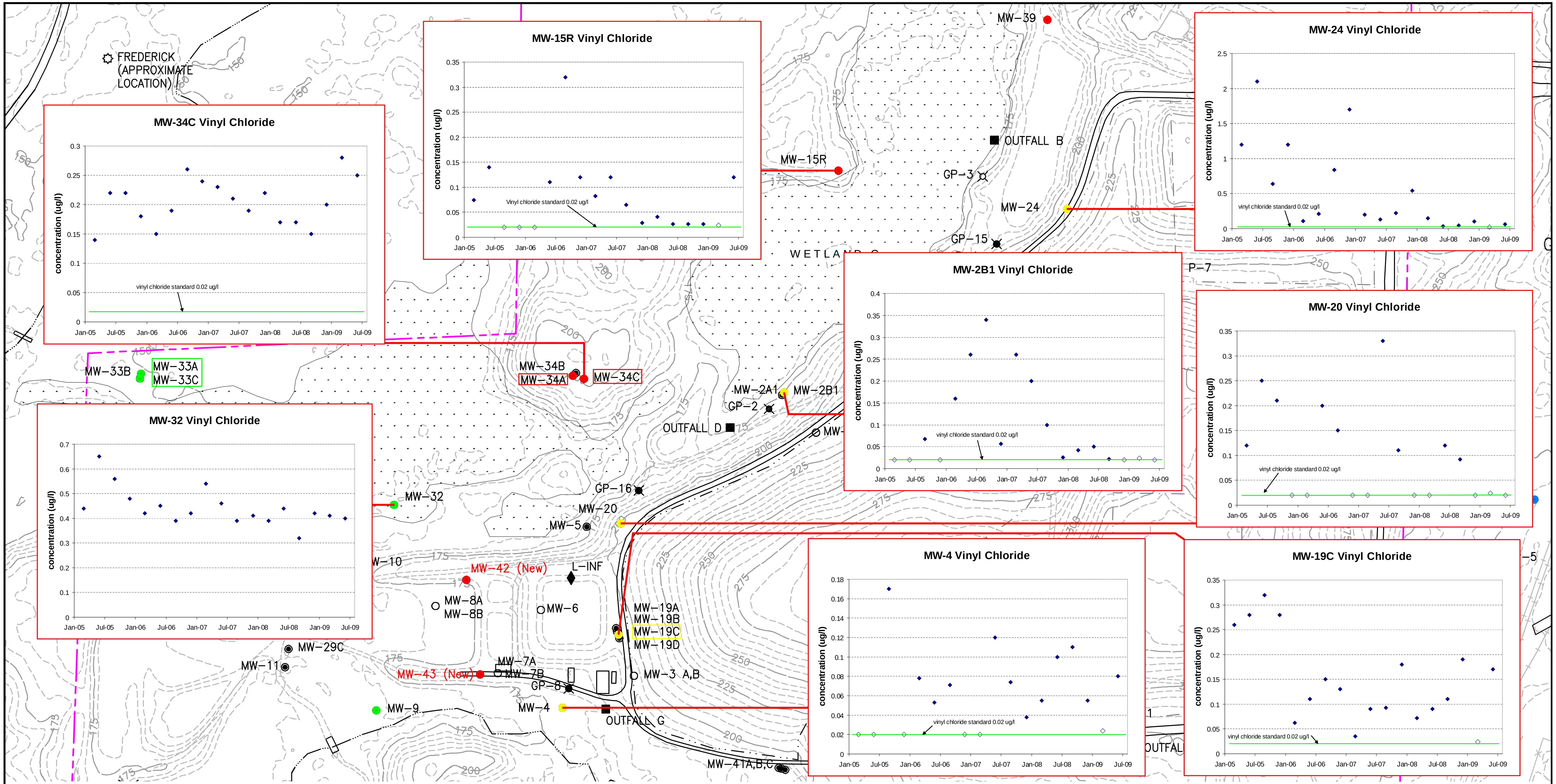

LEGEND:

● MW-32	Monitoring Well or Piezometer
✲ SCOTT	Offsite Private Well
○ MW-15	Decommissioned Monitoring Well or Piezometer
◆ L-INF	Leachate Influent Monitoring Station
⊗ GP-15	Gas Probe
¤ GP-6	Decommissioned Gas Probe
△ GP-7B	Decommissioned Gas Probe Boring
■ OUTFALL B	Stormwater Monitoring Outfall

— — —	Property Line
— · · — · · —	Landfill Development Phase Boundary
～～～	Stream
═══	Access Road
—+—+—	Railroad

MONITORING WELL KEY

🟥	Compliance Monitoring Well
🟨	Performance Monitoring Well
🟩	Downgradient Monitoring Well
🟦	Upgradient (background) Monitoring Well

Figure 2-12
Vinyl Chloride Concentrations Over Time
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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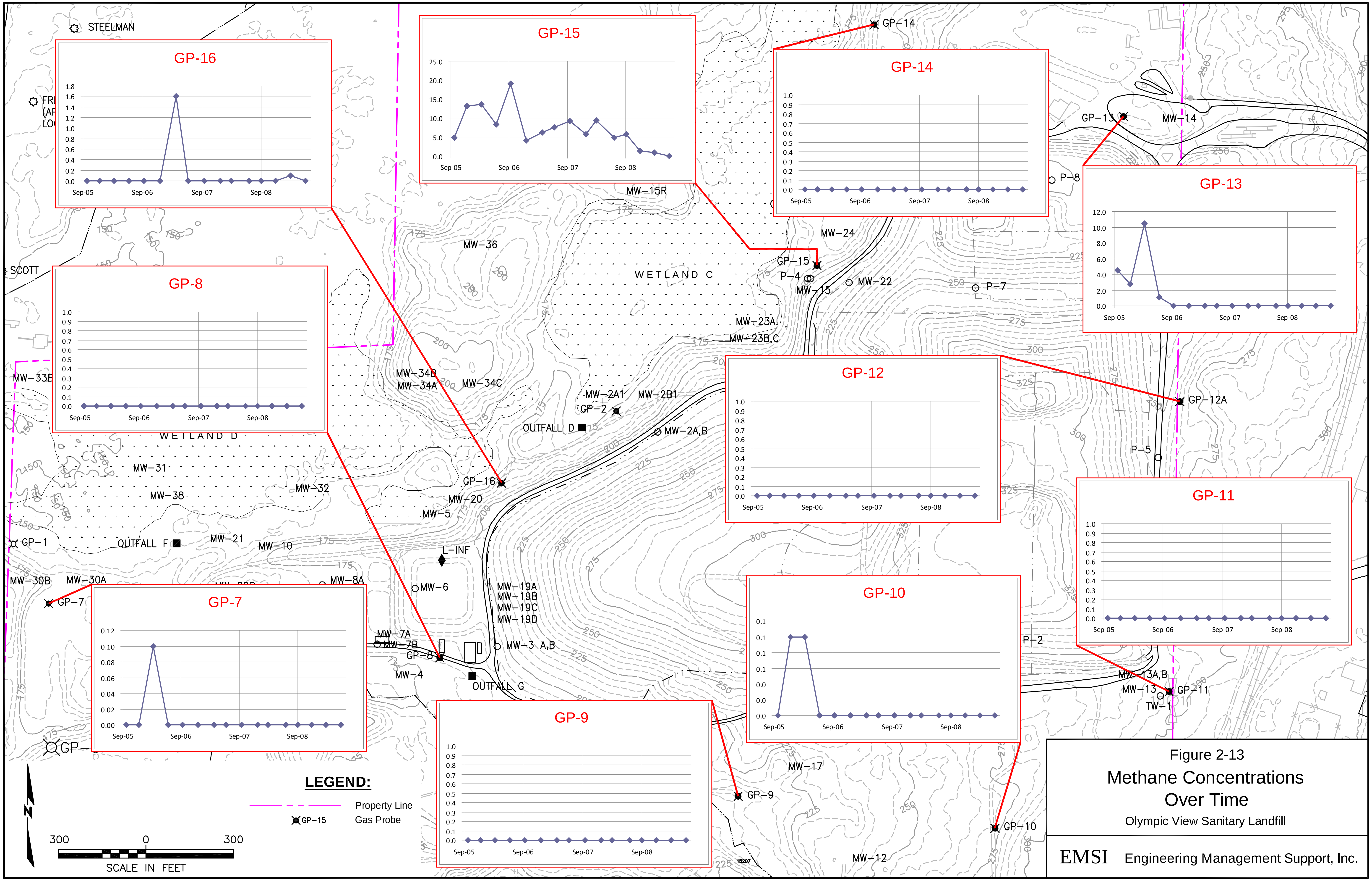

Figure 2-13
Methane Concentrations
Over Time
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

