Interim Action Work Plan

South Transfer Station Phase II

Seattle, Washington
July 24, 2015

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Contents

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Acronyms

ARARs	Applicable or Relevant and Appropriate Requirements
AST	aboveground storage tank
bgs	below ground surface
Ecology	Washington State Department of Ecology
GP	gas probe
HDPE	high-density polyethylene
IA	Interim Action
kg	kilogram
KIP	Kenyon Industrial Park
LFG	landfill gas
MFS	minimum functional standards
mg	milligram
MTCA	Washington state Model Toxics Control Act
NAVD	North American Vertical Datum
NP	north probe
PLP	Potentially Liable Person
PSCAA	Puget Sound Clean Air Agency
RI/FS	Remedial Investigation/Feasibility Study
ROW	right of way
SP	south probe
SPPD	South Park Property Development
SPU	Seattle Public Utilities
SQER	small quantity emission rate
SR	State Route
SRDS	South Recycling Disposal Station
STSII	Seattle Transfer Station Phase II site
TAP	toxic air pollutant
TEQ	toxic equivalence
UST	underground storage tank
VOC	volatile organic compound
WAC	Washington Administrative Code

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1 Introduction

This Interim Action Work Plan has been prepared by the HDR team, including HDR, Herrera Environmental Consultants (Herrera), and Aspect Consulting (Aspect), for Seattle Public Utilities (SPU). It describes an interim action (IA) to be conducted at the former South Recycling and Disposal Station (SRDS) situated on a portion of South Park Landfill (Landfill) (Figure 1). The SRDS was a solid waste transfer station operated by the City of Seattle (City). A new transfer station has been constructed across the road to the north and this IA applies to redevelopment of the SRDS property, now referred to as South Transfer Station Phase II (STSII). South Park Property Development, LLC (SPPD) owns the adjacent property, also situated on a portion of the Landfill, and is addressing contamination issues in an independent, but coordinated effort.

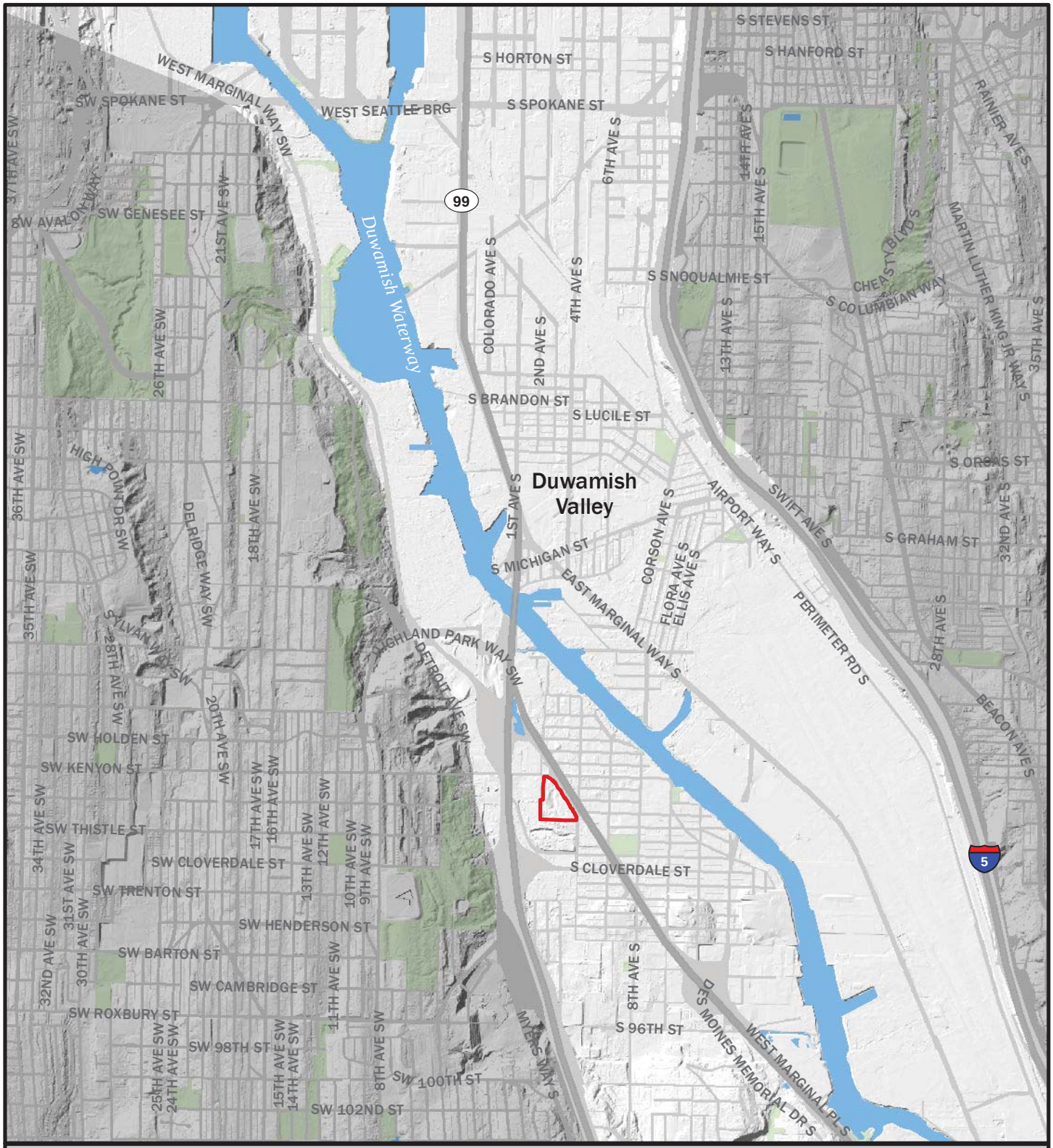
The Landfill is a former municipal solid waste landfill located in the South Park neighborhood of Seattle, Washington (Figure 2). It received solid waste from the 1930s until 1966, when it was closed under existing landfill closure laws. In February 2007, the Landfill was added to Washington State's Hazardous Sites List, based on concerns related to groundwater contamination and the presence of potentially flammable landfill gas (LFG). Groundwater, surface water, soil, and LFG investigations began in the late 1980s, continuing to the present day.

A Remedial Investigation/Feasibility Study (RI/FS) of the entire Landfill Site is presently being conducted under Washington State Model Toxics Control Act (MTCA) Agreed Order No. 6706 (Agreed Order) with the Washington State Department of Ecology (Ecology) to determine the nature and extent of contamination and to evaluate remedial actions necessary for the Site. The City, King County (County), and SPPD were originally identified by Ecology as potentially liable persons (PLPs) for the Landfill Site. SPPD and the City were signatories of the Agreed Order in 2008 and 2009, respectively. An amendment to the Order was issued in 2013, directing SPPD to conduct an IA on their portion of the Landfill Site.

The SPPD IA addresses the SPPD property and contiguous offsite areas where solid waste from Landfill operations extended beneath City rights-of-way, including 5th Avenue South, 2nd Avenue South, and South Sullivan Street. Similarly, the STSII IA addresses the STSII property and where solid waste extends beneath 5th Avenue South. Each PLP will coordinate to mitigate groundwater contamination and LFG associated with the Landfill Site, as well as to control surface water based on independent property development plans.

The following terms are used throughout the document:

- **South Park Landfill (Landfill):** Landfill refers to the extent of refuse or solid waste that was placed during the operation of the South Park Landfill from the 1930s until it was closed in 1966.



Legend

STSII Property

Figure 1.
Site Vicinity Map, South Transfer Station Phase II, Seattle, Washington.

N

0 1,500 3,000 6,000 Feet

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Legend

- Piezometer
- Perimeter gas probe
- STSII Property
- Landfill Boundary (based on RI/FS)

Figure 2.
Site Plan, South Transfer Station Phase II, Seattle, Washington.

N

0 250 500 1,000 Feet

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USDA, Aerial (2013)

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- **Site (capitalized):** Site is used to be consistent with the MTCA definition of the site and includes the Landfill and other areas where contamination has come to be located.
- **site (not capitalized):** site refers either to the STSII or SPPD portion of the Landfill Site, depending on the context.

The IA will be implemented in conjunction with development of the STSII property. Potential current plans for development include:

- Administrative offices
- Surface parking garage
- Materials Recovery Facility (MRF) – on-grade supported by 50-300 piles
- Household Hazardous Waste (HHW) facility – maintain existing features, if possible
- Recycling facility – office, covered storage, and loading dock
- Reuse facility – office, covered storage, and loading dock
- Truck fueling facility – aboveground tank
- Truck washing facility – tied into stormwater system
- Paved truck and tractor parking areas
- Paved traffic circulation areas.
- Stormwater decant/sewer grit facility
- Perimeter pedestrian path

1.1 Rationale for Interim Action

In accordance with Section 430 of Chapter 173-340 of the Washington Administrative Code (WAC 173-340-430), an IA is “a remedial action that is technically necessary to reduce a threat to human health or the environment by eliminating or substantially reducing one or more pathways for exposure to a hazardous substance at a facility”.

The draft RI/FS, submitted in June 2014, compiled Landfill investigation data for soil, cover material, groundwater, LFG, and surface water conducted by the County and/or City over the last 25 years and addressed identified data gaps.

The RI/FS indicated the need for an action to address potential exposure to hazardous substances associated with redevelopment of the STSII property. This IA is intended to protect human health and the environment and to mitigate potential exposure pathways that could occur from redevelopment of the STSII property.

1.2 Description of Interim Action Area

The STSII property is defined by King County tax parcel 7328400005, encompassing 10.3 acres. Two additional strips of land, 60 feet on the west of the STSII parcel and 30 feet on the south, were incorporated into the property in 2003 by City ordinance 121306.

This additional land is in the process of being recorded by King County and brings the site area to approximately 11 acres. The STSII property is bordered by 5th Avenue South to the east, Kenyon Street South to the north, Kenyon Industrial Park (KIP) to the west, and SPPD to the south and partially to the west (Figure 3). The STSII property is presently used by SPU for the following:

- Yard waste collection
- Household Hazardous Waste collection
- Transfer trailer and truck parking, fueling, and vehicle washing.

Most of the property is covered with asphalt and several structures, including the household hazardous waste building, former waste collection building, fueling area, and temporary office trailers.

1.3 Overview of the Interim Action

The IA at STSII is necessary to reduce threats to human health and the environment by eliminating or substantially reducing hazardous substance exposure pathways. Because the redevelopment for the STSII site has not be finalized, and in accordance with MTCA requirements (WAC 173-340-430(3(b)), the IA will not foreclose reasonable alternatives for final cleanup and will be designed to be consistent with the likely final cleanup.

Since 2013, the SPPD parcel (south and west of the STSII) has been undergoing cleanup and redevelopment according to an Ecology-approved IA. Three alternatives were evaluated in the draft SPDD Interim Action Work Plan (Farallon 2013), including:

1. No Action
2. Excavation and Disposal of Solid Waste Off the Site
3. Capping, Landfill Gas and Surface Water Controls, and Monitoring.

These same alternatives were evaluated for the STSII site. Alternative 3 was selected because it:

- Provides for long-term protection of human health and the environment by limiting the potential for direct contact with contaminants, minimizing the potential for groundwater and surface water degradation, and controlling LFG migration
- Provides for development and implementation of monitoring programs to confirm attainment of operational requirements and permit compliance for each medium of concern
- Poses substantially less short-term risk to human health than Alternative 2, which would expose workers to contaminated solid waste or soil during removal, as well as other ancillary risks from shoring, use of heavy equipment, and transporting a large volume of material off the site for disposal.

Legend

STSII Property

Figure 3.
Interim Action Area, South Transfer Station Phase II, Seattle, Washington.

N

0 75 150 300 Feet

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The selected alternative includes installation of asphalt, concrete, or membrane caps, with provisions for LFG and surface water controls; implementation of institutional controls; and compliance monitoring. The LFG collection system will be comprised of horizontal (trench) collectors, conveyance piping, and vents to address areas covered by both cap materials and new buildings planned for construction. The planned control systems will allow for functional transitions to independent actions along the boundaries of the adjacent SPPD and KIP properties. In addition, both LFG and groundwater compliance monitoring will be conducted to assess effectiveness of the IA on the STSII portion of the Landfill Site.

1.4 Purpose of the Interim Action Work Plan

The purpose of the IA Plan is to provide:

- A description of the IA and how it will meet the criteria identified in WAC173-340-430(1), (2), and (3)
- A description of existing area conditions and a summary of available data related to the IA
- Information to support the applicable design elements and construction requirements of WAC 173-340-400(4), (6), and (8).

Additional plans describing the design, implementation, and monitoring of the IA will be prepared and submitted to Ecology for review and comment, including:

- Engineering Design Report for landfill cap, LFG control, and surface water control elements of the IA (WAC 173-340-400[4][a])
- Construction plans and specifications for landfill cap, LFG control, and surface water control elements of the interim action (WAC 173-340-400[4][b])
- Operation and Maintenance Plan for landfill cap and LFG collection elements of the IA (WAC 173-340-400[4][c])
- Construction documentation, such as as-built documents (WAC 173-340-400[6])
- Compliance Monitoring Plan (WAC 173-340-410)
- Sampling and Analysis Plan (WAC 173-340-820)
- Health and Safety Plan (WAC 173-340-810[2]).

1.5 Organization of the Interim Action Work Plan

The IA Plan has been developed in accordance with the provisions of WAC 173-340-430 and consists of the following nine sections:

- **Section 1, Introduction** describes the regulatory framework for conducting the IA, provides an overview of the IA, and describes the purpose of the IA Plan.
- **Section 2, IA Area Features and Background** describes Landfill Site features and other details, such as hydrogeology and surface water bodies in the vicinity, and

presents an overview of previous investigations at the Landfill Site and a summary of environmental conditions relevant to the IA.

- **Section 3, Regulatory Considerations** includes a description of applicable, relevant, or appropriate requirements (ARARs), which are federal, state, and local requirements that will apply to the IA; regulatory agency guidance documents that may also be considered; and the relationship of the IA to planned redevelopment of the STSII property.
- **Section 4, Interim Action Components** presents a summary of the work elements that comprise the IA, including describing the impervious landfill cap, LFG control, and surface water control elements.
- **Section 5, Compliance Monitoring and Reporting** provides a summary of the compliance monitoring and reporting protocols for the IA.
- **Section 6, Schedule** refers to the schedule for implementation of the IA, which will be presented in an amendment to the Agreed Order.
- **Section 7, References** lists documents cited in the IA Plan.
- **Section 8, Limitations** presents the HDR Team's standard limitations

2 Interim Action Area Features and Background

Much of this section has been excerpted from the draft South Park Landfill RI/FS and provides a description of the setting and features of the STSII property, including a discussion of geological and hydrogeological conditions. A summary of prior investigations for the Site is presented in Table 2.4 of the RI/FS report and information summarized below for the IA area is based on the results of previous investigations conducted on behalf of King County, the City, KIP, and SPPD, from the 1980s through 2014.

2.1 Interim Action Area Features and Current Use

The Landfill consists of several parcels situated in the South Park neighborhood of south Seattle. It covers approximately 39 acres and is roughly bounded to the north by South Kenyon Street, to the east by State Route (SR) 99 and Fifth Avenue South, to the south by South Sullivan Street, and to the west by Occidental Avenue South. The Landfill was operated by the City, until it closed in 1966, and included disposal and burning of municipal, commercial, and industrial waste (SPU 1997; Ecology and Environment, Inc. 1988). Since that time, the Landfill has undergone filling and grading activities and has been redeveloped. A detailed description of the history of the Landfill and its owners is provided in Table 2.1 and Appendix A of the RI/FS (Floyd Snider 2014). Appendix A also includes historical aerial photographs illustrating changes to the Landfill boundary and land use over time.

The STSII property is located at 8100 Second Avenue South and covers 11.26 acres overlying the Landfill. The SRDS was constructed on the property in 1966, eventually including a main waste disposal building, a small maintenance facility, a scale house, two vehicle-fueling systems, and several additional small buildings used for offices and household hazardous waste collection. In 2013, the South Transfer Station, a replacement for the SRDS became operational across South Kenyon Street. In January 2014, when the City's North Recycling and Disposal Station closed for a scheduled rebuild, a portion of the SRDS was reopened as the STSII facility, to increase the City's solid waste handling capacity. STSII will accept yard waste while the NRDS is modernized. Once the NRDS reopens (scheduled for 2016), the STSII parcel will be available for redevelopment.

Several of the old SRDS structures, including the old scale houses and the main waste disposal building, are pile-supported. These piles extend to depths of more than 96 feet below ground surface (bgs). The facility is paved, except for some perimeter landscaping and small areas in the interior of the property. Two right-of-ways (ROWs) were added to this parcel in 2003 through the ordinance provided in Appendix A of the RI/FS. The IA also addresses that portion of the Landfill that extends northeast and east of Fifth Avenue South and west of Second Avenue South, along the KIP property line.

Truck fueling systems that remain on the STSII property consist of 2,000- and 3,000-gallon aboveground storage tanks (ASTs) used to store diesel fuel, and a dispenser

island. In 1999, an earlier fueling system was decommissioned. It had consisted of a 10,000-gallon diesel and a 3,000-gallon gasoline underground storage tanks (USTs), dispensers, and underground piping. In 1999, it was reported that a release of petroleum hydrocarbons had occurred and about 250 cubic yards of petroleum-contaminated soil were removed from an excavation beneath the former fuel dispensers as part of the decommissioning. Some residual petroleum hydrocarbons attributed to the former fueling system were left in place. Heavy oil-range petroleum hydrocarbons were also detected and attributed to disposal practices when the property was operated as a landfill.

The property also contains a French drain system of limited extent beneath the compactor structure on the east side of the disposal building, which discharges to the municipal sanitary sewer. The system is designed to capture the seasonal build-up of groundwater beneath the foundation, but drains infrequently.

A stormwater collection system that extends across the parcel connects to the City's storm drain system beneath Second Avenue South, which is connected to the SR 509 storm drain system that flows into wetlands on the west side of the highway.

SRDS buildings are connected to the public sanitary sewer system, located beneath Second Avenue South; water and natural gas mains are located along Fifth Avenue South. The Renton Effluent Treatment System line is located northeast of Fifth Avenue South, along the SR 99 ROW. It is a 96-inch diameter force main sewer line that carries treated effluent from the County's South Treatment Plant in Renton to an outfall in Elliott Bay.

Current redevelopment plans for the STSII parcel include improvements associated with landfill closure and construction of permanent facilities, potentially including a recycling facility, a grit processing facility, parking and an administration building to support other City uses. The existing household hazardous waste facility is expected to remain in place. Some public streets and ROWs will likely be upgraded with the redevelopment.

2.2 Hydrogeology

STSII geologic and hydrogeologic conditions are summarized from information in the RI/FS Work Plan (Farallon 2010), RI/FS Report (Floyd Snider 2014), and the SPPD Interim Action Work Plan (Farallon 2013).

2.2.1 Geology

The Landfill is located in the Duwamish Valley, which is a glacially-carved trough, in-filled with more recent sediments and soil. In many areas of the Duwamish Valley, the ground surface was modified by dredging and fill placement that overlies the alluvial soil (Figure 4). Local geology is based on four defined units: imported fill, alluvial sediments, estuarine deposits, and glacial soil (Figure 5). A description of each unit, including Site-specific information collected during 2011 investigations, is provided below. Logs for Landfill borings, test pits, gas probes, and monitoring wells are provided in Appendix A of the RI/FS Work Plan (Farallon 2010) and Appendix B of the RI/FS Report (Floyd Snider 2014).

Imported Fill/Solid Waste—Imported fill at STSII is composed of solid waste disposed during operation of the Landfill and structural fill placed for development of SRDS by the

City in the 1966. Cover material placed over the solid waste typically consisted of sand, silty sand, gravel, and silty gravel. Lithologic logs for borings completed at STSII indicate that a laterally continuous soil cover is not present.

Solid waste disposed at the Landfill is composed of municipal solid waste, commercial waste from local businesses, residential vehicles, and other recyclable materials. From the 1940s until 1961, solid waste occasionally was burned to reduce volume and promote more-rapid settling and compaction. In general, the thickness of the solid waste ranges from less than 5 feet to approximately 20 feet across STSII (Figure 5).

The composition and texture of solid waste encountered during subsurface investigations varies widely across the Landfill Site. Typical solid waste materials observed in borings on the STSII property include ash, plastic, glass, tires, organic material, and other anthropogenic materials. Materials such as, wood, metal, brick, concrete and other types of construction related debris also were noted in some locations.

Alluvial Sediments—The RI/FS reported that the Landfill was developed on alluvial sediments divided into an upper section of overbank flood deposits and a lower underlying section of silty sands and sands generally described as follows:

- The overbank flood deposits consist of interbedded fine sand and silt containing abundant organic debris associated with marshland vegetation, with a density ranging from loose to firm.
- The underlying sequence of dark gray or black silty sands and sands constitutes the thickest section of the alluvial soil. The upper portion of this silty sand and sand sequence has been described as reddish brown or brown at some boring locations.

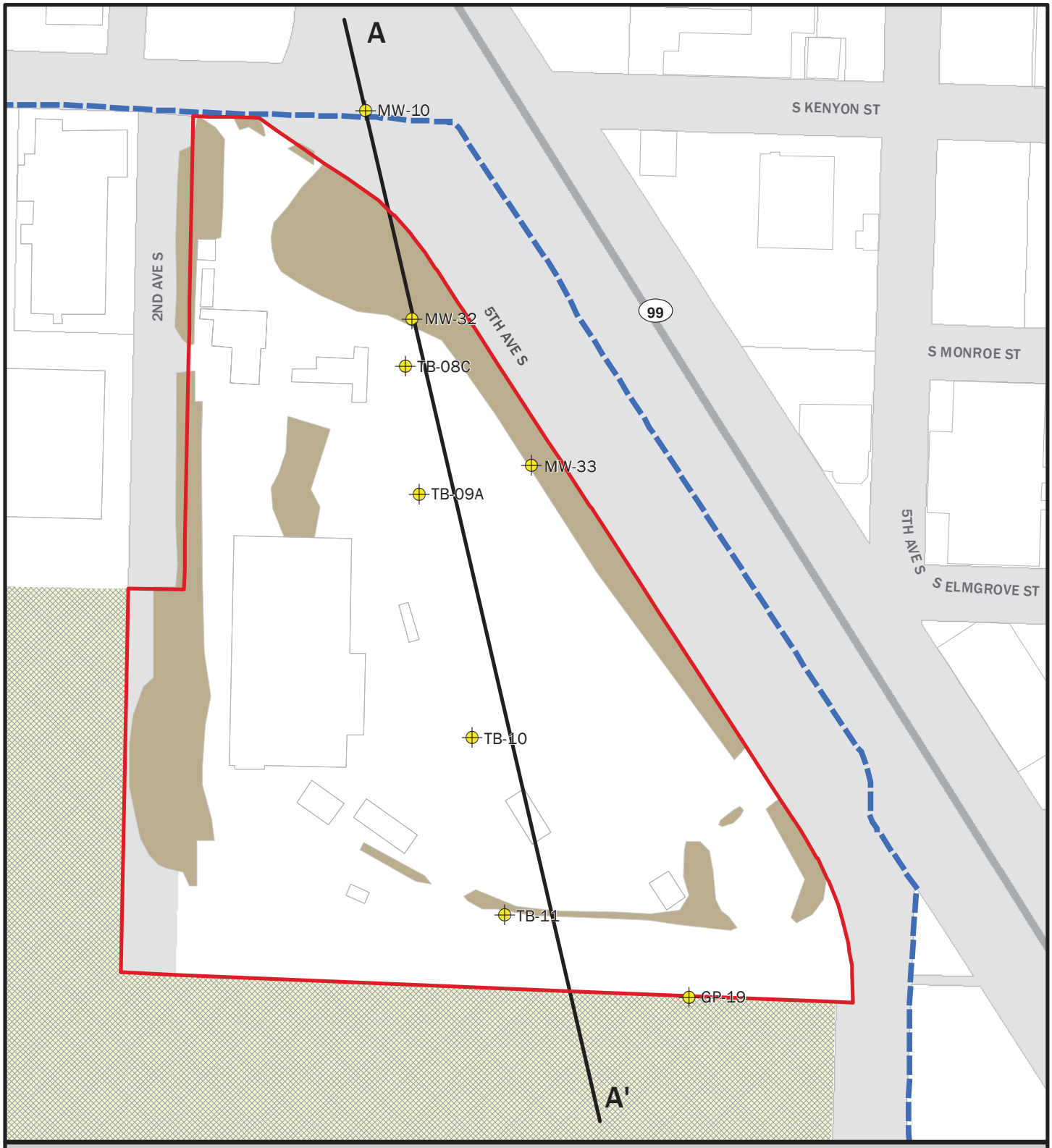
Saturated material in the alluvial sediment strata is regionally referred to as the Alluvial Aquifer. The RI/FS report refers to the Alluvial Aquifer as the Shallow Aquifer. The thickness of alluvial sediments ranges from approximately 25 to 35 feet across STSII.

Estuarine Deposits—Logs for deep borings in the Duwamish Valley indicate a sequence of estuarine deposits progressing upward vertically into an alluvial sequence. The estuarine deposits typically are composed of fine sands and silts with shell fragments, which distinguish sediments deposited on the border of a marine environment. Estuarine deposits were encountered at monitoring well MW-10 (located northeast of STSII) at approximately 44 feet bgs. None of the explorations on the SRDS site were deep enough to encounter the estuarine deposits.

Glacial Soil—Glacial soil, composed of dense silt, sand, and gravel, is present at the margins of the Duwamish Valley, but has not been encountered in borings completed on STSII. It may be present at STSII below the estuarine deposits at depths greater than 65 feet bgs.

2.2.2 Surface Water

There are no surface water bodies on STSII; the Duwamish Waterway is located approximately 1,700 feet to the northeast. It forms at the confluence of the Green and Black Rivers and historically meandered along the valley floor, discharging into Elliott Bay. Figure 1 shows the location of the Landfill in relation to the Duwamish Waterway.



Legend

- STSII Property
- Landfill Boundary (based on RI/FS)
- Cross-section data point
- Cross-section
- Unpaved area
- South Park Property Development
- Right-of-way (ROW)
- Parcel

Figure 4.
Cross-section Location Map,
South Transfer Station Phase II,
Seattle, Washington.

N

0 75 150 300 Feet

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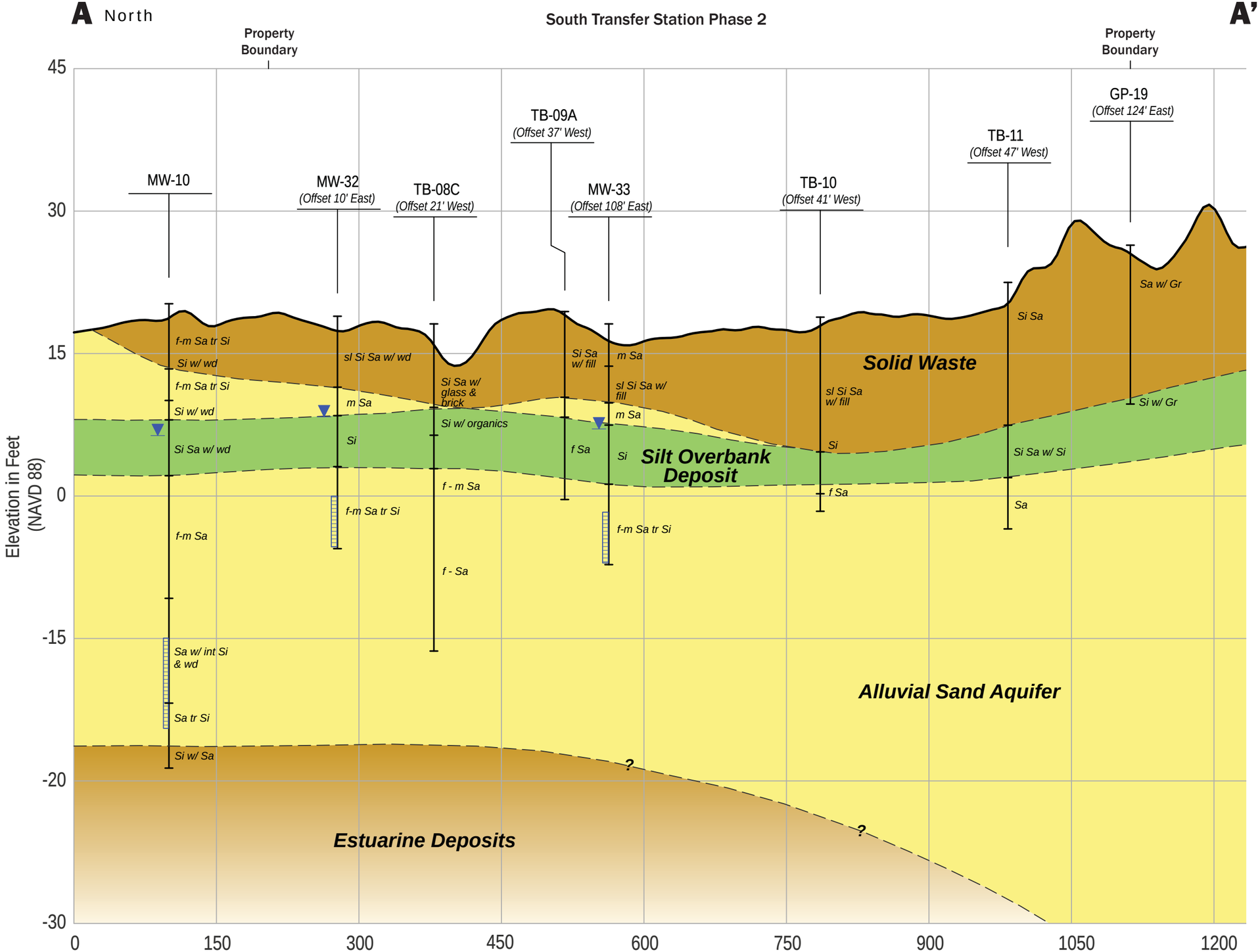
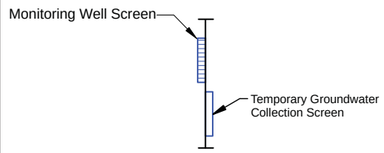


Figure 5.
Cross-Section A - A',
South Transfer Station Phase II,
Seattle, Washington.

Legend

- Static Water Level (January or March 2011)
- Approximate Ground Surface
- Approximate Geologic Unit Contact
- Inferred Geologic Unit Contact

Groundwater Data



Soil Description

Cl	=	Clay	f	=	fine
Sa	=	Sand	m	=	medium
Si	=	Silt	c	=	course
Gr	=	Gravel	w/	=	with
Org	=	Organic	s	=	some
Wd	=	Wood	&	=	and
Deb	=	Debris	sc	=	scattered
Fl	=	Fill	sl	=	slightly
			tr	=	trace
			int	=	interbedded

(Adapted from RI/FS 2014)

0 150'
0 15'

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2.2.3 Groundwater

Groundwater in the vicinity of the Landfill generally occurs within alluvial sediments (also referred to as the Shallow Aquifer in the RI/FS report), sandwiched beneath Silt Overbank Deposit above and estuarine deposits below. There also may be a perched water bearing zone between the refuse and Silt Overbank Deposit in places. The system is described, as follows:

- Perched Zone: discontinuous shallow zone of groundwater and infiltrating precipitation stormwater, ranging from 0 to 5 feet in thickness, occurring at elevations generally from +5 to +15 feet North American Vertical Datum of 1988 (NAVD 88) at STSII. The perched zone was not observed in the STSII monitoring wells.
- Silt Overbank Deposit: fairly continuous within the uppermost portion of the alluvial deposits, which act as low permeability aquitards that separate infiltrating precipitation and overland flow from the Perched Zone and the Shallow Aquifer.
- Shallow Aquifer: continuous groundwater-bearing zone beneath the Silt Overbank Deposit, occurring at elevations generally from +4 to greater than -30 feet NAVD 88 at STSII, bounded by the estuarine/marine deposits.

Groundwater flow in the vicinity of the Landfill is generally toward the Duwamish Waterway. There is no evidence that groundwater elevations are tidally influenced at wells in the Landfill monitoring well network. Monitoring indicates that groundwater levels below the Silt Overbank Deposit are influenced by changes in barometric pressure, indicative of confined aquifer conditions. Groundwater recharge occurs primarily in up-gradient upland areas south and west of the STSII site; however, some precipitation falling on pervious areas of the site infiltrates to the Shallow Aquifer.

2.3 Summary of Environmental Conditions

This section provides a general summary of environmental conditions in the vicinity of the STSII property based on Landfill-related studies through 2014. This section is not intended to be a complete discussion of the nature and extent of contamination, but rather a summary of available data used to support the design of the IA.

The RI/FS report identifies potential exposure pathways at the Landfill, including:

- Direct contact with contaminated soil or solid waste that is not under a controlled landfill cap
- Direct contact with contaminated groundwater (because there are no drinking water wells, such contact would be limited to construction activities below the water table)
- Direct contact/inhalation with indoor air that may contain concentrations of volatile organic compounds (VOCs) from LFG diffusion into structures.

Refer to the RI/FS report for a detailed discussion of chemicals of concern and proposed cleanup standards (Ecology will determine the site's final cleanup standards, as part of the Cleanup Action Plan [CAP]).

2.3.1 Surface Soil

Approximately 80 percent of STSII is paved; solid waste is typically found below the pavement and gravel base layer. It is not customary to analyze soil samples within a closed landfill because they would be considered samples of solid waste, not soil. As such, “soil” samples historically collected at STSII have been acquired from unpaved landscaped areas.

Twenty eight soil samples were collected from surface soil across unpaved landscaped areas around STSII in 2011. All samples were composited by the laboratory into a single “multi-increment” sample and analyzed for the five MTCA metals (Table 1). A detailed discussion of the sample collection process is provided in the RI/FS report.

Table 1. Soil Sample Metals Analytical Results

Metal	Concentration (mg/kg)	MTCA Method C (mg/kg)
Arsenic	20	*87*
Cadmium	2.1	*3,500*
Lead	273	*1,000*[a]
Mercury	0.23	*2*[a]
Chromium (III)	43	*5,250,000*
Hexavalent Chromium	< 0.400	*10,500*

mg/kg – milligrams per kilogram
[a] Method A Industrial properties

Dioxin/furan analysis was also conducted on the multi-increment sample. The calculated toxic equivalence (TEQ) concentration for 2,3,7,8-tetrachloro-dibenzo-p-dioxin of 333 nanograms per kilogram was less than the MTCA method C cleanup level of 1,500 nanograms per kilogram.

No soil chemicals of concern were identified for the STSII property, based on a review of historical soil sampling and sampling conducted for the RI/FS.

2.3.2 Groundwater

A detailed discussion of groundwater conditions for the Landfill Site is provided in the RI/FS report. Groundwater conditions for STSII will be addressed through the CAP for the Site, not within this IA Plan.

2.3.3 Surface Water

There are no surface water bodies within STSII. A discussion of surface water (i.e., stormwater) runoff control is provided below in the discussion of IA components.

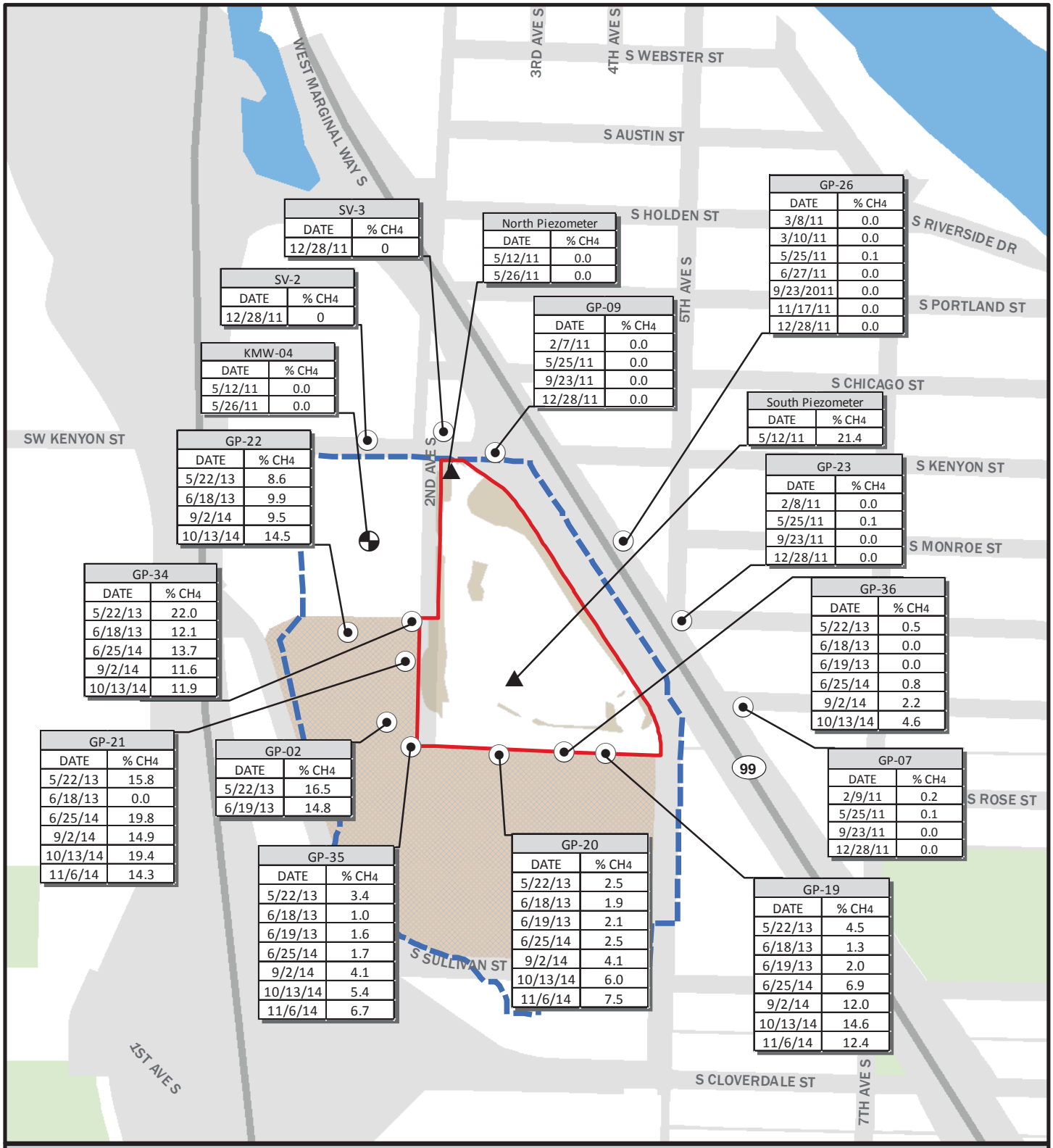
2.3.4 Landfill Gas

Over 36 LFG probes have been installed within and along the perimeter of the Landfill. Recent LFG monitoring performed for the RI/FS defines baseline conditions for both the

SPPD and STSII IAs, with methane concentrations ranging from 0.0 to 85.1 percent at locations on and adjacent to the Landfill. See Figure 6 for methane concentrations at locations on and immediately adjacent to the STSII property. The lower explosive limit for methane is 5 percent by volume. On the STSII property, LFG monitoring was performed at two piezometers located on the Landfill (NP – north probe, near the site boundary and SP – south probe, in the center of the site) and six perimeter probes (GP-07, GP-09, GP-23, and GP-26, SV-2, and SV-3) located offsite to the northeast and north.