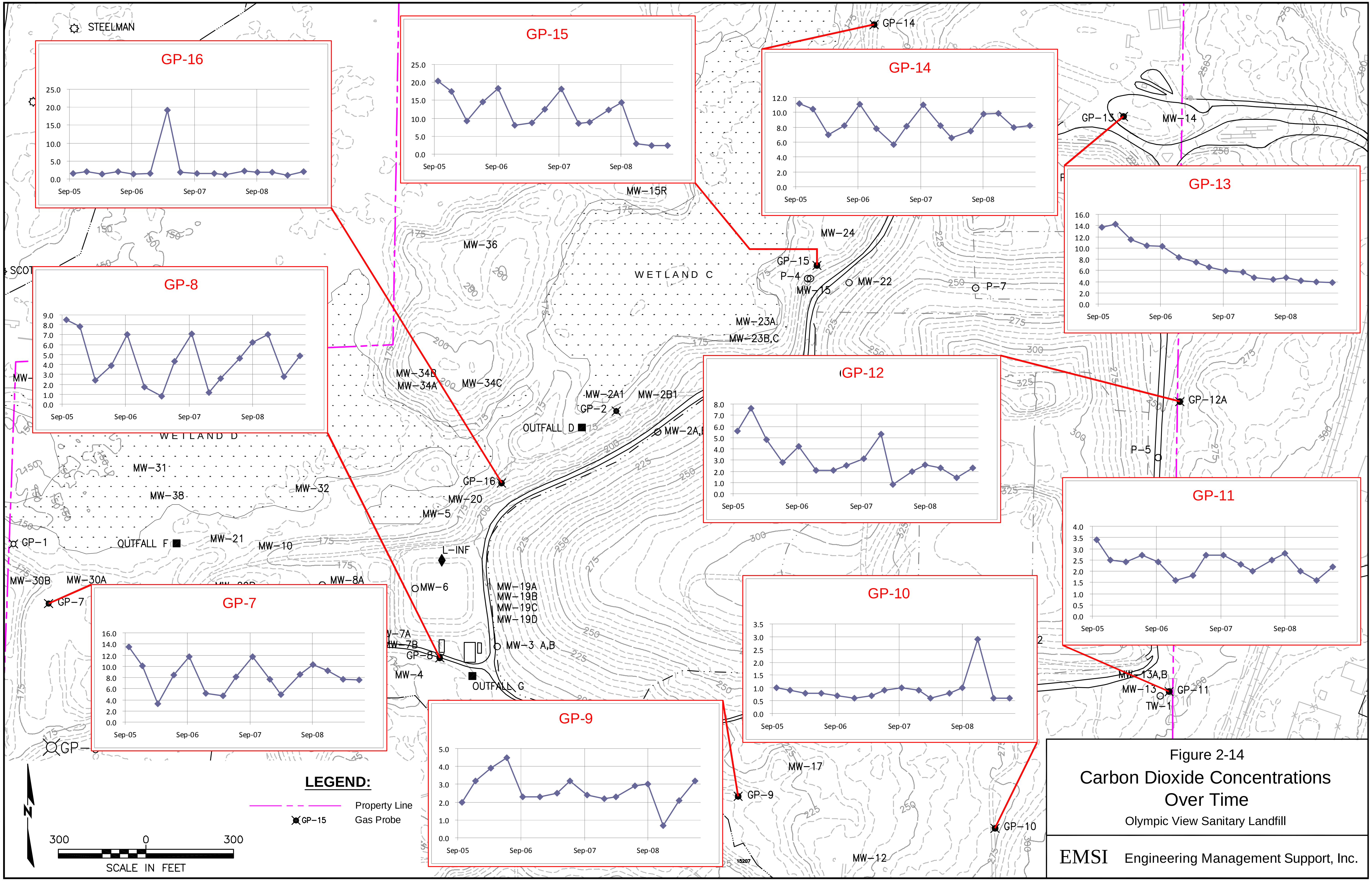

Figure 2-14
Carbon Dioxide Concentrations Over Time
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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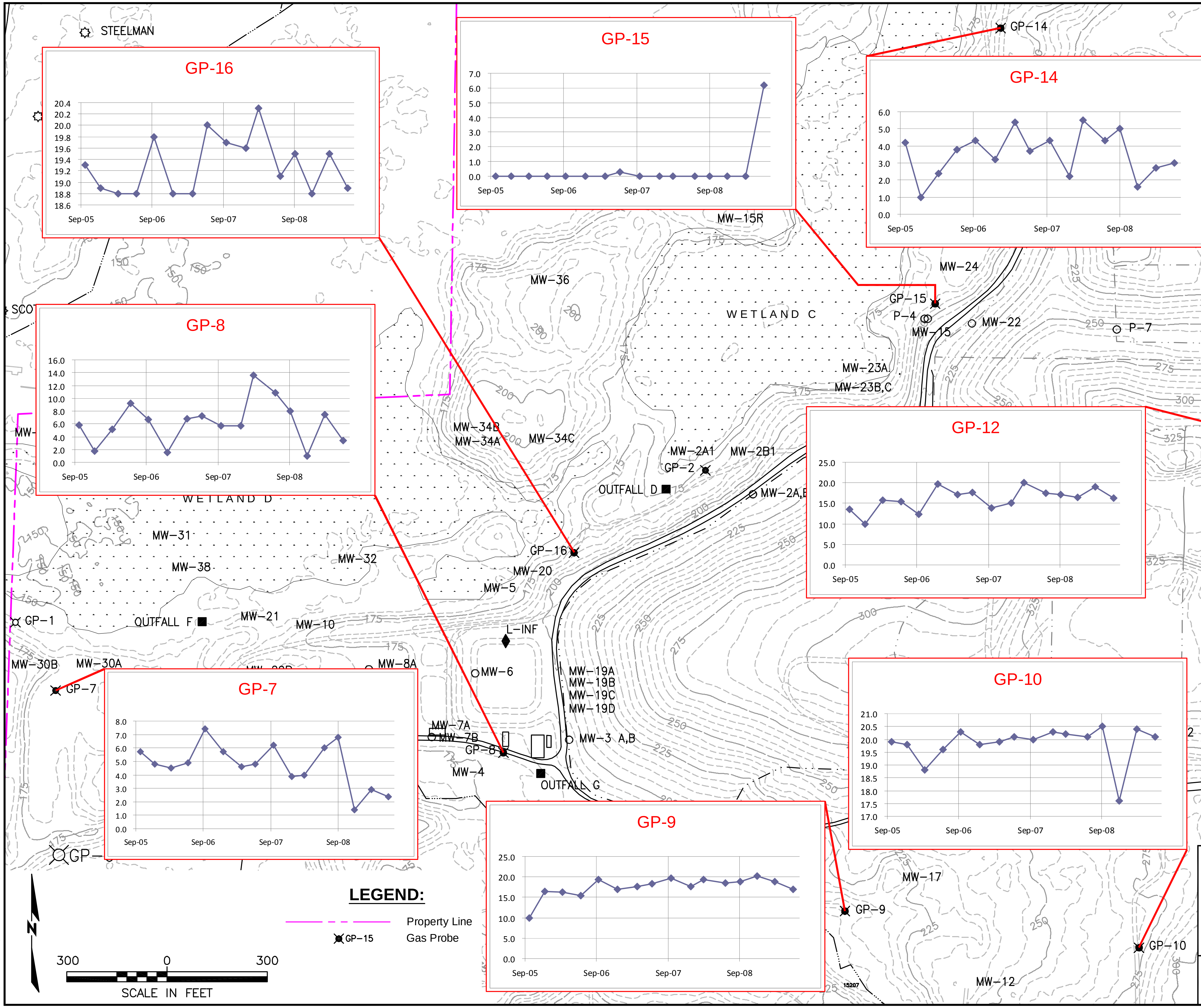

LEGEND:

— - —	Property Line
⊗ GP-15	Gas Probe

Figure 2-15

Oxygen Concentrations

Over Time

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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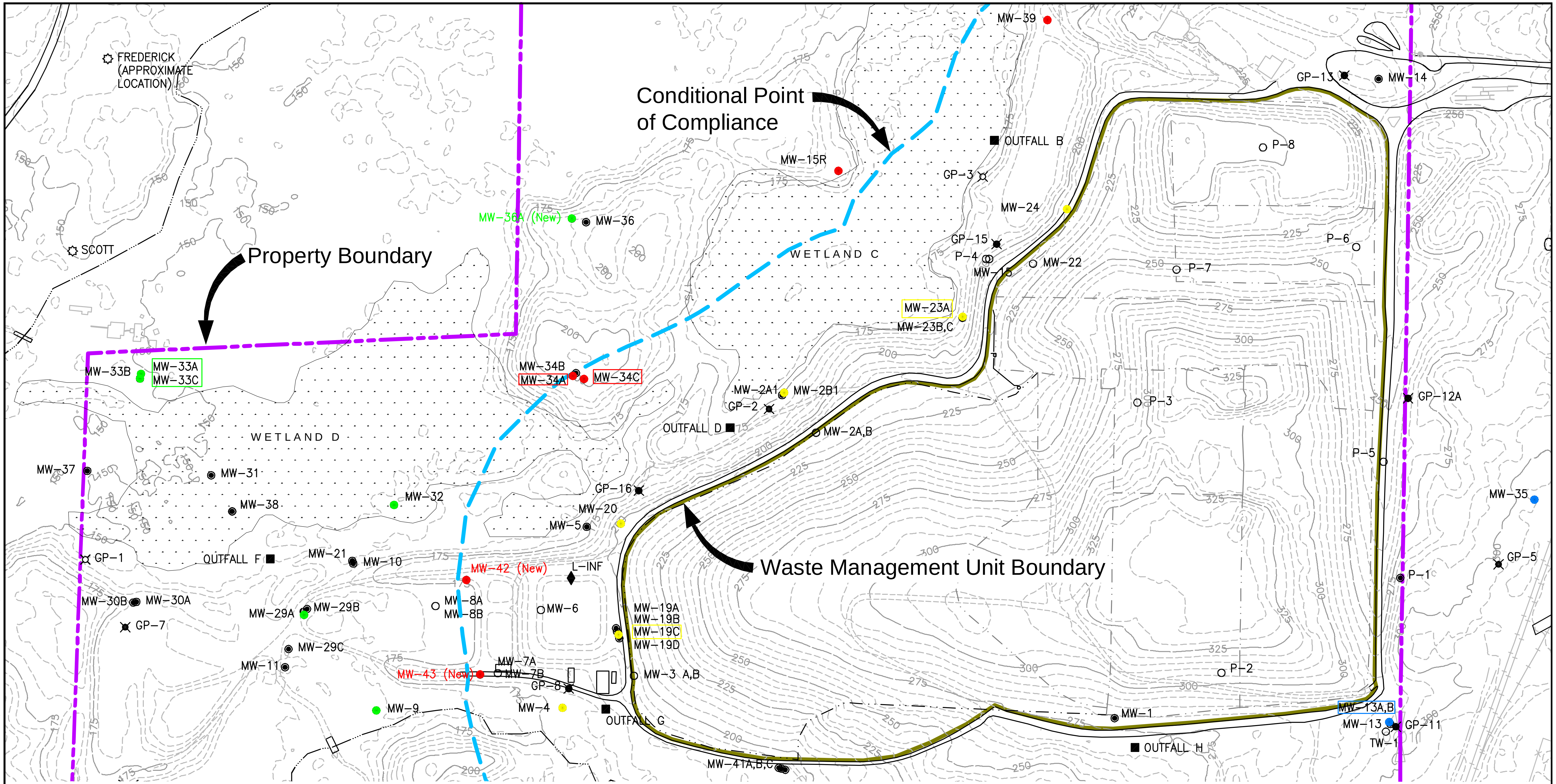

300 0 300
SCALE IN FEET

LEGEND:

◉ MW-32	Monitoring Well or Piezometer
✡ SCOTT	Offsite Private Well
○ MW-15	Decommissioned Monitoring Well or Piezometer
◆ L-INF	Leachate Influent Monitoring Station
✕ GP-15	Gas Probe
☓ GP-6	Decommissioned Gas Probe
△ GP-7B	Decommissioned Gas Probe Boring
■ OUTFALL B	Stormwater Monitoring Outfall

— · — · —	Property Boundary
———	Waste Management Unit Boundary
— — —	Conditional Point of Compliance
— · — · —	Landfill Development Phase Boundary
~~	Stream
═══	Access Road
—+—+—	Railroad

MONITORING WELL KEY

●	Compliance Monitoring Well
●	Performance Monitoring Well
●	Downgradient Monitoring Well
●	Upgradient (background) Monitoring Well

N

Figure 3-1

Conditional Point of Compliance

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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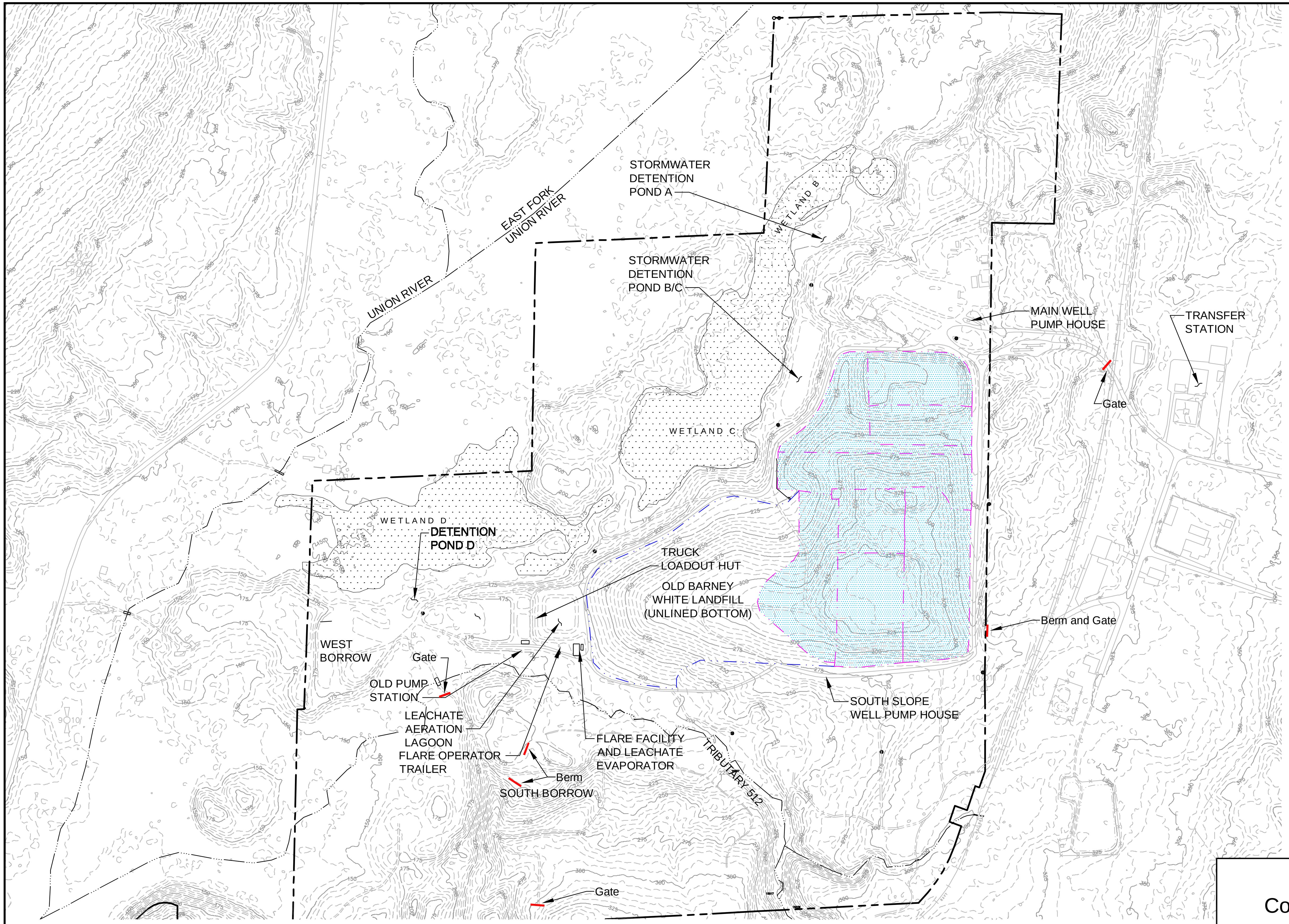

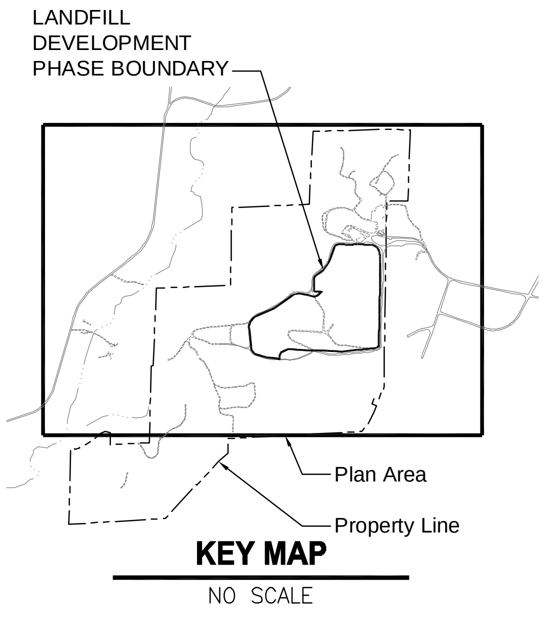

KEY MAP

NO SCALE

NOTES:

1. Contour data based on topographic survey data supplied by Space Imaging LLC & Kitsap County GIS Aerial Imagery, June 2001.
2. Additional property to south (see Key Map).

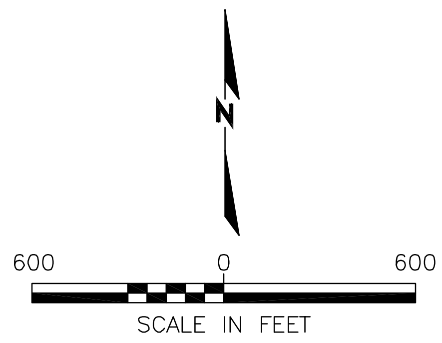

Figure 5-1

Continued Post-Closure Care Facilities

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-5-1.DWG-11X17 FIGURE 05/28/2010 4:23PM

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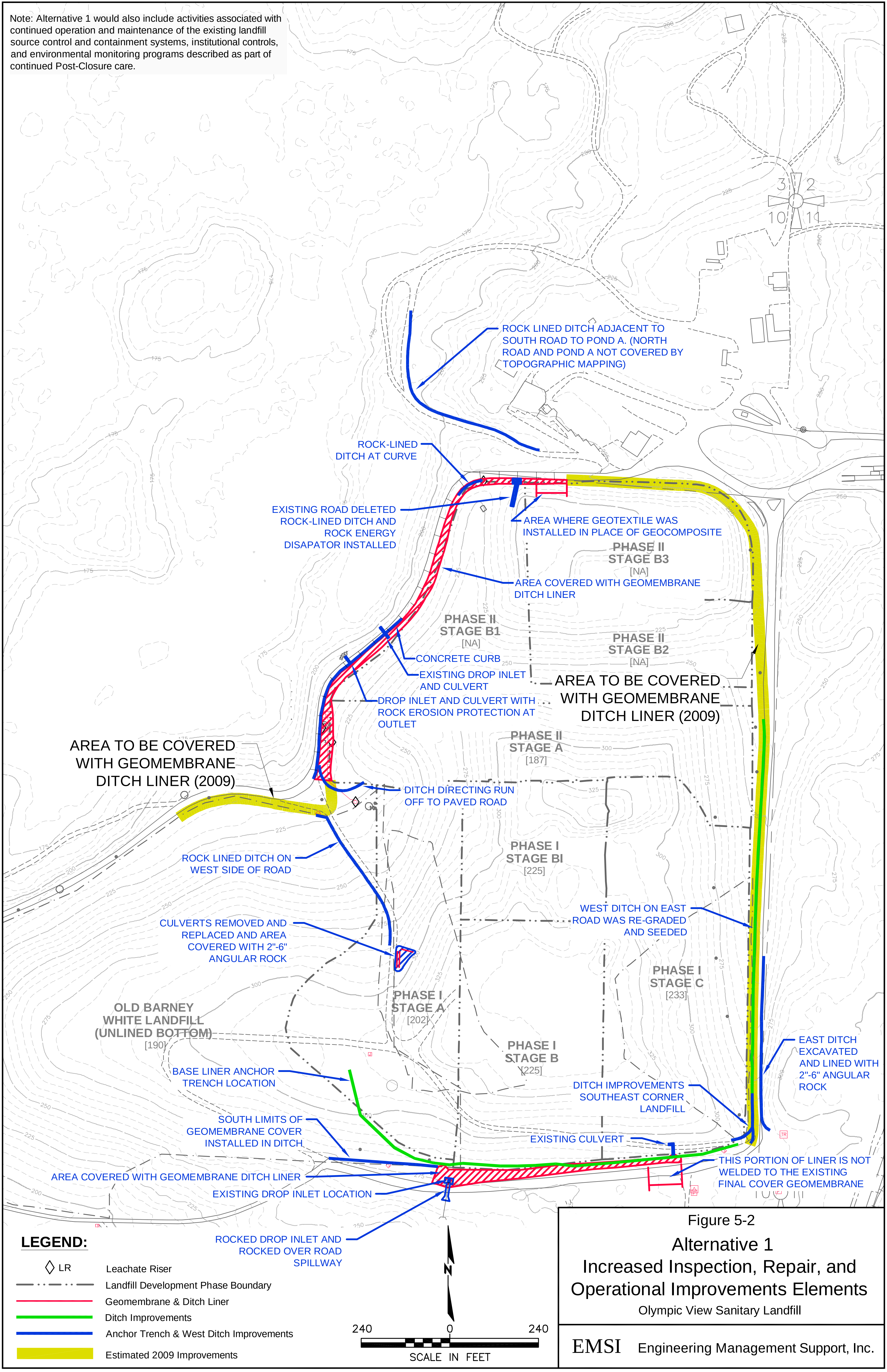


Note: Alternative 1 would also include activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

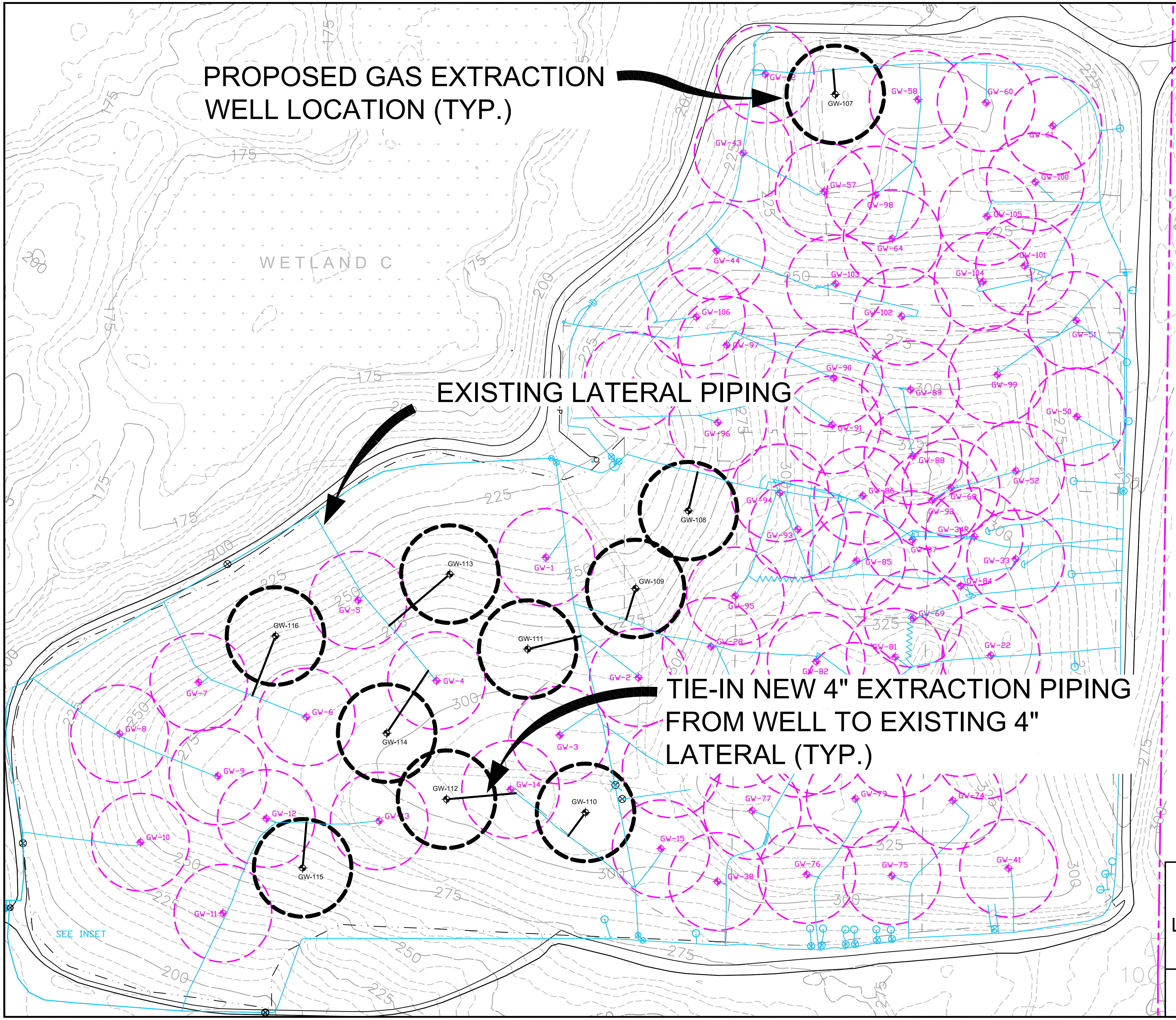
Figure 5-2

Alternative 1

Increased Inspection, Repair, and Operational Improvements Elements

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.



Note: Alternative 2 would also include the increased inspection, repair and operational enhancements of Alternative 1 and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

LEGEND

GW-33 Existing Gas Extraction Well With 100' Radius of Influence

GW-113 Proposed Gas Extraction Well With 100' Radius of Influence

Proposed Tie In to Existing Gas Collection Piping System

N

200 0 200
SCALE IN FEET

Figure 5-3
Alternative 2
Landfill Gas Collection System Upgrades
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

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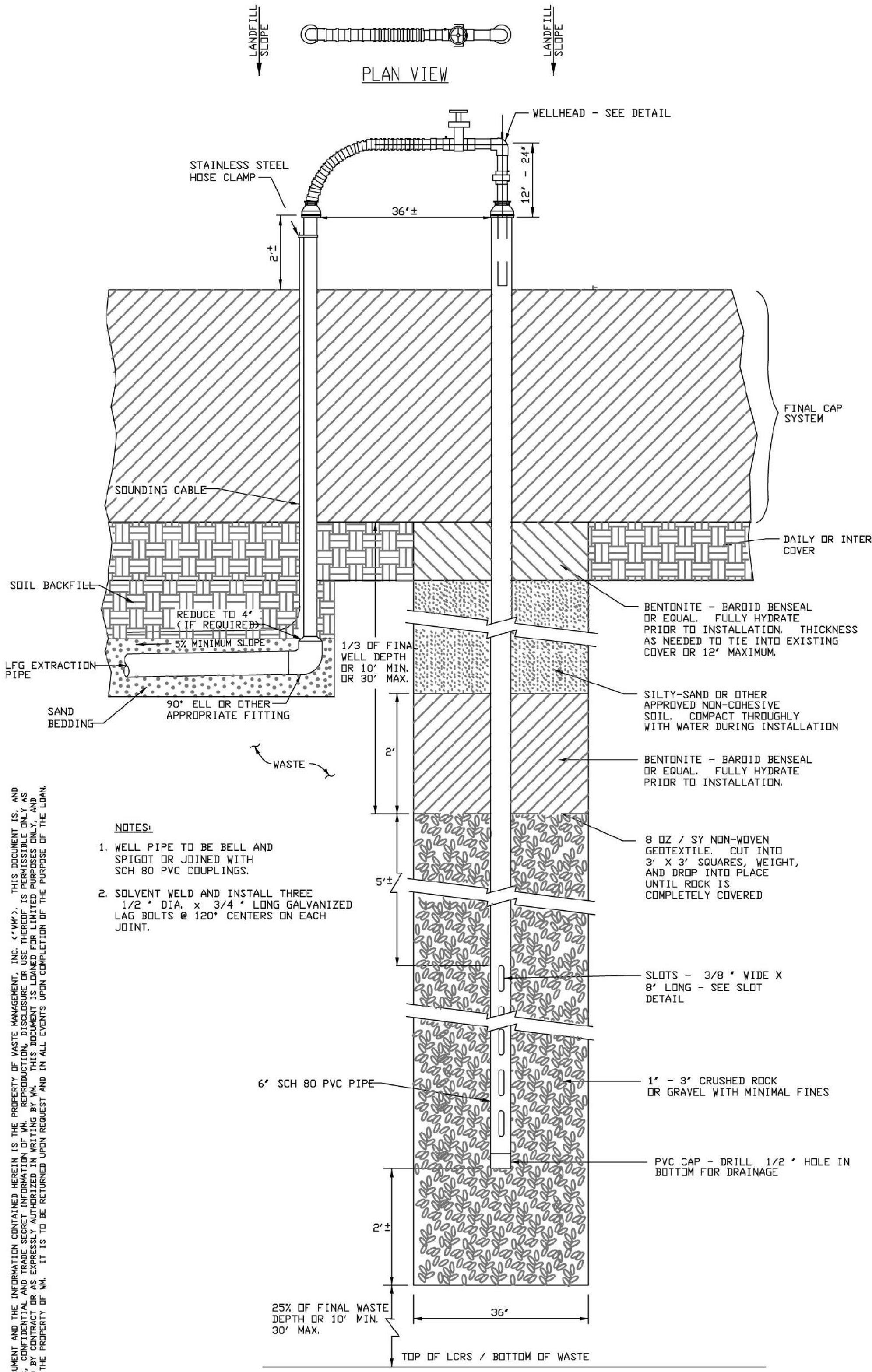
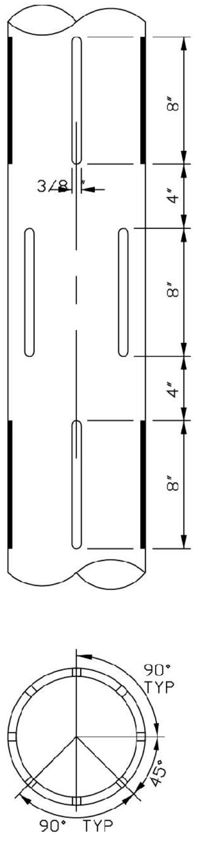


NOTES:

1. WELL PIPE TO BE BELL AND SPIGOT OR JOINED WITH SCH 80 PVC COUPLINGS.
2. SOLVENT WELD AND INSTALL THREE 1/2 ' DIA. x 3/4 ' LONG GALVANIZED LAG BOLTS @ 120° CENTERS ON EACH JOINT.