No methane was detected at interior piezometer NP, but a concentration of 21 percent was detected at SP. Methane concentrations have been negligible at perimeter probe locations, ranging from 0.0 to 0.2 percent. Two of the northern perimeter probes SV-2 and SV-3, located at the new transfer station, are no longer accessible, due to recent development activities and will be replaced during the IA (renamed GP-37 and -38 – shown in Appendix C, Figure 2).

In 2011, LFG samples were collected from piezometers NP and SP and analyzed for VOCs. None of the VOCs exceeded MTCA Soil Gas Industrial Screening Levels (discussed in more detail in the RI/FS report).



Legend

- Monitoring Well
- Piezometer
- Gas Probe
- STSII Property
- Landfill Boundary (based on RI/FS)
- Unpaved area
- South Park Property Development
- Right-of-way (ROW)

Figure 6.
Landfill Gas Monitoring Results on and adjacent to South Transfer Station Phase II, Seattle, Washington.

N

0 225 450 900 Feet

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3 Regulatory Considerations

The RI/FS provides a summary of MTCA requirements for cleanup of landfills within the context of original date of closure and the development of landfill management regulations over the years. This summary is repeated here.

The Landfill is a historical municipal landfill that was originally closed in 1966 under the County's Title 10 provisions for landfills—the only applicable regulations at the time. Washington State's first Minimum Functional Standards (MFS) for solid waste landfills, Chapter 173-301 WAC, became effective in 1972. In November 1985, Chapter 173-301 was replaced by Chapter 173-304 as Washington State's for solid waste landfills. MTCA allows for containment to be the preferred remedy for historical landfill sites and uses MFS (WAC 173-304) as a relevant and appropriate requirement. Closed landfills are considered under MTCA to be sites that have used "containment of hazardous substances" as the preferred remedy. Under WAC 173-340-740(6)f), MTCA states that containment sites will comply with cleanup standards if they meet the following requirements:

> *"WAC 173-340-740(6)(f) The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels will typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:*
>
> > *(i) The selected remedy is permanent to the maximum extent practicable using the procedures in WAC 173-340-360;*
> >
> > *(ii) The cleanup action is protective of human health. The department may require a site-specific human health risk assessment conforming to the requirements of this chapter to demonstrate that the cleanup action is protective of human health;*
> >
> > *(iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494;*
> >
> > *(iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system;*
> >
> > *(v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system; and*
> >
> > *(vi) The types, levels, and amount of hazardous substances remaining onsite and the measures that will be used to prevent migration and contact with those substances are specified in the draft cleanup action plan."*

Approximately 10 years after MFS was developed, USEPA published their *Presumptive Remedy for CERCLA Municipal Landfill Sites Directive* (OSWER Directive 9355.3–11). This document was based on USEPA's experiences on multiple solid waste landfill sites and reflected a growing body of knowledge regarding the key components that were necessary to build long-term containment remedies at solid waste landfills. The FS

conducted for the Landfill Site uses ideas from USEPA's presumptive remedy to refine the MTCA remedial action, while continuing to treat MFS as a key ARAR.

Components of the presumptive remedy for the source area (extent of solid waste) include the following:

- Landfill capping, to include stormwater controls
- LFG collection and treatment
- Institutional controls to supplement engineering controls
- Source area groundwater controls to contain the plume, including leachate collection and treatment, if needed.

The IA has been developed to address the first three of these remedy components. Groundwater issues will be addressed in the CAP.

3.1 Compliance with Applicable Local, State, and Federal Laws

The RI/FS developed a preferred cleanup alternative for the Landfill SIte, including the following components that will be addressed in the IA:

- Landfill Capping
  - Minimum 12 inches of fill material over solid waste
  - Structural section of road base
  - Asphaltic concrete of 4inches minimum thickness or 4 inches minimum thickness of concrete or low permeability membrane
  - Stormwater infrastructure to collect and convey stormwater away from the Landfill.
- Stormwater Control
  - Future development requires capturing the bulk of stormwater before it has an opportunity to make contact with solid waste
  - Future development requires capturing stormwater adequately to meet regulatory obligations with respect to quantity, flow, and quality.
- Landfill Gas Control
  - Future development requires installation of LFG mitigation controls, such as below-slab barriers, ventilated structures, or elevated structures, with passive venting being the primary method of controlling LFG. It is recommended that the system be convertible to an active system in the event that LFG migration is detected in perimeter LFG monitoring probes.
  - Measures may need to be taken to prevent LFG migration through utilities within ROWs.
- Institutional Controls

- Development and implementation of a LFG control system Operations, Maintenance, and Monitoring Plan.

The *Interim Action Work Plan* (Farallon 2013) developed for the SPPD portion of the Landfill Site included these same general IA components. A list of potential ARARs was developed to support the IA alternative selection process, which are provided in Appendix B). Likewise, these ARARs apply to the IA proposed for the STSII portion of the Landfill Site.

ARARs are defined by statutes, regulations, and ordinances to be evaluated when developing cleanup actions. ARARs, along with other information (e.g., published regulatory guidance) defined as information *to be considered*, may influence establishment of cleanup concentrations and requirements for permitting, disposal, cleanup operations, health and safety, and long-term monitoring. The remedial alternatives should meet ARARs and to be considered to the extent practicable.

ARARs listed in Appendix B are separated into three categories that apply to establishing cleanup levels or conducting cleanup actions:

- ***Chemical-specific requirements*** are usually health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.
- ***Location-specific requirements*** are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations.
- ***Action-specific requirements*** are usually technology-based requirements or limitations on actions taken with respect to hazardous substances.

The presumptive remedy developed for CERCLA municipal landfill sites relates primarily to containment of the landfill mass and collection and/or treatment of LFG. This approach was used to refine application of MTCA to the IA, while continuing to treat MFS as a key ARAR. MTCA is not listed in Appendix B, as the IA is being undertaken pursuant to its provisions.

The IA landfill cap meets FS alternative cap requirements allowed by WAC 173-340-710. The cap containment design, in conjunction with the recommended stormwater infrastructure, ensures compliance with these requirements. The LFG controls comply with regulatory standards developed to prevent exposure levels greater than the permissible percentages of methane and carbon dioxide, as well as applicable cleanup standards for volatile organic compounds. Compliance monitoring will be conducted for LFG control system performance.

The King County Board of Health Title 10 regulations requires a permit from the Puget Sound Clean Air Agency (PSCAA) to install a LFG control system at a Landfill. PSCAA requires a permit or Notice of Construction in order to receive an Order of Approval for an active LFG control system, but not for a passive system. Conditions on the STSII property were evaluated to demonstrate that an active treatment system would not be required.

A preliminary evaluation of LFG emissions for the STSII property was conducted using results of EPA's LandGEM LFG emissions modeling and data available from the RI. Model assumptions included:

- Mass of waste-In-place – 224K tons (16.5 kilotons/year disposed over 15 years)
  - Area – 10.3 acres
  - Average refuse thickness – 15 feet
  - Refuse density – 1,800 pounds/cubic yard (default value)
  - Years of operation – 1951 to 1965
- Clean Air Act values for methane generation potential, methane generation decay rate, and methane concentration in LFG [default]
- Benzene and hydrogen sulfide selected as example toxic air pollutants (TAPs) with very low emission thresholds:
  - Benzene – 8.9 microgram per cubic meter (maximum concentration measured at NP on 5/12/2011)
  - Hydrogen sulfide – 36 parts per million by volume (ppmv) (no recent STSII data, so estimated based on SPPD average of all field measurements over time at 34 ppmv, average of 2004 field measurements at 37 ppmv, and average of 2000 lab samples of: 14 ppmv)

Using this input, the LandGEM model calculated:

- LFG generation ~16 cubic feet per minute
- Methane generation ~8 cubic feet per minute
- Benzene emissions ~0.005 pounds per year (less than the *de minimis* rate of 0.331 pounds per year)
- Hydrogen sulfide emissions ~0.07 pounds per day (greater than the *de minimis* rate of 0.013 pounds per day, but less than the small quantity emission rate [SQER] of 0.263 pounds per day).

Based on modeled results for these two compounds, it does not appear that an active LFG control system will be required at STSII, however, the system will be designed to be able to be converted to an active system as a contingency for corrective action. Once the proposed passive venting system is installed, performance monitoring will be used to verify compliance with emissions standards.

3.2 Relationship to Planned STSII Site Development

The IA will be implemented in conjunction with development of the STSII property. Current plans for development include:

- Administrative offices
- Surface parking garage
- Materials Recovery Facility (MRF) – on-grade supported by 50-300 piles

- Household Hazardous Waste (HHW) facility – maintain existing features, if possible
- Recycling facility – office, covered storage, and loading dock
- Reuse facility – office, covered storage, and loading dock
- Truck fueling facility – aboveground tank
- Truck washing facility – tied into stormwater system
- Paved truck and tractor parking areas
- Paved traffic circulation areas.
- Stormwater decant/sewer grit facility
- Perimeter pedestrian path

All buildings will be constructed to function as extensions of the capping and LFG control systems. They will perform independently; but will integrate with the site-wide cap and LFG control system designs.

Grading of the site will be performed in advance of development, allowing utilities to be installed and stubbed out for proposed building development. Preloading for consolidation, pre-excavation to support below-grade foundations, and pile caps may be included as part of the IA. Foundation and structural support may require piling.

Helical piling technology, if required, will prevent down-drag of contaminated material and the creation of new vertical pathways for potential groundwater contaminant migration, as well as the potential for increased LFG migration through foundations. Helical driven grout piles will be used to support buildings and slab on-grade. Piles are screwed into the ground with downforce and torque applied to the shaft and helical tip, so that there is no pile driving hammer, impact noise, or vibration. An envelope of grout is created during installation by injection of high-pressure cement grout through ports at the tip. Grout travels from the tip back up to the surface along the pile shaft, sealing the annular space. The helical tip and shaft remain in the ground. No drill spoils are generated.

Regulatory requirements applicable to the planned development are not listed in Appendix B; however, development will require, at a minimum, the following permits and approvals from the City of Seattle:

- Master Use permit, including conditional use approval
- Grading permit
- Drainage control plan
- Building permits
- Street use permit, with transportation concurrency
- Approvals for water, sewer, and electrical connections.

4 Alternatives Evaluation for Interim Action

The MTCA provisions pertaining to IAs (WAC 173-340-430) require identification and evaluation of alternatives, though not at the detailed level of analyses conducted in support of final cleanup actions. The intent of this IA is to perform work necessary to reduce a threat to human health and the environment by eliminating or substantially reducing one or more pathways for exposure to hazardous substances.

Three cleanup alternatives were considered for the IA:

- Alternative 1—No Action
- Alternative 2—Excavation and Disposal of Solid Waste Offsite
- Alternative 3—Capping, Landfill Gas and Surface Water Controls, and Monitoring.

A brief description of each of these alternatives is presented below. Consideration of these alternatives was based on the known current and site development plans.

4.1 Alternative 1 – No Action

A No Action alternative provides a basis for comparing effectiveness of other alternatives. Inclusion of this alternative helps to ensure that the consequences of taking no action are fully understood.

Under this alternative, no proactive measures would be taken to meet landfill closure requirements under WAC 173-304 MFS. Development of the Interim Action Area, by itself, would not provide short- or long-term protection for human health and the environment through either a removal action (Alternative 2) or installation of an effective cap, landfill gas collection system, and stormwater controls (Alternative 3). The potential would exist for worker direct contact with contaminants and for contaminant migration, with resultant impacts to groundwater, air, surface water, and soil. In addition, there would be no environmental monitoring to assess effectiveness of natural attenuation processes in mitigating risks or to assess risks to human health and the environment under the No Action alternative.

4.2 Alternative 2 – Excavation and Disposal of Solid Waste Offsite

Under Alternative 2, solid waste and any associated contaminated soil in the Interim Action Area would be excavated and disposed of at a permitted solid waste management facility. In some locations of the Interim Action Area, the thickness of solid waste exceeds 20 feet. Because groundwater levels are within the solid waste in some portions of the Interim Action Area, dewatering and treatment of extracted groundwater may be necessary to facilitate excavation and to minimize off-property groundwater quality impacts associated with disturbance of the A-Zone of the Shallow Aquifer. Following excavation and verification that the solid waste and associated contaminated soil were removed, clean fill would be placed in excavated areas to restore the site in preparation for development. Following excavation and restoration activities, compliance groundwater and surface water monitoring would be performed.

4.3 Alternative 3 – Capping, Landfill Gas and Surface Water Controls, and Monitoring

Alternative 3 would include placement of an impervious asphaltic concrete and/or membrane cap over the Interim Action Area where solid waste is present, collection of LFG, control of stormwater, implementation of institutional controls, and compliance monitoring of IA effectiveness. Some limited excavation of solid waste would be necessary under this alternative to facilitate grading, placement of the landfill cap, and installation of underground utilities, including the LFG collection system. Solid waste and associated landfill cover material disturbed during IA activities would be re-interred below the landfill cap. Activities that may generate material for re-interment include grading of the surface to facilitate capping, excavation of trenches for subsurface utilities (storm drains, sanitary sewer, water supply, and other utilities), and an LFG collection system.

Following capping, installation of the surface water runoff control system, and start-up of the LFG control system, LFG migration and surface water compliance monitoring would be conducted.

In accordance with WAC 173-340-440, Alternative 3 would include implementation of institutional controls that limit or prohibit activities that may interfere with the integrity of the IA or that may result in exposure to hazardous substances in the Interim Action Area. Institutional controls would include physical measures, such as fencing to limit access, procedural measures, such as developing and implementing an Operations and Maintenance Plan for the cap systems, or administrative measures, such as recording an environmental covenant on the property title.

4.4 Evaluation of Alternatives

MTCA (WAC 173-340-360[2][a]) stipulates that the following minimum criteria be met when selecting cleanup alternatives and this framework was used in evaluating the alternatives for this Interim Action:

- Protection of human health and the environment
- Compliance with cleanup standards (WAC 173-340-700 through -760)
- Compliance with other ARARs
- Performance of compliance monitoring.

4.4.1 Alternative 1 (No Action)

This alternative does not include actions to address the potential direct contact exposure pathway by humans or the transport of contaminants to surface water or groundwater. This alternative also would not provide for verification of organic contaminant degradation through natural attenuation processes. Alternative 1 is not protective of human health and the environment and is eliminated from further consideration, due to the inability to meet this threshold criterion.

4.4.2 Alternative 2 (Excavation and Disposal of Solid Waste Offsite)

Alternative 2 poses substantial short-term risks during removal of solid waste and associated contaminated soil by excavation based on the potential for worker exposure through direct contact, including inhalation of VOCs or contaminated particulates. In addition, the large volume of material needed to be removed would result in ancillary risks associated with large-scale shoring requirements, operation of heavy equipment, and offsite transportation to a disposal facility. This alternative would provide long-term protection of human health and the environment by preventing potential exposure to contaminants in the Interim Action Area via the direct contact pathway, it would achieve compliance with cleanup standards and ARARs, and it would allow for implementation of a compliance monitoring program.

Although project cost is not a defined evaluation criterion for the IA, Alternative 2 would be cost-prohibitive, due to the volume of material to be handled, transported, and disposed. Preliminary engineering cost estimates for Alternative 2 exceed the costs for Alternative 3 by at least two orders of magnitude.

4.4.3 Alternative 3 (Capping, Landfill Gas and Surface Water Controls, and Monitoring)

This alternative would achieve compliance with landfill closure standards and provide controls for the potential direct contact exposure pathway by humans and transport of contaminants to surface water or groundwater in the Interim Action Area. Alternative 3 poses substantially less risk of exposure during implementation than Alternative 2 by covering the waste in-place, minimizing excavation. In most areas, cover soil or clean fill would be placed to facilitate placement of asphaltic concrete or membrane caps, which would limit the potential for direct contact with contaminated material. The impervious landfill cap would also block contact with rainwater, limiting the potential for generation of contaminated runoff, as well as infiltration through solid waste to the groundwater below. Surface water controls built into the cap would further minimize the potential for infiltration. This alternative would comply with MTCA and the identified ARARs (Appendix B), and would include compliance monitoring following implementation of the IA.

Alternative 3 addresses the primary components of the CERCLA presumptive remedy for municipal landfill sites, described in Section 3.1 — Compliance with Applicable Local, State, and Federal Laws. Alternative 3 is the selected IA alternative for the Interim Action Area because this alternative:

- Is protective of human health and the environment by limiting the potential for direct contact with contaminants and minimizing the potential for degradation of groundwater and surface water in the Interim Action Area. In addition, LFG migration would be controlled by a LFG collection system.
- Provides for IA compliance monitoring through development and implementation of monitoring programs to confirm attainment of operational requirements and compliance with permit requirements for each medium of concern.
- Poses substantially less short-term risk to human health than Alternative 2, which would expose workers to contaminated solid waste or soil during the removal action,

and has other ancillary risks from shoring, use of heavy equipment, and transporting a large volume of material offsite for disposal.

4.4.4 Requirements for Landfills under MTCA

As discussed in the RI/FS Report, MTCA allows for containment as a preferred remedy for historical landfill sites and uses WAC 173-304 (MFS) as an ARAR. Closed landfills are considered under MTCA to be sites that have used "containment of hazardous substances" as the preferred remedy. Under WAC 173-340-740(6)(f), MTCA states that containment sites comply with cleanup standards if they meet the following requirements:

> "The department recognizes that, for those cleanup actions selected under this chapter that involve containment of hazardous substances, the soil cleanup levels would typically not be met at the points of compliance specified in (b) through (e) of this subsection. In these cases, the cleanup action may be determined to comply with cleanup standards, provided:
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>
> (iii) The cleanup action is demonstrated to be protective of terrestrial ecological receptors under WAC 173-340-7490 through 173-340-7494.
>
> (iv) Institutional controls are put in place under WAC 173-340-440 that prohibit or limit activities that could interfere with the long-term integrity of the containment system.
>
> (v) Compliance monitoring under WAC 173-340-410 and periodic reviews under WAC 173-340-430 are designed to ensure the long-term integrity of the containment system.
>
> (vi) The types, levels, and amount of hazardous substances remaining on-site and the measures that would be used to prevent migration and contact with those substances are specified in the draft cleanup action plan".

5 Interim Action Components

Demolition and site grading, landfill capping and LFG control, and redevelopment activities will be conducted as part of the IA. Demolition will include removal or abandonment of all pavement, structures (except for the household hazardous waste facility), tanks, utilities, and landscape features. The site will be graded in preparation for constructing the cap to allow control of stormwater flow, minimize exposure to waste, and control LFG. The integrated cap and LFG control system will include trenches for gas collection, aggregate LFG collection layer under the asphaltic cover, piping for gas conveyance, and vents for gas dispersion. The work will be sequenced, starting at the

site perimeter and progressing incrementally toward the center to minimize LFG emissions from uncovered areas, allow for control system phasing as development continues, and allow for focused monitoring. Redevelopment will include incorporation of LFG control features into newly constructed structures, when necessary. An Engineering Design Report will be developed and then plans and specifications produced to define system installation requirements.

5.1 Demolition and Site Grading

The entire STSII property will be cleared of aboveground features (except for the household hazardous waste facility), exposing both refuse and whatever soil and gravel base course cover that was applied prior to previous paving. New site work will consist primarily of raising the grade by adding new fill. The site is prone to settle under new fill loads, due to the presence of compressible refuse and silt overbank deposits in the subsurface. Without mitigation, estimated settlements range from 2 to 6 inches for areas with new fill placed. Settlement could result in pavement distress, foundation settlement, and damage to utilities.

To minimize the risk of settlement, preloading and surcharging could be used in areas where new fill is expected. Dynamic compaction is not recommended because of environmental considerations associated with the potential for groundwater contamination. Preloading entails placement of fill soils for many weeks to months ahead of final grading to allow settlement to occur before construction. Used in combination with preloading, surcharging is the placement of a larger volume or height of fill above the final grading plan to accelerate the settlement process.

5.1.1 Clearing and Grubbing

Clearing and grubbing will be performed to prepare the site for minor re-grading of refuse, building foundation preparation, and filling to raise the grade of the site. Limited clearing and grubbing is necessary, due to extensive existing site build out.

5.1.2 Asphalt and concrete removal

Existing asphalt and concrete will be salvaged and processed as building materials to the extent practicable, and stockpiled for reuse. Asphalt can be tilled up with paving machines and stockpiled onsite to be mixed into the new asphalt cap material. Concrete from roadway surfaces and structures can be hammered out and stockpiled for crushing. All rebar in concrete must be removed prior to crushing. Crushed concrete will be used as aggregate material in the asphalt cap subbase and potentially as aggregate in LFG collection trenches.

5.1.3 Structures removal

The entire STSII property will be cleared of aboveground structures, except for the household hazardous waste facility. Existing structures with deep foundation support systems (grade beams and piles) will be demolished a minimum of 5 feet below cap subgrade or as necessary to accommodate new building development.

5.1.4 Utilities

Removal or abandonment of existing utilities and underground structures will be necessary during activities associated with the IA and site redevelopment. The decision to remove versus abandon existing utilities will be based on utility size, proximity to grading activities associated with placement of the cap and/or LFG collection system, and conflicts with planned utility layout. Any abandoned utilities will be capped and trenches will be filled with impermeable materials to eliminate potential migration pathways for LFG.

5.2 Landfill Capping and LFG Control System Installation

The IA components for landfill closure will include three capping designs, LFG control systems under the cap, surface water collection and routing, and considerations for site utilities associated with redevelopment.

5.2.1 Capping

The MFS for solid waste handling requires that a landfill cap be installed per WAC 173-304 to perform two functions:

- Minimize infiltration of stormwater into the solid waste, thereby creating additional leachate
- Mitigate risk to human health and the environment by preventing direct contact exposure with solid waste.

To achieve these functions, two designs are prescribed for landfill caps in WAC 173-304-460:

1) Placement of at least 2 feet of low permeability soil (permeability of less the 10^{-6} centimeter per second (cm/sec)
2) Use of a geo-membrane layer with a 50-mil (milliinch) thickness.

WAC 173-340-710(4)(f) allows for variances or waiver provisions included in other applicable regulations to be accessible as part of the MTCA process. Based on this provision, a variance from the prescribed landfill cap alternatives identified above was granted to SPPD development as part of that IA. This was based on the conditions under which the Landfill was originally closed and how contiguous parcels were planned for development. A similar variance is being sought to allow cover material with greater permeability than 10-6 cm/sec for the STSII IA. The variance request is provided in Appendix A.

Five cap designs are proposed for this interim action, described as follows:

- Asphaltic Concrete Cap over the majority of STSII where development plans call for large-vehicle access, parking, and construction of a variety of building types to accommodate multiple SPU activities
- Geo-Membrane and Soil Cover Cap around the boundary of STSII in landscaped areas
- Geo-Membrane and Concrete Cap will be used for the pedestrian path.

- Low-permeability Membrane Cap (Barrier) under Building Foundations to function as building methane mitigation system and landfill cap.
- Soil Cap in existing landscape areas or where large trees will remain.

Impervious surfaces, such as landfill caps, will affect LFG by reducing discharge to the atmosphere, reduce infiltration of stormwater, and increase runoff that will require installation of surface water controls. The landfill cap must accommodate future actions, as well as maintain integrity of the drainage system as differential settlement occurs.

Figures 7 and 8 show a conceptual site development layout (still under development) and corresponding LFG collection system. Figure 9 shows details and examples of cover system sections and transitions.

Asphaltic Concrete/Concrete Cap

The asphaltic concrete or concrete landfill cap is designed to address structural requirements to support redevelopment, reduce the infiltration of stormwater, and mitigate risk to human health and the environment by preventing direct contact exposure with solid waste. The cap will be constructed across a majority of the STSII site, following removal of existing asphalt. It will be constructed on a mixture of imported fill and soil cover beneath the existing asphalt, which is expected to be absent or of minimal thickness. The asphalt concrete and concrete caps will provide a functional working surface, requiring specific design considerations to address surface water controls and to provide for durability, flexibility, and operational compatibility with future use requirements. The use of a cap for containment of waste will include a maintenance program consisting of periodic inspections and re-sealing to maintain imperviousness.

The asphaltic concrete cap will be composed of a minimum of three layers:

- Twelve-inch minimum thickness compacted structural fill that may or may not include existing cover soil, depending on existing cover thickness and geotechnical properties
- Eight-inch minimum thickness crushed rock
- Four-inch minimum thickness asphalt cover

The concrete cap will be designed to accommodate structural loading. Protection measures for settlement, including underlayments of geotechnical reinforcing fabric and/or additional crushed rock, will be used to prevent cracking of the asphaltic concrete where yielding soils are encountered during construction.

Geo-Membrane and Soil Cover Cap

This cap is proposed for areas that will not be paved with asphalt, including landscaped buffers, planter islands, and gravel road shoulders. The low-permeability membrane cap will act as a barrier to infiltrating stormwater and will mitigate risk to human health and the environment by preventing direct contact exposure with solid waste. This type of cap system requires specific design considerations to address drainage controls and to provide for durability.

The geo-membrane and soil cover cap will be composed of a minimum of three layers:

- Twenty-four-inch minimum thickness compacted structural fill that may or may not include existing cover soil, depending on existing cover thickness and geotechnical properties
- A minimum 50-mil-thickness high-density polyethylene (HDPE) membrane
- Eight-inch minimum thickness crushed rock with 3-inch minimum thickness concrete sidewalk or 8-inch minimum thickness cover soil with 4-inch minimum topsoil in unpaved areas.

The cap design is not intended to require removal of existing large, established trees. It is assumed that landscaping at the base of the trees will continue to block direct contact with refuse.

Geo-Membrane and Concrete Cap

A pedestrian path located along the east property boundary will be constructed with a concrete surface, including a subsurface geomembrane to provide additional protection.

Low-permeability Membrane Cap (Barrier) under Building Foundations

A low-permeability membrane cap will be installed under all buildings to function as a methane mitigation control system in addition to landfill cover. Each building will be designed with a separate membrane barrier comprised of minimum 30 mil polyvinyl chloride (PVC) or 50 mil HDPE liner over a building-specific LFG collection system (see Section 4.3.3). The membrane barrier will be protected above and below by sand or equivalent geotextile material, providing a cushioning layer for protection from penetration. Building foundations and concrete slabs will be placed over the membrane barrier, further protecting the membrane.

Soil Cap

Minimum 24 inches of soil cover will be used in areas where existing mature trees may be retained.

Cover System Transitions

Cover system transitions will occur at the property boundaries and at building locations. The north and east perimeter boundaries will have a perimeter LFG collection trench. The cover systems in these locations will extend over the top of the perimeter collection trench and extend to the property boundary. The pedestrian path along the east property line will include a membrane liner in addition to the asphalt concrete cap, extending a minimum of 10 feet over the perimeter trench and directly below the concrete path (see Detail 1 on Figure 9). Cover system transitions along the south and east boundaries will tie into existing asphalt on the SPPD and KIP properties to provide a continuous cover. The lining system will terminate in an anchor trench similar to Detail 1 on Figure 9.

Cover system transitions at buildings will be implemented by extending building system membranes a minimum of 3 feet beyond the building foot print, allowing an overlap with the asphalt concrete cap.

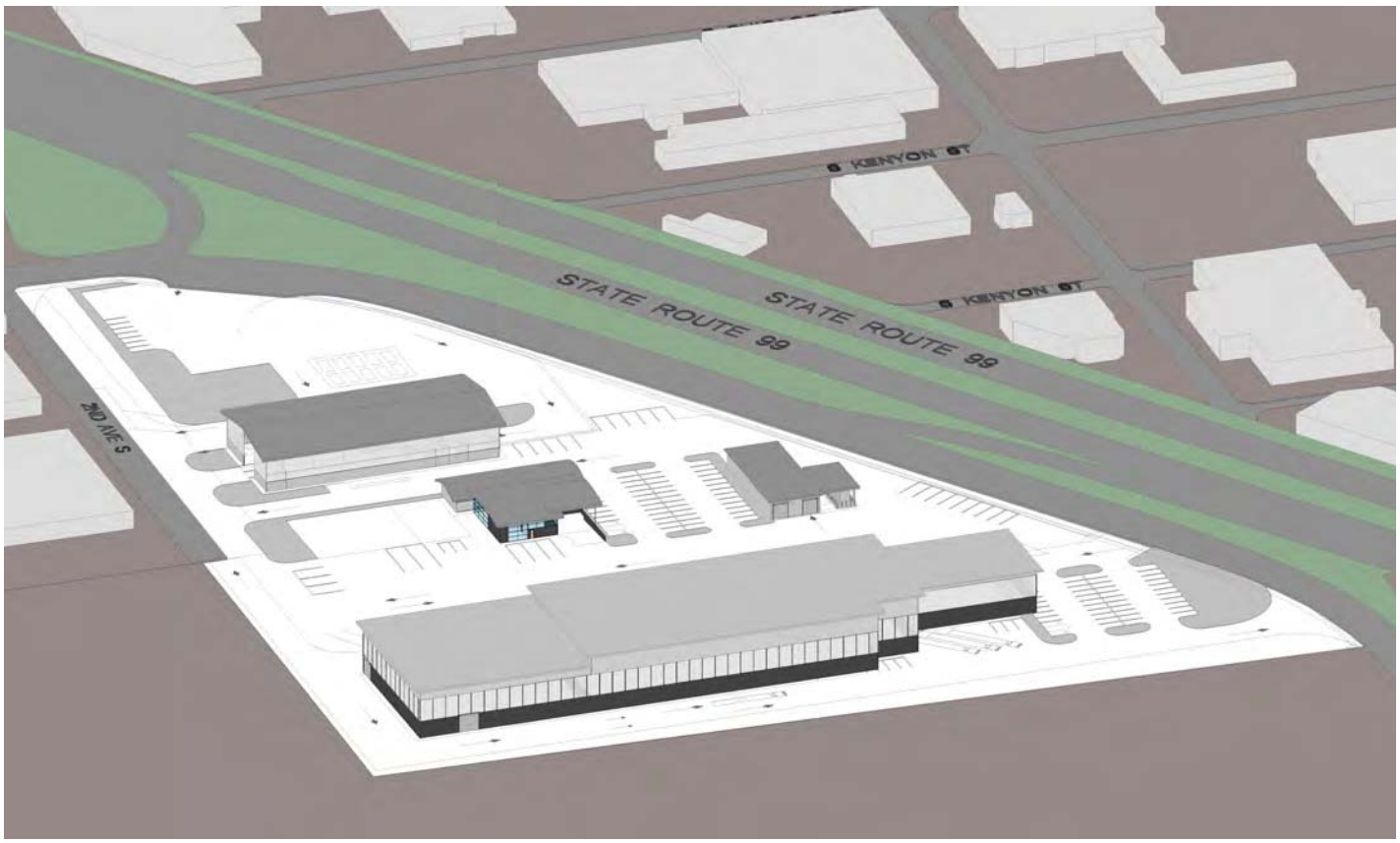

Figure 7.
Axonometric Aerial View Looking Northeast, South Transfer Station Phase II, Seattle, Washington.

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Not to scale

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strategy • science • engineering

HERRERA

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Aspect

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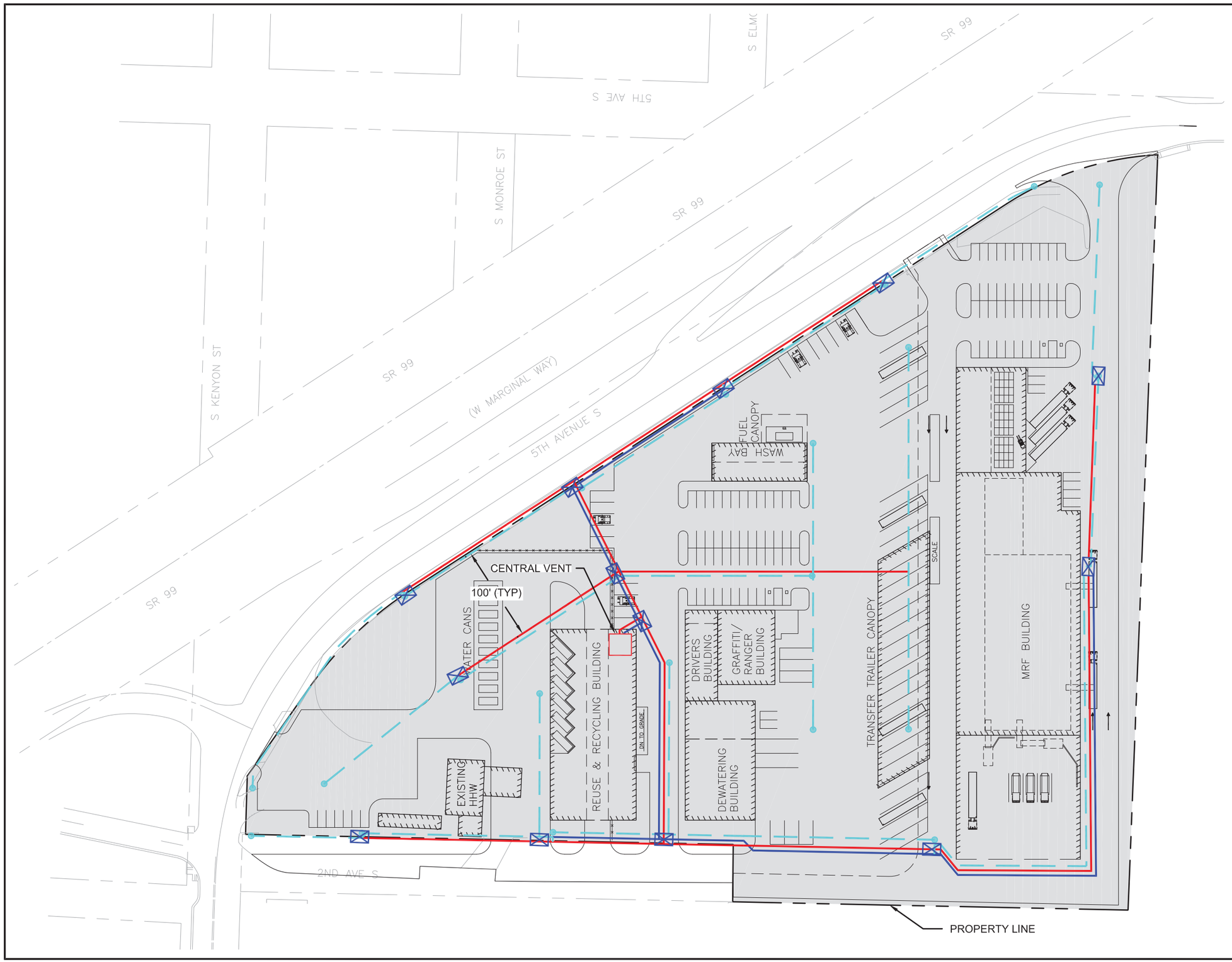

Figure 8.
Conceptual LFG System Site Plan, South Transfer Station Phase II, Seattle, Washington.