TYPICAL LFG COLLECTION WELL

NO SCALE



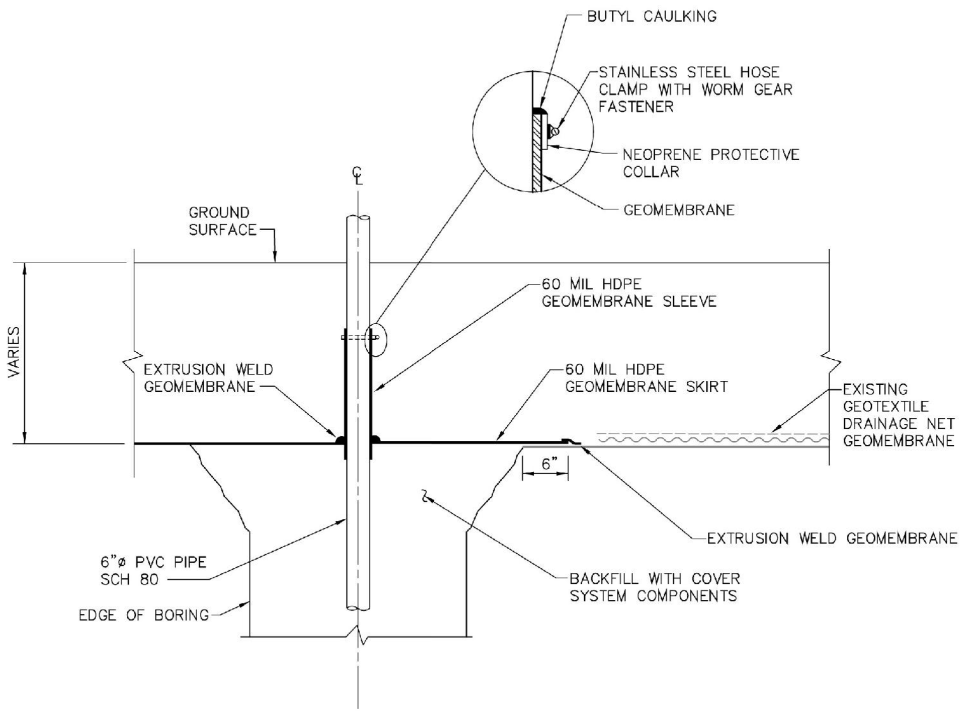
SLOT DETAIL

NO SCALE

PROPOSED LANDFILL GAS WELL SCHEDULE

WELL	DESIGN WELL (SCFM)	WELLHEAD SIZE	WELL PIPE SIZE	EXTRACTION PIPE SIZE	ORIFICE PLATE SIZE	EASTING	NORTHING	APPROX. DEPTH
MW-107						1158736.28	190004.77	
MW-108						1158435.20	189151.44	
MW-109						1158326.93	188992.02	
MW-110						1158224.27	188533.12	
MW-111						1158105.77	188867.84	
MW-112						1157939.38	188560.16	
MW-113						1157946.27	189021.57	
MW-114						1157816.68	188695.60	
MW-115						1157644.36	188419.46	
MW-116						1157588.81	188894.88	

NOTE:
WELL LOCATIONS ARE APPROXIMATE AND MAY BE ADJUSTED TO ACCOMODATE FIELD CONDITIONS AND FACILITATE CONSTRUCTION.



COVER PENETRATION REPAIR DETAIL

NO SCALE

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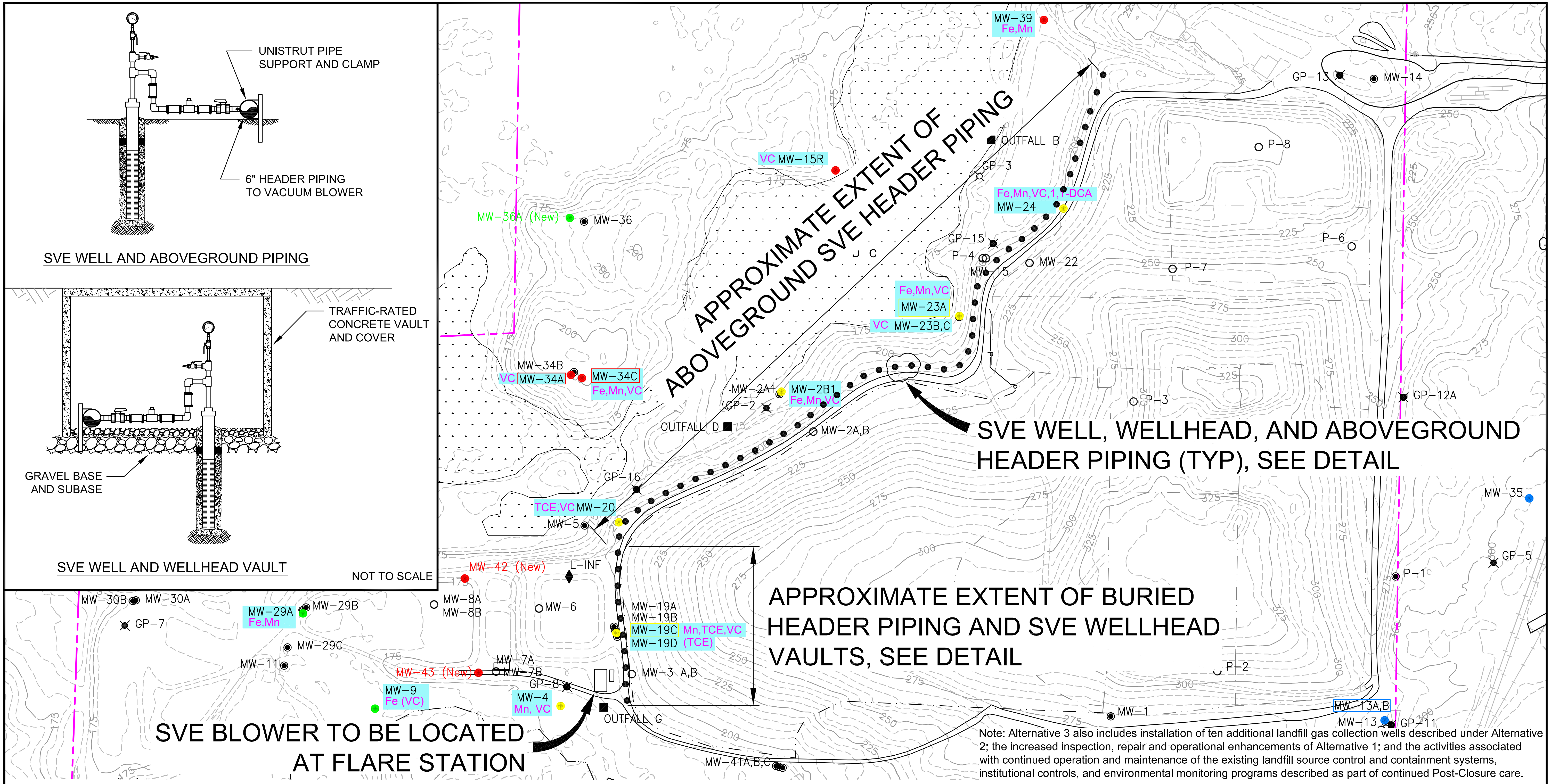
Figure 5-4

Landfill Gas Extraction Well Details

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.



APPROXIMATE EXTENT OF ABOVEGROUND SVE HEADER PIPING

SVE WELL, WELLHEAD, AND ABOVEGROUND HEADER PIPING (TYP), SEE DETAIL

APPROXIMATE EXTENT OF BURIED HEADER PIPING AND SVE WELLHEAD VAULTS, SEE DETAIL

SVE BLOWER TO BE LOCATED AT FLARE STATION

Note: Alternative 3 also includes installation of ten additional landfill gas collection wells described under Alternative 2; the increased inspection, repair and operational enhancements of Alternative 1; and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

300 0 300
SCALE IN FEET

N

LEGEND:

● MW-32	Monitoring Well or Piezometer	— — — —	Property Line
✲ SCOTT	Offsite Private Well	— · · — · · —	Landfill Development Phase Boundary
○ MW-15	Decommissioned Monitoring Well or Piezometer	～～～	Stream
◆ L-INF	Leachate Influent Monitoring Station	═══	Access Road
✖ GP-15	Gas Probe	—+—+—+—	Railroad
⌧ GP-6	Decommissioned Gas Probe		
△ GP-7B	Decommissioned Gas Probe Boring		
■ OUTFALL B	Stormwater Monitoring Outfall		

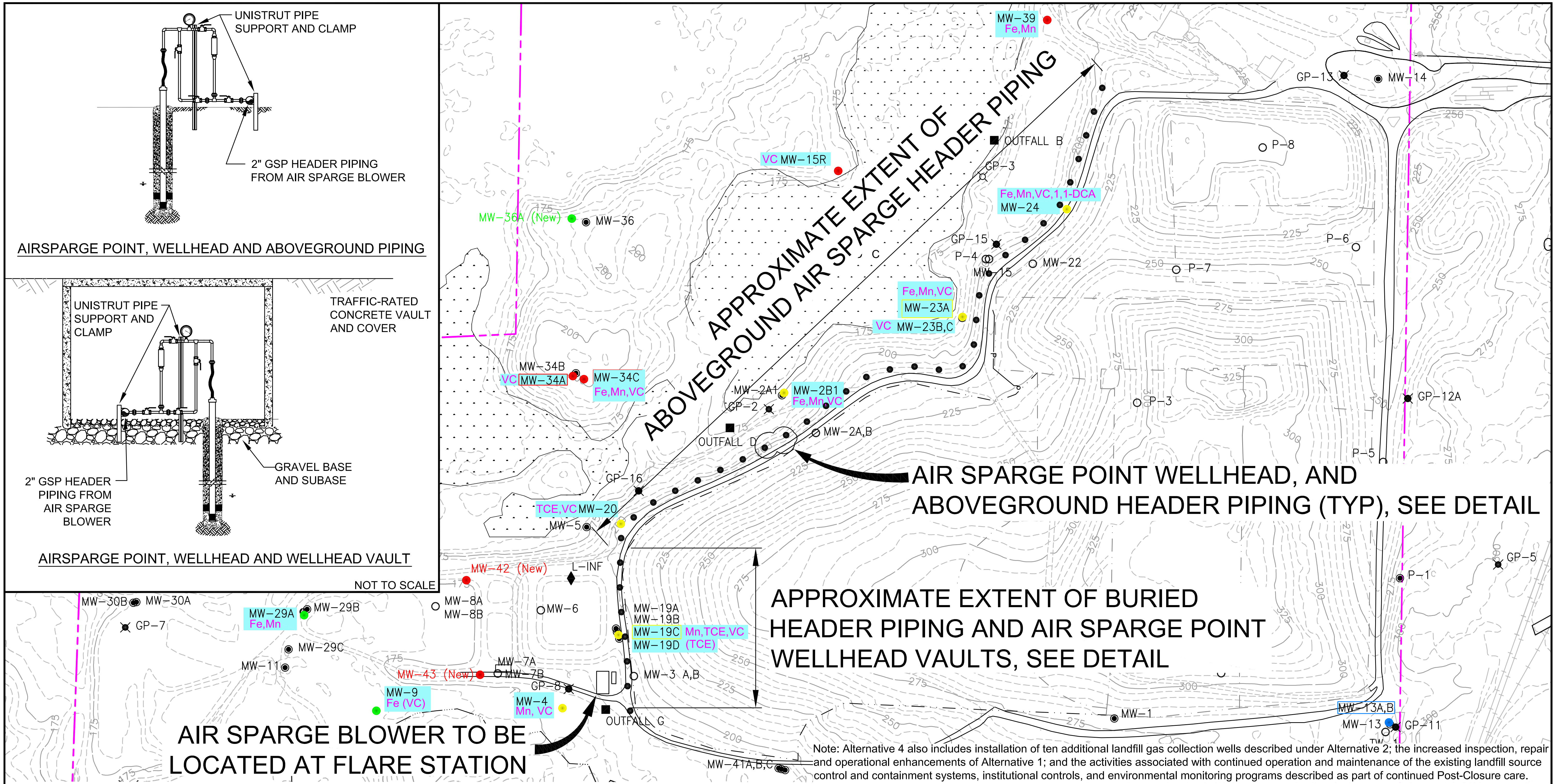
MONITORING WELL KEY

🔴	Compliance Monitoring Well
🟡	Performance Monitoring Well
🟢	Downgradient Monitoring Well
🔵	Upgradient (background) Monitoring Well