Legend

- ACTIVE LFG MANIFOLD
- PASSIVE LFG MANIFOLD
- PERFORATED LFG PIPE
- CLEAN OUT
- ACTIVE/PASSIVE VALVE BOX

N

0 50 100 200

Scale in Feet

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Aspect CONSULTING

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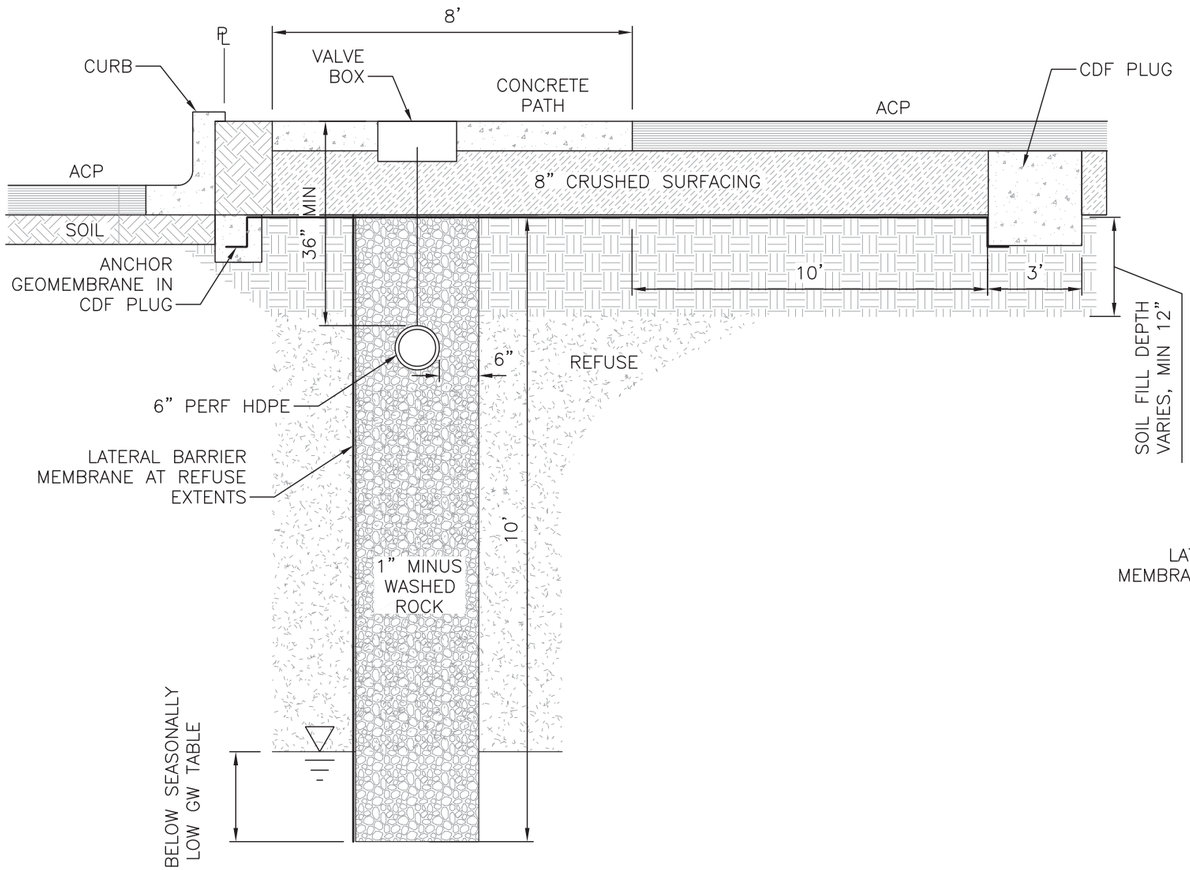
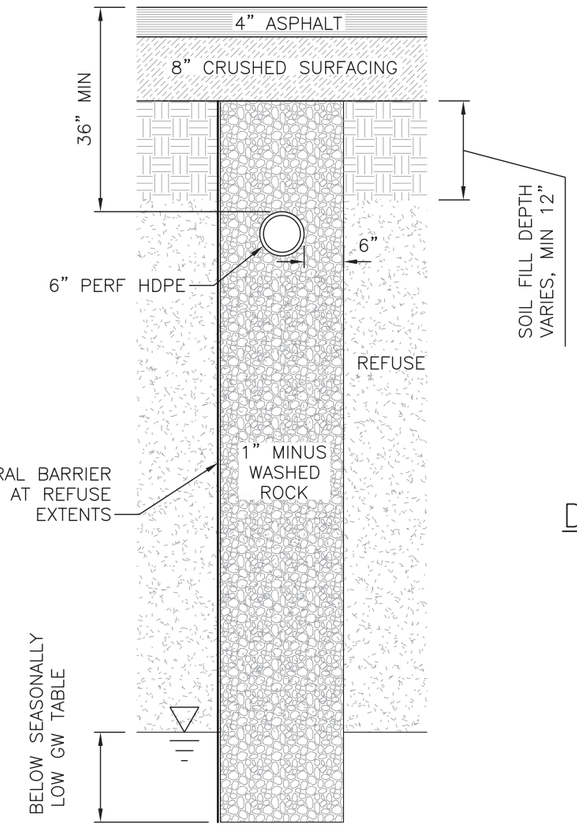
Figure 9.
Cap & LFG System Typical Details,
South Transfer Station
Phase 2, Seattle, Washington.



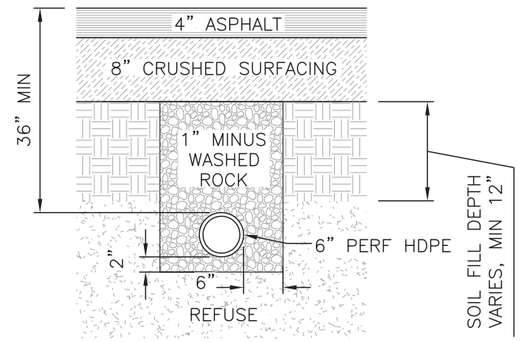
DETAIL 1 – MEMBRANE COVER WITH DEEP PERIMETER LFG TRENCH

SCALE: NTS



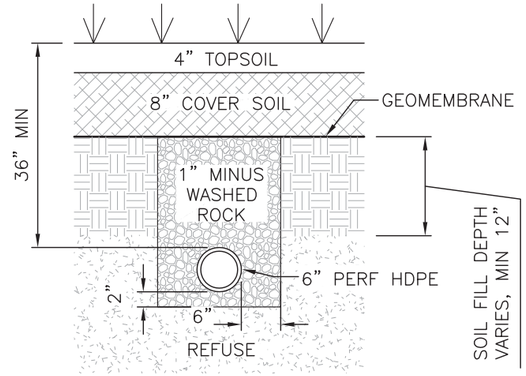
DETAIL 2 – ASPHALT COVER WITH DEEP PERIMETER LFG TRENCH

SCALE: NTS



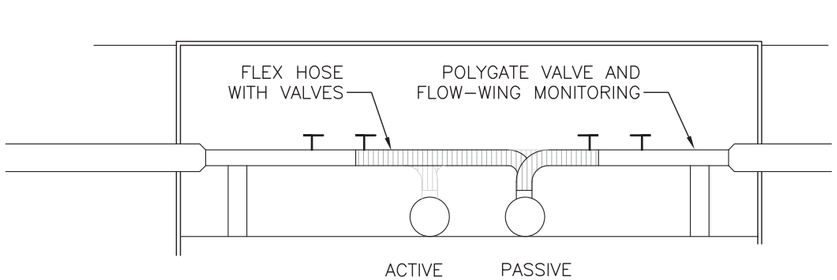
DETAIL 3 – ASPHALT COVER WITH SHALLOW INTERNAL LFG TRENCH

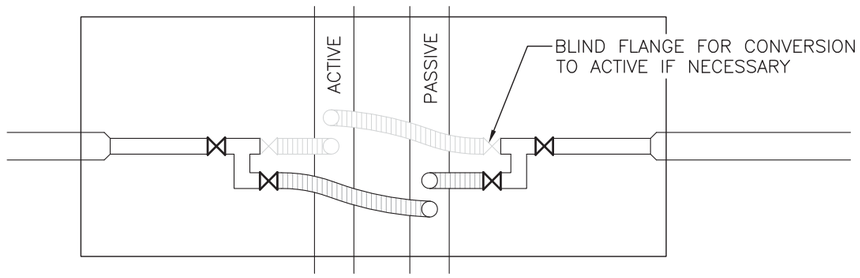
SCALE: NTS



DETAIL 4 – MEMBRANE COVER WITH SHALLOW INTERNAL LFG TRENCH

SCALE: NTS





DETAIL 5 – ACTIVE/PASSIVE VALVE BOX

SCALE: NTS

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O:\proj\Y2014\14-05904-000\CAD\Dwg\Figure 9.dwg

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5.2.2 LFG Control System

The LFG control system includes gas collection network of piping under the cover system and conveyance and venting components. The system is being planned to operate passively, relying on LFG to collect in horizontal preferential pathways consisting of gravel trenches with perforated pipes that will then route to vents located throughout the site. In the event additional collection control is necessary, the system can be converted to an active collection system. An active manifold will be installed next to the passive manifold at the time the passive system is built. The active manifold could be connected to a blower and a vacuum applied for LFG extraction to allow passive to active collection at discrete locations throughout the site. Figure 8 shows a general layout for LFG controls related to conceptual site redevelopment.

LFG collection across the interior of the parcel will consist of perforated HDPE pipe in shallow gravel filled trenches. Trenches will be spaced no more than 100 feet on-center for optimal collection. Around the perimeter of the site, LFG collection will consist of the same features; however, the trench will penetrate deeper into the waste to intercept and collect LFG for venting. A barrier membrane liner will be placed in the perimeter trench at the waste fringe. A barrier membrane will not be installed within the collection trench when refuse is present beyond the property boundary, so as not to isolate refuse or LFG that exists beyond the trench.

Flow control valve assemblies, equipped with gate valves and monitoring ports, will be installed in valve boxes at the connection of collection trenches to both active and passive manifolds. Gate valves will be used to adjust flow and vacuum, as required; monitoring ports will be used to monitor gas composition and pressures. Collector pipes and manifolds will be sloped so that condensate drains to collection sumps located at select locations. The sumps will discharge to the sanitary sewer. Figure 9 shows typical cross sections and details related to the LFG collection system.

5.2.3 LFG Control System Compatibility with Adjacent Systems

The STSII LFG control system is a passive collection and venting system that includes additional manifold piping and valve stations to allow conversion of discrete sections or the entire system to an active collection system to provide system contingency and increased system flexibility and control. The STSII system includes an interior site LFG collection system that integrates with the cover system to provide broad coverage LFG collection and control separate from the building collection systems. The building methane mitigation and LFG control systems are isolated from the site wide system to allow individual building control and system flexibility.

Along the STSII perimeter property boundaries, a deep perimeter collection trench will be installed. The perimeter trench will function as a preferential pathway for collection and venting of LFG. Along the south and southwest property boundaries (adjacent to the SPPD property) the perimeter collection trench may be off-set from the property boundary approximately 60 feet and equipped with one-way barometric valves on the trench vents to minimize short circuiting of atmospheric air from the STSII system to the SPPD system. The one way valves will allow the system to remain passive and mitigate any short-circuiting of atmospheric air if the SPPD collection system radius of influence extends beyond the location of the STSII perimeter trench location. This operating

interface is being coordinated to ensure system compatibility. To provide system flexibility and contingency, the STSII perimeter collection trenches will also include manifold piping to allow conversion of the system from passive collection to active collection. These features will allow the systems to operate compatibly and independently.

Along the west property boundary adjacent to the KIP property, the perimeter collection trench will be installed immediately adjacent to the property boundary without an offset, as the KIP property does not have an active LFG collection system that could cause potential short-circuiting of atmospheric air. The collection trench will not be constructed with a membrane barrier to function as a preferential pathway for LFG both from waste on both sides of the trench. Additionally, the venting system serving the perimeter trench can be fitted with barometric valves (one way valves) to allow the system to remain passive and mitigate any short-circuiting of atmospheric air if adjacent site control systems are modified in the future. These features will allow the systems to operate compatibly and independently.

5.2.4 Surface Water Control and Utilities

Surface water controls provided for in the cap design will prevent potential exposure and mobilization of contaminants associated with solid waste. Goals for surface water controls associated with the IA include:

- Capturing and conveying stormwater runoff across the STSII property before it has an opportunity to make contact with buried solid waste
- Meeting stormwater regulatory obligations, with respect to conveyance, quantity, flow, and quality.

The conceptual site redevelopment plan shown in Figure 7 has not been finalized; however, one concept-level planning of surface water controls and other utilities necessary for site redevelopment (e.g., sanitary sewer, water supply, electrical, gas, etc.) has been initialized. Figure 10 shows a general layout for surface water controls, sanitary sewer, and water supply related to one potential conceptual option for site redevelopment; Figure 11 shows typical cross sections for utility trenching related to the cap. The following discussion provides a general overview of planned surface water controls and other utilities, and the design guidelines to be followed in the planning process.

Stormwater is currently captured by catch basins and surface inlets across the STSII site and then conveyed through a network of underground pipes that connect to a 30-inch diameter storm pipe on the western edge of the property. This storm pipe flows north within the 2nd Ave South ROW, until it connects with municipal trunk lines beneath South Kenyon Street. The IA will utilize a similar network of inlets and conveyance pipes that connect to the same municipal trunk lines at the northwest corner of the property. Additional storm drain piping beneath the site will be minimized by using surface sheet flow to the maximum extent practicable. Onsite stormwater controls for treatment and flow control will be finalized once redevelopment site plans are developed. Stormwater controls will be designed in accordance with requirements of Stormwater, Drainage, and Erosion Control regulations (Chapter 22.802 of the Seattle Municipal Code).

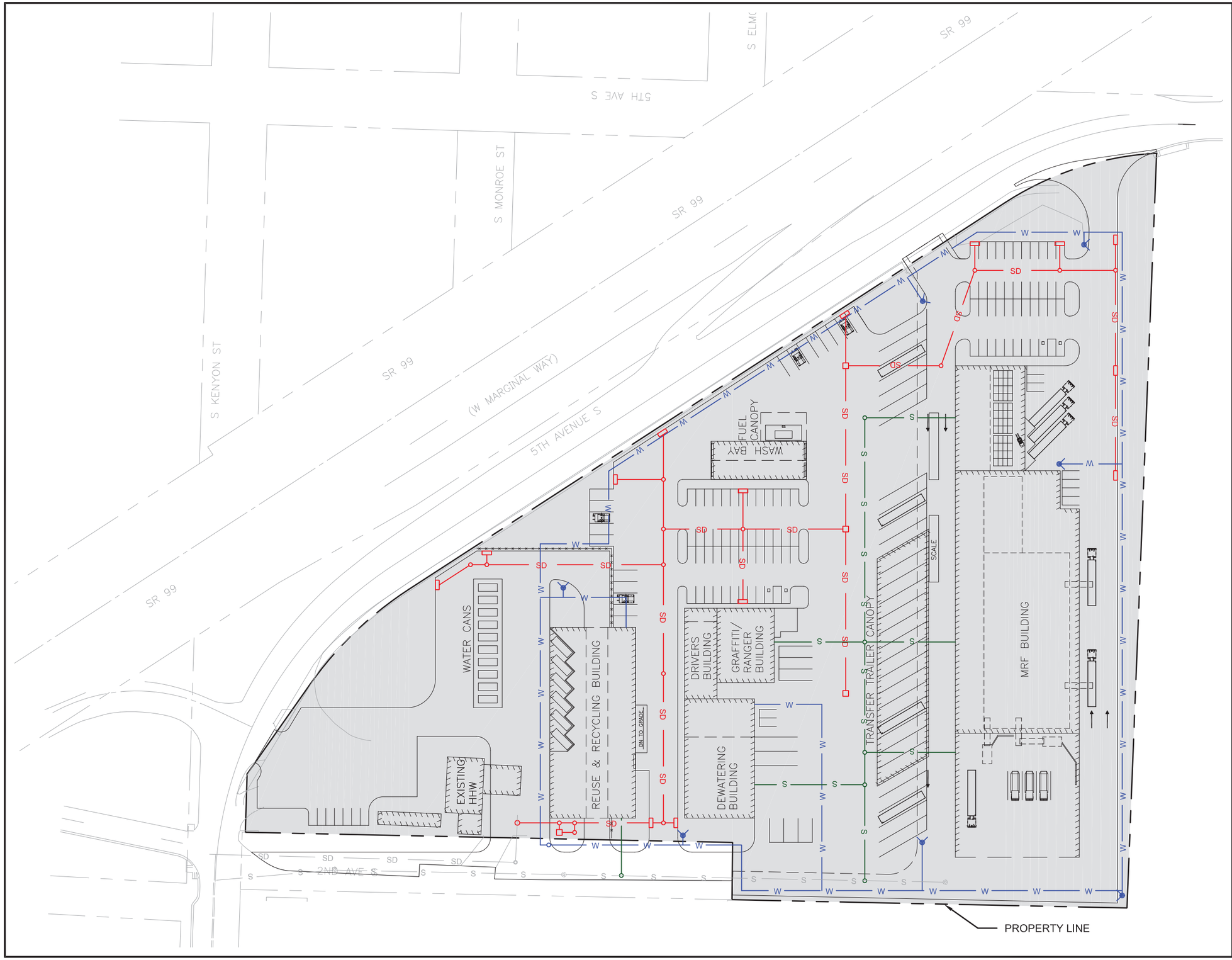

Figure 10.
Utility Systems Site Plan,
South Transfer Station
Phase II, Seattle, Washington.

Legend

- SD — STORM
- S — SEWER
- W — WATER
- MANHOLE
- CATCH BASINS
- FIRE HYDRANT

N

0 50 100 200

Scale in Feet

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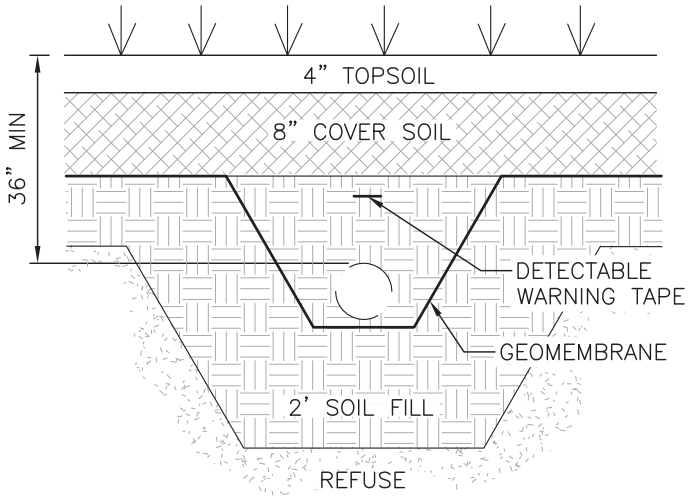
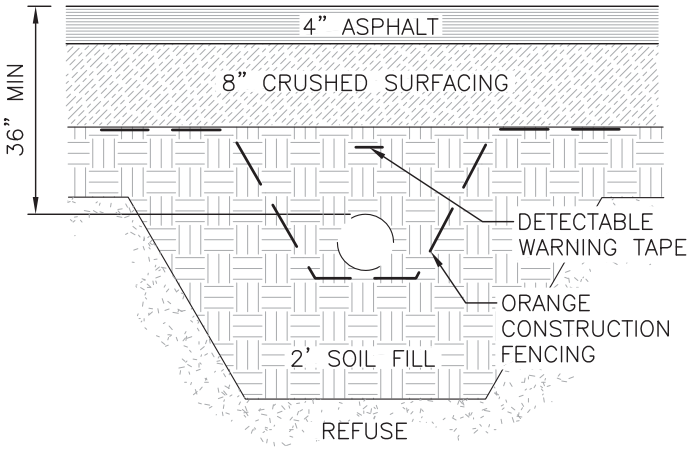


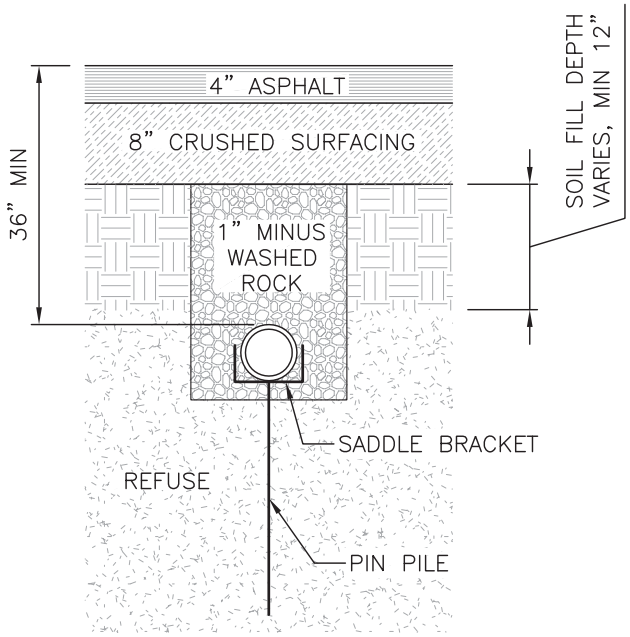
UTILITY CORRIDOR WITH SOIL COVER

SCALE: NTS



UTILITY CORRIDOR WITH ASPHALT COVER

SCALE: NTS



PILE SUPPORTED UTILITIES

SCALE: NTS

Figure 11
Utility Trenching Details,
South Transfer Station
Phase II, Seattle, Washington.

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Other subsurface utilities (e.g., sanitary sewer, water supply, and gas) will generally utilize the existing connection locations along the perimeter of the STSII property to tie into the respective offsite systems. Alignment of onsite utilities will be finalized during final redevelopment site planning.

Electric service will be provided via overhead lines along the southern and western edges of the property.

Surface water controls and other utilities will generally follow the design guidelines noted below:

- To the extent practicable, utilities will be co-located within shared trenches, with required separation for incompatible utilities (e.g., 10 feet horizontal separation between water lines and sanitary sewer lines).
- For efficient operation of the LFG collection system, utility trenches will be outfitted with gas barriers of impermeable material, such as plugs or collars, to eliminate preferential pathways for LFG migration. These barriers will be located at appropriate intervals along the trenches and at property boundaries.
- Utilities will be designed to accommodate differential settling. High deflection couplings will be used to connect pipe segments. Pipe slopes will be designed to achieve a post-settlement slope that meets the minimum requirements outlined in the City's Standard Design Criteria. A factor of safety, based on geotechnical analysis and sound engineering judgment, will be applied to the design of pipe slopes. Particular care will be given to the slope of gravity utilities so that flow reversal is not created as settlement occurs.

Limited excavation of solid waste may be necessary as part of the IA to facilitate grading for stormwater, placement of the landfill cap, and installation of subsurface utilities and the LFG collection system. Solid waste and associated landfill cover material disturbed during IA activities will be re-interred, if practical, below the landfill cap.

5.3 Redevelopment

Current redevelopment plans for the STSII parcel include construction of permanent facilities, including a recycling facility, a grit facility, parking and an administration building to support other City uses. The existing household hazardous waste facility is expected to remain in place.

5.3.1 Building Foundations

Development of buildings on the landfill will require a range of foundation types to address dynamic and static loads. Grade supported foundations and deep foundations are anticipated as part of development. All building foundation systems will include a membrane barrier and subsurface gas collection system for LFG control extending a minimum of 3 feet beyond the building footprint.

Grade-supported foundations

Grade-supported foundations consist of elements supported on surface or near-surface subgrade soils, including shallow foundations (spread and strip footings) and mat foundations. Examples of these types of foundation and integrated LFG mitigation and cap sections are shown on Figure 12.

Deep foundations

Deep foundations will consist of piles embedded into non-liquefiable, dense glacial till. These foundations will be required due to the presence of compressible refuse and silt overbank deposits at the site, and the heavy structural loads associated with the proposed MRF and possibly the grit and decant facility. The depth to the glacial till below existing grade is estimated to be on the order of 100 to 120 feet, but may be shallower or deeper in some areas. The preferred pile type helical driven piles, was selected to be able to be installed to these depths while minimizing the potential to drive waste into subsurface soil strata, creating an opportunity for vertical groundwater or LFG migration into underlying aquifers.

These concerns can be mitigated using helical driven piles that avoid additional drag loading after the settlement that takes place following completion of site grading, preloading, and surcharging. Utilizing driven piles instead of drilled piles will eliminate creation of drill spoils brought to the surface during installation. Utilizing a conical or helical shaped pile-tip reduces the possibility of direct transfer of refuse or contaminated soil downward during installation. Pressurized cement grout introduced at the pile-tip fills the annular space between the pile shaft and surrounding soil, further blocking soil, groundwater, and gas migration.

5.3.2 Building Membrane Liners

Permanent facilities that disturb the landfill cap will be required to provide the same waste containment control as the rest of the capping system. To ensure this, a membrane liner will be installed as part of each building foundation system. If piles are required for the building foundation, the membrane will be booted around installed piles (see Figure 12). The boots allow for settlement without damage to the liner system.

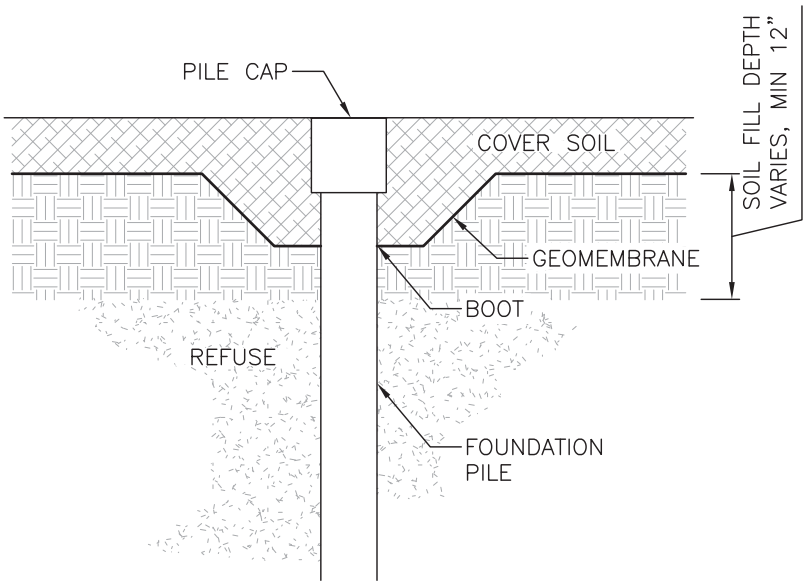
5.3.3 Building LFG Control Systems

Perforated LFG collection pipes will be installed under building geomembrane liners at no greater than 50-foot centers for optimal collection. LFG will be passively vented up to the roof of each building and maintained as a separate system from the rest of the site LFG controls (see Figure 13).

Occupied enclosed structures will be equipped with methane detection systems that activate alarms to notify occupants if the methane levels exceed 1.25 percent methane by volume (25 percent of the LEL).

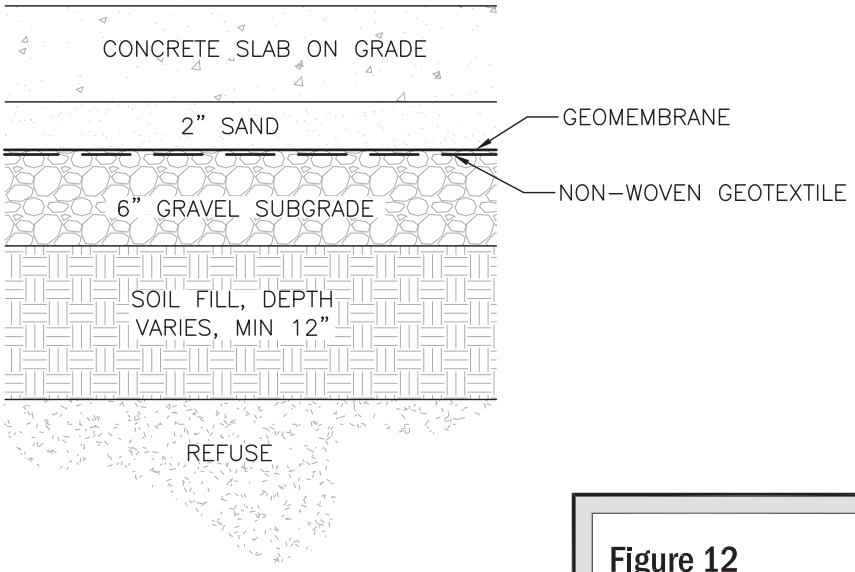
5.3.4 Utilities

Utilities for site redevelopment will include water supply, sanitary sewer, storm drainage, and electricity. Natural gas is not currently provided to the site, but may be considered during site design. Utilities will be located in shared trenches, where practical and allowable, to minimize excavation and address individual utility sizing and additional conduits to accommodate future MRF development. Settlement considerations will be incorporated into the utility design and measures to minimize or mitigate settlement, such as soil compaction methods to be incorporated along utility trenches and mechanical joints that may be used to allow some movement where pipes enter stable structures, like buildings on piles.



LINER UNDER PILE CAPS

SCALE: NTS



LINER UNDER SLAB ON GRADE

SCALE: NTS

Figure 12
Conceptual Cap Under Facilities, South Transfer Station Phase II, Seattle, Washington.

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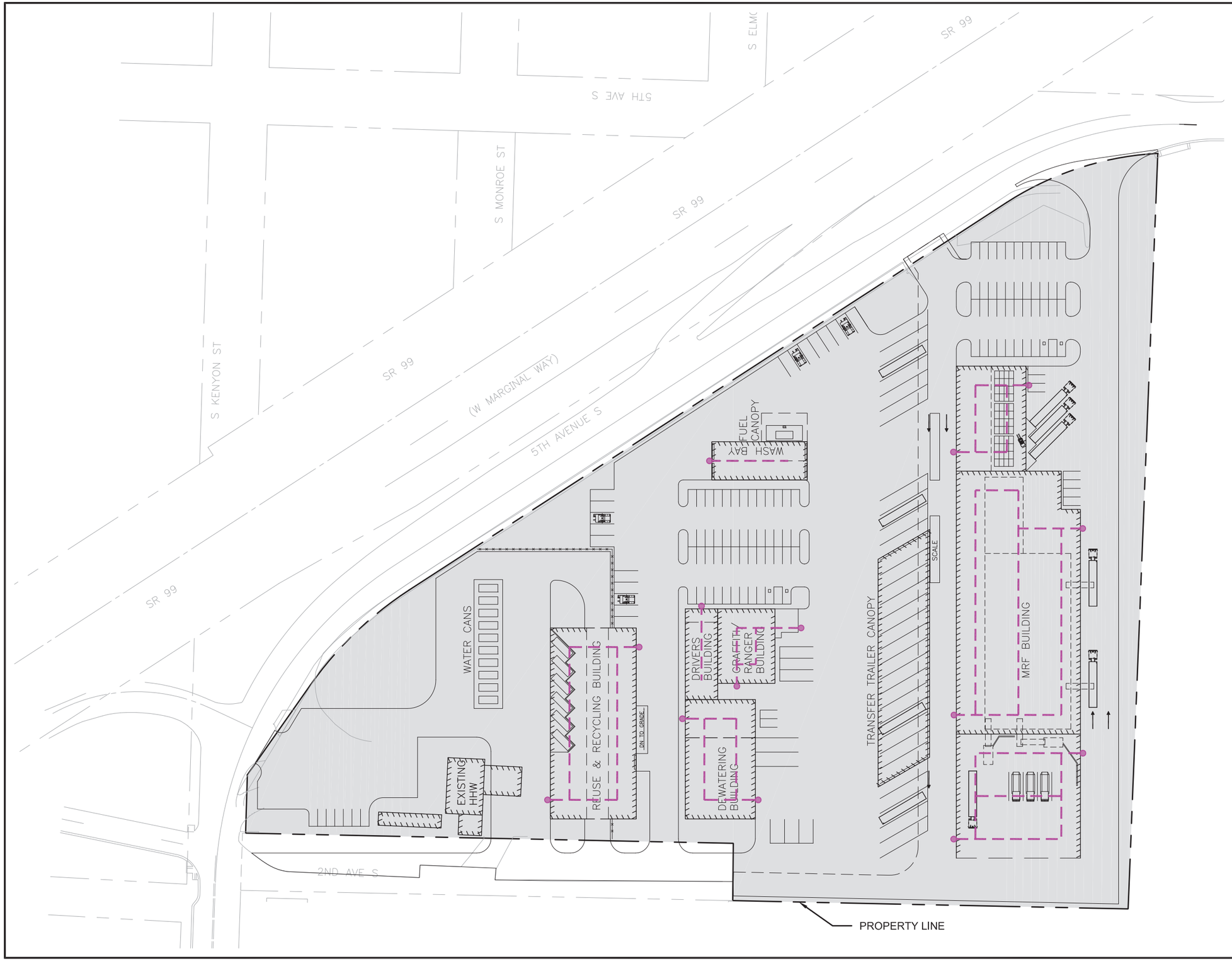

Figure 13.
LFG System Building Plan
South Transfer Station Phase II,
Seattle, Washington

Legend

- PERFORATED LFG PIPE UNDER BUILDINGS
- PASSIVE VENT TO TOP OF BUILDING

N

0 50 100 200

Scale in Feet

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Water service will likely be provided from the northwest from the existing 12-inch main under 2nd Avenue South. Water will be provided to all buildings onsite and to fire hydrants.

Sanitary sewer service is anticipated to generally drain via gravity to the west/northwest to the 12-inch main located under 2nd Avenue South. Sewer connections will be required for occupied spaces onsite, including the administrative building and recycle/reuse area, as well as areas requiring a connection for process water disposal, such as the grit/decant facility and the MRF for wash down. Surface water drainage from the transfer trailer parking area used to store trucks loaded with garbage also will be routed to the sanitary sewer.

Storm water drainage collected across the site will require flow and quality control using a subsurface stormwater vault, anticipated to be located on the northern portion of the site under the vactor parking area, where the site is more open (i.e. not under buildings). Discharge from the storm water vault is anticipated to drain to the northwest to the 30-inch storm pipe located under 2nd Avenue South.

Electrical service may come from both the east and west from 5th Avenue South and 2nd Avenue South, respectively. Primary power will be brought in overhead. Electrical service will be provided for all facilities, as well as site lighting (parking, roadways). Information regarding communication utilities (fiber optic and telephone) is not available from the preliminary project basemap and will be assessed once the final basemap is available.

5.3.5 Pedestrian Access

The pedestrian path will be 8 feet wide, concrete paved, include some landscaping, with a potential for wayfinding and/or educational signage. The path will underlain by a membrane liner to mitigate any potential risk of public exposure to buried waste or LFG. The path will require a crosswalk across South Kenyon Street, assumed to be near 2nd Avenue South to avoid the off ramp from southbound State Route 99, and will connect to the new sidewalk on the bus yard property south of STSII. The pedestrian path will be located outside site perimeter fencing to prevent public access to SPU operational areas. Figure 9 shows typical section of pedestrian path and membrane liner.

5.3.6 Institutional Controls

Institutional controls will be implemented in accordance with WAC 173-340-440 to limit or prohibit activities that will diminish the integrity of the IA or potentially result in exposure to hazardous substances at the STSII property. These institutional controls may include physical measures, such as fencing to limit access and an operation and maintenance plan for upkeep of LFG controls. Development of covenants will be finalized in the CAP issued by Ecology and will be recorded within 90 days of the Interim Action construction activities.

6 Compliance Activities

Monitoring for the IA will be conducted during LFG control system installation to address health and safety concerns and to ensure construction quality, during system commissioning to determine whether design controls are functional, and during long-term operations to determine whether the system remains effective (long-term monitoring will be integrated with a comprehensive Site-wide monitoring plan to be developed based on the CAP). Prior to initiation of monitoring for offsite gas migration, two new gas probes must be installed at the northern site perimeter. In the event that monitoring determines that control systems are not working adequately, corrective actions must be taken to provide safe environments to those affected and either system configurations or operations altered to achieve controls.

6.1 Monitoring and Reporting

WAC 173-340-410 identifies three types of compliance monitoring to include:

- **Protection monitoring** to confirm that human health and the environment are adequately protected during construction and then during the operation and maintenance of the IA
- **Performance monitoring** to confirm that the IA has attained cleanup standards and, if appropriate, remediation levels or other performance standards (e.g., construction quality control measurements or monitoring) necessary to demonstrate compliance with a permit or, where a permit exemption applies, the substantive requirements of other laws
- **Confirmational monitoring** to confirm long-term effectiveness of the IA once cleanup standards and, if appropriate, remediation levels or other performance standards, have been attained.

All three types of monitoring applicable to the IA are described in the Compliance Monitoring Plan (Appendix C). A comprehensive Landfill Site-wide Compliance Monitoring Plan will be prepared following development of the CAP.

The IA Compliance Monitoring Plan includes visual and field instrument monitoring during construction of the landfill cap, LFG control system, and stormwater control system. LFG monitoring at probes and wells also will be conducted following construction. Initial monitoring results will be provided in an Interim Action Construction Report; construction documentation will meet the requirements of WAC 173-340-400(6)(b). Long-term monitoring results will documented in annual monitoring reports, based on requirements developed in the CAP.

6.2 Corrective Actions

Monitoring LFG in probes and ambient air in buildings will be performed in accordance with the Compliance Monitoring Plan during implementation of the IA, during operation of the environmental control systems, and during long-term monitoring developed in the CAP. If exceedances occur, corrective actions may need to be initiated to remain in compliance with regulatory requirements at the landfill perimeter as well as within structures on and off the landfill. Figures 1 and 2 in the Compliance Monitoring Plan (Appendix C) provide decision tree flow charts for monitoring including trigger levels for

actions and response. Corrective actions if necessary will be initiated to address the specific issues noted during monitoring or subsequent inspections to address health and safety concerns and to ensure design controls are functional, and during long-term operations to determine whether the system remains effective to mitigate exposures or potentially explosive atmospheres to confirm the system remains effective in mitigating methane hazards.

Corrective actions will require notifications to property owners and regulators. Corrective actions may include targeted cover system or foundation sealing, penetration sealing, LFG collection system adjustment, system augmentation, or conversion from passive LFG venting to active collection using a blower to induce a vacuum for enhanced collection.

6.2.1 Landfill perimeter

Methane concentrations in soil gas at the boundary of solid waste must not exceed 5 percent by volume (the LEL). The GEM 2000 instrument will be used to measure methane at the six perimeter probes (GP-07, -09, -23, -26, -37, and -38) per the Sampling and Analysis Plan (see Appendix C). If methane exceeds the LEL, additional monitoring will be conducted both at the probes and at selected nearby offsite buildings and corrective actions will be initiated.

6.2.2 Building monitoring

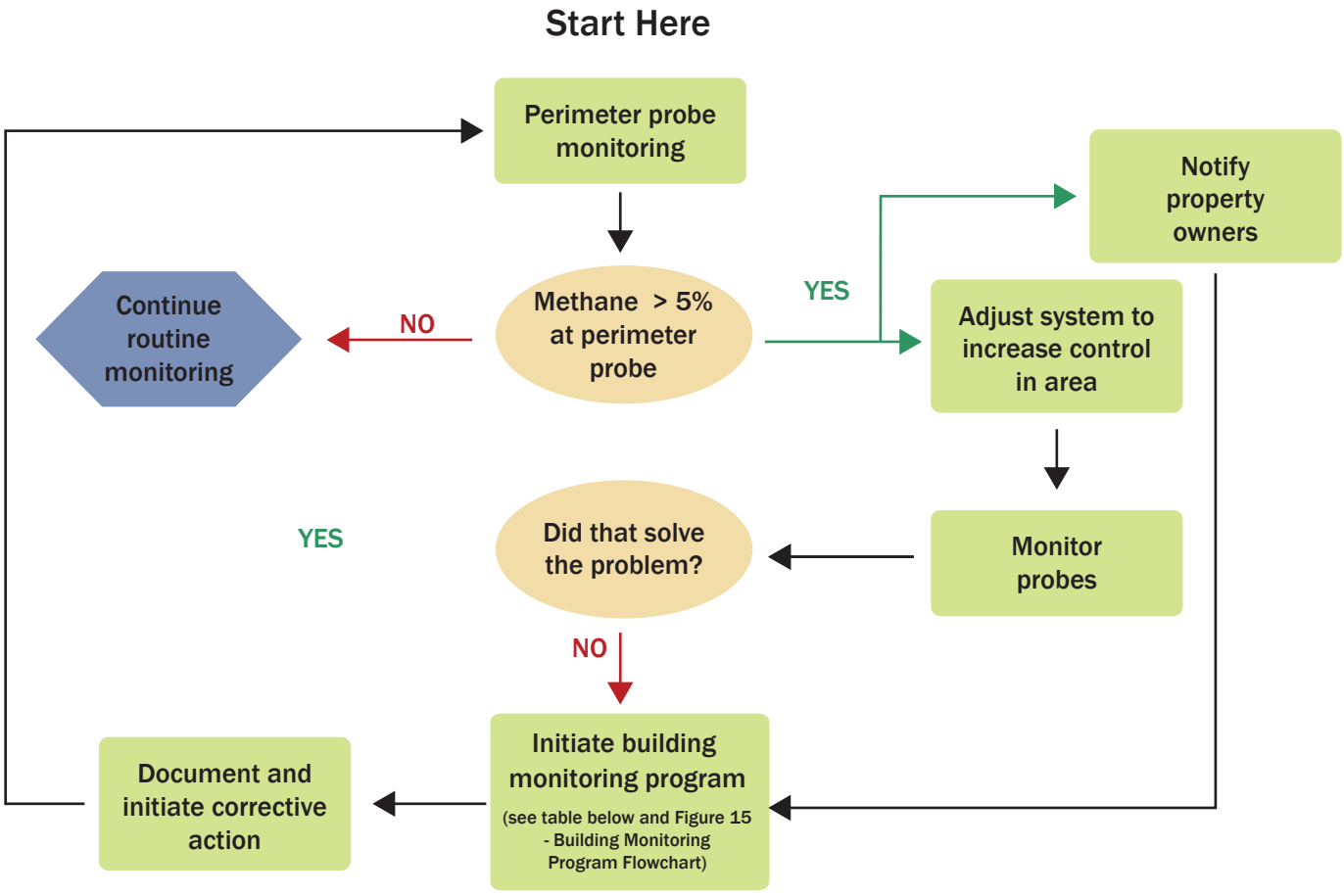
Building monitoring protocols have been developed for the STSII property site and adjacent property structures off of the landfill. Specific monitoring methods and designated perimeter probes have been identified in Figures 3 and 4 in the Compliance Monitoring Plan (Appendix C) to provide a decision tree for monitoring including trigger levels for actions and response. The building monitoring protocols have been developed to address situations where buildings are equipped with continuous monitoring methane detectors as well as for buildings that do not have detectors. Response levels detected exceedances are similar for both on and off landfill occupied structures.

Offsite buildings

Methane concentrations inside buildings and structures off the landfill must not exceed 100 parts per million volume (ppmv), equivalent to 0.01 percent by volume or 0.2 percent of the LEL per Dept. of Public Health (Seattle - King Co). Offsite building monitoring will be conducted by the building owners following notification by SPU, as indicated in the flow chart presented in Figure 14. The need for building monitoring will be determined based on identification of methane exceeding 5 percent by volume in adjacent perimeter probes during routine monitoring.

Onsite buildings

Methane concentrations inside buildings and structures on the landfill must not exceed 1.25 percent by volume, equivalent to 25 percent of the LEL. Building monitoring will be conducted based on the flowchart presented in Figure 15. Onsite buildings will be equipped with methane meters. Buildings constructed during STSII redevelopment will include vent systems. Initially, the vent systems will operate passively, with the potential for conversion to active systems. Meters in all buildings will be set to alarm at the 1.25 percent level, indicating the need for monitoring with hand-held meters sensitive to below 100 ppmv. Monitoring will continue on a daily basis if methane is found to exist between 5,000 and 100 ppmv. Extended monitoring will be coordinated with implementation of corrective actions.



Probe Location	Adjacent Buildings
GP-23	Bank of America (two buildings)
GP-07	Eagle Eye Enterprises, LLC
GP-26	Rick Larson Enterprises, Inc.
GP-09	NA
GP-37	NA
GP-38	NA

Figure 14.
STSII Perimeter
Gas Probe Monitoring Flowchart.

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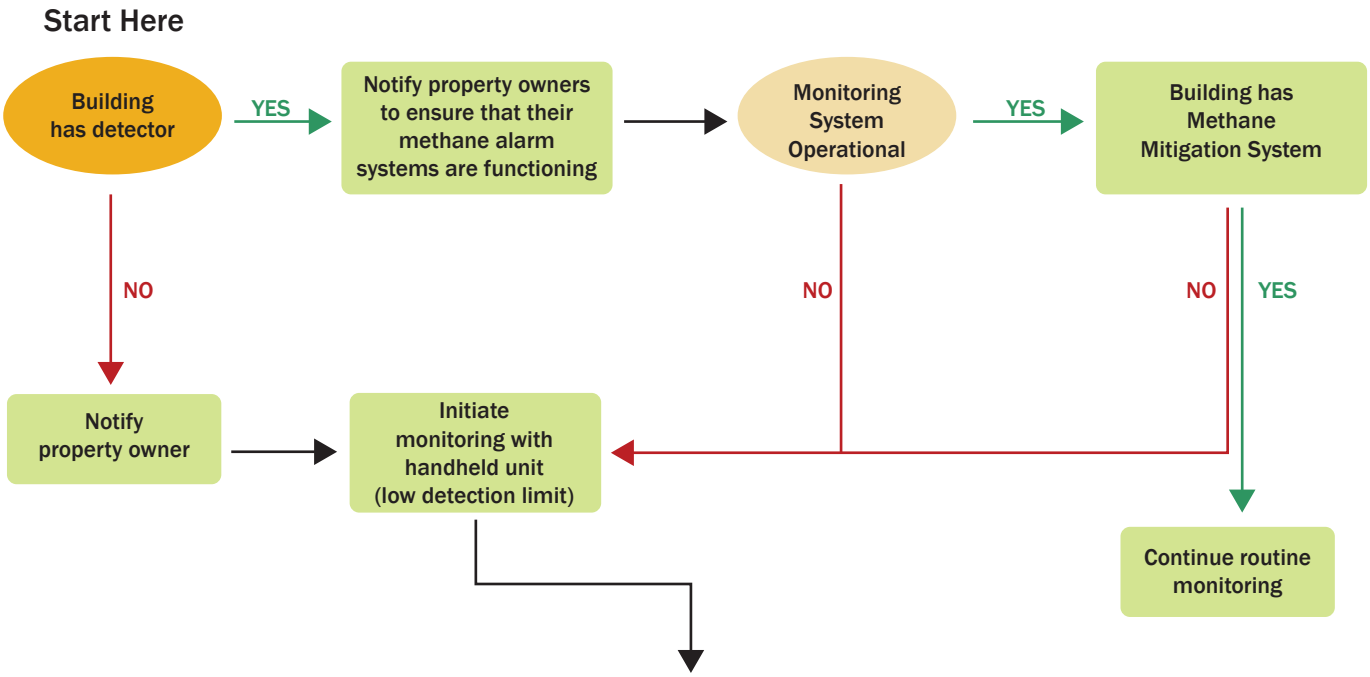

> 1.25% Methane (by volume)	< 1.25% Methane (by volume) > 100 ppm		< 100 ppm Methane (by volume)
• Evacuate buliding • ID source	< 1.25% > 5000	< 5000 > 100 ppm	Continue routine probe monitoring
	• Evacuate buliding • ID source	Monitor daily	
Verify methane concentrations with second meter			
• Notify PLP Group, Dept. of Ecology, Dept. of Public Health (Seattle - King Co.) • Document			
Potential corrective action • Seal cracks • Ventilation • Install alarm • System augmentation • Active collection			

Figure 15.
Building Monitoring Program Flowchart (STSII Redevelopment).

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6.3 Gas Probe Installation

Boring locations for new LFG probes GP-37 and GP-38 will be marked and measured in the field, and the locations adjusted, as necessary, based on access constraints and presence of utilities (see Appendix C Figure 2). One-Call and private utility location services will be used to confirm subsurface utility locations. The proposed boring locations are outside of the Landfill footprint and installation is not expected to occur in solid waste.

The LFG probe borings will be advanced using a push-probe drill rig to approximately 10 feet below ground surface [bgs], depending on depth to groundwater, which has been measured at 12 feet deep in the area.

Discrete soil samples will be collected continuously at 4-foot intervals for soil classification and field screening using a 2-inch diameter probe-drive sampler attached to the probe rods. Soil will be classified by a licensed geologist in general accordance with the Unified Soil Classification System (USCS) and the American Society for Testing and Materials (ASTM) D2488-06, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

During drilling, conditions at the borehole and soil samples brought to the surface will be field-screened for the presence of VOCs using a photoionization detector (PID). The PID is designed to detect and measure VOC vapor in air, but it does not detect methane. The VOC concentration will be used to monitor worker health and safety during drilling. Pertinent geologic and hydrogeologic subsurface conditions and PID readings will be recorded on a soil probe boring log. A Landtec GEM 2000 (Plus) meter will be used to measure methane, carbon dioxide, carbon monoxide, oxygen, and hydrogen sulfide.

Gas probes will be constructed with 0.75-inch schedule 40 polyvinyl chloride (PVC), including 5 feet of 0.010-inch machine-slotted well screen with a 10/20 silica sand pre-packed filter. A #2/12 sand filter pack will extend 2 feet above the top of the screen and a blank riser above the screen will be sealed by bentonite chips and concrete, completed with a flush-mount protective casing. The gas probes will be constructed in accordance with Washington Administrative Code (WAC) 173-160-400, Minimum Standards for Construction and Maintenance of Resource Protection Wells and Geotechnical Soil Borings. Each probe will include a locking cap.

Investigation-derived waste, including soil and water generated during gas probe installations, will be placed into 20-gallon drums, then labeled and stored on the STSII property if visual or VOC monitoring indicate contamination is present. Considering that these probes will be located outside of the Landfill boundary, if no visible contamination is observed, the soil cuttings will be taken to the transfer station and the decontamination water will be used to hydrate bentonite chips during probe construction. It is anticipated that the volume of soil cuttings and decontamination water generated will each be less than 5 gallons.

A gas probe boring log, including installation details, will be completed for each probe. The logs will provide a soil description, water level, instrument readings, and construction details. This information will be incorporated into the IA Construction Report.

7 Schedule

The schedule for the Interim Action is indicated in the table below:

Milestone	Date
Engineering Design Report for the LFG control system; operation and maintenance plans for capping and LFG Control Systems	80 days from Ecology approval of Interim Action Work Plan
Initiation of Interim Action Compliance Monitoring	Within 90 days prior to start of Construction
Start of Construction – Interim Action Elements	Mid 2016 to 2017
Demolition and regrading	2017
Construction of Cap; LFG controls system	2017
Building Construction	2018
Interim Action Report	60 days from completion of construction of the interim action elements with annual addenda documenting ongoing compliance monitoring and until compliance monitoring begins for the South Park Landfill Site.
Institutional Controls	90 days from completion of interim action construction elements.

8 References

American Society for Testing and Materials International (ASTM).

2006 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). ASTM D2488-06. American Society for Testing and Materials. 11 p.

Farallon Consulting

2010 Remedial Investigation/Feasibility Study Work Plan – South Park Landfill Site Seattle, Washington, prepared for Seattle Park Property Development, LLC and Seattle Public Utilities. November 3.

Farallon Consulting

2013 Interim Action Work Plan – South Park Landfill Site Seattle, Washington, prepared for Seattle Park Property Development, LLC. February 22.

Floyd|Snider

2014 Remedial Investigation/Feasibility Study (Draft Final) – South Park Landfill, prepared for City of Seattle and Seattle Park Property Development, LLC. June.

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Appendix A.
Request for Ecology Cover System Variance

Request for Ecology Cover System Variance, Interim Action Work Plan, South Transfer Station Phase II, Seattle, Washington

RATIONALE PROVIDED TO THE WASHINGTON STATE DEPARTMENT OF ECOLOGY IN SUPPORT OF REQUEST TO ALLOW THE ASPHALTIC CONCRETE CAP TO VARY FROM PROVISIONS OF WAC 173-304, MINIMUM FUNCTIONAL STANDARDS FOR SOLID WASTE HANDLING

The Minimum Functional Standards for Solid Waste Handling regulation WAC-173-304 (MFS) prescribed cover is that, at closure, the landfill cap consists of either:

- A minimum of 2 feet of low-permeability soil (permeability of less than 10^{-6} centimeters per second) plus a 6-inch topsoil vegetative layer; or
- A geomembrane layer acting as a barrier to infiltrating stormwater and marking the depth below which solid waste occurs, plus a 6-inch topsoil vegetative layer.

Three cap designs for the Interim Action are summarized as follows:

- **Asphaltic Concrete Cap** over gently sloping areas of the Interim Action Area where development plans call for large-vehicle access and parking, and construction of administrative and shop buildings. The asphaltic concrete cap will cover the majority of the Interim Action Area.

  This cap design does not comply with MFS criteria above as the design does not consist of either 2 feet of low-permeability soil or a geomembrane layer, and does not include a 6-inch vegetative layer.

- **Low-Permeability Membrane Cap** over steeper areas; areas to be landscaped or areas located within 10 feet of proposed pedestrian path along the east boundary of the Interim Action Area. This design includes a minimum 50-mil geomembrane and complies with MFS criteria above.

- **Low-permeability Membrane Cap (Barrier) under Building Foundations** to function as building methane mitigation system and landfill cover. Each building will be designed with a separate membrane barrier comprised of minimum 30 mil poly vinyl chloride (PVC) or 50 mil high density polyethylene (HDPE) liner over a LFG collection system. The membrane barrier will be protected above and below by sand or equivalent geotextile material providing a cushioning layer for protection from penetration. Building foundations and concrete slabs will be placed over the membrane barrier further protecting the membrane.

The cap systems as designed are considered to be protective of human health and the environment, and to allow for future use of the redeveloped property. The proposed design for the three types of caps planned for the Interim Action Area (plus the proposed stormwater control system capturing, treating, and conveying stormwater away from the Interim Action Area) minimizes stormwater infiltration of stormwater into the solid waste, thereby reducing production of additional leachate. The proposed cap designs also practicably mitigate risk to human health and the environment by preventing direct contact exposure with solid waste while still providing a working surface for the redeveloped property. The proposed LFG collection system will effectively control methane and other landfill gases from collecting beneath the caps and will control migration of landfill gases out of the Interim Action Area. The proposed cap designs satisfy

the MFS objectives of preventing infiltration of stormwater and preventing direct contact exposure to solid waste, and are designed to enable maximum flexibility in adapting to future measures that may be employed on adjacent parcels as the remedy for the South Park Landfill Site as a whole.

The asphalt pavement cover will be installed with a continuous slope, allowing conventional drainage and will be designed so that rain will flow quickly across the pavement during a significant precipitation event. Within a few minutes after storm passage, the pavement will quickly drain and evaporate dry. This will significantly reduce the duration of any rainwater "head" above the pavement that would contribute to water penetration through the pavement. In contrast, a low permeability soil cap with surface vegetative layer will not promote overland flow to a storm water control system and could create a "water sponge" effect, retaining stormwater and creating a water "head" for prolonged seepage through the soil cover. Landfill cap operation and maintenance procedures, including periodic inspections, will help ensure pavement integrity and minimize stormwater infiltration. Protection measures for settlement, including underlayments of geotechnical reinforcing fabric and additional crushed rock, will prevent cracking of the asphaltic concrete where yielding soils are encountered during construction.

Section 710(5) of Chapter 173-340 of the Washington Administrative Code (WAC 173-340-710[5]) indicates that for purposes of MTCA, a regulatory variance or waiver is appropriate if the substantive conditions for a regulatory variance or waiver requirement in a potentially applicable state or federal law are met and that interim action and cleanup action are protective of human health and the environment. The provisions for variances in the MFS are contained in WAC 173-304-700, which indicates that a variance request would be granted if:

- The solid waste handling practices or location do not endanger public health, safety, or the environment; and
- Compliance with the regulation from which variance is sought would produce hardship without equal or greater benefits to the public.

As indicated and supported in the Interim Action Work Plan, allowing the asphaltic concrete cap to vary from the provisions of the MFS is appropriate for the Interim Action Area because the proposed design is protective of human health and the environment in this specific situation based on the following information:

- Although the asphaltic concrete cap does not provide a minimum of 2 feet of low-permeability soil of less than 10^{-6} centimeters per second or a geomembrane layer per the MFS, the asphaltic cap system is a relatively impervious surface that provides erosion protection measures and minimizes infiltration of stormwater into the solid waste, and therefore leachate production. Because the South Park Landfill is unlined and solid waste has been in contact with groundwater for decades in some areas, the importance of reducing stormwater infiltration with an impervious cap system is reduced.
- The South Park Landfill was closed in 1966 in accordance with applicable regulations at the time. The cover system in the Interim Action Area was maintained under WAC 173- 301, the governing regulation for solid waste landfill closures, until WAC 173-301 was superseded by the MFS in 1985.
- Portions of the South Park Landfill Site were developed prior to adoption of the MFS set forth in WAC 173-304 in 1985. These properties have operated without documented incidents concerning the direct contact exposure pathway.

- The asphaltic concrete cap will serve the two primary functions of a landfill cap per the MFS: effectively minimizing stormwater infiltration and preventing direct exposure with solid waste and affected media.

With regard to the Ecology request for additional substantiation for the requested MFS variance for the asphaltic concrete cap design, and to the MFS WAC-173-304-700(1)(b) variance criterion that strict MFS compliance would present hardship without equal or greater benefits to the public, the following issues are pertinent.

Regarding use of 2 feet of low-permeability soil in the asphaltic concrete cap design:

- Non-clay low permeability soil is not available locally and for practical purposes it is difficult to find sources that will dependably meet a permeability requirement of 10^{-6} centimeters per second in the quantities required for a 2-foot cover over an approximately 11-acre area. However, low permeability soil material has been produced by amending glacial till with 3 to 5 percent bentonite, mixed with pug mill and compacted in 4-inch layers at the King County Cedar Hills Regional Landfill
- Clay is not a competent structural soil for asphalt pavement design. The localized loads from heavy vehicles on the redeveloped property cannot be supported, and the clay will deform under heavy loads on asphalt paving with standard gravel sub-base and quickly cause cracking and failure of the asphalt pavement, even with standard asphalt concrete pavement over crushed rock.

Regarding use of an infiltration barrier *geomembrane layer plus a 6-inch topsoil vegetative layer* in the asphaltic concrete cap design:

- The asphaltic concrete cap does contain a provision for a geotextile and supplementary crushed rock if bearing soils are determined to be geotechnically yielding during cap construction. While this geotextile is not a 50-mil minimum low permeability geomembrane, it would provide protection against settlement and subsequent cracking and breaching of the integrity of the asphaltic concrete cap.
- While a 50-mil minimum geomembrane infiltration barrier could be considered in the asphaltic concrete cap design, it would add significant cost and will not provide the geotechnical protection against differential settlement offered by the geotextile in the design. Retaining any infiltrating stormwater below the asphaltic cap and above the geomembrane would adversely affect the integrity of the asphaltic concrete cap with its intended use as a working surface on the redeveloped property.
- Reducing the permeability of the asphaltic concrete cap by incorporating a membrane within the asphaltic concrete was considered. Constructability concerns were identified related to high temperature applications, punctures, and achievable reductions in permeability.
- With regard to an overlying vegetative layer, this would not be suitable as a working surface for the redeveloped property.

Regarding hardship imposed with strict compliance with MFS in the asphaltic concrete cap design without equal or greater benefit to the public:

- If glacial till is amended with bentonite to create a low-permeability soil, approximately 35,000 cubic yards would be required. Purchasing and delivering glacial till, amending the material with 3 to 5 percent bentonite mixing in a pug mill and placement with

compaction in 4-inch lifts with quality control testing would add an incremental cost to the proposed design on the order of $2,400,000, providing little, if any, benefit to the public.

- If low-permeability soil is to be used in the asphaltic concrete design, approximately 35,000 cubic yards would be imported. Importing 35,000 cubic yards of bentonite clay from Wyoming, including rail shipping, truck in-haul, compaction and quality control, geotechnical fabric, and extra crushed rock to achieve suitable geotechnical stability, would add an incremental cost to the proposed design on the order of $10,000,000, providing little, if any, benefit to the public.
- As the finish grade would be higher with 2 feet of low permeability material beneath the asphaltic concrete cap, there would be an incremental cost to the proposed design on the order of $40,000 for rock-filled gabion basket retaining walls.
- The extra weight of 5 feet of additional imported material (2 feet of clay plus 3 feet of crushed rock) will cause additional settlement of the old solid waste and renew settlement of compressible soils beneath the landfill. The solid waste and compressible soils settlement will likely be differential and unpredictable, and range from 1 to 12 inches. The settlement due to compressible soils will be slow and prolonged, occurring over as much as 10 to 15 years. Due to the compressible soils settlement, the asphalt pavement will begin cracking and breaking up quickly after placement, and related asphalt pavement problems will persist over the duration of the compressible soils settlement.
- The extra thickness of additional imported material will necessitate redesign of the grading plan, the stormwater control system, and the LFG control system. Perimeter elevations need to match surrounding surface elevations. Grades will change in some areas, and new surface elevation contours will need to be redeveloped. The estimate cost for the redesign sums to approximately $50,000.
- Reducing the permeability of the asphaltic concrete cap by incorporating a membrane within the asphaltic concrete would add an estimated incremental cost of approximately $510,000 with uncertain results and would provide little, if any, benefit to the public.

Appendix B.
Applicable or Relevant and Appropriate Requirements, Interim Action, South Park Landfill

Applicable or Relevant and Appropriate Requirements, Interim Action, South Park Landfill

Potential Chemical-Specific ARARs[1]	Source	Description and Relevance
National Ambient Air Quality Standards	40 CFR 50	Specifies primary and secondary National Ambient Air Quality Standards, National Emission Standards for Hazardous Air Pollutants, and performance standards for new and existing stationary sources. National Ambient Air Quality Standards are applicable to those elements of the Interim Action pertaining to the collection and management of LFG.
Federal Regulations Implementing the Toxic Substances Control Act	40 CFR 700-799, as applicable	Specifies testing, handling and disposal requirements for materials contaminated with polychlorinated biphenyls (PCBs), dioxins/furans, etc. These regulations would apply to material generated during conduct of the Interim Action that is found to be contaminated with toxic substances regulated under TSCA.
State Dangerous Waste Regulations	WAC 173-303	Establishes regulatory requirements for the generation, handling, storage, transport, treatment, and disposal of dangerous wastes in the State of Washington under the provisions of the Washington State Hazardous Waste Management Act. These regulations apply to waste deemed dangerous or extremely hazardous to public health or the environment. The regulations would apply to material generated during conduct of the Interim Action that is found to be contaminated with dangerous waste, and requires treatment and disposal off the Site.
Washington State Minimal Functional Standards for Landfills	WAC 173-304-460	This regulation applies to facilities that dispose of solid waste in landfills, with the exception of inert, demolition, and wood waste landfills. It specifies limits on methane concentrations at the property boundary and in on-site and off-site structures, and requires compliance with ambient air quality standards and emission standards at the property boundary. This regulation applies only to solid waste landfills that operated after 1985, but it is a minimum requirement for solid waste landfill cleanups.
Puget Sound Clean Air Agency (PSCAA) Notice of Construction	Regulation I	Requires a Notice of Construction and Application for Approval before constructing or modifying an air contaminant source. This would apply to the Interim Action due to potential emissions of LFG.
PSCAA Emission Standards for Toxic Air Pollutants	Regulation III	Implements at a regional level the National Emission Standards for Hazardous Air Pollutants (NESHAPS). It requires best available control technology for sources of toxic air contaminants; and requires that toxic air contaminants be quantified and compared against acceptable source impact levels for each contaminant. PSCAA Emission Standard for Toxic Air Pollutants are applicable to air emissions from the LFG collection system.
King County Board of Health Regulations	Title 10	The requirements established in this regulation meet or exceed the requirements established by the Washington State Minimum Functional Standards for Solid Waste Handling. Applicable chemical-specific requirements are the same as those described for the Minimal Functional Standards (see WAC 173-304-460 above).
Potential Location-Specific ARARs[1]	**Source**	**Description and Relevance**
Federal Archeological Resource Preservation	RCW 27-53	This law addresses the discovery, identification, excavation, and study of archaeological resources; and the communication of information to state and federal agencies regarding the possible impact of constructions activities on Washington State archaeological resources. Although the Interim Action Area has been extensively disturbed during operation of the landfill, this law is potentially applicable during implementation of the Interim Action.
State Permits for Archeological Excavation and Removal	WAC 25-48	Establishes application and review procedures for the issuance of archaeological excavation and removal permits, and for the issuance of civil penalties for violations. This law is potentially applicable in the event that archaeological resources are identified during implementation of the Interim Action.

Potential Action-Specific ARARs[1]	Source	Description and Relevance
Monitoring and Maintenance		
Federal Occupational Safety and Health Standards	29 CFR 1910.120	Requires that employers develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program must be designed to identify, evaluate, and control safety and health hazards, and provide for emergency response for hazardous waste operations. This regulation is applicable to the implementation of the Interim Action.
State Occupational Health Standards	WAC 296-62	Establishes rules designed to protect the health of employees and help to create a healthy work place by establishing requirements to control health hazards. Requirements for chemical hazard communication programs, workplace lighting levels and exposure records are in the safety and health core rules of this chapter. This regulation is applicable to the implementation of the Interim Action.
Well Construction Standards	WAC 173-160 Part Two	Part Two of this regulation defines minimum standards for the construction and decommissioning of the water resource protection wells that will be installed as part of the groundwater monitoring program to be implemented as part of the Interim Action. Resource protection wells may not be used to withdraw or inject water for domestic, industrial, municipal, commercial, or agricultural purposes. The standards defined in this regulation are directly applicable to the Interim Action groundwater monitoring program.
Groundwater Monitoring Plan	WAC 173-304-490	This regulation addresses groundwater monitoring requirements for solid waste landfills, including provision for a minimum of one up-gradient and two down-gradient monitoring wells. The monitoring plan must specify procedures for sample collection, preservation and shipment, laboratory analysis and associated quality control protocols, and health and safety. Although this requirement applies only to landfills that operated after 1985, these monitoring requirements will be incorporated into the groundwater monitoring program that will be conducted as part of the RI/FS.
Excavation and Filling		
State Particulate Matter Standards	WAC 173-470	Establishes maximum acceptable levels for particulate matter in ambient air based on the criteria defining particulate matter that have been developed by the U.S. Environmental Protection Agency. This regulation establishes requirements for monitoring, measuring, and reporting particulate matter data. It applies to dust-producing activities during implementation of the Interim Action, particularly excavation and filling.
PSCAA Fugitive Dust Standards	Regulation I	Establishes emission standards for fugitive dust. Like the previous ARAR, this regulation applies to dust-producing activities during implementation of the Interim Action, particularly excavation and filling.
Treatment, Discharge, and Disposal		
NPDES Permit	WAC 173-220	Establishes a state individual permit program, applicable to the discharge of pollutants and other wastes and materials to the surface waters of Washington State, operating under state law. Permits issued under this chapter are designed to satisfy the requirements for discharge permits under both the Federal Water Pollution Control Act and Washington State Water Pollution Control Act. This requirement is applicable to the control, collection, management, and discharge of stormwater runoff during and after construction of the Interim Action.
State Waste Discharge General Permit Program	WAC 173-226	Establishes a state general permit program, applicable to the discharge of pollutants, wastes, and other materials to waters of the state, including discharges to municipal sewerage systems. Permits issued under this regulation are designed to satisfy the requirements for discharge permits under the federal Water Pollution Control Act and the Washington State Water Pollution Control Act. Although this permit is not required because of MTCA's permit exemption, it will be obtained for the drainage control systems to be constructed as part of the Interim Action because an NPDES permit is required and Ecology issues a combined NPDES/state waste discharge permit.

Potential Action-Specific ARARs[1]	Source	Description and Relevance
Treatment, Discharge, and Disposal (continued)		
Industrial Waste Discharge to Metropolitan King County Sewer System	KCC 28.84.060	Establishes rules and regulations applicable to water pollution abatement activities, including the disposal of sewage into the metropolitan sewer system, whether delivered from within or from without the county. Authorizes King County to develop and implement such procedures and to take any other actions as may be necessary to ensure that local public sewers and private sewers discharging or proposing to discharge into the metropolitan sewer system are constructed and developed in accordance with applicable laws, regulations and plans. This regulation applies to implementation of the drainage control elements of the Interim Action.
State Minimum Functional Standards for Solid Waste Handling	WAC 173-304-460	This regulation is applicable to facilities that dispose of solid waste in landfills with the exception of inert, demolition, and wood waste landfills. The regulation establishes standards for landfill cover, surface water control, LFG collection, access control, and compliance monitoring.
King County Board of Health Regulations	Title 10	The requirements established in this regulation meet or exceed the requirements established by the Washington State Minimum Functional Standards for Solid Waste Handling (see above), and are applicable to the Interim Action for compliance monitoring programs and as performance standards for the design of control systems.
City of Seattle Review (in numerical order by SMC title and chapter)		
Street Use	SMC Title 15, as applicable	Requires a written permit for any proposed activities that use City of Seattle street right-of-way (ROW), including construction activities and movement of equipment. Because the toe of the landfill extends in to City of Seattle ROW, it will be necessary to conduct work in the ROW to implement the Interim Action. City of Seattle review requirements are applicable for elements of the interim action.
Water Connection	SMC 21.04	Specifies an application and approval process for connecting to the City of Seattle water supply system. Water connection is potentially needed for dust control during grading.
Side Sewer Connection	SMC 21.16	Requires connection of all sources of polluted water with the nearest accessible sanitary sewer. Sewer connection will be needed for discharge of LFG condensate and possibly leachate.
Electrical Service Connection	SMC 21.49	Specifies an application and approval process for obtaining electrical service from Seattle City Light Department. Electrical service will be needed to power sump pumps for LFG condensate and blower motors for LFG control.
Building Codes	SMC Title 22, as applicable	Includes a number of requirements applicable to the Interim Action, including electrical, mechanical, fire, and energy codes; and regulations for grading, stormwater, drainage, and erosion control (see more detail below).
Stormwater, Drainage, and Erosion Control	SMC 22.802	Specifies a drainage control review and approval process for projects that involve land-disturbing activities or new or replaced impervious surface. The Interim Action will require a Drainage Control Plan and a Construction Stormwater Control Plan.
Grading	SMC 22.804	Specifies a process for application and approval of a grading permit for earth-moving activities. Grading must preserve natural drainage patterns, and not create unstable slopes or contribute to increased turbidity or other forms of pollution in a watercourse.
Noise Control	SMC 25.08	Specifies maximum permissible noise levels for construction activities and facility operation in industrial zones, depending on the zoning designation of receiving properties.
Environmentally Critical Areas	SMC 25.09	Specifies development standards for actions affecting environmentally critical areas. Wetlands associated with drainage ditches were determined not to meet the city's wetland definition.

Source: Farallon 2013

NOTES

[1]As noted in Section 3.1. Because it is understood that Washington MTCA is the overarching regulation governing all aspects of the Interim Action, it is not included in this table.

Pursuant to Section 090 of Chapter 70.105D of the Revised Code of Washington (RCW 70.105D.090), PLPs conducting a remedial action under an agreed order with Ecology are exempt from some state-administered procedural requirements and the procedural requirements of any local laws requiring or authorizing local government permits or approvals for the remedial action. However, the substantive requirements of state and local laws requiring permits or approvals shall be complied with.

Pursuant to WAC 173-340-710(9), the state agencies and local governments that have potential permits subject to the permit exemption have been consulted. The substantive requirements of the permits that are exempt, to the extent they are currently known, have been incorporated into this Interim Action Work Plan. Therefore, the substantive requirements of state and local laws subject to the permit exemption will be met during the Interim Action.

ARARs = applicable or relevant and appropriate requirements CFR = Code of Federal Regulations

KCC = King County Code

MTCA = Washington State Model Toxics Control Act Cleanup Regulation NPDES = National Pollutant Discharge Elimination System

RCW = Revised Code of Washington

RI/FS = Remedial Investigation/Feasibility Study SMC = Seattle Municipal Code

WAC = Washington Administrative Code

Appendix C.
Interim Action Compliance Monitoring Plan

Interim Action Compliance Monitoring Plan

South Transfer Station Phase II

Seattle, Washington
July 24, 2015

Contents

Figures

Appendices

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Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
LFG	landfill gas
MTCA	Washington State Model Toxics Control Act Cleanup Regulation
RI/FS	Remedial Investigation/Feasibility Study
SPPD	South Park Property Development
SRDS	South Recycling Disposal Station
WAC	Washington Administrative Code

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1 Introduction

This Interim Action Compliance Monitoring Plan has been prepared by the HDR team, including HDR, Herrera Environmental Consultants (Herrera), and Aspect Consulting (Aspect), for Seattle Public Utilities SPU. It describes materials approval, construction inspection, and landfill gas (LFG) monitoring to be conducted in support of an interim action (IA) to be conducted at the former South Recycling and Disposal Station (SRDS), situated on a portion of South Park Landfill (Landfill) located in south Seattle (Figure 1). The IA applies to redevelopment of the SRDS property, now referred to as South Transfer Station Phase II (STSII). South Park Property Development, LLC (SPPD) owns the adjacent property, also situated on a portion of the Landfill, and is conducting an IA in an independent, but coordinated effort.