Figure 5-5
Alternative 3
Vadose Zone Gas Investigation And Extraction
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-5-5.DWG-50FT 05/27/2010 9:09AM



APPROXIMATE EXTENT OF ABOVEGROUND AIR SPARGE HEADER PIPING

AIR SPARGE POINT WELLHEAD, AND ABOVEGROUND HEADER PIPING (TYP), SEE DETAIL

APPROXIMATE EXTENT OF BURIED HEADER PIPING AND AIR SPARGE POINT WELLHEAD VAULTS, SEE DETAIL

AIR SPARGE BLOWER TO BE LOCATED AT FLARE STATION

Note: Alternative 4 also includes installation of ten additional landfill gas collection wells described under Alternative 2; the increased inspection, repair and operational enhancements of Alternative 1; and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

300 0 300

SCALE IN FEET

LEGEND:

◉ MW−32	Monitoring Well or Piezometer	—— — — ——	Property Line
✡ SCOTT	Offsite Private Well	— · — · —	Landfill Development Phase Boundary
○ MW−15	Decommissioned Monitoring Well or Piezometer	∼∼∼	Stream
◆ L−INF	Leachate Influent Monitoring Station	═══	Access Road
✖ GP−15	Gas Probe	┼┼┼	Railroad
⌘ GP−6	Decommissioned Gas Probe		
△ GP−7B	Decommissioned Gas Probe Boring		
■ OUTFALL B	Stormwater Monitoring Outfall		

MONITORING WELL KEY

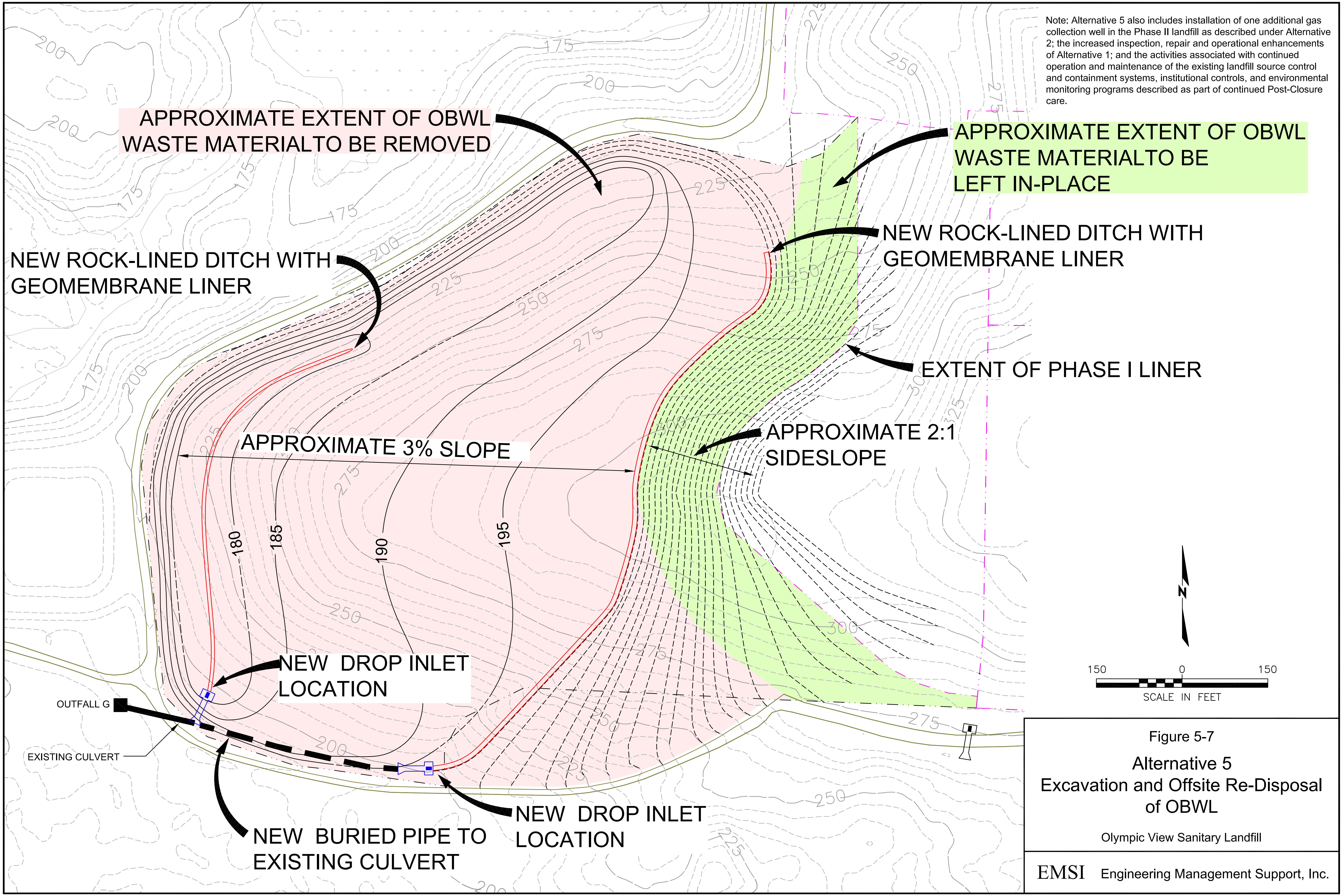
🔴	Compliance Monitoring Well
🟡	Performance Monitoring Well
🟢	Downgradient Monitoring Well
🔵	Upgradient (background) Monitoring Well

N

Figure 5-6
Alternative 4
Air Sparge Wall
Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-5-6.DWG-75FT 05/27/2010 9:12AM



Note: Alternative 5 also includes installation of one additional gas collection well in the Phase II landfill as described under Alternative 2; the increased inspection, repair and operational enhancements of Alternative 1; and the activities associated with continued operation and maintenance of the existing landfill source control and containment systems, institutional controls, and environmental monitoring programs described as part of continued Post-Closure care.

Figure 5-7

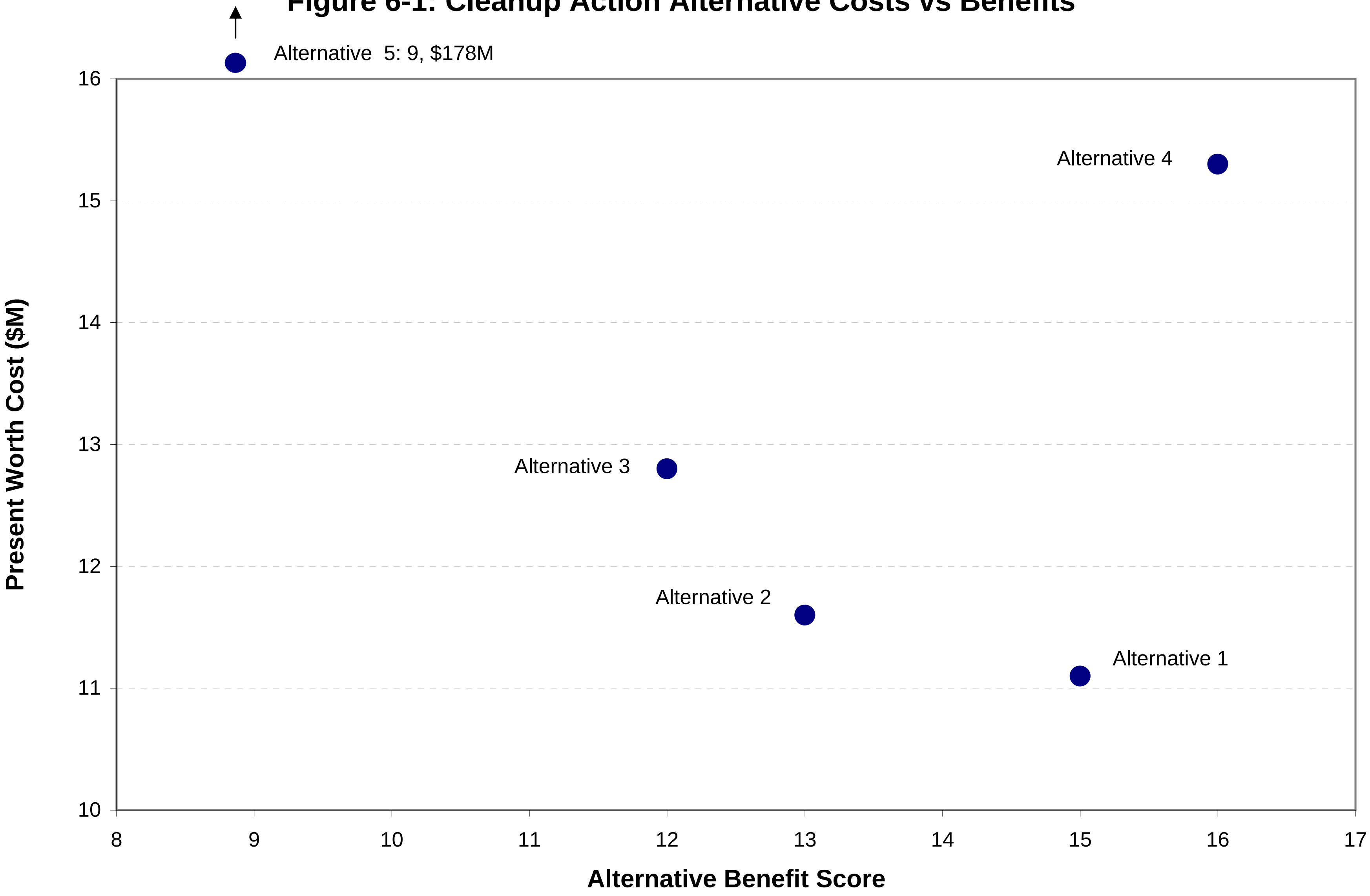
Alternative 5
Excavation and Offsite Re-Disposal of OBWL

Olympic View Sanitary Landfill

EMSI Engineering Management Support, Inc.

M:\CLIENTS\EMSI\WASTE-MAN-OVSL\PARAMETRIX\BL2982003P06T04F2-1 11-9-07\OVSL-FIG-5-7.DWG-LAYOUT 05/27/2010 9:13AM

Figure 6-1: Cleanup Action Alternative Costs vs Benefits



Appendix A

Estimated Costs for Cleanup Action Alternatives

Table A-1

Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
DIRECT CAPITAL COST - Alternative 1				
Environmental Monitoring				
New groundwater monitoring wells	3	each	10,000	30,000
Leachate System				
Leachate repairs and upgrades	1	LS	25,000	25,000
Landfill Gas System				
Flare and LEU repairs	1	LS	22,500	22,500
Gas system repairs and upgrades	1	LS	46,900	46,900
Landfill gas well re-abandonment	1	LS	70,000	70,000
Cover System				
Additional drainage channel/cover improvements	1	LS	430,000	430,000
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 1				**624,000**
Capital Cost Contingency (scope and cost) 25%				156,000
TOTAL - CAPITAL COST ESTIMATE - Alternative 1				**780,000**

Table A-1
Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1 ** (Year 0)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	172,500	172,500
Leachate hauling	1	LS	75,000	75,000
Leachate disposal	1	LS	300,000	300,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	54,000	54,000
Flare and leachate evaporation unit operation and monitoring	1	LS	155,400	155,400
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	35,000	35,000
Electrical power				
Electrical power costs	1	LS	55,000	55,000
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	18,700	18,700
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	73,100	73,100
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1				**1,086,800**
Contingency (scope and cost) 10%				108,700
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 1 (Year 0)				**1,196,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-1
Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1 ** (Year 1)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	139,200	139,200
Leachate hauling	1	LS	56,300	56,300
Leachate disposal	1	LS	225,000	225,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	54,000	54,000
Flare and leachate evaporation unit operation and monitoring	1	LS	126,600	126,600
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	28,500	28,500
Electrical power				
Electrical power costs	1	LS	48,100	48,100
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	14,000	14,000
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	69,700	69,700
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1				**909,500**
Contingency (scope and cost) 10%				91,000
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 1 (Year 1)				**1,001,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-1
Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1 ** (Year 2)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	105,900	105,900
Leachate hauling	1	LS	37,500	37,500
Leachate disposal	1	LS	150,000	150,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	54,000	54,000
Flare and leachate evaporation unit operation and monitoring	1	LS	97,800	97,800
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	22,000	22,000
Electrical power				
Electrical power costs	1	LS	41,300	41,300
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	9,400	9,400
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	66,400	66,400
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1				**732,400**
Contingency (scope and cost) 10%				73,200
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 1 (Year 2)				**806,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-1

Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	NUMBER	UNIT	UNIT COST ($)	TOTAL COST ($)
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1 ** (Year 3)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	72,500	72,500
Leachate hauling	1	LS	18,800	18,800
Leachate disposal	1	LS	75,000	75,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	54,000	54,000
Flare and leachate evaporation unit operation and monitoring	1	LS	68,900	68,900
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	15,500	15,500
Electrical power				
Electrical power costs	1	LS	34,400	34,400
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	4,700	4,700
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	63,000	63,000
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1				**554,900**
Contingency (scope and cost) 10%				55,500
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 1 (Year 3)				**610,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-1
Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1 ** (Year 4 and forward)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	39,200	39,200
Leachate hauling	1	LS	0	0
Leachate disposal	1	LS	0	0
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	54,000	54,000
Flare and leachate evaporation unit operation and monitoring	1	LS	40,100	40,100
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	9,000	9,000
Electrical power				
Electrical power costs	1	LS	27,500	27,500
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	0	0
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	59,600	59,600
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 1				**377,500**
Contingency (scope and cost) 10%				37,800
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 1 (Year 4 and forward)				**415,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-1

Estimated Cost to Implement Alternative 1 - Increased Inspection, Repair and Operational Improvements

Feasibility Study - Olympic View Sanitary Landfill

YEAR	n	P/F(i=3%)	CAPITAL COSTS ($)	O&M AND MONITORING COSTS ($/yr)	SUBTOTAL COSTS ($)	PRESENT WORTH OF COSTS ($)	CUMULATIVE PRESENT WORTH ($)
PRESENT WORTH COST ESTIMATE							
2010	0	1.00000	780,000	1,196,000	1,976,000	1,976,000	1,976,000
2011	1	0.97087		1,001,000	1,001,000	972,000	2,948,000
2012	2	0.94260		806,000	806,000	760,000	3,708,000
2013	3	0.91514		610,000	610,000	558,000	4,266,000
2014	4	0.88849		415,000	415,000	369,000	4,635,000
2015	5	0.86261		415,000	415,000	358,000	4,993,000
2016	6	0.83748		415,000	415,000	348,000	5,341,000
2017	7	0.81309		415,000	415,000	337,000	5,678,000
2018	8	0.78941		415,000	415,000	328,000	6,006,000
2019	9	0.76642		415,000	415,000	318,000	6,324,000
2020	10	0.74409		415,000	415,000	309,000	6,633,000
2021	11	0.72242		415,000	415,000	300,000	6,933,000
2022	12	0.70138		415,000	415,000	291,000	7,224,000
2023	13	0.68095		415,000	415,000	283,000	7,507,000
2024	14	0.66112		415,000	415,000	274,000	7,781,000
2025	15	0.64186		415,000	415,000	266,000	8,047,000
2026	16	0.62317		415,000	415,000	259,000	8,306,000
2027	17	0.60502		415,000	415,000	251,000	8,557,000
2028	18	0.58739		415,000	415,000	244,000	8,801,000
2029	19	0.57029		415,000	415,000	237,000	9,038,000
2030	20	0.55368		415,000	415,000	230,000	9,268,000
2031	21	0.53755		415,000	415,000	223,000	9,491,000
2032	22	0.52189		415,000	415,000	217,000	9,708,000
2033	23	0.50669		415,000	415,000	210,000	9,918,000
2034	24	0.49193		415,000	415,000	204,000	10,122,000
2035	25	0.47761		415,000	415,000	198,000	10,320,000
2036	26	0.46369		415,000	415,000	192,000	10,512,000
2037	27	0.45019		415,000	415,000	187,000	10,699,000
2038	28	0.43708		415,000	415,000	181,000	10,880,000
2039	29	0.42435		415,000	415,000	176,000	11,056,000
TOTAL - ESTIMATED COSTS:			780,000				**11,060,000**

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	NUMBER	UNIT	UNIT COST ($)	TOTAL COST ($)
DIRECT CAPITAL COST - Alternative 2				
Construct Additional Landfill Gas Extraction Wells				
Surveying/site layout	1	day	1,500	1,500
Assumed number of new landfill gas wells to be constructed	10	number		
New well area: construct pad for drill rig, excavate cover, remove geomembrane (backhoe)	10	day	1,600	16,000
Drilling and completion of new gas wells (depth assumed from video of adjacent wells):				
GW-107	33	lin ft	222	7,300
GW-108	60	lin ft	222	13,300
GW-109	48	lin ft	222	10,700
GW-110	40	lin ft	222	8,900
GW-111	40	lin ft	222	8,900
GW-112	40	lin ft	222	8,900
GW-113	37	lin ft	222	8,200
GW-114	40	lin ft	222	8,900
GW-115	40	lin ft	222	8,900
GW-116	37	lin ft	222	8,200
Haul drill cuttings off-site during drilling (backhoe + operator; truck + driver)	10	day	2,800	28,000
Seal around new well and tie-in to existing geomembrane cover:				
Materials	10	each	500	5,000
Labor - crew of 2	10	day	1,040	10,400
Backfill, compact around new well; grade; reseed:				
Truck hauling of materials	10	day	1,200	12,000
Backhoe to complete grading	10	1/2 day	800	8,000
Tie-in new wells to existing gas collection piping laterals:				
Excavate and stockpile cover materials, remove geomembrane	10	day	1,600	16,000
Trench, 4" HDPE LFG extraction piping, bedding, backfill, compaction	1,200	lin ft	20	24,000
Haul trench spoils off-site	10	1/2 day	600	6,000
Connection of new HDPE extraction piping to existing lateral	10	each	500	5,000
Materials to patch geomembrane cover above new trench	10	each	1,000	10,000
Labor to seal geomembrane patch	10	day	1,040	10,400
Backhoe to re-place cover materials and complete grading	10	1/2 day	800	8,000
Final surveying	0.5	day	1,500	800
			SUBTOTAL	253,000
Miscellaneous Costs				
RD/RA Workplan	1	LS	5,000	5,000
Well permits	10	each	100	1,000
Remedial Action Summary (Construction Completion Report)	1	LS	4,000	4,000
Regulatory Oversight	1	LS	2,000	2,000
			SUBTOTAL	12,000
SUBTOTAL - DIRECT CAPITAL COST - Alternative 2				265,000
INDIRECT CAPITAL COST - Alternative 2				
Engineering Design, Procurement, Administrative, and Legal Costs	1	%	10	26,500
Construction Management (% of Direct Capital Costs)	1	%	10	26,500
Project Management (% of Direct Capital Costs)	1	%	6	15,900
Contractor's General Requirements (assume monthly rental of job trailer, storage box, and portable toilet; and administration support	2	MO	4,000	8,000
SUBTOTAL - INDIRECT CAPITAL COST - Alternative 2				77,000
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 2				**342,000**
CAPITAL COST - Alternative 1 - Increased Inspection, Repair and Operational Improvements				
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 1				**624,000**
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternatives 1 and 2				**966,000**
Capital Cost Contingency (scope and cost) 25%				242,000
TOTAL - CAPITAL COST ESTIMATE - Alternatives 1 and 2				**1,208,000**

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2 ** (Alternative 1 plus 10 new LFG wells) [Year 0]				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	172,500	172,500
Leachate hauling	1	LS	75,000	75,000
Leachate disposal	1	LS	300,000	300,000
Landfill Gas System				
Gas collection system monitoring and operation (incl. 10 new LFG wells)	1	LS	59,100	59,100
Flare and leachate evaporation unit operation and monitoring	1	LS	155,400	155,400
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	35,000	35,000
Electrical power				
Electrical power costs	1	LS	55,000	55,000
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	18,700	18,700
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	73,100	73,100
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2				**1,091,900**
Contingency (scope and cost) 10%				109,200
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 2 (Year 0)				**1,201,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2 ** (Year 1)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	139,200	139,200
Leachate hauling	1	LS	56,300	56,300
Leachate disposal	1	LS	225,000	225,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	59,100	59,100
Flare and leachate evaporation unit operation and monitoring	1	LS	126,600	126,600
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	28,500	28,500
Electrical power				
Electrical power costs	1	LS	48,100	48,100
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	14,000	14,000
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	69,700	69,700
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2				**914,600**
Contingency (scope and cost) 10%				91,500
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 2 (Year 1)				**1,006,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2 ** (Year 2)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	105,900	105,900
Leachate hauling	1	LS	37,500	37,500
Leachate disposal	1	LS	150,000	150,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	59,100	59,100
Flare and leachate evaporation unit operation and monitoring	1	LS	97,800	97,800
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	22,000	22,000
Electrical power				
Electrical power costs	1	LS	41,300	41,300
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	9,400	9,400
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	66,400	66,400
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2				**737,500**
Contingency (scope and cost) 10%				73,800
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 2 (Year 2)				**811,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2 ** (Year 3)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	72,500	72,500
Leachate hauling	1	LS	18,800	18,800
Leachate disposal	1	LS	75,000	75,000
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	59,100	59,100
Flare and leachate evaporation unit operation and monitoring	1	LS	68,900	68,900
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	15,500	15,500
Electrical power				
Electrical power costs	1	LS	34,400	34,400
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	4,700	4,700
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	63,000	63,000
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2				**560,000**
Contingency (scope and cost) 10%				56,000
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 2 (Year 3)				**616,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2 ** (Year 4 and forward)				
Cover System				
Cover inspections	1	LS	5,000	5,000
Weed control	1	LS	10,000	10,000
Cover repairs	1	LS	5,000	5,000
Leachate System				
Leachate system operation and maintenance	1	LS	39,200	39,200
Leachate hauling	1	LS	0	0
Leachate disposal	1	LS	0	0
Landfill Gas System				
Gas collection system monitoring and operation	1	LS	59,100	59,100
Flare and leachate evaporation unit operation and monitoring	1	LS	40,100	40,100
Surface emissions monitoring	1	LS	2,900	2,900
Technical support	1	LS	9,000	9,000
Electrical power				
Electrical power costs	1	LS	27,500	27,500
Electrician	1	LS	2,500	2,500
Environmental Monitoring				
Landfill gas probe monitoring	1	LS	27,500	27,500
Leachate sampling	1	LS	0	0
Groundwater and stormwater sampling	1	LS	62,200	62,200
Laboratory analyses	1	LS	59,600	59,600
Quality assurance and statistical evaluations	1	LS	4,900	4,900
Reporting	1	LS	28,100	28,100
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 2				**382,600**
Contingency (scope and cost) 10%				38,300
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative 2 (Year 4 and forward)				**421,000**

**Based on budgeted or projected costs for 2009 operation, maintenance, and monitoring activities as provided by Waste Management.

Table A-2
Estimated Cost to Implement Alternative 2 - Landfill Gas Collection System Upgrades
Feasibility Study - Olympic View Sanitary Landfill

YEAR	n	P/F(i=3%)	CAPITAL COSTS ($)	O&M AND MONITORING COSTS ($/yr)	SUBTOTAL COSTS ($)	PRESENT WORTH OF COSTS ($)	CUMULATIVE PRESENT WORTH ($)
PRESENT WORTH COST ESTIMATE							
2010	0	1.00000	1,208,000	1,201,000	2,409,000	2,409,000	2,409,000
2011	1	0.97087		1,006,000	1,006,000	977,000	3,386,000
2012	2	0.94260		811,000	811,000	764,000	4,150,000
2013	3	0.91514		616,000	616,000	564,000	4,714,000
2014	4	0.88849		421,000	421,000	374,000	5,088,000
2015	5	0.86261		421,000	421,000	363,000	5,451,000
2016	6	0.83748		421,000	421,000	353,000	5,804,000
2017	7	0.81309		421,000	421,000	342,000	6,146,000
2018	8	0.78941		421,000	421,000	332,000	6,478,000
2019	9	0.76642		421,000	421,000	323,000	6,801,000
2020	10	0.74409		421,000	421,000	313,000	7,114,000
2021	11	0.72242		421,000	421,000	304,000	7,418,000
2022	12	0.70138		421,000	421,000	295,000	7,713,000
2023	13	0.68095		421,000	421,000	287,000	8,000,000
2024	14	0.66112		421,000	421,000	278,000	8,278,000
2025	15	0.64186		421,000	421,000	270,000	8,548,000
2026	16	0.62317		421,000	421,000	262,000	8,810,000
2027	17	0.60502		421,000	421,000	255,000	9,065,000
2028	18	0.58739		421,000	421,000	247,000	9,312,000
2029	19	0.57029		421,000	421,000	240,000	9,552,000
2030	20	0.55368		421,000	421,000	233,000	9,785,000
2031	21	0.53755		421,000	421,000	226,000	10,011,000
2032	22	0.52189		421,000	421,000	220,000	10,231,000
2033	23	0.50669		421,000	421,000	213,000	10,444,000
2034	24	0.49193		421,000	421,000	207,000	10,651,000
2035	25	0.47761		421,000	421,000	201,000	10,852,000
2036	26	0.46369		421,000	421,000	195,000	11,047,000
2037	27	0.45019		421,000	421,000	190,000	11,237,000
2038	28	0.43708		421,000	421,000	184,000	11,421,000
2039	29	0.42435		421,000	421,000	179,000	11,600,000
TOTAL - ESTIMATED COSTS:			1,210,000	14,580,000			**11,600,000**