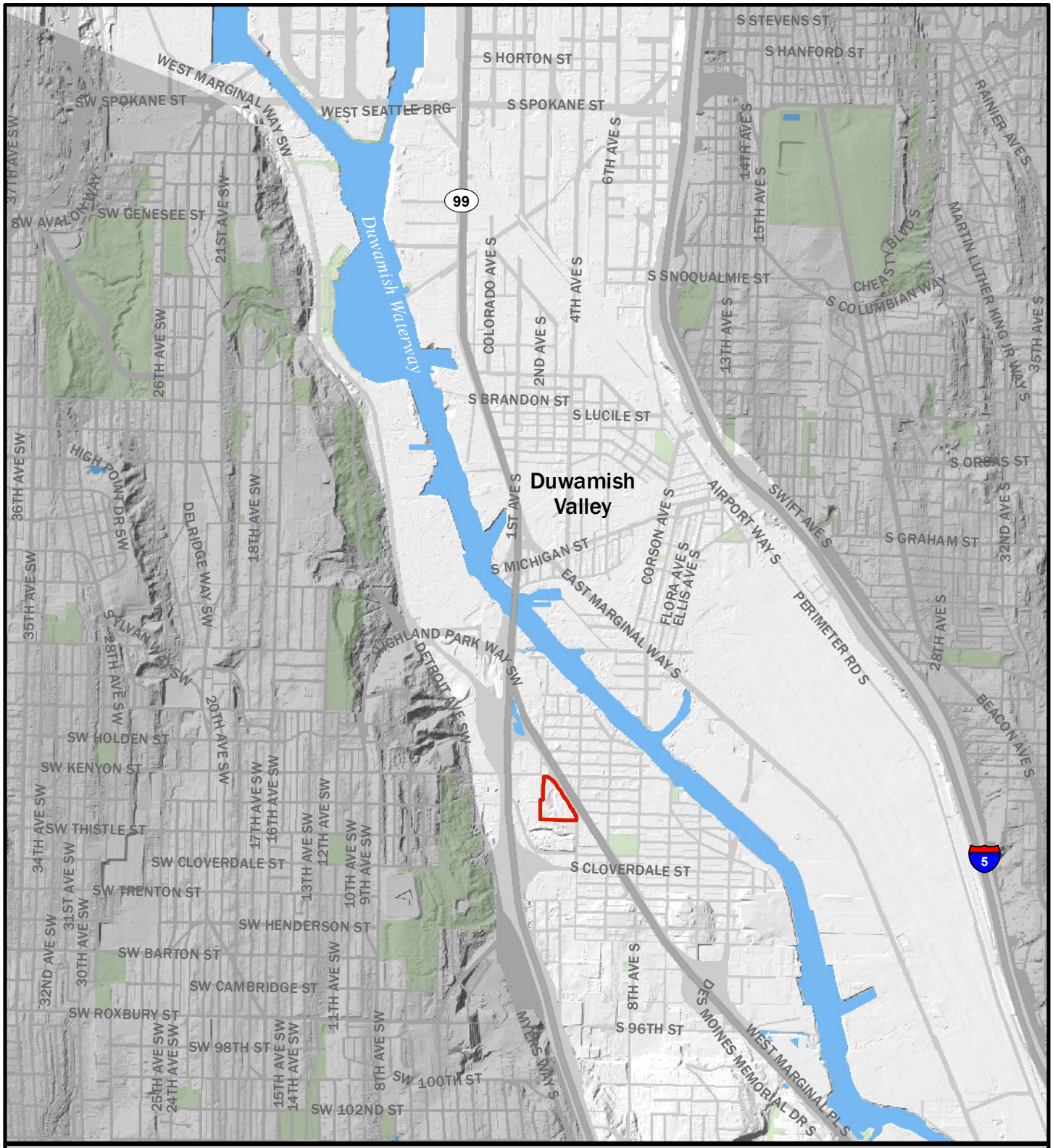
A Remedial Investigation/Feasibility Study (RI/FS) of the entire Landfill Site is presently being conducted under Washington State Model Toxics Control Act (MTCA) Agreed Order No. 6706 (Agreed Order) with the Washington State Department of Ecology (Ecology) to determine the nature and extent of contamination and to evaluate remedial actions necessary for the Site. SPPD and the City of Seattle (City) were signatories of the Agreed Order in 2008 and 20009, respectively. An amendment to the Order was issued in 2013, directing SPPD to conduct an IA on their portion of the Landfill Site. No such Order has been issued to address the SPS2 property; however, the City has chosen to pursue an IA in preparation for planned near-term site development.

The SPPD IA addresses the SPPD property and contiguous offsite areas where solid waste from Landfill operations extended beneath City rights-of-way, including 5th Avenue South, 2nd Avenue South, and South Sullivan Street. Similarly, the STSII IA addresses the STSII property and where solid waste extends beneath 5th Avenue South. Each site will coordinate to mitigate groundwater contamination and LFG associated with the Landfill Site, as well as to control surface water based on independent site development plans.

Landfill Site background and environmental conditions are presented in the draft RI/FS report (Floyd Snider 2014) and components of the IA are presented in the Interim Action Work Plan (Herrera 2015), and are not reiterated here. The Interim Action Work Plan also describes regulatory considerations related to the IA, including applicable federal, state, and local requirements; agency guidance documents that also may be considered; and the relationship of the IA to planned development of the SPPD property.

1.1 Purpose

The IA at STSII is necessary to reduce threats to human health and the environment by eliminating or substantially reducing hazardous substance exposure pathways. In conformance with MTCA requirements (WAC 173-340-430(3(b)), the IA includes landfill capping, installation of LFG and surface water controls, and monitoring.
WAC 173-340-410 identifies three types of required monitoring to include:



Legend

STSII Property

Figure 1.
Site Vicinity Map, South Transfer Station Phase II, Seattle, Washington.

N

0 1,500 3,000 6,000 Feet

FLOYD | SNIDER strategy • science • engineering

HERRERA

HDR

Aspect CONSULTING

K:\Projects\Y2014\14-05904-000\Project\Compliance_MP\vicinity_map.mxd (5/1/2015)

- Protection monitoring to confirm that human health and the environment are adequately protected during construction and then during the operation and maintenance of the IA.
- Performance monitoring to confirm that the IA has attained cleanup standards or remediation levels, and other performance standards (e.g., construction quality control measurements or monitoring) necessary to demonstrate compliance with a permit or the substantive requirements of other laws.
- Confirmational monitoring to confirm long-term effectiveness of the IA once cleanup standards and, if appropriate, remediation levels or other performance standards, have been attained.

All three types of monitoring applicable to the IA are described in this plan; a comprehensive, long-term Site Compliance Monitoring Plan will be prepared following development of the cleanup action plan (CAP).

This monitoring plan includes visual and field instrument monitoring during construction of the landfill cap, LFG control system, and stormwater control system, as well as installation of additional LFG monitoring probes. LFG control system vent and STSII site perimeter probe monitoring will be conducted following construction. Construction documentation will be provided in an Interim Action Construction Report that meets the requirements of WAC 173-340-400(6)(b). Monitoring results will be provided in annual Interim Action Monitoring Reports, until such time that remedial action monitoring reporting is initiated.

2 Interim Action Components

Demolition and site grading, landfill capping and LFG control, and redevelopment activities will be conducted as part of the IA. Demolition will include removal of all pavement, structures (except for the household hazardous waste facility), tanks, utilities, and landscape features. The site will be graded in preparation for constructing the cap to allow control of stormwater flow. The integrated cap and LFG control system will include trenches for gas collection, piping for gas conveyance, and vents for gas dispersion. Redevelopment will include incorporation of LFG control features into newly constructed structures, when necessary.

Demolition will include removal of aboveground features, expected to expose both refuse and whatever soil and gravel base course cover that was applied prior to previous paving. The site will be graded prior to installing the cover system, which may involve relocating refuse and adding both fill and gravel to allow for proper stormwater control.

The IA components will include both asphalt and geomembrane cap designs, LFG control systems under the asphalt cap, surface water collection and routing, and considerations for site utilities associated with redevelopment.

The LFG control system includes gas collection, conveyance, and venting components. The system will operate passively, relying on LFG to collect in horizontal preferential pathways consisting of gravel trenches with perforated pipes that will then be routed to vents. In case isolated portions of the site need to be converted to an active collection

system, an active manifold will be installed next to the passive manifold. The active manifold could be connected to a blower and a vacuum applied for LFG extraction.

Stormwater will be captured and conveyed across the STSII property before it has an opportunity to make contact with buried solid waste. Stormwater monitoring will be conducted separate from the IA to meet stormwater regulatory obligations, with respect to conveyance, quantity, flow, and quality.

Buildings constructed on the cap will require a geomembrane barrier as part of their foundation system. If piles are required for the building foundation, the geomembrane will be booted around installed piles. Perforated LFG collection pipes will be installed under the geomembrane to collect LFG which will be conveyed by solid to passive vents. Onsite occupied spaces will be equipped with methane detectors that activate alarms to notify occupants if methane exceeds an established concentration. Each building will maintain a system separate from the rest of the site LFG controls.

Six perimeter LFG probes installed around the STSII property will be monitored for offsite gas migration during the IA to determine the need to test for further testing in offsite buildings.

3 Protection Monitoring

Protection monitoring will be conducted to confirm that human health and the environment are adequately protected during construction and then during the operation and maintenance period of the IA. Protection monitoring will be addressed through implementation of a site-specific health and safety plan developed by the construction contractor to meet WAC 173-340-810 – Worker Safety and Health Requirements, and WAC 296-62 – General Occupational Health Standards. Continuous monitoring will be conducted in areas of exposed refuse during removal of asphalt and trenching until a competent cover system is installed.

4 Performance Monitoring

All aspects of construction will be performed under the oversight of a professional engineer registered in the state of Washington. During construction, detailed records will be kept of all aspects of the work performed, including construction techniques and materials used, items installed, and tests and measurements performed. Performance monitoring includes observing and documenting construction of the landfill cap and commissioning of the landfill gas control system. Monitoring and sampling and analysis procedural requirements are provided in the Sampling and Analysis Plan (Appendix A).

4.1 Landfill Cap Monitoring

The landfill cap will be constructed according to the general plans and specifications provided in the Interim Action Plan. The asphaltic concrete cap will consist of three layers:

- Minimum 12-inch-thick compacted structural fill that may or may not include pre-existing cover soil, depending on existing thickness and geotechnical properties.
- Minimum 8 inches of crushed rock.
- Minimum 4-inch-thick asphalt cover.

Cover soil previously placed over solid waste is expected to have variable thicknesses ranging from 0 to 48 inches. Additional layers, consisting of the following, may be constructed at the direction of the Project Engineer:

- Geotextile or geogrid material placed over existing cover soil that yields during construction.
- An approximate 12-inch structural section placed beneath roadways and/or building foundations to be included within the 24-inch-minimum compacted fill layer.

Total thickness of the asphaltic concrete cap will be a minimum of 24 inches, depending on thickness and geotechnical properties of the existing cover soil and thickness of asphalt.

Performance monitoring for construction of the asphaltic concrete cap will entail providing oversight to ensure conformance with the plans and specifications. This will include:

- Measuring and observing base surface preparations.
- Reviewing aggregate and asphaltic concrete quality characteristics.
- Subsurface utilities will be designed with trench plugs to prevent migration of landfill gas. Stormwater, water, fire control systems tested using low pressure air testing or hydrostatic leak testing.
- Observing placement of the asphalt surface and reviewing surface finish quality.
- Observing seam and seal applications such that no cracks or weak seams result that would act as conduits for transmitting infiltrating stormwater or short-circuiting the LFG collection system, or that would present an exposure pathway to the soil beneath.

Performance monitoring for construction of geomembrane liners associated with geomembrane soil cover and membranes beneath buildings will entail providing oversight to ensure conformance with the plans and specifications. This will include:

- Subgrade preparation and acceptance
- Seam testing
- Material certification.

4.2 Landfill Gas Control Monitoring

Landfill gas migration criteria under Minimum Functional Standards (MFS) for Solid Waste Handling are defined in WAC 173-304-460 and King County Board of Health Title 10 regulations as:

- Methane concentrations in soil gas at the boundary of solid waste must not exceed 5 percent by volume (the lower explosive limit [LEL]) – applicable at perimeter probes (see Figure 2).
- Methane concentrations inside buildings and structures on the landfill must not exceed 1.25 percent by volume (25 percent of the LEL) – applicable to buildings constructed during redevelopment and buildings already existing on the site.
- Methane concentrations inside buildings and structures off the landfill must not exceed 100 parts per million volume (ppmv), 0.01 percent by volume and 0.2 percent of the LEL.

The landfill does not currently appear to be producing LFG under pressure, with barometric pumping the primary mechanism for gas movement. Placement of subgrade material and landfill cap surfaces across the entire site is expected to have little effect on this mechanism as the existing site is predominately paved. The Interim Action Plan reported a toxic air pollutant (TAP) source first-tier review conducted for the STSII portion of the Landfill, comparing emissions of representative compounds to acceptable source impact levels (ASILs) listed in WAC 173-460-150. The review indicated a very low likelihood of exceedances for compounds analyzed by EPA Method TO-15.

4.2.1 Site Monitoring

LFG control system monitoring for methane will be conducted monthly at vent(s) and piezometers NP and SP during cover system construction. Visual monitoring during construction will be conducted as described in the site-specific Health and Safety Plan. If methane concentrations in the vent(s) or piezometers exceed 5 percent by volume, the six perimeter probes will be monitored for methane, oxygen, carbon monoxide, carbon dioxide, hydrogen sulfide, and pressure.

Methane detectors will be installed in STSII buildings following construction. Building detector instrument testing will be performed as part of the installation process and air quality inside the buildings will be determined based on corrective action monitoring, discussed below.

Following installation of the LFG control system, the six perimeter probes (GP-07, -09, -23, -26, -37, and -38) will be monitored using the GEM 2000 instrument for methane to compare against the 5 percent by volume criterion. To the extent possible, perimeter probe monitoring will be scheduled to occur after at least 12 hours of falling barometric pressure conditions forecasted to include a pressure drop of at least 0.25 inch of mercury. If methane exceeds the LEL, additional monitoring will be conducted and the potential for switching to an active LFG control system will be examined.

Monitoring of perimeter probes will be conducted once a month, commencing with start of initiating construction. Once the LFG control system is installed and the first round of baseline monitoring is completed, monitoring will be conducted at the open vent(s) and perimeter probes according to the following schedule:

Legend

- New perimeter gas probe
- Existing perimeter gas probe
- STSII Property
- Landfill Boundary (based on RI/FS)

Note: LFG control system vent locations to be determined, based on future redevelopment plan.

Figure 2.
New LFG Probe Locations,
South Transfer Station Phase II,
Seattle, Washington

N

0 225 450 900 Feet

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- Monthly for 4 months
- Quarterly for at least 8 quarters and then integrating with the long-term monitoring schedule finalized in the CAP.

If system operational adjustments are made, the schedule will restart from the beginning. Monitoring will include measurements of methane, oxygen, carbon monoxide, hydrogen sulfide, oxygen, temperature, percent of LEL, and pressure at the open vent (southwest corner of the site) and methane only at all six perimeter probes.

4.2.2 Building Monitoring

The need for offsite building monitoring will be triggered by methane levels of concern at perimeter probes during regularly scheduled events; the need for onsite building monitoring will be triggered by methane detector alarm system notification.

Off-Site Buildings

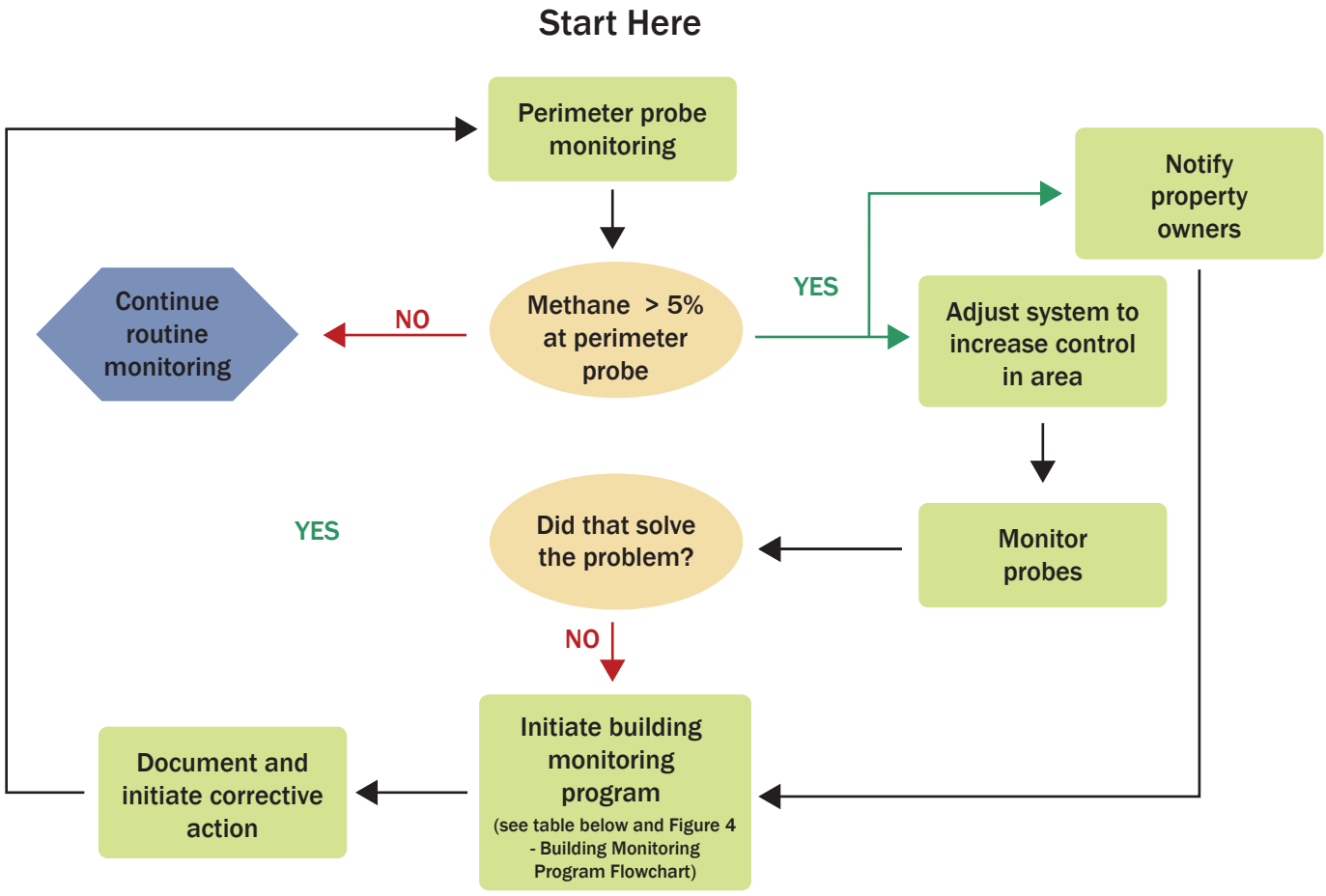
Methane concentrations inside buildings and structures off the landfill must not exceed 100 parts per million volume (ppmv), equivalent to 0.01 percent by volume or 0.2 percent of the LEL. The need for building monitoring will be based on identification of methane exceeding 5 percent in an adjacent perimeter probe (see Figures 3 and 4). If a perimeter probe concentration exceeds 5 percent by volume, building monitoring will be conducted either with handheld or fixed monitors that can quantify methane below the 100 ppmv level. Monitoring will continue on a daily basis if methane is found to exist between 5,000 and 100 ppmv. Extended monitoring will be coordinated with implementation of corrective actions.

On-Site Buildings

Methane concentrations inside buildings and structures on the landfill must not exceed 1.25 percent by volume, equivalent to 25 percent of the LEL. Buildings erected during redevelopment of the site will be equipped with vent systems and methane meters. Initially, vent systems will operate passively, with the potential for conversion to active systems. Meters will be set to alarm at the 1.25 percent level, indicating the need for monitoring with hand-held meters sensitive to below 100 ppmv (see Figure 4). Monitoring will continue on a daily basis if methane is found to exist between 5,000 and 100 ppmv. Extended monitoring will be coordinated with implementation of corrective actions.

5 Confirmational Monitoring

Confirmational monitoring for the IA will involve periodic inspections conducted according to procedures described in an Operations and Maintenance Plan, to be developed following LFG control system commissioning. Cap integrity and LFG control system effectiveness will be evaluated through visual assessments and use of field monitoring instruments. The Plan will include record drawings, operations reference materials, monitoring equipment information, monitoring procedures, and will specify requirements for record-keeping of inspections and repairs, and reporting.



Probe Location	Adjacent Buildings
GP-23	Bank of America (two buildings)
GP-07	Eagle Eye Enterprises, LLC
GP-26	Rick Larson Enterprises, Inc.
GP-09	NA
GP-37	NA
GP-38	NA

Figure 3.
STSII Perimeter
Gas Probe Monitoring Flowchart.

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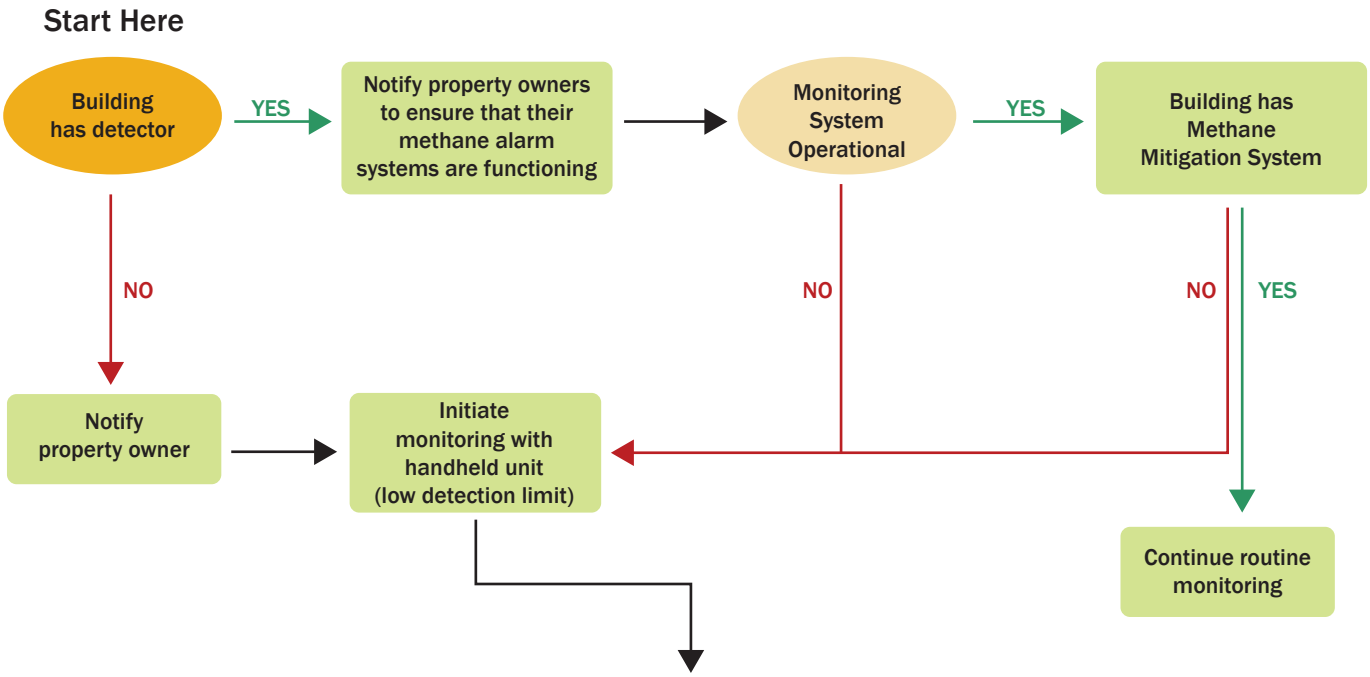

> 1.25% Methane (by volume)	< 1.25% Methane (by volume) > 100 ppm		< 100 ppm Methane (by volume)
• Evacuate buliding • ID source	< 1.25% > 5000	< 5000 > 100 ppm	Continue routine probe monitoring
	• Evacuate buliding • ID source	Monitor daily	
Verify methane concentrations with second meter			
• Notify PLP Group, Dept. of Ecology, Dept. of Public Health (Seattle - King Co.) • Document			
Potential corrective action • Seal cracks • Ventilation • Install alarm • System augmentation • Active collection			

Figure 4.
Building Monitoring Program Flowchart (STSII Redevelopment).

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5.1 Landfill Cap Monitoring

The Operations and Maintenance Plan will describe long-term monitoring and maintenance procedures for the cap. The primary goal of proper maintenance will be to prevent uncontrolled exposure to solid waste, short-circuiting of the landfill gas control system, and infiltration of stormwater. The Plan will:

- Establish an inspection and monitoring program to identify damaged cap systems and evaluate remedy effectiveness.
- Provide for timely repair and replacement needed to restore damaged or intruded cap systems.
- Specify measures to minimize the potential for disturbances of solid waste.

5.2 Landfill Gas Control Monitoring

The Operations and Maintenance Plan will describe long-term gas vent and perimeter probe monitoring. The primary goal of vent monitoring will be to evaluate direct emissions to the atmosphere; the primary goal of probe monitoring will be to evaluate potential lateral offsite LFG migration. The Plan will:

- Reiterate the monitoring schedule provided above.
- Identify monitoring parameters, instrumentation, and quality control requirements.
- Identify LFG concentration thresholds and protocols for conversion from a passive to an active LFG control system.

The plan will address methane detection and response protocols for onsite buildings. Buildings will be constructed with LFG collector systems and each occupied onsite building will have methane detectors installed.

The plan will address methane detection and response protocols for offsite buildings. If methane is detected at perimeter probes, the plan will include a response protocol, such as:

- Notifications to owners and/or operators of potentially affected properties
- Additional gas probe monitoring in existing or new gas probes
- Monitoring offsite building interiors
- Evaluating a change from a passive to an active LFG collection system

6 Reporting

Reporting for the IA compliance monitoring program will include preparation of an Interim Action Construction Report, documenting the construction of the Interim Action elements, and annual monitoring reporting. Annual reporting will transition to a schedule developed for site-wide long-term reporting identified in the CAP.

6.1 Interim Action Construction Report

Within 3 months of LFG control system commissioning, the engineer responsible for construction oversight will prepare as-built drawings and a report documenting all aspects of facility construction and commissioning. The report will contain an opinion from the engineer, based on testing results and inspections, as to whether the IA was constructed in substantial compliance with the plans and specifications and related documents. The report will include records of monitoring during construction and the first month of system operation, which will establish baseline conditions.

6.2 Annual Monitoring Reports

After completion of construction, annual Interim Action Program Reports activities will be submitted to Ecology in March for the previous calendar year. The reports will document activities associated with confirmational compliance monitoring, including monitoring results from landfill cap annual inspections, LFG control system open vent monitoring, and perimeter probe monitoring. Progress reports will summarize operation and maintenance activities, data (including analytical laboratory reports), data interpretation for trends, and mitigation measures.

7 References

Farallon Consulting, L.L.C. (Farallon).

2013. *Interim Action Work Plan, South Park Landfill Site, Seattle, Washington*. Prepared for South Park Property Development, LLC, January 16.

Floyd|Snider.

2014. *Draft Final South Park Landfill Remedial Investigation/Feasibility Study*. Prepared for City of Seattle and South Park Property Development, LLC, June.

Appendix A. Sampling and Analysis Plan

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Sampling and Analysis Plan: Appendix A to Interim Action Compliance Monitoring Plan

South Transfer Station Phase II

Seattle, Washington
July 24, 2015

Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

bgs	below ground surface
CMP	Compliance Monitoring Plan
IA	Independent Action
LEL	lower explosive limit
PID	photoionization detector
PVC	polyvinyl chloride
LFG	landfill gas
RI/FS	Remedial Investigation/Feasibility Study
SAP	Sampling and Analysis Plan
SPU	Seattle Public Utilities
SRDS	South Recycling Disposal Station
STSII	South Transfer Station Phase II
USCS	Unified Soil Classification System
VOC	volatile organic compounds
WAC	Washington Administrative Code

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1 Introduction

This Sampling and Analysis Plan (SAP) has been prepared by the HDR team, including HDR, Herrera Environmental Consultants (Herrera), and Aspect Consulting (Aspect), for Seattle Public Utilities (SPU). It describes specific requirements for field monitoring, sample collection, and analysis in support of the compliance monitoring program that will be implemented as part of the Interim Action (IA) during redevelopment of the former South Recycling and Disposal Station (SRDS), now referred to as South Transfer Station Phase II (STSII).

The IA consists of demolition of structures and pavement on the STSII property and installation of a landfill cap, landfill gas (LFG) controls, and surface water controls, and implementation of institutional controls. Descriptions of the IA and the STSII property are provided in the IA Compliance Monitoring Plan (CMP). The STSII property is situated on a portion of South Park Landfill (Landfill) in south Seattle (Figure 1).

The CMP describes three types of compliance monitoring to be conducted at STSII:

- Protection monitoring during construction.
- Performance monitoring during LFG control system commissioning.
- Confirmational monitoring following commissioning to evaluate long-term effectiveness (not a part of the IA).

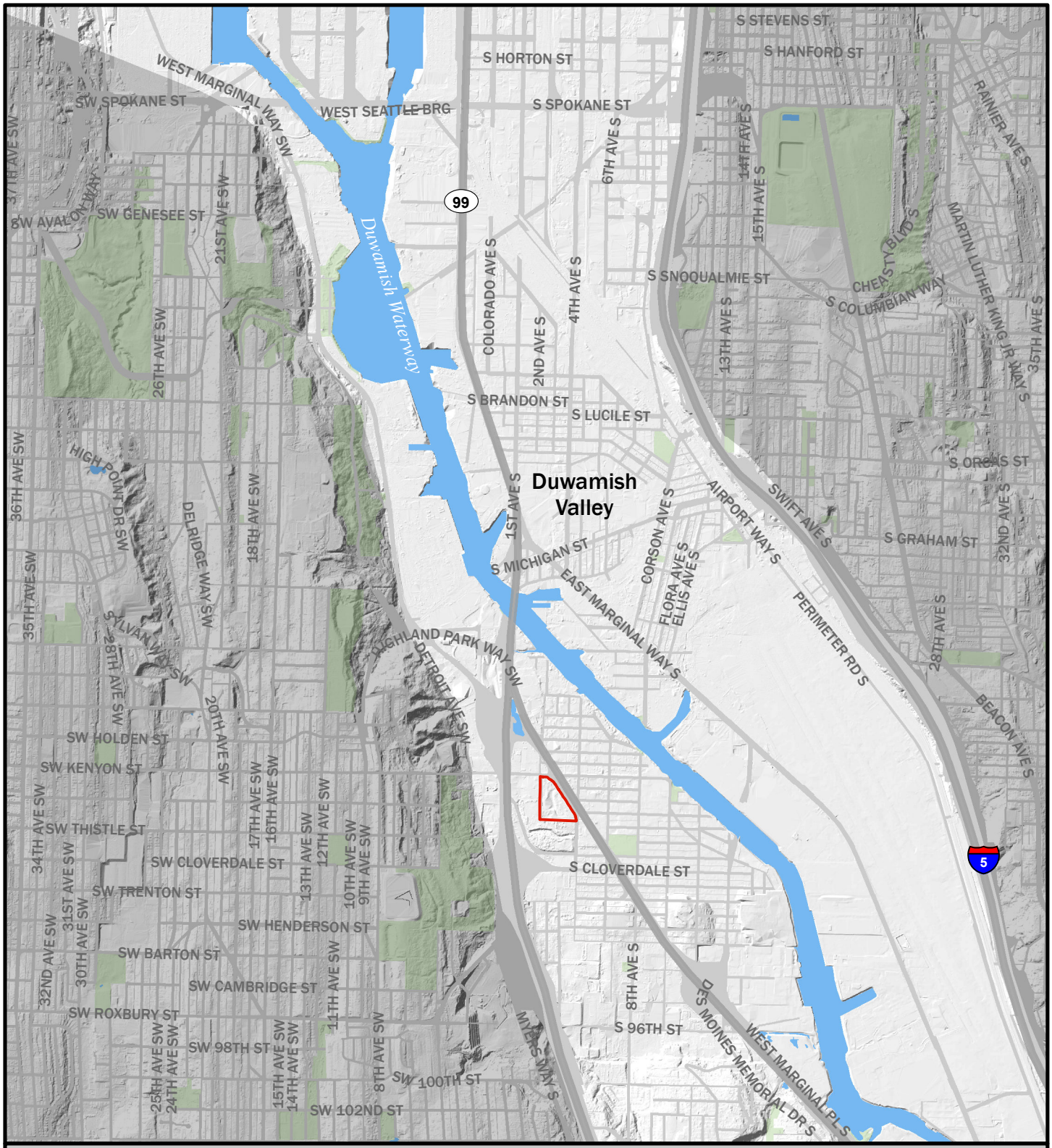
The purpose of the SAP is to define specific requirements for field monitoring, sample collection, and sample analysis to ensure monitoring described in the CMP is conducted according to technically acceptable protocols.

The SAP provides a description of construction observation requirements to be followed during CMP implementation and provides protocols for monitoring LFG and indoor air, as well as sampling discharge from the LFG control system.

The specific objectives of the SAP are to:

- Provide the basis for conducting and documenting field activities described in the CMP.
- Describe sample locations, frequency, quantities, analytical methods, and documentation protocols for compliance monitoring.
- Identify equipment and methodology used for monitoring LFG and indoor air, and sampling LFG control system discharge, if required.

The SAP addresses activities conducted during IA construction and commissioning of the STSII cap and LFG control elements. Post-construction operation, maintenance, and monitoring will be documented in an operation and maintenance plan.



Legend

STSII Property

Figure 1.
Site Vicinity Map, South Transfer Station Phase II, Seattle, Washington.

N

0 1,500 3,000 6,000 Feet

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2 Overview of Compliance Monitoring Program and Summary of Field Tasks

This section provides an overview of the compliance monitoring program, including a summary of field tasks.

2.1 Protection Monitoring

Protection monitoring will be addressed through implementation of site-specific health and safety plans developed by all entities involved in construction or monitoring that may result in exposures to hazardous substances.

Protection monitoring will be performed during:

- Demolition of existing structures and pavement removal
- Construction of the cap
- Construction of the LFG control system
- Operation and maintenance of the IA
- Gas probe installation

2.2 Performance Monitoring

Performance monitoring during construction will include oversight by the Owner's Representative or Engineer to ensure conformance of the plans and specifications, including:

- Measuring and observing base surface preparations.
- Reviewing aggregate and asphaltic concrete quality characteristics.
- Observing placement of the asphalt surface and reviewing surface finish quality.
- Observing seam and seal applications, including performance testing, such that no cracks or weak seams result that would act as conduits for transmitting infiltrating stormwater or short-circuiting the LFG collection system, or that would present an exposure pathway to the soil beneath.

Performance monitoring during the LFG control system commissioning process will include:

- Preconstruction baseline LFG monitoring at two existing interior piezometers, four existing perimeter LFG probes, and two proposed perimeter LFG probes located north of South Kenyon Street.
- Periodic monitoring of two on-site piezometers, the LFG control system vent, and five perimeter probes (existing and planned).
- Periodic monitoring of off-site buildings if perimeter probe methane concentrations exceed 5 percent by volume – the lower explosive limit (LEL).

2.3 Confirmational Monitoring

Confirmational monitoring will begin following LFG control system commissioning, as described in the Operations and Maintenance Plan, to be developed upon completion of LFG system commissioning, to include:

- Periodic inspections to evaluate landfill cap integrity
- Landfill gas vent and perimeter probe monitoring
- On-site and off-site building monitoring protocols

3 Landfill Gas Monitoring Locations and Frequency

The locations and monitoring frequency for IA gas probes, vent, piezometers, and buildings are described below.

3.1 Baseline Monitoring

Prior to commencement of construction activities, six perimeter LFG probes (GP-07, -09, -23, -26, -37, and -38) and two on-site piezometers (NP and SP) will be monitored to establish baseline conditions (Figure 2). Monitoring will be conducted with a Landtec GEM 2000 (Plus) gas monitoring instrument for:

- Methane
- Oxygen
- Carbon monoxide
- Carbon dioxide
- Hydrogen sulfide
- Pressure

3.2 Protection Monitoring

Monitoring during construction will be conducted using hand-held meters capable of measuring methane at concentrations based on action levels identified in site-specific health and safety plans. Action levels will be established for protection of workers due to inhalation and for the potential for explosive conditions. Continuous monitoring will be conducted in areas of exposed refuse during removal of asphalt and trenching until a competent cover system is installed.

Legend

- ▲ Piezometer
- ⊙ Perimeter gas probe
- STSII Property
- Landfill Boundary (based on RI/FS)

Note: LFG control system vent locations to be determined, based on future redevelopment plan.

Figure 2.
Interim Action Compliance Monitoring Location Map, South Transfer Station Phase II, Seattle, Washington.

N

0 225 450 900 Feet

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3.3 Performance Monitoring

3.3.1 Site Monitoring

Monthly monitoring of the LFG control system vent and piezometers NP and SP will be conducted with the GEM 2000 during construction activities. If methane concentrations in the vent(s) or piezometers exceed 5 percent by volume, the six perimeter probes will be monitored for the six parameters listed above.

Monitoring will be conducted quarterly for the first year after construction is completed. The GEM 2000 will be used to monitor the vent, piezometers, and perimeter probes for the seven parameters listed above. If methane concentrations exceed 5 percent in perimeter probes, off-site interior building monitoring will be performed according to the protocol provided in Figures 3 and 4.

Following installation of the LFG control system, the six perimeter probes (GP-07, -09, -23, -26, -37, and -38) will be monitored using the GEM 2000 instrument for methane to compare against the 5 percent by volume criterion. To the extent possible, perimeter probe monitoring will be scheduled to occur after at least 12 hours of falling barometric pressure conditions forecasted to include a pressure drop of at least 0.25 inch of mercury. If methane exceeds the LEL, additional monitoring will be conducted and corrective actions initiated.