Table A-3

Estimated Cost to Implement Alternative 3 - Vadose Zone Gas Investigation and Extraction Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	NUMBER	UNIT	UNIT COST ($)	TOTAL COST ($)
DIRECT CAPITAL COST - Alternative 3				
Soil Gas Survey				
Soil gas survey Work Plan	1	LS	5,000	5,000
Surveying	2	day	1,200	2,400
Mobilization/demobilization	1	LS	1,000	1,000
Geoprobe drill rig	5	day	4,000	20,000
Rental of Landtec GEM 2000 gas meter	5	day	100	500
Field geologist/engineer	5	day	850	4,300
Pickup truck	5	day	75	400
Soil Gas Survey Report	1	LS	10,000	10,000
			SUBTOTAL	43,600
SVE Pilot Test				
SVE pilot testing, incl Report	1	LS	50,000	50,000
			SUBTOTAL	50,000
System Construction 54 SVE wells; 5' well screen/well; 2 cfm/ft well screen: 540 cfm				
Surveying/site layout	2	day	1,500	3,000
Assumed number of shallow (10 ft) SVE wells w/ 50 ft ROI	54	number		
Shallow SVE well installation	540	feet	155	83,700
SVE wellhd fittings (shutoff and sample valves, sample port, FERNCOs, reducers, bushings)	54	each	75	4,100
Vapor flow meter, sample port, and vacuum gauge (at each well and blower)	55	each	500	27,500
6" PVC conveyance piping from SVE wells to "flare station"	3,000	lin ft	20	60,000
6" x 2" PVC reducing tee	54	each	27.80	1,600
5/8" Unistrut pipe support	2,640	lin ft	2.20	5,800
6" strut clamps	300	each	4.50	1,400
Trench for 6-inch SVE conveyance piping in road (2.5' W x 2' D)	550	lin ft	40	22,000
Sand bedding for SVE conveyance piping and fill (2.5' W x 2' D), includes 15% expansion	113	cu yd	30	3,400
Disposal of trench spoils and drill cuttings - assume Subtitle D landfill	116	cu yd	10	1,200
Precast manhole, frame, and cover (over SVE wellhead in road)	10	each	1,200	12,000
Valve box and cover (for shutoff valves in road)	10	each	200	2,000
Gravel base for well vaults	10	cu yd	30	300
Concrete slab on-grade for SVE blower	1	LS	7,500	7,500
Fencing around SVE blower equipment, and gate (8' H chain link)	80	lin ft	75	6,000
Sound insulation blanket around remediation equip (attached to fencing)	640	sq ft	12	7,700
Vacuum blower 540 cfm, 60 hp; 1,000 cfm moisture knockout vessel, explosion proof mtr	1	LS	26,000	26,000
Thermal oxidizer (1,000 cfm capacity) - assume not needed	0	LS	225,000	0
Oxidizer offgas scrubber (1,000 cfm capacity) - assume not needed	0	LS	110,000	0
Equipment rental for installation of blower	1	day	2,000	2,000
Misc. piping, supports, valves, one flow meter, in treatment compound	1	LS	2,000	2,000
Misc. installation (piping, supports, equipment) labor - 2 persons 1 month	320	hour	50	16,000
Blower equipment control panel	1	LS	10,000	10,000
Electrical main disconnect and breaker panel	1	LS	5,000	5,000
Autodialer	1	LS	2,000	2,000
Electrical and controls wiring installation and testing	1	LS	10,000	10,000
Startup/troubleshooting	2	day	850	1,700
Misc. monitoring equipment/magnahelics	1	LS	500	500
Final surveying	0.5	day	1,500	800
			SUBTOTAL	325,000
Miscellaneous Costs				
RD/RA Workplan	1	LS	10,000	10,000
Well permits	54	each	100	5,400
Remedial Action Summary (Construction Completion Report)	1	LS	5,000	5,000
Operation, Maintenance, and Monitoring Manual	1	LS	5,000	5,000
Regulatory Oversight	1	LS	5,000	5,000
			SUBTOTAL	30,000
SUBTOTAL - DIRECT CAPITAL COST - Alternative 3				448,600
INDIRECT CAPITAL COST				
Engineering Design, Procurement, Administrative, and Legal Costs	1	%	10	44,900
Construction Management (% of Direct Capital Costs)	1	%	10	44,900
Project Management (% of Direct Capital Costs)	1	%	6	26,900
Contractor's General Requirements (assume monthly rental of job trailer, storage box, and portable toilet; and administration support)	4	MO	4,000	16,000
SUBTOTAL - INDIRECT CAPITAL COST - Alternative 3				133,000
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 3				**582,000**
CAPITAL COST - Alternative 1 - Increased Inspection, Repair and Operational Improvements				
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 1				**624,000**
CAPITAL COST - Alternative 2 - Landfill Gas Collection System Upgrades				
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 2				**342,000**
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternatives 1, 2, and 3				**1,548,000**
Capital Cost Contingency (scope and cost) 25%				387,000
TOTAL - CAPITAL COST ESTIMATE - Alternatives 1, 2, and 3				**1,935,000**

Table A-3
Estimated Cost to Implement Alternative 3 - Vadose Zone Gas Investigation and Extraction
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 3 *				
Labor:				
Technician: assumes 5 hrs/week	260	hr	85	22,100
Project management and reporting (Quarterly Status Reports)	160	hr	125	20,000
Rental of Landtec GEM 2000 gas meter; one day per week	52	day	100	5,200
Maintenance and repair of equip, misc. materials/field supplies, electrician	1	LS	2,000	2,000
Electrical power				
SVE blower (60 hp, assume 50 running hp)	327,200	kwh	0.12	39,300
Area lighting, assume included in landfill flare/evaporator costs	0	kwh	0.12	0
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative				**89,000**
Contingency (scope and cost) 10%				8,900
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative				**98,000**

**Note: Operation, maintenance, and monitoring costs for Alternative 3 also include operation, maintenance, and monitoring costs for Alternative 2.
See Present Worth Cost Estimate on next page.

Table A-3
Estimated Cost to Implement Alternative 3 - Vadose Zone Gas Investigation and Extraction
Feasibility Study - Olympic View Sanitary Landfill

YEAR	n	P/F(i=3%)	CAPITAL COSTS ($)	Alternative 2 O&M AND MONITORING COSTS ($/yr)	Alternative 3 O&M AND MONITORING COSTS ($/yr)	SUBTOTAL COSTS ($)	PRESENT WORTH OF COSTS ($)	CUMULATIVE PRESENT WORTH ($)
PRESENT WORTH COST ESTIMATE								
2010	0	1.00000	1,935,000	1,201,000	98,000	3,234,000	3,234,000	3,234,000
2011	1	0.97087		1,006,000	98,000	1,104,000	1,072,000	4,306,000
2012	2	0.94260		811,000	98,000	909,000	857,000	5,163,000
2013	3	0.91514		616,000	98,000	714,000	653,000	5,816,000
2014	4	0.88849		421,000	98,000	519,000	461,000	6,277,000
2015	5	0.86261		421,000		421,000	363,000	6,640,000
2016	6	0.83748		421,000		421,000	353,000	6,993,000
2017	7	0.81309		421,000		421,000	342,000	7,335,000
2018	8	0.78941		421,000		421,000	332,000	7,667,000
2019	9	0.76642		421,000		421,000	323,000	7,990,000
2020	10	0.74409		421,000		421,000	313,000	8,303,000
2021	11	0.72242		421,000		421,000	304,000	8,607,000
2022	12	0.70138		421,000		421,000	295,000	8,902,000
2023	13	0.68095		421,000		421,000	287,000	9,189,000
2024	14	0.66112		421,000		421,000	278,000	9,467,000
2025	15	0.64186		421,000		421,000	270,000	9,737,000
2026	16	0.62317		421,000		421,000	262,000	9,999,000
2027	17	0.60502		421,000		421,000	255,000	10,254,000
2028	18	0.58739		421,000		421,000	247,000	10,501,000
2029	19	0.57029		421,000		421,000	240,000	10,741,000
2030	20	0.55368		421,000		421,000	233,000	10,974,000
2031	21	0.53755		421,000		421,000	226,000	11,200,000
2032	22	0.52189		421,000		421,000	220,000	11,420,000
2033	23	0.50669		421,000		421,000	213,000	11,633,000
2034	24	0.49193		421,000		421,000	207,000	11,840,000
2035	25	0.47761		421,000		421,000	201,000	12,041,000
2036	26	0.46369		421,000		421,000	195,000	12,236,000
2037	27	0.45019		421,000		421,000	190,000	12,426,000
2038	28	0.43708		421,000		421,000	184,000	12,610,000
2039	29	0.42435		421,000		421,000	179,000	12,789,000
TOTAL - ESTIMATED COSTS:			1,940,000					**12,790,000**

Table A-4
Estimated Cost to Implement Alternative 4 - Air Sparge Wall
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
DIRECT CAPITAL COST - Alternative 4				
Air Sparging Pilot Test				
Air Sparging pilot testing, incl Report	1	LS	50,000	50,000
			SUBTOTAL	50,000
System Construction 37 AS points; 100' deep; 2' well screen/well; 5 cfm/well: 270 cfm				
Surveying/site layout	1	day	1,500	1,500
Assumed number of deep (100 ft) air sparge points w/ 50 ft Zone of Influence	37	number		
Deep air sparge point well installation	3,700	feet	155	573,500
AS point wellhd fittings (shutoff and sample valves, sample port, p gauge, flow meter)	37	each	75	2,800
2" GSP conveyance piping from compressor to air sparge points	3,000	lin ft	22	66,000
2" x 1/2" GSP reducing tee	37	each	18.70	700
5/8" Unistrut pipe support	2,840	lin ft	2.20	6,200
2" strut clamps	300	each	1.65	500
Trench for 2-inch air sparge conveyance piping in road (2.5' W x 2' D)	550	lin ft	40	22,000
Sand bedding for AS conveyance piping and fill (2.5' W x 2' D), includes 15% expansion	113	cu yd	30	3,400
Disposal of trench spoils and drill cuttings - assume Subtitle D landfill	139	cu yd	10	1,400
Precast manhole, frame, and cover (over Air Sparge points wellhead in road)	7	each	1,200	8,400
Valve box and cover (for shutoff valves in road)	7	each	200	1,400
Gravel base for well vaults	7	cu yd	30	200
Concrete slab on-grade for air sparge compressor	1	LS	7,500	7,500
Air sparge oil-free rotary screw compressor; 270 cfm; 75 hp; operate at 60 psi	1	LS	70,000	70,000
Equipment rental for installation of compressor	1	day	2,000	2,000
Misc. piping, supports, valves in compressor compound	1	LS	1,000	1,000
Misc. installation (piping, supports, equipment) labor - 2 persons 1 month	320	hour	50	16,000
Compressor equipment control panel	1	LS	10,000	10,000
Electrical main disconnect and breaker panel	1	LS	5,000	5,000
Autodialer	1	LS	2,000	2,000
Electrical and controls wiring installation and testing	1	LS	10,000	10,000
Startup/troubleshooting	2	day	850	1,700
Misc. monitoring equipment/magnahelics	1	LS	500	500
Final surveying	0.5	day	1,500	800
			SUBTOTAL	815,000
Miscellaneous Costs				
RD/RA Workplan	1	LS	10,000	10,000
Well permits	37	each	100	3,700
Remedial Action Summary (Construction Completion Report)	1	LS	5,000	5,000
Operation, Maintenance, and Monitoring Manual	1	LS	5,000	5,000
Regulatory Oversight	1	LS	5,000	5,000
			SUBTOTAL	29,000
			SUBTOTAL - DIRECT CAPITAL COST - Alternative 4	894,000
INDIRECT CAPITAL COST				
Engineering Design, Procurement, Administrative, and Legal Costs	1	%	10	89,400
Construction Management (% of Direct Capital Costs)	1	%	10	89,400
Project Management (% of Direct Capital Costs)	1	%	6	53,600
Contractor's General Requirements (assume monthly rental of job trailer, storage box, and portable toilet; and administration support)	4	MO	4,000	16,000
			SUBTOTAL - INDIRECT CAPITAL COST - Alternative 4	248,000
			SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 4	**1,142,000**
CAPITAL COST - Alternative 1 - Increased Inspection, Repair and Operational Improvements				
			SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 1	**624,000**
CAPITAL COST - Alternative 2 - Landfill Gas Collection System Upgrades				
			SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 2	**342,000**
			SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternatives 1, 2, and 4	**2,108,000**
			Capital Cost Contingency (scope and cost) 25%	527,000
			TOTAL - CAPITAL COST ESTIMATE - Alternatives 1, 2, and 4	**2,640,000**

Table A-4
Estimated Cost to Implement Alternative 4 - Air Sparge Wall
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative 4 *				
Labor:				
Technician: assumes 5 hrs/week	260	hr	85	22,100
Project management and reporting (Quarterly Status Reports)	160	hr	125	20,000
Groundwater monitoring to assess performance - see Alternative 1 costs	0	each	0	0
Rental of Landtec GEM 2000 gas meter; one day per week	52	day	100	5,200
Maintenance and repair of equip, misc. materials/field supplies, electrician	1	LS	2,000	2,000
Electrical power				
Air Sparge compressor (75 hp, assume 65 running hp)	425,300	kwh	0.12	51,000
Area lighting, assume included in landfill flare/evaporator costs	0	kwh	0.12	0
SUBTOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COSTS - Alternative				**100,300**
Contingency (scope and cost) 10%				10,000
TOTAL - ANNUAL OPERATION, MAINTENANCE, AND MONITORING COST ESTIMATE - Alternative				**110,000**

**Note: Operation, maintenance, and monitoring costs for Alternative 4 also include operation, maintenance, and monitoring costs for Alternative 2.
See Present Worth Cost Estimate on next page.