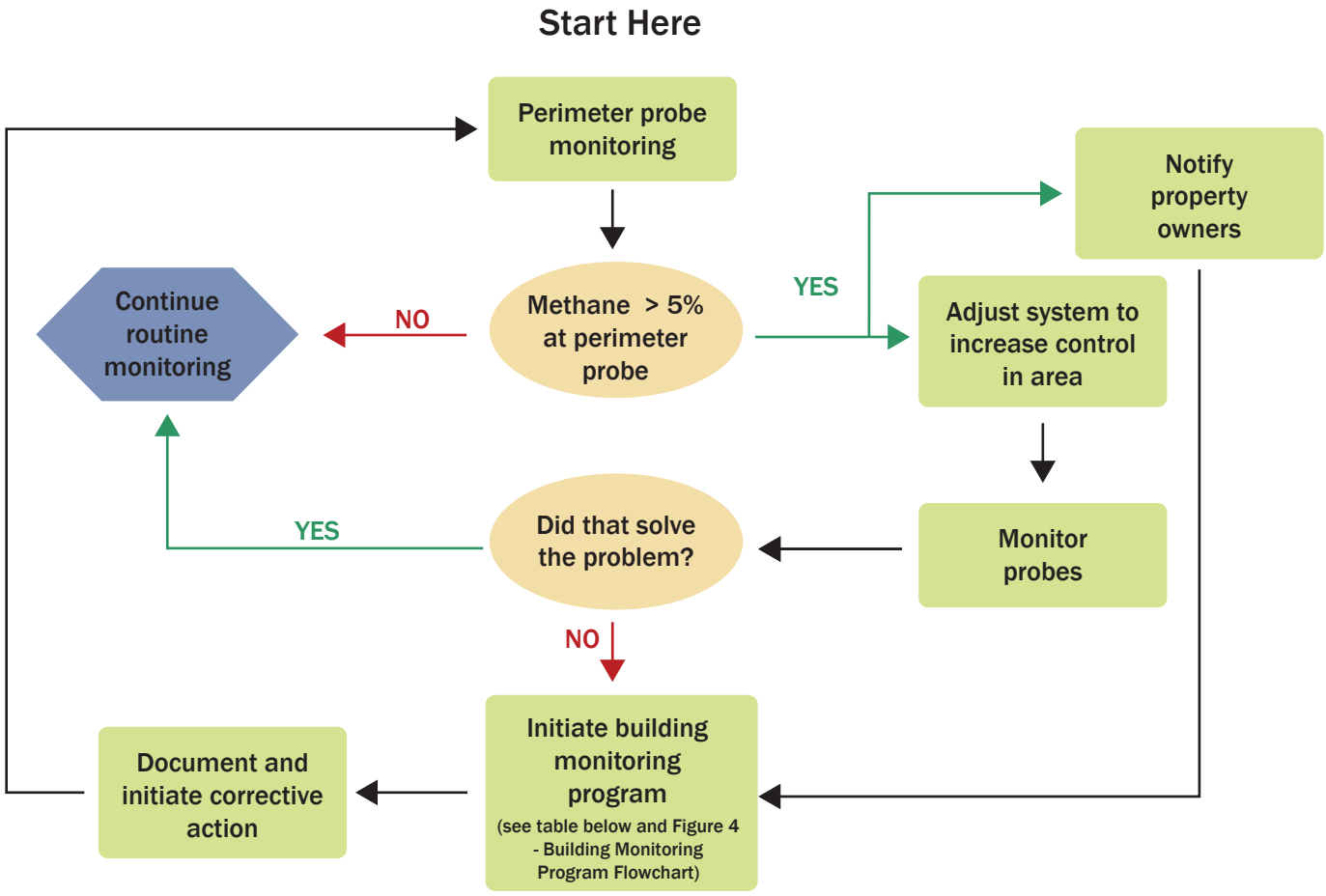
Monitoring of perimeter probes will be conducted once a month, commencing with the start of initiating construction. Once the LFG control system is installed and the first round of baseline monitoring is completed, monitoring will be conducted at the open vent(s) and perimeter probes according to the following schedule:

- Monthly for 4 months
- Quarterly for at least 8 quarters and then integrating with the long-term monitoring schedule finalized in the CAP

If system operational adjustments are made, the schedule will restart from the beginning. Monitoring will include measurements of methane, oxygen, carbon monoxide, hydrogen sulfide, oxygen, temperature, percent of LEL, and pressure at the open vent (southwest corner of the site) and methane only at all six perimeter probes.

3.3.2 Building monitoring

The need for off-site building monitoring will be triggered by methane levels of concern at perimeter probes during regularly scheduled events; the need for on-site building monitoring will be triggered by methane detector alarm system notification.



Probe Location	Adjacent Buildings
GP-23	Bank of America (two buildings)
GP-07	Eagle Eye Enterprises, LLC
GP-26	Rick Larson Enterprises, Inc.
GP-09	NA
GP-37	NA
GP-38	NA

Figure 3.
STSII Perimeter
Gas Probe Monitoring Flowchart.

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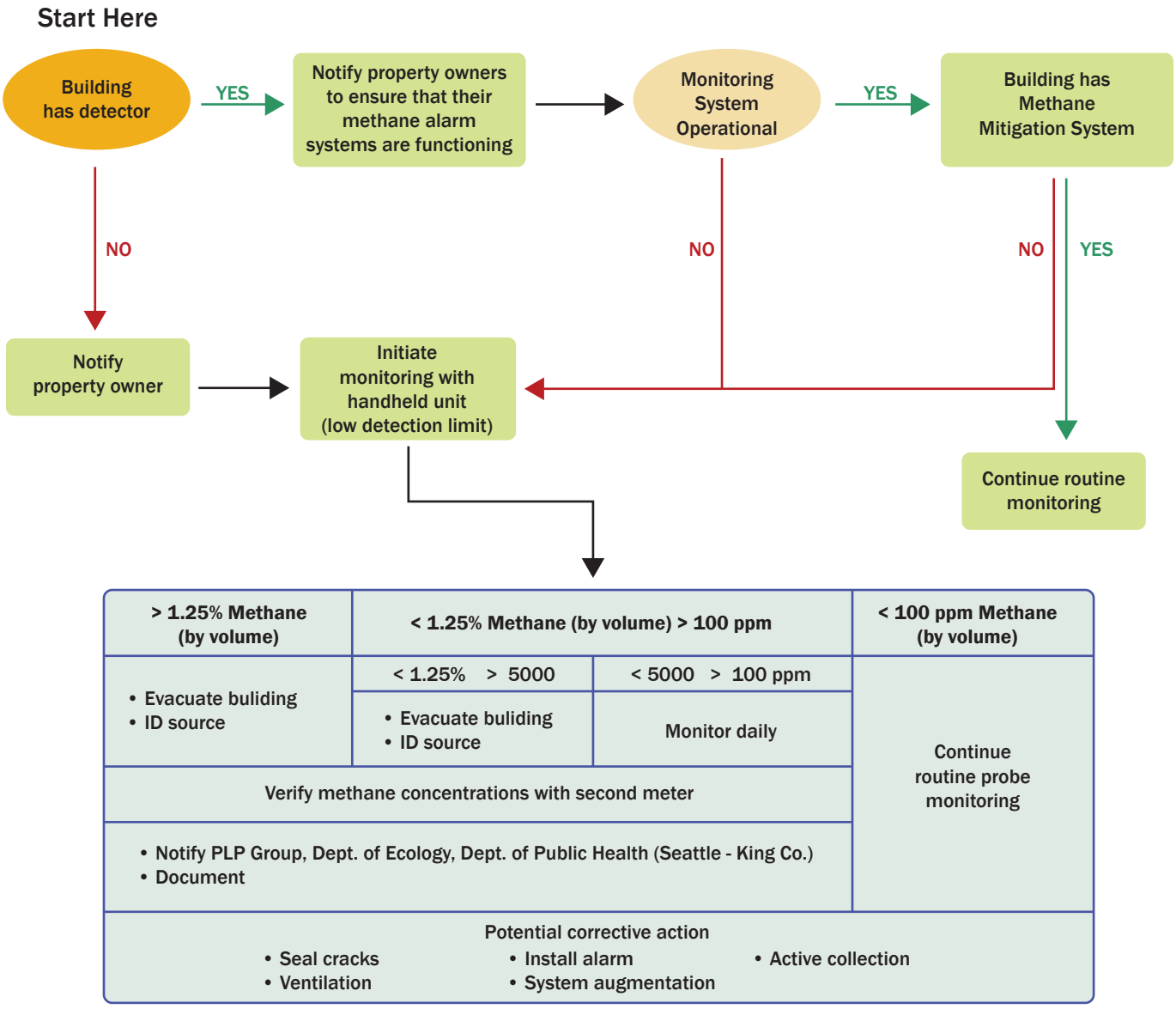

Figure 4.
Building Monitoring Program Flowchart (STSII Redevelopment).

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Off-Site Buildings

Methane concentrations inside buildings and structures off the landfill must not exceed 100 parts per million volume (ppmv), equivalent to 0.01 percent by volume or 0.2 percent of the LEL. The need for building monitoring will be based on identification of methane exceeding 5 percent in an adjacent perimeter probe (see Figures 3 and 4). If a perimeter probe concentration exceeds 5 percent by volume, building monitoring will be conducted either with handheld or fixed monitors that can quantify methane below the 100 ppmv level. Monitoring will continue on a daily basis if methane is found to exist between 5,000 and 100 ppmv. Extended monitoring will be coordinated with implementation of corrective actions.

On-Site Buildings

Methane concentrations inside buildings and structures on the landfill must not exceed 1.25 percent by volume, equivalent to 25 percent of the LEL. Buildings erected during redevelopment of the site will be equipped with vent systems and methane meters. Initially, vent systems will operate passively, with the potential for conversion to active systems. Meters will be set to alarm at the 1.25 percent level indicating the need for monitoring with hand-held meters sensitive to below 100 ppmv (see Figure 4). Monitoring will continue on a daily basis if methane is found to exist between 5,000 and 100 ppmv. Extended monitoring will be coordinated with implementation of corrective actions.

3.4 Confirmational Monitoring

The Operations and Maintenance Plan will describe long-term gas vent, perimeter probe, and building monitoring. Each building constructed on the STSII property will have its own methane LFG collector system and methane detectors installed.

4 Field Procedures

This section summarizes the field procedures and protocols to be followed as part of the IA compliance monitoring program. The Health and Safety Plan (Attachment A of the CMP) defines protection monitoring requirements; instrument calibration and operation must be performed based on individual manufacturer requirements. The Landtec GEM 2000 Operations Manual is provided as Appendix A.

4.1 Outdoor Monitoring

4.1.1 Gas Probe and Piezometer Monitoring

The ideal condition for LFG probe monitoring is low barometric pressure following at least 12 hours of falling barometric pressure, with a drop of at least 0.25 inches mercury. Barometer charts available at the following links will be used to forecast appropriate monitoring conditions. The first link provides a graphical barometric record over the previous 6 days; the second link provides a 10-day forecast map:

http://www-k12.atmos.washington.edu/k12/grayskies/plot_nw_wx.cgi?Measurement=Pressure&station=SEA&interval=168&timezone=8&rightlab=y&connect=lines&groupby=overlay&begmonth=1&begday=1&begyear=2011&beghour=0&endmonth=1&endday=1&endyear=2011&endhour=0

http://www.wunderground.com/weather-forecast/US/WA/Seattle.html

LFG probe and vent monitoring will be conducted according to the instructions summarized below:

- Calibrate Landtec GEM 2000 (Plus) using a 4 percent oxygen span gas and a 50 percent methane/35 percent carbon dioxide calibration gas according to the GEM instruction manual (Appendix A).
- Connect the GEM to the LFG probe using silicone or polyethylene tubing. Typically the probe will have a labcock or pressure fitting plug with a quick connect.
- Open the labcock or connect the quick connect and measure the barometric and static pressure at each probe with the GEM prior to purging.
- If possible, measure the water level in the gas probe to determine the level is not above the top of the probe screen.
- Purge the probe until methane, carbon dioxide, and oxygen percentages stabilize, defined as when readings change by less than 10 percent for three consecutive measurements over 10-second intervals
- Evacuate a minimum of one probe volume before recording the final instrument readings – 3/4 -inch diameter Schedule 40 PVC probe volume is 100 milliliters (ml) per foot; GEM flow rate is 300 ml/minute. Table 1 provides a summary of probe construction details and purging volumes.

4.2 Indoor Air Monitoring

The need for off-site building monitoring will be based on methane exceeding 5 percent by volume in an adjacent perimeter probe. Monitoring will be conducted either with handheld or fixed monitors that can quantify methane below the 100 ppmv level. If methane is found to exist between 5,000 and 100 ppmv. Monitoring will continue on a daily basis. Extended monitoring will be coordinated with implementation of corrective actions.

The need for on-site building monitoring will be based on methane exceeding 1.25 percent by volume, identified by fixed meters installed at selected locations. Meters will be set to alarm at the 1.25 percent level, indicating the need for monitoring with hand-held meters sensitive to below 100 ppmv. If methane is found to exist between 5,000 and 100 ppmv, monitoring will continue on a daily basis. Extended monitoring will be coordinated with implementation of corrective actions.

Monitoring indoor air for methane will be conducted according to the instructions summarized below:

Table 1. Gas Probe Purge Times, South Park Custodial Landfill, King County, Washington.

Gas Probe	Depth (ft)	Stickup (ft)	Total Length (ft)	Probe Diameter (ft)	Probe Radius (ft)	Volume (ft^3)	Volume (cc)	GEM 2000 1 Purge Volume Time 300 cc/min pump (min)	SKC Pump 1 Purge Volume Time 3000 cc/min pump (min)
GP-7	4.5	1.48	5.98	0.063	0.031	0.02	519	1.73	0.17
GP-9	9.0	1.35	10.35	0.063	0.031	0.03	899	3.00	0.30
GP-23	6.0	2.00	8.00	0.167	0.083	0.17	4,940	16.47	1.65
GP-26	10.0	0.00	10.00	0.063	0.031	0.03	868	2.89	0.29
GP-37	10.0	0.00	10.00	0.063	0.031	0.03	868	2.89	0.29
GP-38	10.0	0.00	10.00	0.063	0.031	0.03	868	2.89	0.29
NP	13.0	0.00	13.00	0.083	0.042	0.07	2007	6.69	0.67
SP	10.0	0.00	10.00	0.083	0.042	0.05	1,544	5.15	0.51

- Notify the property owners/ building owners and tenants and offer to perform building monitoring.
- Inspect the building to assess construction characteristics, such as heating, ventilation, and air conditioning systems, and for possible sources of contaminants that may influence monitoring results, such as petroleum hydrocarbons and chemical products.
- Monitor interiors of buildings using a detector capable of measuring methane to below 100 ppmv according to manufacturer instructions.
- Complete a walk-through of the building with the monitoring instrument operating continuously; pay particular attention to cracks in concrete slab floors or other features with a potential for LFG flow.
- Record measurements when methane is detected, noting locations and concentrations.

5 Field Documentation

Documentation of field activities will be provided on forms discussed below and provided in Appendix B.

5.1 Daily Field Report

Field personnel will keep a daily log to record a summary of each day's events. Documentation will include the date, job number, project identification, weather conditions, sample collection data, personnel present and responsibilities, field equipment used, and deviations from the SAP.

5.2 Gas Probe Data Sheet

A gas probe data sheet will be completed to record LFG monitoring results at probes and the LFG Control System vent. The sheet will include the probe/vent identification, date, time, well head and barometric pressures, purge rate, time, and parameter measurements, including methane, carbon monoxide, carbon dioxide, oxygen, and hydrogen sulfide.

5.3 Chain of Custody Record

A chain of custody record will be completed when a sample is collected for laboratory testing. It provides a written record of sample collection and transmittal to the laboratory. The form includes the client name, project name and number, date, time sampled, sample identifier, sampler's signature, requested analysis, and initial and final vacuum for Summa Canister sample collection.

Appendix A. Landtec GEM 2000 Operations Manual

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GEM™2NAV Plus
GEM™2NAV
GEM™2000 Plus
GEM™2000

GAS ANALYZER & EXTRACTION MONITORS

OPERATION MANUAL
for
Serial Numbers 10000 and up

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Software Support Tel: +1 (909) 783-3636 x 6131
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Phone: +55 (11) 5181-6591
Web: www.landtecbrazil.com.br

This manual is subject to revision without prior notice. Please periodically check our website for a newer revision.

Revision	Date	Approved by	Translated from	Comment
A	Oct-2009		N/A	*This document uses Arial, Wingdings, Wingdings 2, Wingdings 3, GI2k fonts. Printing of this document to PDF should only be done if these fonts are present. "Whitespace" has been removed from many of the graphical images and the images are otherwise "cropped" to reduce the total number of pages. These alterations of the actual screen images do not detract from the technical content presented*1st Release of this manual
B	Nov-2009	MC & SM	N/A	Minor Corrections / Final Proofing
B1	Nov-2009	SM	N/A	Minor corrections to images
C1	16-Feb-2010	SM	N/A	Explanation of single media format & software installation.
C1a,b	1-Mar-2010	SM	N/A	Environmental Chamber Clarified. H_2S & CO specs modified
C2	Nov - 2010	MC	N/A	Clarified instruments are not total hydrocarbon analyzers, cross gas interference and solutions for typical interferences.

Contents

1 Introduction

LANDTEC is the premier manufacturer of products, instruments and software for landfill gas extraction and regulatory monitoring compliance. LANDTEC has provided the landfill industry with a technologically innovative family of products for more than a decade. These products are the result of field-proven experience in design, operation and maintenance of landfills for environmental compliance.

The GEM2000, GEM2000 Plus, GEM2NAV and GEM2NAV Plus instruments designed by LANDTEC, are specifically for use on landfills to monitor landfill gas (LFG) extraction systems, flares and migration control systems. These instruments sample and analyze the Methane, Carbon Dioxide and Oxygen content of LFG. The GEM instruments are not total hydrocarbon analyzers. The Plus versions (GEM2000 Plus and GEM2NAV Plus) also sample and analyze Carbon Monoxide and Hydrogen Sulfide. The NAV versions (GEM2NAV and GEM2NAV Plus) include an integral GPS (Global Positioning System). The readings are displayed and stored in the instrument and can be downloaded to a personal computer for reporting, analyzing and archiving. Since there are variations to the features of the instruments, this single manual is designed to cover all instrument versions. Throughout this manual, the term GEM2xxx is intended to refer to ANY of the GEM instruments with a serial number above 10,000. Features specific to one particular instrument will be designated within this manual to be specific for the particular instrument.

The GEM instruments are shipped in a protective hard case with a foam interior that offers additional protection, transportation convenience and component hardware storage. When properly sealed, the hard case is watertight. The hard case is equipped with a pressure relief valve (located under the handle on the case) that is normally kept closed. If there is a change in elevation, the hard case may not open until the pressure relief valve is opened to equalize internal pressure. When shipping an instrument to LANDTEC for calibration or service, always ship it in the hard case to protect unit from damage. It is a good idea to also call and generate a Service or Repair Authorization (RA) prior to sending the instrument. This ensures proper routing of your instrument once it arrives at LANDTEC. The RA also will detail a list of reasons as to why the instrument is being returned for service. If an RA does not exist when the instrument arrives it can delay service of your instrument.

Carefully unpack the contents of the instrument package, inspect and inventory them. The following items should be contained in your package:

- The GEM2000, GEM2000 Plus, GEM2NAV or GEM2NAV Plus instrument (Plus instruments have a Silver Keyboard and the numbers 1, 3, 5, 7, and 9 will be white on a blue background with a red highlight.)
- Operation Manual
- Registration/Warranty Card
- Soft carrying case with replaceable protective window and carrying strap
- Clear ¼" vinyl sampling hose assembly (5 ft.) with external water trap filter assembly
- Blue ¼" polyurethane pressure sampling hose (5 ft.)
- Spare internal particulate filter element
- Polypropylene male connector (hose barb) connects to blue & clear tubing
- Spare O-rings for the male connectors
- Spare external water trap filter element
- 100-240 volt battery charger
- Software on CD-ROM
- USB communications cable
- Temperature probe (optional)
- Hard carrying case

Complete the Registration/Warranty Card and return it to LANDTEC. The model and serial numbers are located on the back of the instrument.

Immediately notify shipping company if the instrument or accessories are damaged due to shipping. Please keep all packaging material and take pictures to document the damage. Next, contact LANDTEC immediately so that a claim can be established with the shipping company.

For questions regarding instrument operation and procedures, please contact LANDTEC at the regional office of your choice. General Operational Features

1.1 Physical Characteristics of the GEM2xxx instruments

1	Exhaust Port
2	Temperature / Gas Pod / Communications Socket (Connector “A”)
3	Power Socket (Connector “B”)
4	Particulate Filter Housing (on back of instrument)
5	Sample Inlet, Static or System Pressure Port
6	Impact Pressure Port

①	① key
②	② key, up arrow, '∧' cursor key, scroll up
③	③ key
④	④ key, left arrow, '<' cursor key, scroll left
⑤	⑤ key
⑥	⑥ key, right arrow, '>' cursor key, scroll right
⑦	⑦ key
⑧	⑧ key, down arrow, '∨' cursor key, scroll down
⑨	⑨ key
⓪	⓪ key, (zero) key, Backlight operation, Keyboard Lock (press and hold for 2 second to activate keyboard lock, press again to deactivate the lock)
	Pump Operation, Pump On/Off, Backspace Key (press and hold for 1 second to backspace)
↵	Enter/Store key
⑩	Red Power Button, On-Off (Press and Hold for 2-3 seconds for normal On-Off function, Press and Hold for 15 seconds to forcibly turn off the instrument)

1.2 Storage

Do not keep the instrument in the trunk of a car or shed because it may be exposed to temperature extremes.

After use or before storing the instrument it should be purged with clean nitrogen or air. Purging with nitrogen may prolong the oxygen sensor's life. When not in use, instruments and accessories should be kept clean, dry and warm inside of their hard case.

The instrument batteries should be discharged and fully charged at least once every four weeks regardless of indicated charge state. The discharge function may be carried out with the use of the Data Logging Function in GA mode of operation.

1.3 Battery/Charging

The Battery Charger IS NOT covered by the unit UL certification. Warning - To reduce the risk of ignition of a flammable or explosive atmosphere, charge batteries only in an area known to be non-hazardous" or equivalent.

The battery used in the GEM2xxx instrument is an encapsulated six cell, Nickel Metal Hydride pack. This type of battery is not as susceptible to "memory effects" as Nickel Cadmium batteries, although it is not recommended that the unit be given short-term charges. When the flashing LED indicates "Trickle Charge" the charging is completed and the unit should be disconnected from the charger.

The battery charger indicates when the unit is charging, charged or if there is a fault. A full charge should take approximately 2 hours.

1.4 Instrument Certification

The GEM2xxx is UL/Sira certified for use in hazardous locations. Specifically certified as to intrinsic safety for use in hazardous locations Class I, Zone 1, AEx ib d IIA T1 (Ta=32°F to +104°F).

When the GEM2xxx instrument is in the hazardous area it shall only be externally attached via connector A to devices that are marked with the UL File Number E203142

For the certification to remain intact it is vital that the instructions in this manual are followed closely and repair of this equipment be carried out in accordance with the applicable code of practice by an approved repair facility. See section 7.2 for a list of authorized repair locations.

It is the responsibility of the operator to determine the protection concept and classification required for a particular application.

1.5 Safety Information

The GEM2xxx instruments are normally used for measuring gases from landfill sites. Inhalation of any gas may be harmful to health and in some cases may be fatal. It is the responsibility of the user to ensure that they are adequately trained in the safety aspects of the gases being used and that appropriate procedures be followed. In particular, where hazardous gases are being monitored or used the gas exhausted from the analyzer must be piped to an area where it is safe to discharge the gas. Hazardous gas can also be expelled from the instrument when purging with clean air.

1.6 Turning the Instrument On/Off

When switching the instrument on, a long beep will sound, followed by the LANDTEC logo being displayed and the self-test will commence. Whenever a key is pressed the unit will emit a short 'beep' as an acknowledgement. This function cannot be turned off.

When switching the instrument off, the On/Off button must be held down for approximately 2-3 seconds, at which point a clean air purge will be carried out. If for any reason the instrument 'locks-up' and will not switch off, press and hold the On/Off button for 15 seconds. This will force the instrument to switch off.

1.7 Warm-up Self Test

When switched on, the instrument will briefly display the LANDTEC logo and perform a predetermined self-test sequence taking approximately 30 seconds, during this time many of the instrument's functions are tested, including:

- General operation
- Pump function
- Gas flow measurement
- Calibration
- Backlight function
- Solenoid function

During the self-test, the following information is also displayed:

- Software version
- Serial Number
- Calibration due date
- Date format
- Operating language
- Communication Baud rate

Depending upon your version of GEM2xxx instrument you may see additional items listed from the self-test as well.

1.8 Warning and Error Display

During the self-test, if any operational parameters are out of specification or the pre-programmed recommended calibration/service date has passed errors or warnings may be displayed. Only three errors/warnings can be displayed at any time. To ascertain if more errors occurred, use the '∧' and '∨' key to scroll up/down the list, to exit from this screen press the "Enter/Store" key '↵'.

1.8.1 WARNING Displayed

All warnings displayed will be prefixed by the word ''**WARNING**' followed by a relevant description. Two types of warnings may be displayed.

1. General warnings that may not have an effect on the instrument's function and those where the self-test has detected a function that is outside the usual programmed operating criteria (e.g. Battery charge low, memory nearly full, etc.).
2. Specific warnings of operational parameters that can affect the performance of the instrument (e.g. O_2 Cell out of calibration, CH_4 out of calibration, CO_2 out of calibration, etc.).

The most likely reason for the errors is either an incorrect user calibration, or sensor failure. If an incorrect user calibration has caused the warning, it should be correctable by way of returning the instrument to factory settings, zeroing or carrying out a user calibration as necessary for the relevant function.

1.8.2 ERROR Displayed

All errors displayed will be prefixed by the word '**ERROR**' followed by a number and description. The errors detected by the self-test are usually caused by a user calibration being out of specification or possibly memory corruption. This will have an effect on the functionality of the instrument and should be corrected before use (e.g. 01 - User cal data, CH_4 reading or channel out of specification, 02 - User cal data, CO_2 reading out of specification).

If any other Warnings or Errors are displayed, contact a LANDTEC Authorized Service Facility for further information.

1.9 Service Information Screen

Upon self-test completion, the instrument will display service information including when the next manufacturers service is due, what type of service agreement the instrument is under (if applicable), and when the last factory gas check was performed. To exit from this screen press the "Enter/Store" key '↵'.

1.10 Technician ID Screen

The Technician ID screen is displayed after the Service Information screen. It is not necessary to input a Technician ID but it is suggested to do so for record purposes. Up to four characters can be entered to identify the technician performing the readings. This technician ID will be appended to all readings that are taken until the instrument is turned off. To change the Technician ID simply turn the instrument off and back on again. The Technician ID can be input through a virtual key board shown on the instruments display. Letters or numbers can be selected by using the '∧' and '∨' keys to scroll up/down and the '<' and '>' to scroll left and right. Pressing the "Enter/Store" key '↵' will select the highlighted character. Once the Technician ID is selected, or to bypass selecting any characters press the '①' button.

1.11 Gas Reading Screen

After inputting or bypassing the Technician ID, the instrument will go into the Gas Reading screen, also considered the normal operation screen. All operations are carried out from this starting point. The following information is displayed in various boxed sections at this time:

- Current programmed time and date
- Current selected ID code
- Pump status
- Pump run time
- Three main constituent gases – CH_4, CO_2, O_2 (in %)
- Two minor gases – CO & H_2S and indication of H_2 (GEM2xxx Plus instruments only)
- Balance gas
- Last read time/date (if previous data is in memory)
- Technician ID
- External devices (displays pod type or temperature probe readings when attached)
- % LEL CH_4 (if selected through LSGAM)
- Barometric pressure reading.
- Current relative pressure reading (GA mode only)
- Gas Pod or Temperature Probe reading (if connected)
- Battery Charge graph (5 segment, flashes at 20% remaining)
- Memory Usage graph (5 segment, flashes at 5% remaining)

Other options:

① Menu	Allows access to all instrument user functions.
③ Next ID / GPS Screen /	Allows the next ID to be selected (if IDs are available). (GPS Screen is for GEM2NAV Models when ID's are not used)
⑤ Measure Flow	For GEM mode only.
⑦ Previous Reading	Allows the previous reading of the selected ID to be viewed (if data is available).
↵ Store Reading	Stores the current displayed reading. (GA mode only)

1.11.1 Keypad Lock

After the instrument enters into the Gas Reading Screen, and from this point forward, the keypad can be locked by pressing and holding the backlight key for approximately 2 seconds. A message will display at the bottom of the display instructing you that to release the lock you will need to press and hold the backlight button.

1.12 Optional Gas Pods

Optional Gas Pods are available for use with the instruments. These pods are available for a variety different gases. For certain gases, more than one PPM range may be available; consult with a sale representative for the Gas Pod that would best meet your specific needs. Connection to the instrument is made via the communications socket and exhaust port. The detected PPM level is displayed in the upper right area of the gas read screen and is saved in the same manner as the other gas readings. The Gas Pods are not classified as intrinsically safe they should not be attached or detached from the instrument in hazardous areas.

Gas Type	Range (PPM)	Resolution (PPM)
H_2S	0-50	0.1
	0-200	1.0
	0-5000	35
CO	0-1000	1.0
SO_2	0-20	0.1
	0-100	1.0
H_2	0-1000	1.0
HCN	0-100	1.0

Gas Pods are intended for use as an inexpensive detection means and not for regulatory reporting purposes. If a Gas Pod, indicates the presence of the pod's selected gas, further testing should be performed with regulatory approved instrumentation. LANDTEC recommends that field calibration be performed using the relevant gas and concentration, prior to sampling with a Gas Pod. If calibrated properly, the accuracy of these Gas Pods are typically 5-10% Full Scale. Certain gases used to calibrate gas pods may be dangerous or fatal to your health. Be familiar with material safety data sheets (MSDS) prior to using any gas.

1.13 Memory

The instrument's memory is volatile. It is maintained by a battery back-up system, which will maintain the memory while the battery is being charged.

The memory is **not** to be used as a permanent storage medium and any data should be downloaded to a computer with permanent storage as soon as possible. An Instrument should never be stored for prolonged periods with valuable data in its memory.

When using the instrument please cover the communications and charging sockets with their "dust plugs". Although unlikely, sudden shocks, high levels of electromagnetic interference or static discharge may cause memory corruption or loss. Additionally the use of cell phones or other high powered devices near the instrument may cause radio frequency interference and may cause memory corruption or loss. If this occurs, the instrument may need to be Cold Started and the calibration reset to factory settings before further use. **NOTE: Cold Starting will erase all data in the instrument including resetting the following to default values:**

- Time and Date
- Language Settings
- Screen Contrast Setting
- Mode of Operation
- Field Calibration

1.13.1 Cold Start

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.
(For Gas Calibration Error Messages, confirm that Factory Settings and User Calibration are done).

A Cold Start should only be carried out to correct an instrument if no other course of action has proved successful. This function **WILL ERASE** the instrument memory entirely. After a cold start is performed the user will need to reset the instrument to factory settings, perform a field calibration, reset the internal time/date to the default settings, and load device IDs into the instrument. Please note that the time/date and device IDs may only be updated through the communication software. They cannot be updated manually.

To carry out a cold start, turn the instrument on, before the instrument enters into the self-test screen press and continue to hold the '↵' key until a pass code entry screen is displayed. At this point the '↵' key may be released. Enter the pass-code **12345** and press '↵' to confirm.

After the pass-code entry has been accepted, the instrument serial number will be displayed along with the hours in use, pump run time and service dates. There are four options from this screen;

1 - Cold Start
2 - Recover readings
3 - Print readings
0 - Exit

ONLY select option '**1'** if a Cold Start is to be carried out. Press key '**1**' to confirm this operation or press key '**0**' to continue with normal operation. If you select '**1**' to confirm the cold start a message will be displayed confirming the cold start operation and all memory will be cleared. The instrument will continue to the technician ID screen.

1.13.2 Recover Readings

THIS FUNCTION SHOULD BE USED ONLY AS A LAST RESORT.

Recover readings is a low level memory function that should only be used as a last resort if all your readings were inadvertently deleted and you know how many readings you had. This function moves the memory buffer and can cause instrument corruption. Contact LANDTEC before attempting to recover readings. After using this function, it is recommended that you download data from the GEM and then perform a cold start to ensure all memory is cleared and returned to an initialized state.

1.13.3 Print Readings

This function is performed as a technical support diagnostic tool and can assist LANDTEC personnel in troubleshooting certain types of problems.

1.14 Radio Frequency (RF) Interference

The gas sensors, especially the Methane sensor, are sensitive to RF interference.

Any device that transmits radio waves can cause your gas readings to fluctuate. Cell phones are the most common cause of the problem. You should never use your cell phone while you are taking gas readings.

2 The LANDTEC System Gas Analyzer Manager (LSGAM) Software

Beginning with GEM2xxx serial number 10000 and above, LSGAM is the only software that will communicate with the instrument.

2.1 Configuration Options

The GEM2xxx and LANDTEC System Gas Analyzer Manager (LSGAM) software can be utilized in a number of ways:

- Configured for operation with the LANDTEC System online service
- Used offline as a local application storing information on the desktop/laptop computer
- Use of the GEM2xxx out of the box without software; (this does not allow the user to generate flow rate values, select comments or select IDs with the instrument. This also prevents downloading of readings to the computer. It also does not allow the user to correct the time and date or to clear the memory, unless cold started.)

2.2 LANDTEC System Online Users

The procedures included in this section are intended for those who connect to the LANDTEC System online service. The LANDTEC System is an online collaboration tool to Collect, Validate, Analyze, and Communicate information based on field data obtained using LANDTEC instrumentation.

If you are a currently registered user on the LANDTEC System, please log in at http://www.landtecsystem.com/. If you are not currently using the LANDTEC System, you may register by contacting LANDTEC in the US: (800) 821-0496 or International: +1 (909) 783-3636.

Online reference for using LANDTEC System Gas Analyzer Manager (LSGAM) with the LANDTEC System can be found under the About → Help & Support menu within the LANDTEC System.

If you do not have login information please contact LANDTEC System Technical Support at +1 (909) 783-3636 extension 6131. Alternately, you may contact your local LANDTEC office for information on connecting to the LANDTEC System online service.

2.3 Offline Users

The procedures included in the section describe use of the LANDTEC System Gas Analyzer Manager (LSGAM) Software while **NOT** connected to the LANDTEC System online service.

2.3.1 Installation with the CD

System Requirements

- Windows XP, Vista, 7
- Pentium 750MHz or faster
- 128MB RAM
- 200MB Hard Drive Space Available
- CD-ROM Drive
- Available USB port

NOTE: The computer may need some administrative privileges to install the program. Program may run on other versions of Windows but LANDTEC has not tested the program on older versions of windows or with lesser processor and memory requirements.

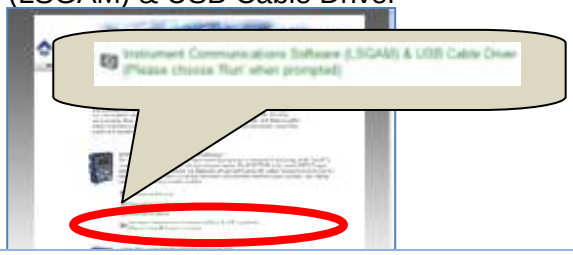
As part of LANDTEC's continual improvement process, LANDTEC has consolidated its product information and instrument communications software into one menu structure. On your memory stick or CD you will find technical information, instrument communication software, USB cable drivers, videos and instrument manuals.

To install the USB Cable Drivers and LSGAM (instrument communication software) from this media format, you will need to place your CD or memory stick into your computer. If you have a CD it should automatically start. If you have a memory stick, you may have to browse to it in your computer and then click on the ***ClickHereToStart.htm*** icon.

Once the media opens, you will need to choose your appropriate application area from one of the application categories. This example is for a **GEM2NAV** instrument being used on a ***Landfill Gas*** application. After the page opens you'll click on the link titled ***Instrument Communications Software (LSGAM) & USB Cable Driver.***

Step A
—Click on LANDFILL GAS

Step B
—Click on Instrument Communications Software (LSGAM) & USB Cable Driver



Step C
—Install Components of the Instrument Communication Software

Step D
—Choose
"Step 1 – Install USB Drivers"

Step E
—Choose
“Step 2 – Install LSGAM Software”

The software will automatically update if an internet connection is available when the software starts. This software has been tested with Windows XP. Partial testing on Windows Vista and Windows 7 is complete and the software is performing as expected.

Should you have any difficulties, please don’t hesitate to contact us. Our Software support group can be reached at (909) 783-3636 x6131 or support@landtecna.com

The instrument communicates to the computer by means of a USB. This USB cable requires drivers to be installed prior to use on the computer. From the CD (or USB memory stick) choose the first option “Step 1— Install USB Drivers”

The Java programming is an import part of this software and will be loaded with the CD install. If you have internet access, it is recommended to update your java to the latest version by going to http://www.sun.com

then click the Java Icon under the “downloads” section. Once at the Java downloads you’ll see links to download the latest version of Java for your computer. The java icon, shown below, will be in the task tray at the bottom of your computer screen where your time is shown. There will also be a GAM log icon, shown below, that will be created on your desk top during installation.

2.3.2 Startup

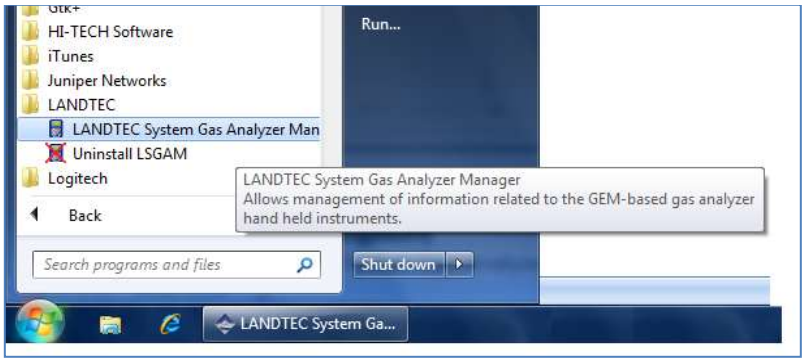
Up Once the USB cable drivers are installed and you’ve checked for the latest Java Runtime from the www.sun.com website, click on “Step 2 — Install LSGAM”. LSGAM will install placing an Icon on your desktop and a new Start Menu Group named LANDTEC.

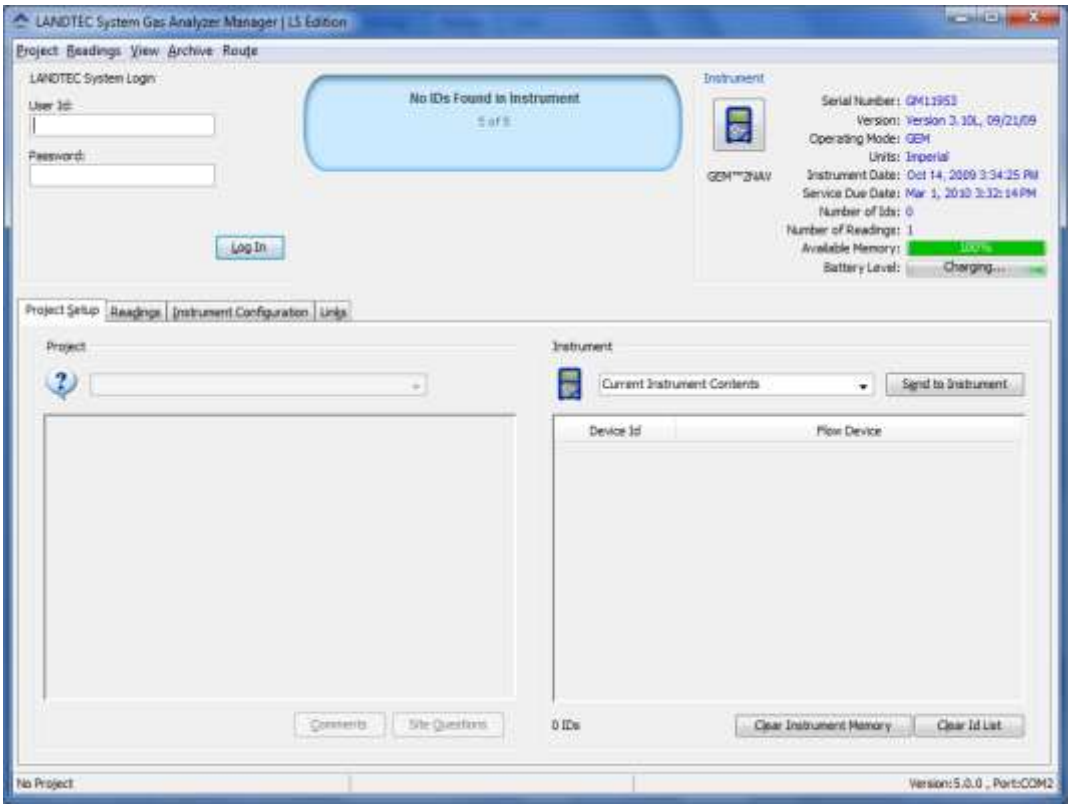
Starting LSGAM can be easily done by doing one of the following:

Double-Click on the Desktop icon.

OR - go to;

Start → All Programs → LANDTEC → LANDTEC System Gas Analyzer Manager



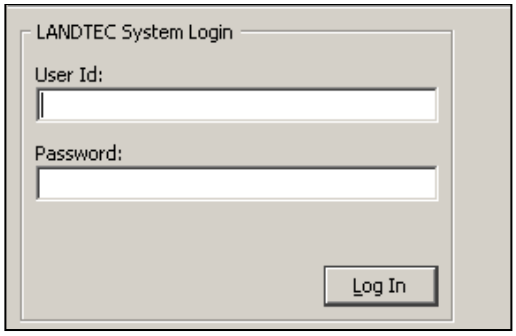


2.3.3 Navigation

The LANDTEC System Gas Analyzer Manager User Interface allows for easy access and navigation to various utilities to use the LANDTEC portable instrument on a day to day basis. The following is a general description of the user interface.

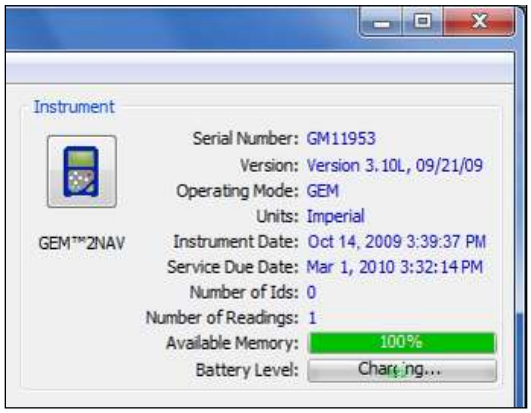
LANDTEC System Login

When LSGAM is used with the LANDTEC System online service, the username and password will be entered in the screen below, if you are using LSGSM as a desktop application the User Id and Password fields do not need to be filled in.

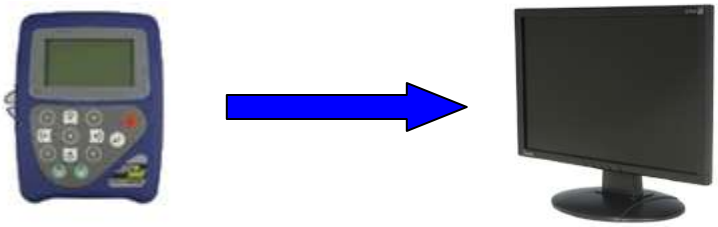


The Progress section indicates the status of the current process. For example, when starting up LSGAM, this will show you the activity of the software.

The Instrument section displays whether or not an instrument is connected. This also downloads the IDs, readings, and comments. If an instrument is found the following details are shown about the instrument:



2.4 Connecting to the Instrument

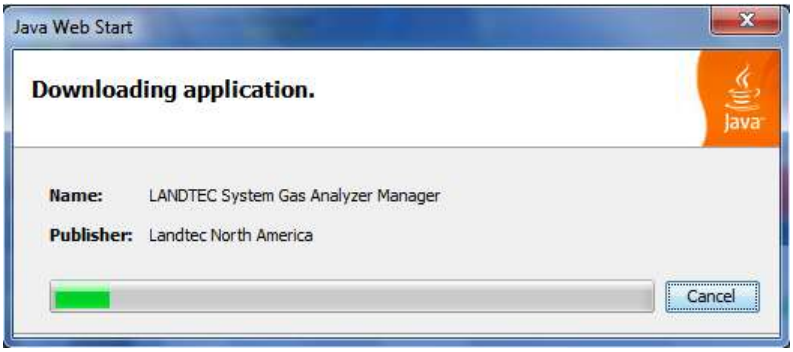


1. Connect the GEM2xxx with the USB or RS-232 Download Cable to your Computer
2. Instrument must be powered ON and in the Gas Reading screen
3. Launch the LSGAM software by clicking on the icon on your desktop

This is the first screen you will see when starting the program.

Once the software is installed on your computer with an internet connection this instrument communications program has Auto application updates. This enables you to always have the most current version of the instrument communications LSGAM.

If an update to LSGAM is available, you will see this notice when connected to the internet.



Click on OK this will return you to the desktop and you will then need to click on the  LSGAM shortcut again.

The GEM2xxx must be connected to computer and turned ON. It must also be in the Gas Reading screen. The LSGAM software will automatically download any information in the instrument including readings, comments and IDs.

Note: Connection of instrument to computer should not be performed in a hazardous area.

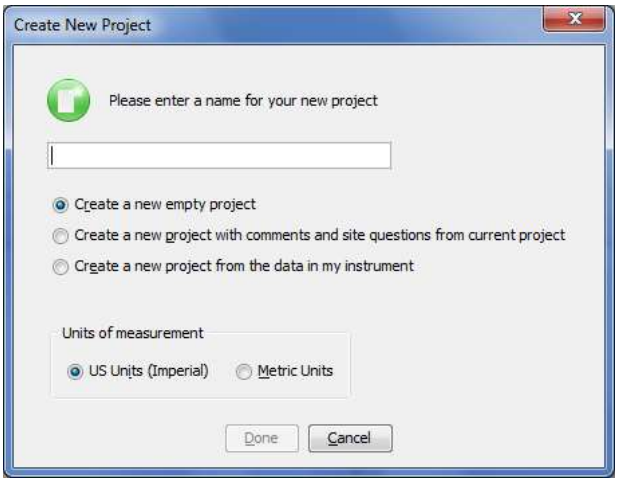
A new instrument containing no information will display only the instrument information: Serial Number, Version, Operating Mode, Instrument Date, Service Due Date, Number of IDs, Number of Readings, Available Memory, and Battery Level.

2.5 Create a Project / Select a Project

Projects are a collection of Device IDs and their associated reading history. A project can be created using LSGAM to contain a group of sequenced IDs and chronological history of instrument readings.

To create a Project, click on the Project menu and select New Project.

Upon selecting **New Project…** you will be prompted to enter a Project Name and select from one of three options.



Create a New Empty Project
This option creates a blank project where you configure all IDs and Comments.

Create a New Project with comments and site questions from a Current Project
Selecting this option allows the user to create a new project that will have the same Comments and Site Questions as an existing project.

Create a New Project from the data in a GEM2xxx instrument
This option will create a New Project and automatically associate the IDs, Comments, and Site Questions that exist in the connected portable instrument.

2.6 ID Setup

An ID represents a physical sampling point in the field. An ID can be allocated to field components such as extraction wellheads, gas transmission lines, or passive monitoring probes. LSGAM allows users to configure an ID for each sampling point in order to obtain accurate readings with LANDTEC portable instrumentation

IDs are created, modified, and removed from the Project Setup tab in the software.

2.6.1 Creating Comments

Comments should be setup prior to creating new IDs. The user can define Comments that can be associated with a reading in the portable instrument.

If you selected Create a New Project, when creating your project, you will need to click on the Create Comments button. Comments can be entered in this setup screen or loaded from a file and will be displayed in the user interface.

Typical Comments Might Include
Valve Fully Open
Valve Partially Open
Valve Closed
Air Leak in Wellhead
Water Blockage in Header
Surging at well
Sample Port Needs Replacement
More Vacuum Needed
5 Day Recheck

2.6.2 Creating IDs

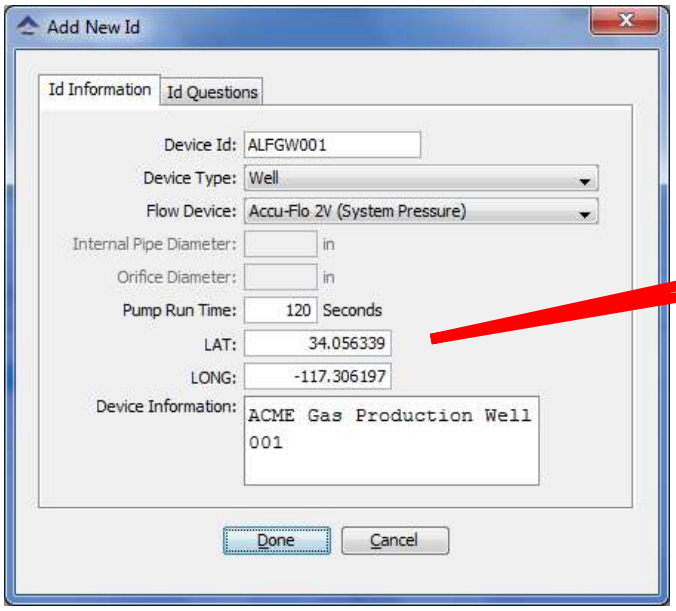
There are several ways to input IDs to the Project. The following describes each process:

Creating new IDs with LSGAM

To create a new ID using the LANDTEC System Gas Analyzer Manager, Right Click on the left ID pane beneath your active project and select the Add New ID option.

The Add New ID form will be displayed. From the ID Information tab of this form, entry of the following is

available:



*Note: LAT & LONG will only be available on **GEM2NAV** models*

ID INFORMATION

Device ID: Must be eight (8) alphanumeric character spaces. (For example, ALFGW001)

Device Type:

- Well: An active gas extraction well connected to a piping network which may require a flow rate reading.
- Sample Port: A sample point along a gas transmission line that may require a flow rate.
- Probe: A passive gas migration monitoring probe that does not require a flow rate.

The GEM2xxx calculates flow rate values specific to each device type (listed above). The available flow devices programmed in GEM mode are listed below.

Flow Devices:

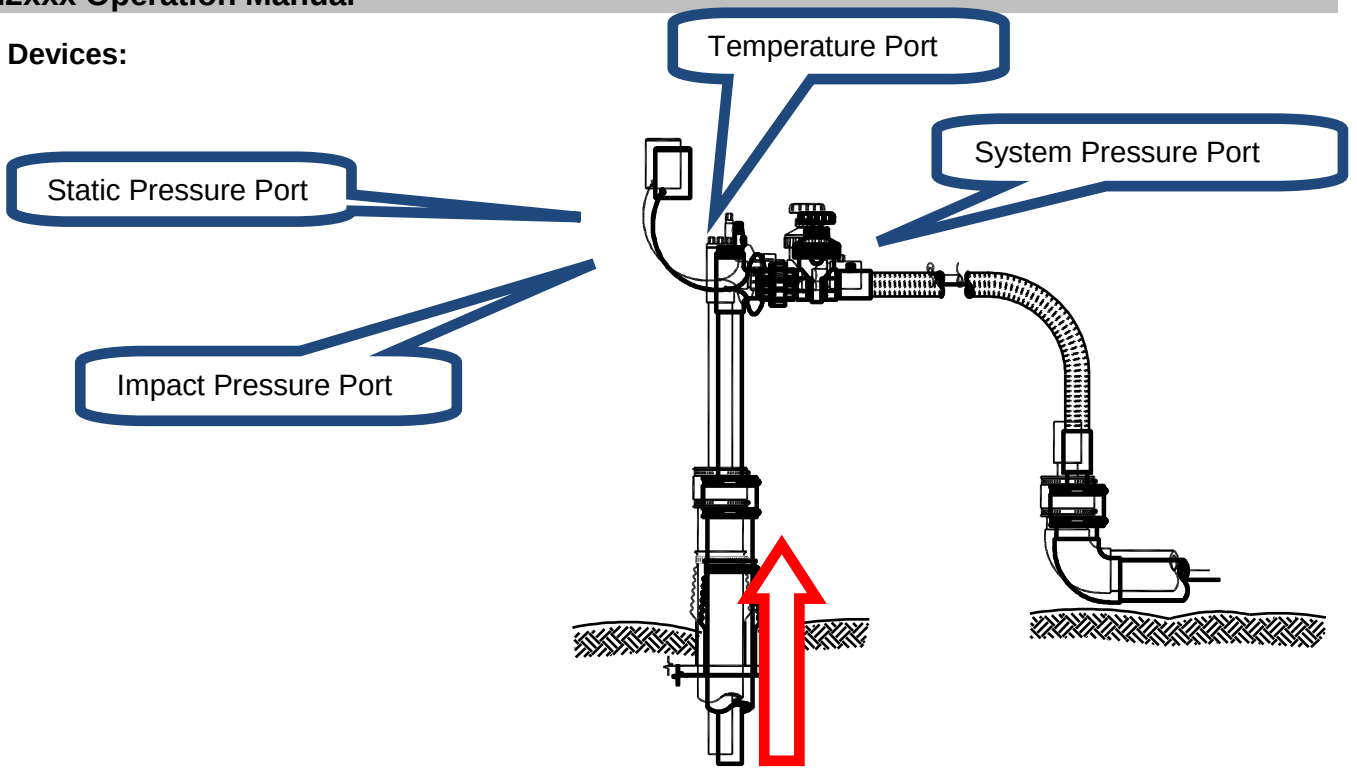


Figure 1 - ACCU-FLO Vertical Wellhead

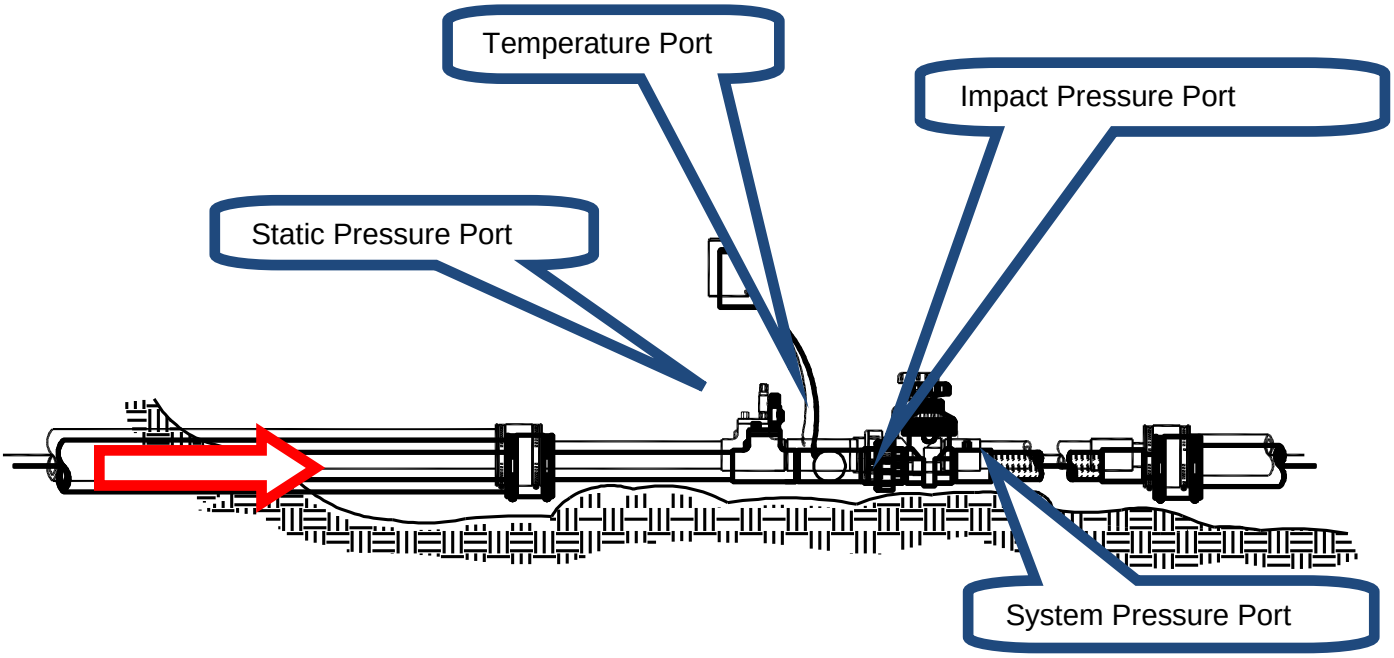


Figure 2 - ACCU-FLO Horizontal Wellhead

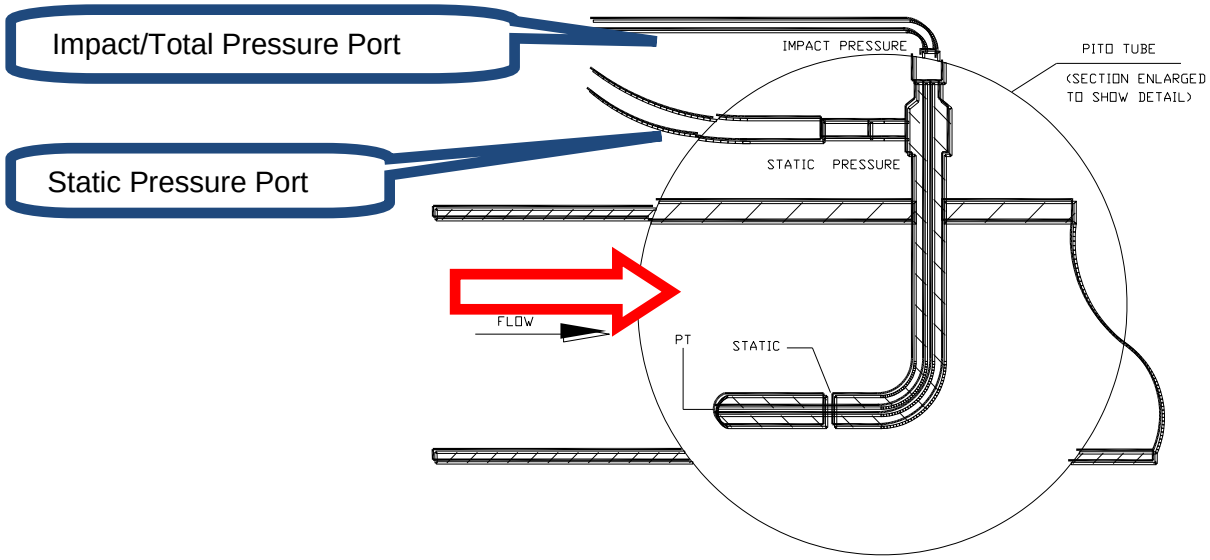


Figure 3 - Pitot Tube

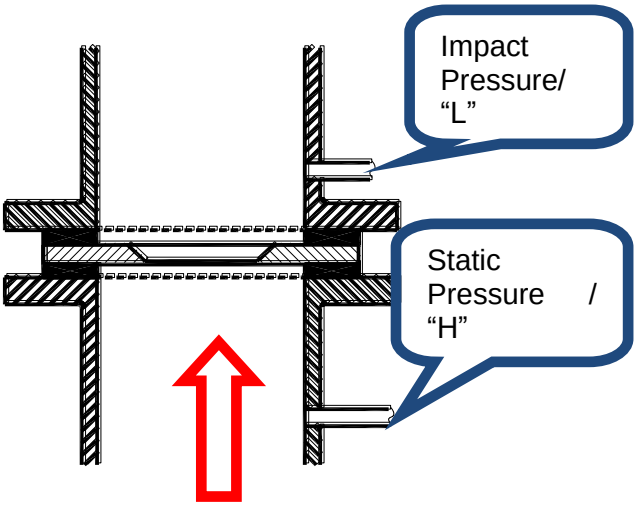
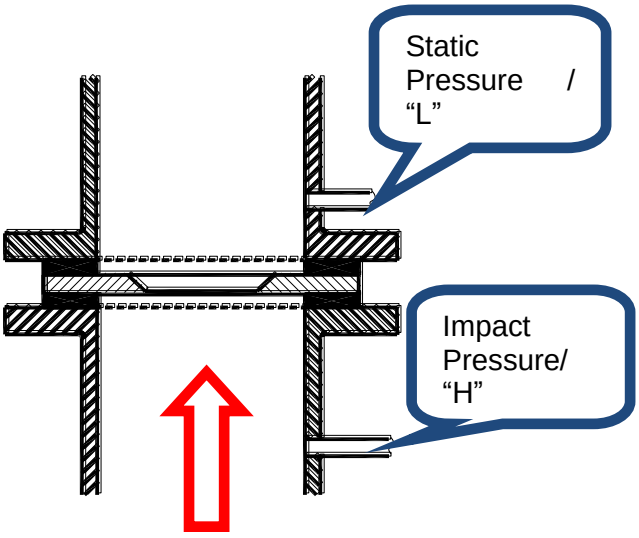


Figure 4 - Orifice Plate (WellSide)



Orifice Plate

Flow Device Name Programmed in GEM	Orientation	Size	System Pressure
ACCU-FLO 1.5V	Vertical	1.5 inch	
ACCU-FLO 1.5H	Horizontal	1.5 inch	
ACCU-FLO 2V	Vertical	2.0 inch	
ACCU-FLO 2H	Horizontal	2.0 inch	
ACCU-FLO 3V	Vertical	3.0 inch	
ACCU-FLO 3H	Horizontal	3.0 inch	
Orifice Plate			
Pitot Tube			
User Input			
Orifice Plate WellSide			
ACCU-FLO-1.5V (System Pressure)	Vertical	1.5 inch	✓
ACCU-FLO-1.5H (System Pressure)	Horizontal	1.5 inch	✓
ACCU-FLO-2V (System Pressure)	Vertical	2.0 inch	✓
ACCU-FLO-2H (System Pressure)	Horizontal	2.0 inch	✓
ACCU-FLO-3V (System Pressure)	Vertical	3.0 inch	✓
ACCU-FLO-3H (System Pressure)	Horizontal	3.0 inch	✓
Orifice Plate-System Side (System Pressure)			✓
Pitot Tube (System Pressure)			✓
User Input (System Pressure)			✓
Orifice Plate WellSide (System Pressure)			✓

Pipe Diameter: The pipe inside diameter (ID) is required for Orifice Plate and Pitot Tube type flow devices.

Orifice Diameter: The field for orifice bore diameter is available for all Orifice Plate flow devices.

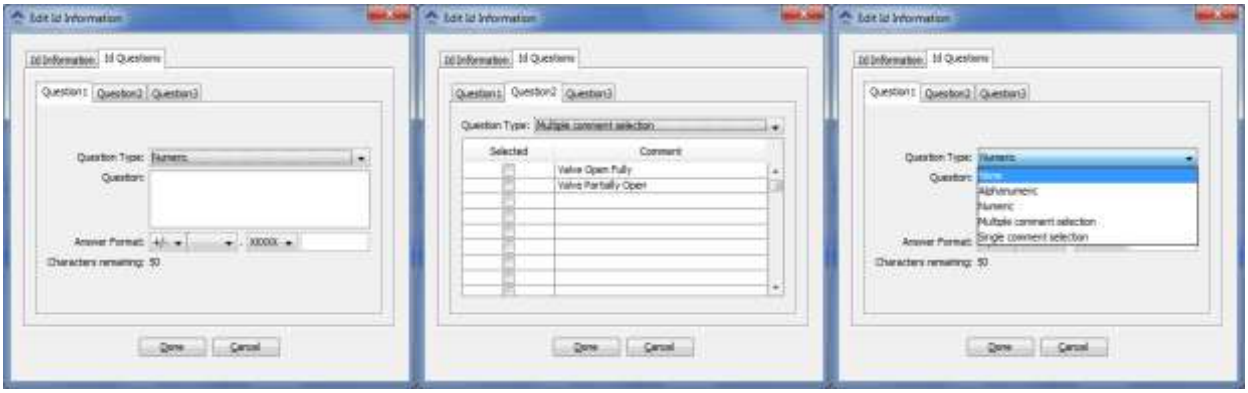
Pump Run Time: Indicates the duration the instrument's pump will run while sampling for the selected ID.

Device Information: Allows the user to enter general information for the device. This will display on the screen of the instrument if the user chooses the ③ View ID Details option from the ID selection screen on the instrument.

ID QUESTIONS

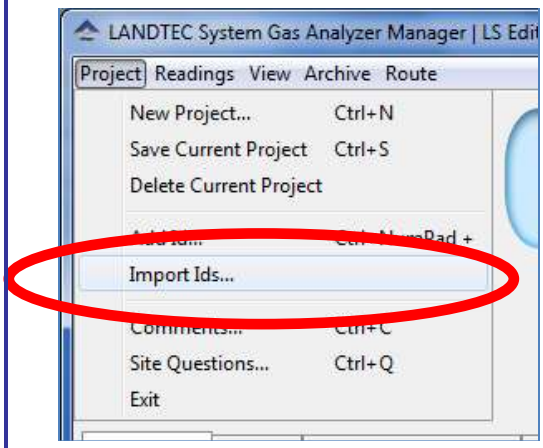
There are 5 Question Types that can be selected:

- **None -** No question will be prompted to the user
- **Alphanumeric -** An alphanumeric answer can be entered when taking a reading
- **Numeric** - A numeric only answer can be entered when taking a reading
- **Multiple Comment selection -** Up to 8 comments that may be appropriate for this device ID can be selected in the ID setup. Then one or all of the comments can be selected when taking a reading.
- **Single comment selection -** Up to 8 comments that may be appropriate for this device ID can be selected in the ID Setup but only one comment can be selected when taking a reading. Comments related to valve position are often used with a Single Comment Selection because the valve can only be in one position.



Importing DataField CS IDs

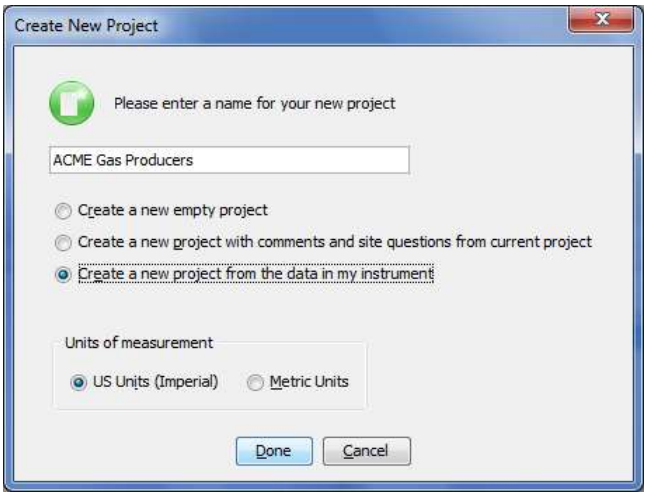
If you have existing ID files from DataField CS v3.2.x, these files can be imported by LSGAM. To begin this operation select the ***Import IDs…*** option from the ***Project*** menu.



Select an ID file generated by DataField CS v3.2.x.

2.6.3 Create a new project based upon IDs ALREADY IN THE INSTRUMENT:

To create a Project based on the information in the instrument, select ***Create a new project from the data in my instrument***.

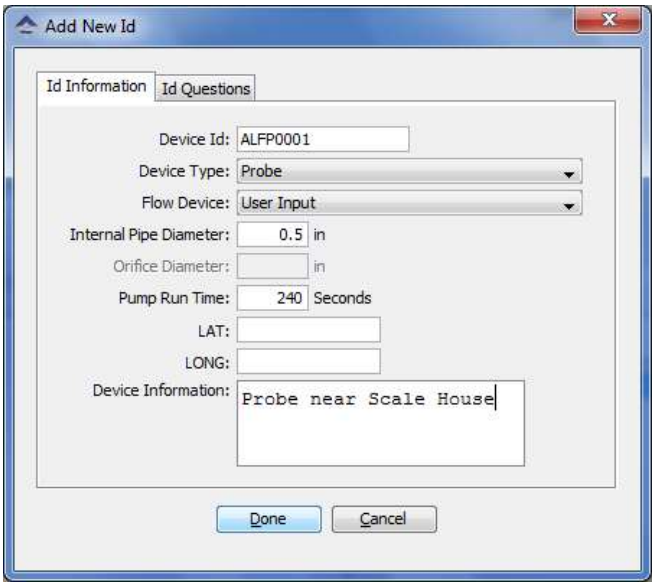


Note: When using the Creating a new project from the data in the instrument option, only IDs NOT associated with other projects will be created into the new project.

Creating a Device ID that does not measure flow Example- Probe or Sample Port

If there is no flow device you will choose User Input. When choosing the User Input option you will need to enter the appropriate pipe inside diameter and pump run time.

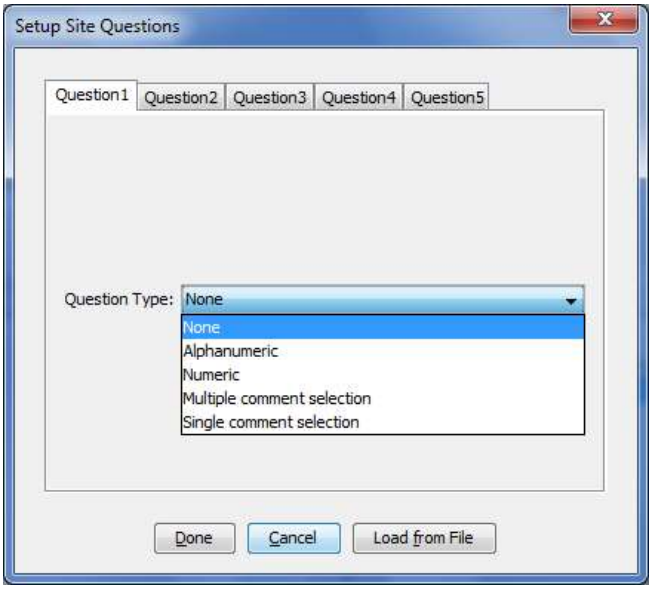
This ID is then generally sent to the GA mode [Landfill Gas Analyzer] of the instrument. Because this mode of the instrument does not read flow will not show the pressure readings screens that are in the GEM mode for vacuum and impact pressures.



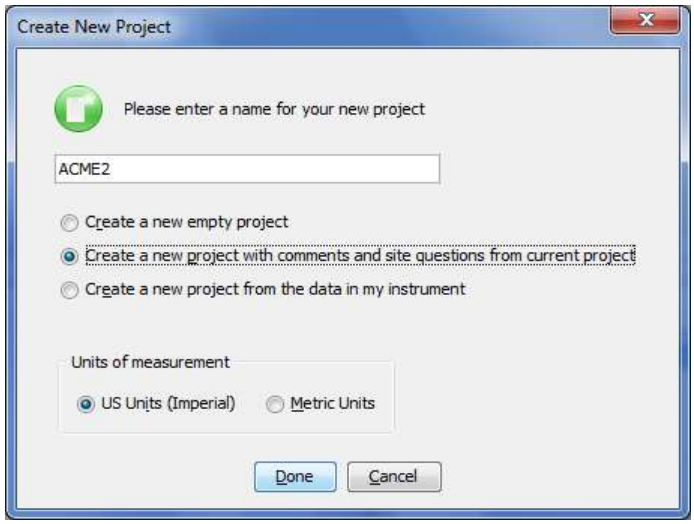
2.7 Creating your Site Questions

Site questions are setup in the same manner as ID questions however unlike ID questions, the answers for Site questions will apply to all subsequent readings until the site question is updated. A total of 5 site questions can be sent to your instrument. These must be updated each time you use the GEM. This is done by going to the ① Menu selection on the instrument and choosing [Update Site Data]

The options for questions are Alphanumeric – Numeric – Multiple or Single comment selection.



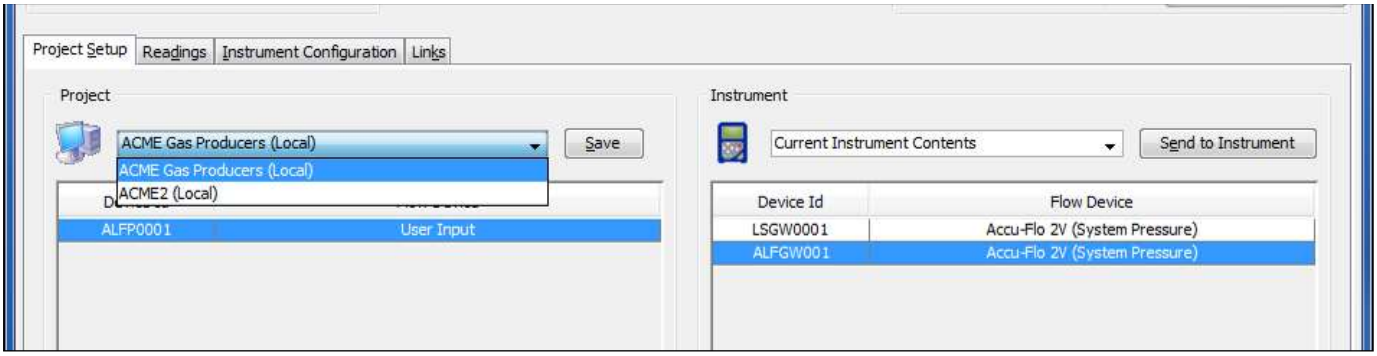
These Site Questions may be used again with another project by selecting the Create New Project and create new project with comments and **site questions** from current project.



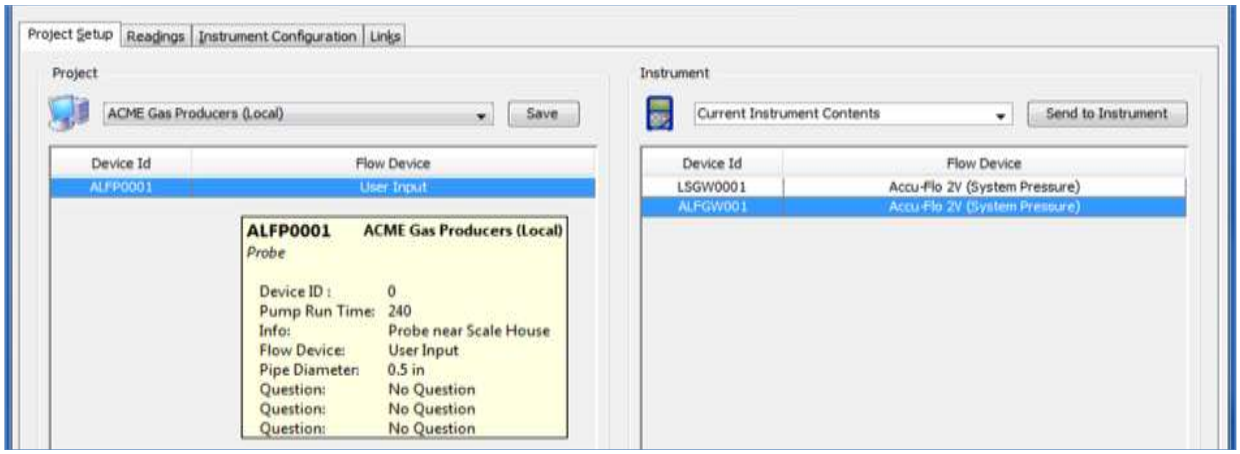
The project will be created and the IDs, Comments, and Site Questions that exist in the instrument will be applied to the new project.

Working with Device IDs

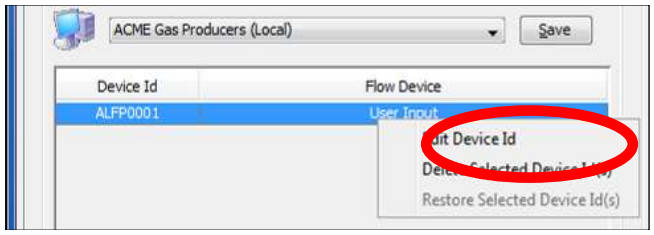
Once some IDs are added to your project you may need to occasionally edit them or reference them. First select the project which you want to work with from the project drop down list.