Table A-4
Estimated Cost to Implement Alternative 4 - Air Sparge Wall
Feasibility Study - Olympic View Sanitary Landfill

YEAR	n	P/F(i=3%)	CAPITAL COSTS ($)	Alternative 2 O&M AND MONITORING COSTS ($/yr)	Alternative 4 O&M AND MONITORING COSTS ($/yr)	SUBTOTAL COSTS ($)	PRESENT WORTH OF COSTS ($)	CUMULATIVE PRESENT WORTH ($)
PRESENT WORTH COST ESTIMATE								
2010	0	1.00000	2,640,000	1,201,000	110,000	3,951,000	3,951,000	3,951,000
2011	1	0.97087		1,006,000	110,000	1,116,000	1,083,000	5,034,000
2012	2	0.94260		811,000	110,000	921,000	868,000	5,902,000
2013	3	0.91514		616,000	110,000	726,000	664,000	6,566,000
2014	4	0.88849		421,000	110,000	531,000	472,000	7,038,000
2015	5	0.86261		421,000	110,000	531,000	458,000	7,496,000
2016	6	0.83748		421,000	110,000	531,000	445,000	7,941,000
2017	7	0.81309		421,000	110,000	531,000	432,000	8,373,000
2018	8	0.78941		421,000	110,000	531,000	419,000	8,792,000
2019	9	0.76642		421,000	110,000	531,000	407,000	9,199,000
2020	10	0.74409		421,000	110,000	531,000	395,000	9,594,000
2021	11	0.72242		421,000	110,000	531,000	384,000	9,978,000
2022	12	0.70138		421,000	110,000	531,000	372,000	10,350,000
2023	13	0.68095		421,000	110,000	531,000	362,000	10,712,000
2024	14	0.66112		421,000	110,000	531,000	351,000	11,063,000
2025	15	0.64186		421,000	110,000	531,000	341,000	11,404,000
2026	16	0.62317		421,000	110,000	531,000	331,000	11,735,000
2027	17	0.60502		421,000	110,000	531,000	321,000	12,056,000
2028	18	0.58739		421,000	110,000	531,000	312,000	12,368,000
2029	19	0.57029		421,000	110,000	531,000	303,000	12,671,000
2030	20	0.55368		421,000	110,000	531,000	294,000	12,965,000
2031	21	0.53755		421,000	110,000	531,000	285,000	13,250,000
2032	22	0.52189		421,000	110,000	531,000	277,000	13,527,000
2033	23	0.50669		421,000	110,000	531,000	269,000	13,796,000
2034	24	0.49193		421,000	110,000	531,000	261,000	14,057,000
2035	25	0.47761		421,000	110,000	531,000	254,000	14,311,000
2036	26	0.46369		421,000	110,000	531,000	246,000	14,557,000
2037	27	0.45019		421,000	110,000	531,000	239,000	14,796,000
2038	28	0.43708		421,000	110,000	531,000	232,000	15,028,000
2039	29	0.42435		421,000	110,000	531,000	225,000	15,253,000
		TOTAL - ESTIMATED COSTS:	2,640,000					**15,250,000**

Table A-5
Estimated Cost to Implement Alternative 5 - Excavation and Offsite Re-Disposal of OBWL
Feasibility Study - Olympic View Sanitary Landfill

	QUANTITY		ESTIMATED COST	
DESCRIPTION	**NUMBER**	**UNIT**	**UNIT COST ($)**	**TOTAL COST ($)**
DIRECT CAPITAL COST - Alternative 5				
Excavation and Installation of New Cover				
Surveying site control	5	day	1,500	7,500
Mobilization/demobilization	1	LS	100,000	100,000
Silt fence	4,860	lin ft	1.16	5,600
Clear and grub stockpile area west of leachate pond	10	acre	5,050	50,500
Establish staging area to load trucks to haul materials to transfer station	1	LS	10,000	10,000
Excavate and stockpile soil cover materials (36 acres):				
12" of vegetative topsoil and soil cover	57,836	Bcy	4.71	272,400
12" drainage layer	57,836	Bcy	4.71	272,400
6" low permeability soil	28,918	Bcy	4.71	136,200
Remove geosynthetics cover materials:				
60 mil HDPE	1,561,560	sq ft	0.20	312,300
Geonet	1,561,560	sq ft	0.20	312,300
Geotextile	1,561,560	sq ft	0.20	312,300
Load 30 cy roll-offs at site w/ FE loader (assumes 35 sq ft of 60 mil rolls-up to 1 cu ft)	4,957	cu yd	2.00	9,900
30 cy roll-offs haul to Transfer Station	165	each	50	8,300
Rail haul to Arlington, OR (assumes 4,500 cu ft open top gondola cars)	30	gondola	2,900	87,000
Unload cost at landfill	30	gondola	500	15,000
Disposal taxes/fees (weight of HDPE unknown, assume 50 tons/gondola car)	1,500	ton	2.30	3,500
Transfer station and landfill disposal fee	1,500	ton	15	22,500
Landfilled material in OBWL: assume 4 loaders, 6 trucks/hr/loader, 10 Bcy/truck, 9600 Bcy/wk				
Excavate trash, load trucks (assumes LFG wells and piping excavated along w/ trash)	2,100,000	Bcy	2	3,843,000
Dust control	1,094	days	820	897,000
Health & safety surcharge for site contractor	10	%	3,843,000	384,300
Haul trash to Transfer Station (double in-place cy; 20 cy trucks; 2 round trips/hr; $150/hr)	210,000	truckld	75	15,750,000
Rail haul to Arlington, OR (assumes 75 tons per gondola car)	21,000	gondola	2,900	60,900,000
Unload cost at landfill	21,000	gondola	500	10,500,000
Disposal taxes/fees (weight of landfilled material unknown, assume 1,500 lbs/cy)	1,575,000	ton	2.30	3,623,000
Transfer station and landfill disposal fee	1,575,000	ton	15	23,625,000
Construct rock lined ditches w/ geomembrane liner:				
Backhoe and operator	60	hour	200	12,000
Geomembrane (East ditch: 1,140' L x 8' W; West ditch: 735' L x 6' W)	13,530	sq ft	2	22,200
Rip rap rock - assume average 18" thickness	750	cu yd	39	29,300
Precast concrete drop inlet and spillway	2	each	20,000	40,000
New CMP piping from drop inlets to Outfall G	360	lin ft	139	50,000
Re-route (install new) LFG piping in NE corner and along southern edge of OBWL	2,500	lin ft	50	125,000
Construct cover over remaining trash adjacent to Phase I using stockpiled material:				
Place and compact 6" of low permeability soil	11,752	Lcy	6.72	79,000
60 mil geomembrane	488,160	sq ft	1.64	800,600
Geonet composite	488,160	sq ft	1.00	488,200
Place 12" drainage layer	18,080	Bcy	6.34	114,600
Geotextile fabric	488,160	sq ft	1.00	488,200
Place and compact 12" of vegetative topsoil and soil cover	23,504	Lcy	6.72	157,900
Fertilize/reseed/mulch surface of cover	11	acre	5,000	56,000
Materials testing technician and equipment (assuming 4,500 cy/day placed)	12	days	1,050	12,600
Surveying control	12	days	1,500	18,000
Regrade area of OBWL where trash was removed:				
Remaining stockpiled low permeability soil - place and compact	25,841	Lcy	6.72	173,700
Place remaining stockpiled drainage layer materials	39,756	Bcy	6.34	252,100
Remaining stockpiled vegetative topsoil and soil cover materials - place and compact	51,682	Lcy	6.72	347,300
Surveying control	12	days	1,500	18,000
Misc. sitework	1	LS	300,000	300,000
Monitoring during construction:				
Meteorological	54	month	2,000	108,000
Health and safety monitoring	54	month	6,500	351,000
Surveying ("record drawings")	5	day	1,500	7,500
			SUBTOTAL	125,511,000
Miscellaneous Costs				
RD/RA Workplan	1	LS	100,000	100,000
Remedial Action Summary (Construction Completion Report)	1	LS	50,000	50,000
Regulatory Oversight (1 FTE; 4.5 years)	9,360	hour	100	936,000
			SUBTOTAL	1,086,000
SUBTOTAL - DIRECT CAPITAL COST - Alternative 5				126,597,000
INDIRECT CAPITAL COST - Alternative 5				
Engineering Design, Procurement, Administrative, and Legal Costs	1	LS	2,000,000	2,000,000
Construction Management (assumes 4 FTE; 4.5 yrs)	37,440	hour	85	3,182,400
Project Management (assumes 1 FTE; 4.5 yrs)	9,360	%	125	1,170,000
Contractor's General Requirements (assume monthly rental of job trailers, storage containers, and portable toilets; and administration support)	54	month	8,000	432,000
SUBTOTAL - INDIRECT CAPITAL COST - Alternative 5				6,784,000
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 5				**133,400,000**
CAPITAL COST - Alternative 1 - Increased Inspection, Repair and Operational Improvements				
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 1				**624,000**
CAPITAL COST - Alternative 2 - Landfill Gas Collection System Upgrades (only one of 10 landfill gas extraction wells)				
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternative 2 (Alternative 2 divided by 10)				**34,000**
SUBTOTAL - CAPITAL COST (DIRECT AND INDIRECT) - Alternatives 1, 2, and 5				**134,100,000**
Capital Cost Contingency (scope and cost) 25%				33,500,000
TOTAL - CAPITAL COST ESTIMATE - Alternatives 1, 2, and 5				**168,000,000**

Notes:
Bcy = bank cubic yards
Lcy = loose cubic yards (assume 1.3 Lcy/Bcy)

Table A-5
Estimated Cost to Implement Alternative 5 - Excavation and Offsite Re-Disposal of OBWL
Feasibility Study - Olympic View Sanitary Landfill

YEAR	n	P/F(i=3%)	CAPITAL COSTS ($)	O&M AND MONITORING COSTS ($/yr)**	SUBTOTAL COSTS ($)	PRESENT WORTH OF COSTS ($)	CUMULATIVE PRESENT WORTH ($)
PRESENT WORTH COST ESTIMATE							
2010	0	1.00000	168,000,000	1,196,000	169,196,000	169,196,000	169,196,000
2011	1	0.97087		1,001,000	1,001,000	972,000	170,168,000
2012	2	0.94260		806,000	806,000	760,000	170,928,000
2013	3	0.91514		610,000	610,000	558,000	171,486,000
2014	4	0.88849		415,000	415,000	369,000	171,855,000
2015	5	0.86261		415,000	415,000	358,000	172,213,000
2016	6	0.83748		415,000	415,000	348,000	172,561,000
2017	7	0.81309		415,000	415,000	337,000	172,898,000
2018	8	0.78941		415,000	415,000	328,000	173,226,000
2019	9	0.76642		415,000	415,000	318,000	173,544,000
2020	10	0.74409		415,000	415,000	309,000	173,853,000
2021	11	0.72242		415,000	415,000	300,000	174,153,000
2022	12	0.70138		415,000	415,000	291,000	174,444,000
2023	13	0.68095		415,000	415,000	283,000	174,727,000
2024	14	0.66112		415,000	415,000	274,000	175,001,000
2025	15	0.64186		415,000	415,000	266,000	175,267,000
2026	16	0.62317		415,000	415,000	259,000	175,526,000
2027	17	0.60502		415,000	415,000	251,000	175,777,000
2028	18	0.58739		415,000	415,000	244,000	176,021,000
2029	19	0.57029		415,000	415,000	237,000	176,258,000
2030	20	0.55368		415,000	415,000	230,000	176,488,000
2031	21	0.53755		415,000	415,000	223,000	176,711,000
2032	22	0.52189		415,000	415,000	217,000	176,928,000
2033	23	0.50669		415,000	415,000	210,000	177,138,000
2034	24	0.49193		415,000	415,000	204,000	177,342,000
2035	25	0.47761		415,000	415,000	198,000	177,540,000
2036	26	0.46369		415,000	415,000	192,000	177,732,000
2037	27	0.45019		415,000	415,000	187,000	177,919,000
2038	28	0.43708		415,000	415,000	181,000	178,100,000
2039	29	0.42435		415,000	415,000	176,000	178,276,000
TOTAL - ESTIMATED COSTS:			168,000,000				**178,000,000**

**Operation, maintenance, and monitoring costs for Alternative 5 are the same as those for Alternative 1.