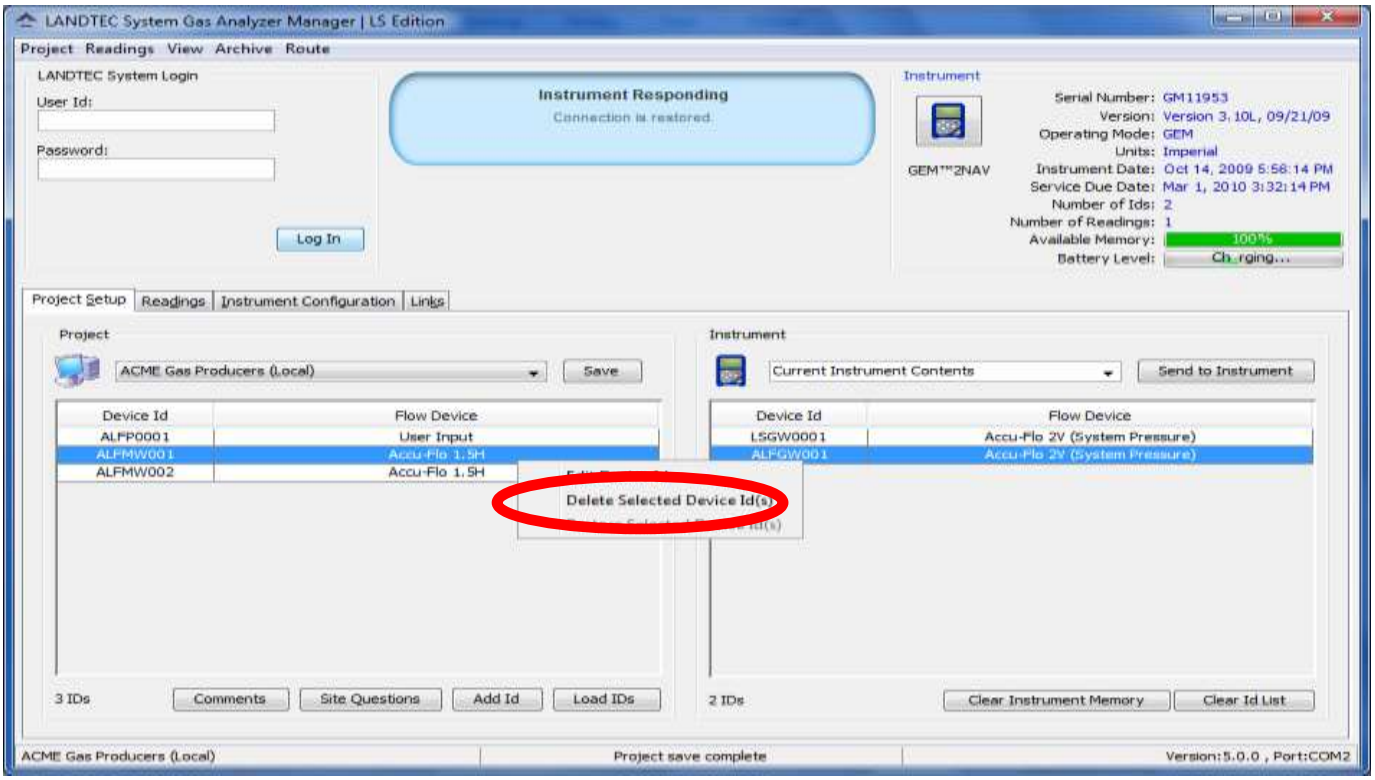
Placing the mouse cursor over a specific device ID will show detailed information about that ID.



To edit a Device ID, right click on the desired device and select ***Edit Device ID***.



To delete an existing ID, right click on the desired device and select ***Delete Selected Device ID(s)***.

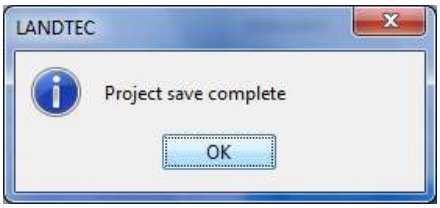


Upon clicking on Delete Selected Device Id(s) you will see the line ~~strikeout~~.

The computer Icon will now display a red * over the image. This indicates that the IDs are NOT saved. Deleted IDs are displayed with a line through the information on the screen. To restore a deleted ID, right click on the ID and click ***Restore Selected Device ID(s).***

Note: Deleted ID's can only be restored while the project state is unsaved. Once saved, the ID changes are saved and restoration cannot be completed.

Once all work with the device ID's is complete, click on the Save button.



After clicking on OK, the device is removed and the computer icon returns to the unaltered state .

2.8 Sending IDs to the instrument

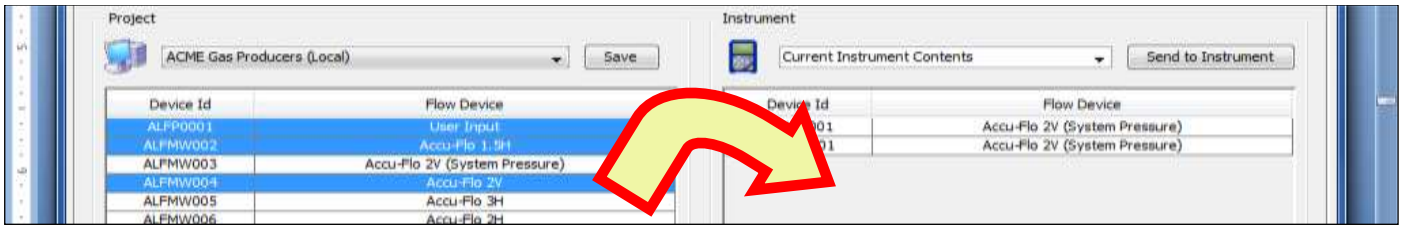
Once IDs have been created in the project, they must be uploaded to the instrument. To perform this operation, select the desired IDs from the left hand table under the Project name (computer side), left click and hold while dragging the IDs to the right hand table and release the mouse button. This is action is know as a "Drag & Drop".

Three basic methods of selecting IDs exist.

- Select Specific ID(s)
- Select a Range of IDs
- Select All IDs

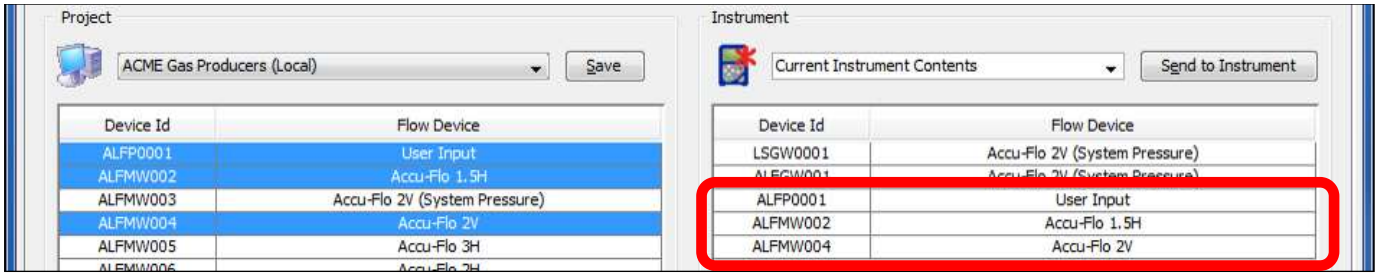
Specific IDs

To Select Specific List of IDs, place the mouse arrow at the edge of the first cell and hold down the left Ctrl key. Now click the next ID cell that you wish to select. Repeat this as many times as necessary.

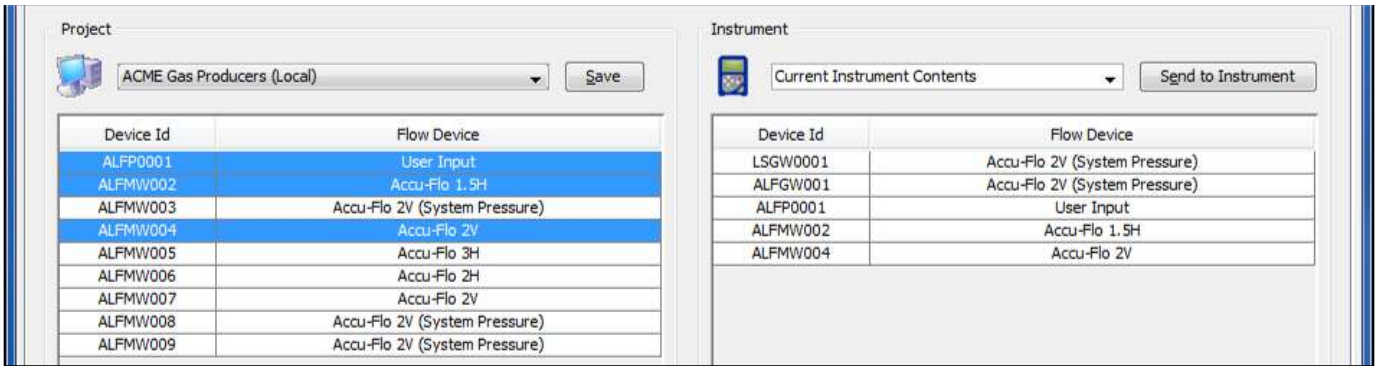


Selected IDs (shown as Highlighted). Arrow depicts "Drag & Drop" action after selection.

Now "Drag & Drop" the IDs from the left (computer window) to the right (instrument window). During the "Drag &Drop" process, the arrow will change to .



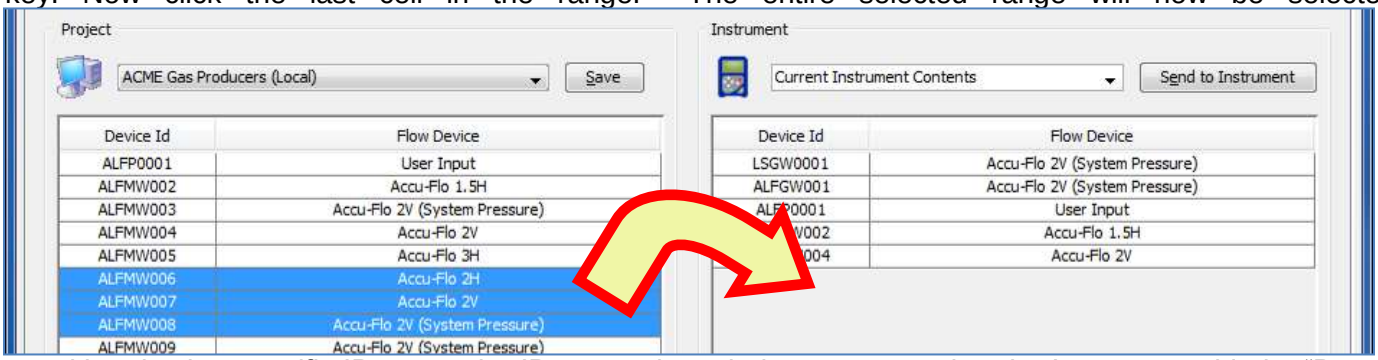
The selected IDs ALFP001, ALFMW002, and ALFMW004 now appear on the Right (Instrument) side. At this point the IDs are on the Instrument side but have NOT been sent to the instrument. The instrument with the red * indicates this unsent ID state. Click on the Send to Instrument button to send these IDs to the instrument.



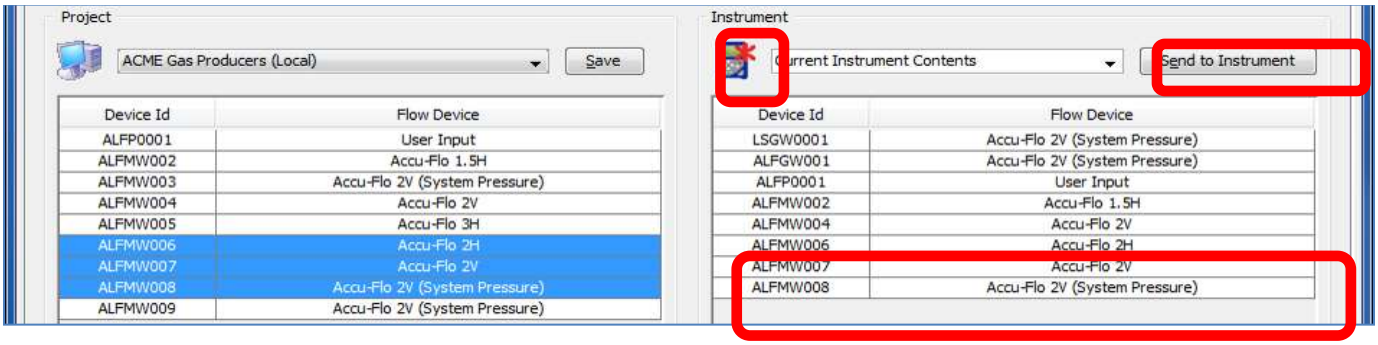
After the IDs are sent to the instrument, the instrument  will appear without the red *

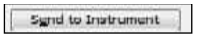
Range of IDs

To Select A Range of IDs, place the mouse arrow at the edge of the first cell and hold down the left shift key. Now click the last cell in the range. The entire selected range will now be selected.



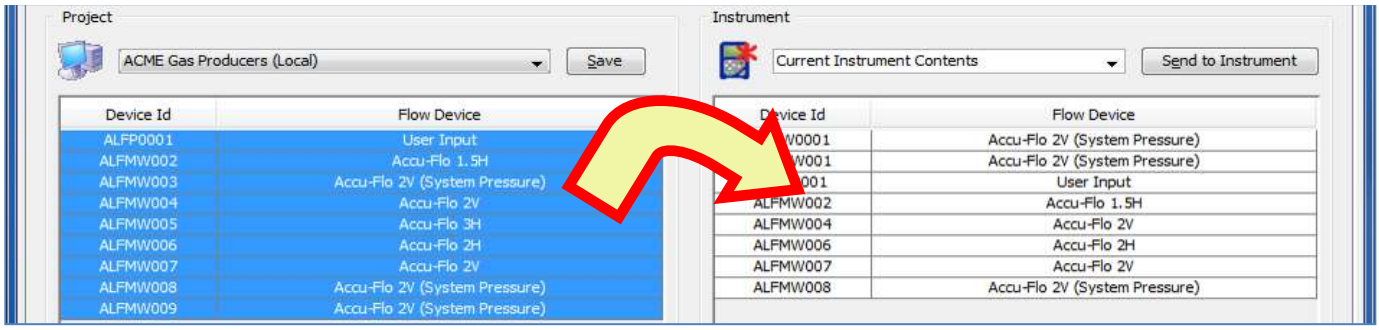
As with selecting specific IDs once the IDs are selected, they are moved to the Instrument side by "Drag & Drop". The Instrument icon will appear with a red * and the ID's will need to be sent to the instrument.



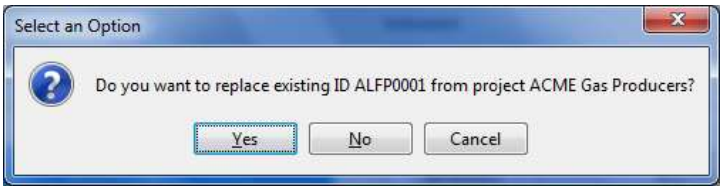
Click on the Send to Instrument button  to send these IDs to the instrument.

Selecting All IDs

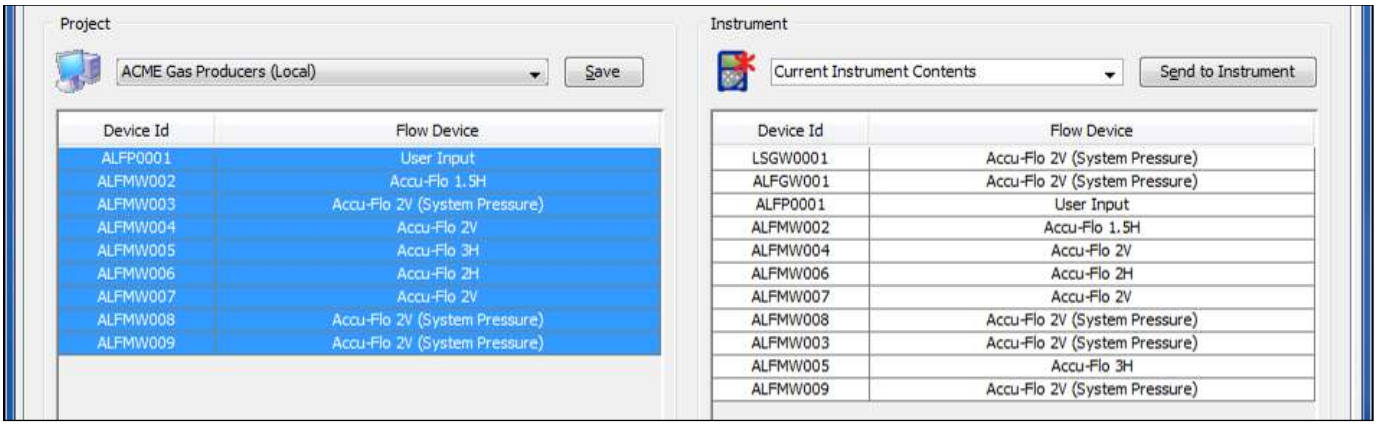
All IDs can be selected by selecting one ID in the Project window and then pressing Ctrl-A.

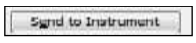


Now move IDs from the Project Side to the Instrument Side by dragging and dropping them.

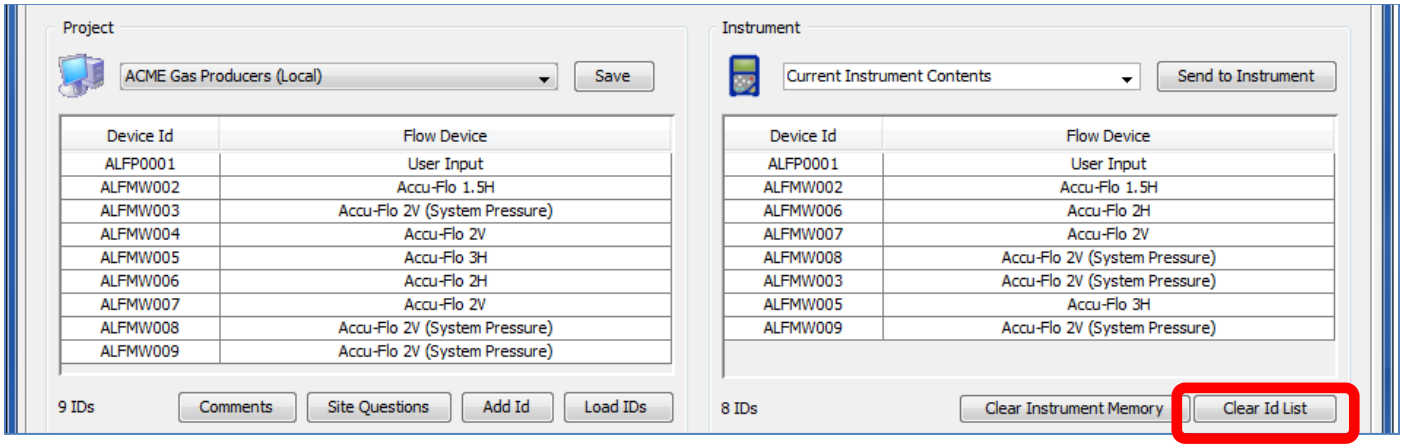


If you are dragging and dropping an ID that is already on the instrument side, you will be prompted with the above message. Answer Yes to update the IDs on the instrument side from those on the computer side. Answer No to ignore IDs that are already in the instrument. Answer Cancel to cancel the action without sending ID's to the instrument side.

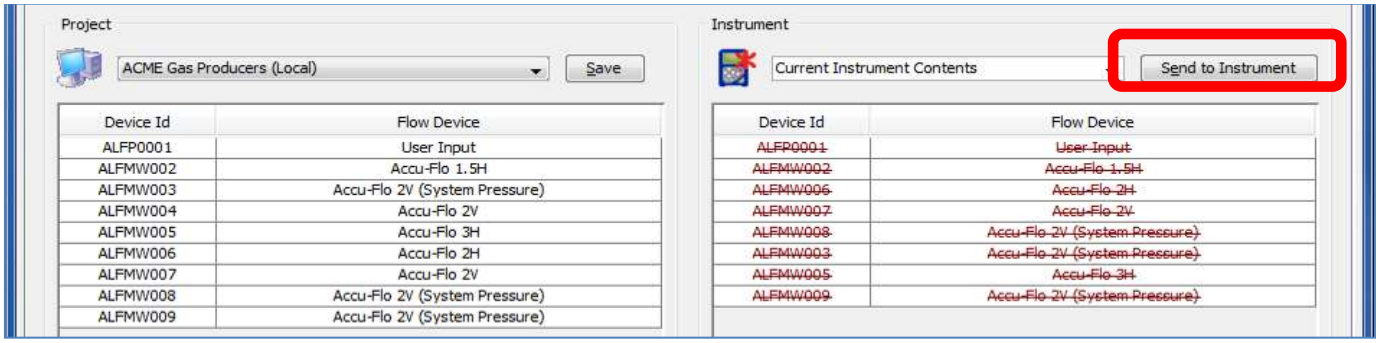


Click on the Send to Instrument button  to send these IDs to the instrument.

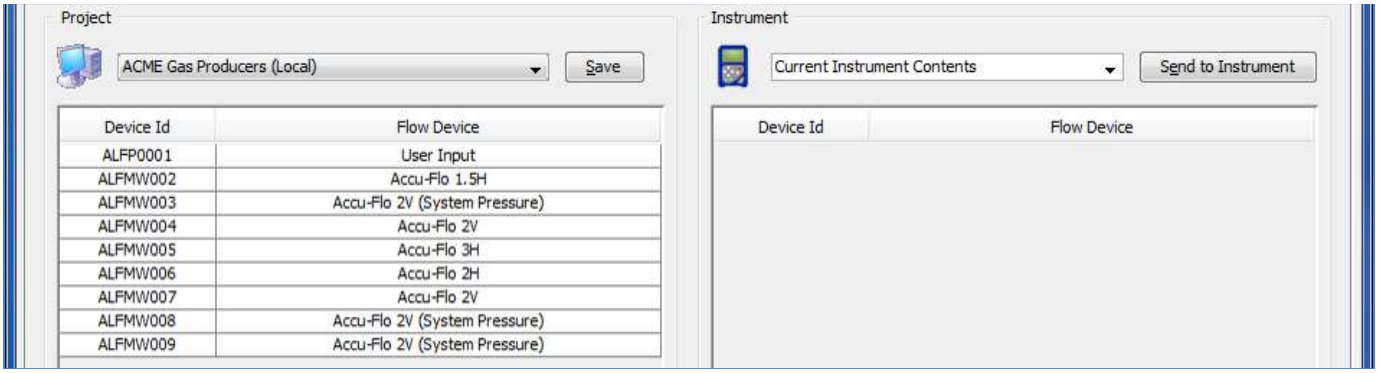
Clearing ID s from your instrument or Deleting a Project



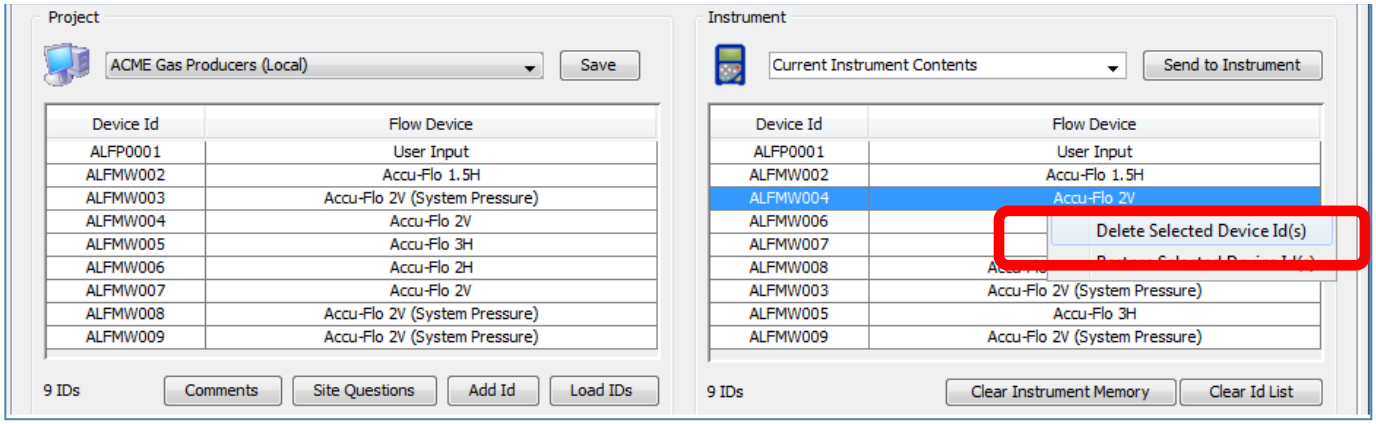
In current instrument contents when selecting the Clear ID List option it will draw lines through the IDS.



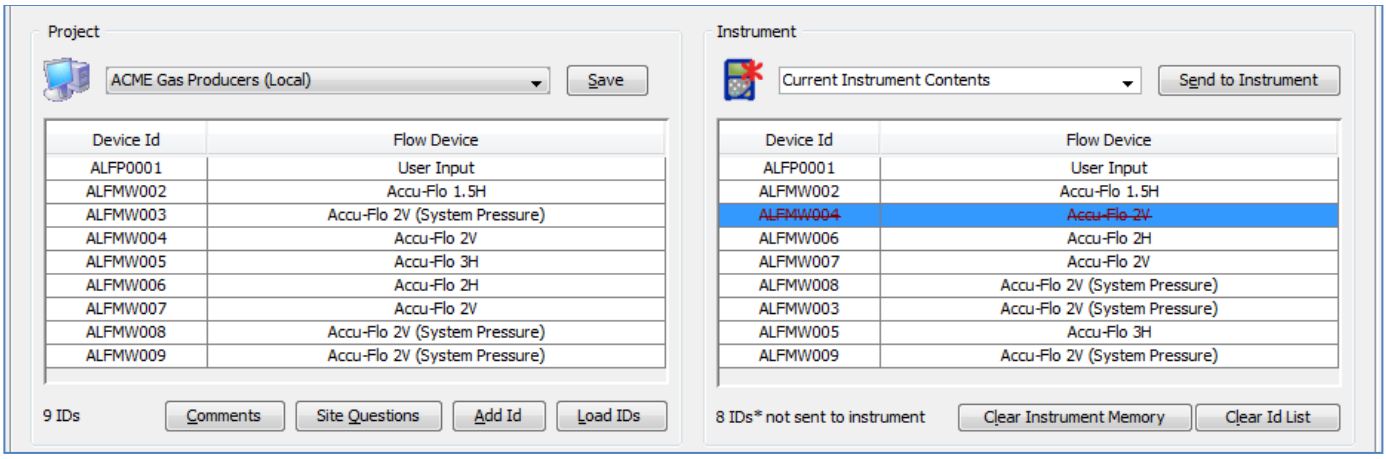
You then need to select ***Send to Instrument***. This will clear all IDs from the GEM2xxx in both the GEM and GA mode.

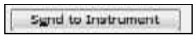


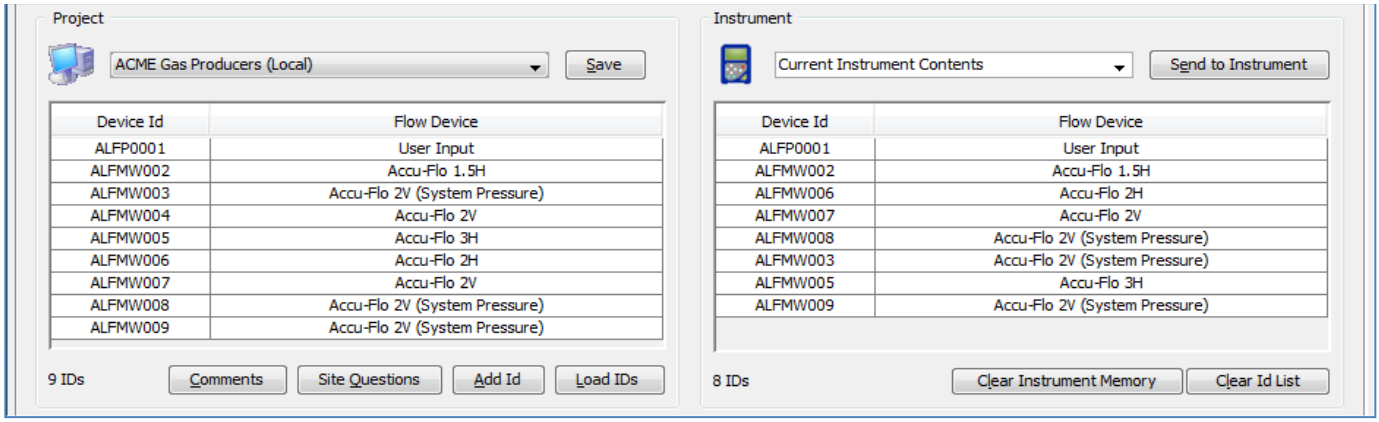
You may also delete one ID from a list by highlighting the ID RIGHT CLICK with your mouse and select the Delete Selected Device option. If you have selected the wrong ID and deleted then you may select the Restore option to return the ID to the list.



Upon selecting Delete Selected Device Id(s) you will see a ~~strikeout~~ line appear through the ID



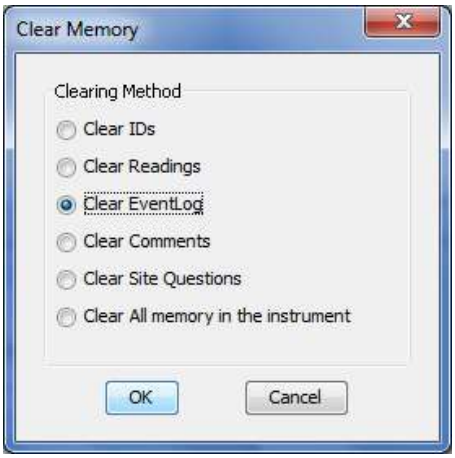
Click on the Send to Instrument button  to send the ID corrections to the instrument.



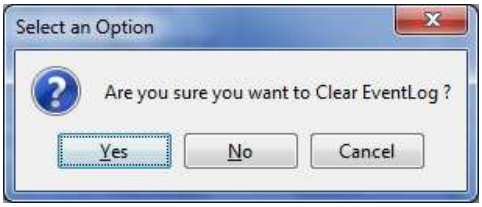
The instrument contents will now be updated and the ALFMW004 ID no longer shows in the instrument side of the list.

Clearing the Instrument Memory

The Clear Instrument Memory function  allows various parts of the instrument's memory to be cleared. Upon clicking on the Clear Instrument Memory button the following options are available.



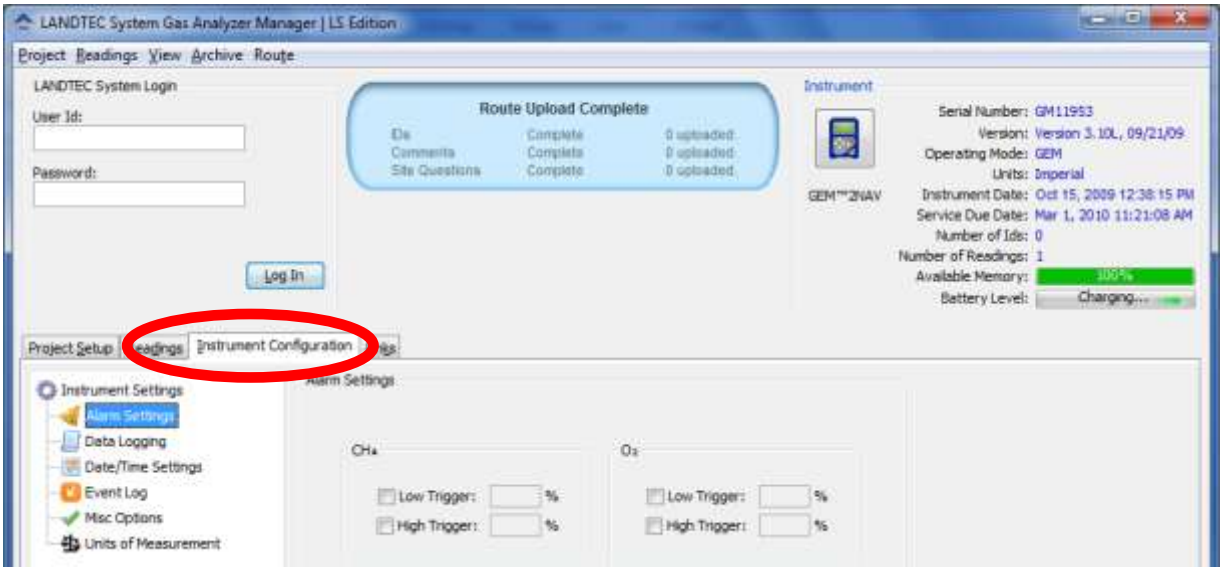
Please Note: Clear functions in the instrument affect both GEM and GA modes of instrument operation.
Upon selecting a memory type to clear, and clicking OK, a prompt will appear to confirm the selected action.



Answer Yes to perform the action.
Answer No or Cancel to return to the clear memory dialog.

2.9 Instrument Settings

The LANDTEC System Gas Analyzer Manager software allows users to change many of the operational settings of the instrument. To view and change the available settings click on the ***Instrument Configuration*** tab.

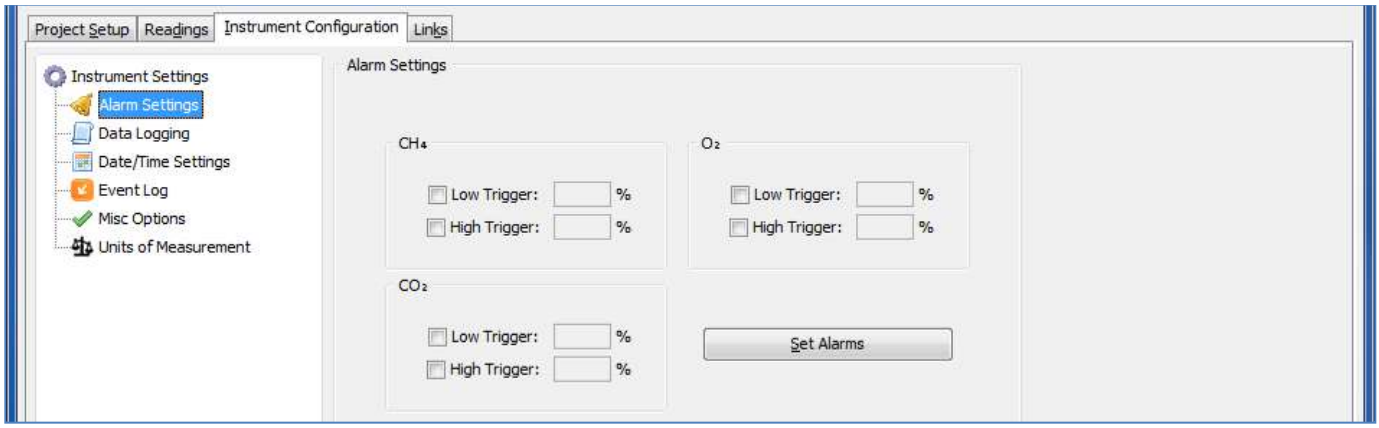


In the Instrument Configuration user interface, there is an Instrument Settings option tree. The Instrument Settings tree allows for easy navigation to the following categories:

- **Alarm Settings**
- **Data Logging**
- **Date/Time Settings**
- **Misc Options**
- **Units of Measurement**

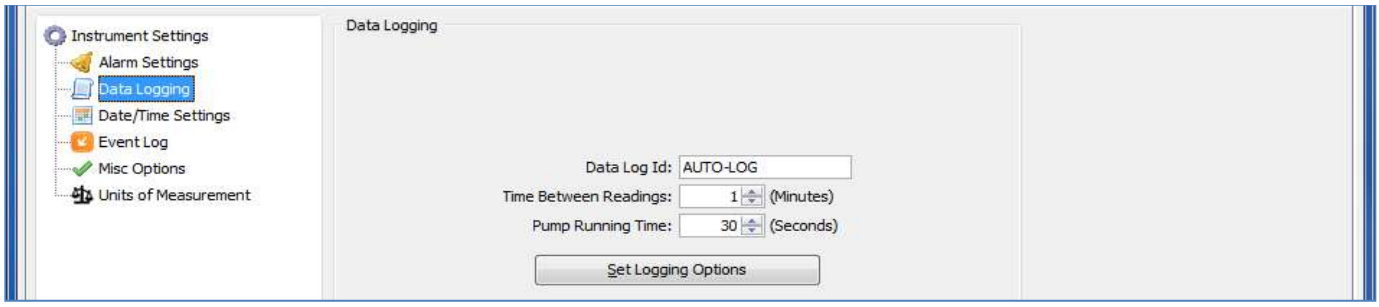
The following sections describe each option category.

2.9.1 Alarm Settings



The Alarm Settings options control the activation and deactivation of the audible alarms in the GEM2xxx instrument. Audible alarms can be configured for CH_4, CO_2, and O_2 parameters. Each parameter can be configured with a Low Trigger and/or High Trigger for the alarm. To activate any specific alarm, click and place a checkmark in the desired box. This will activate the entry field to place the value. The values must be 0 – 100 percent. When alarms are set, the instrument will beep and flash the parameter on the screen if an alarm threshold is surpassed when taking a gas reading.

2.9.2 Data Logging



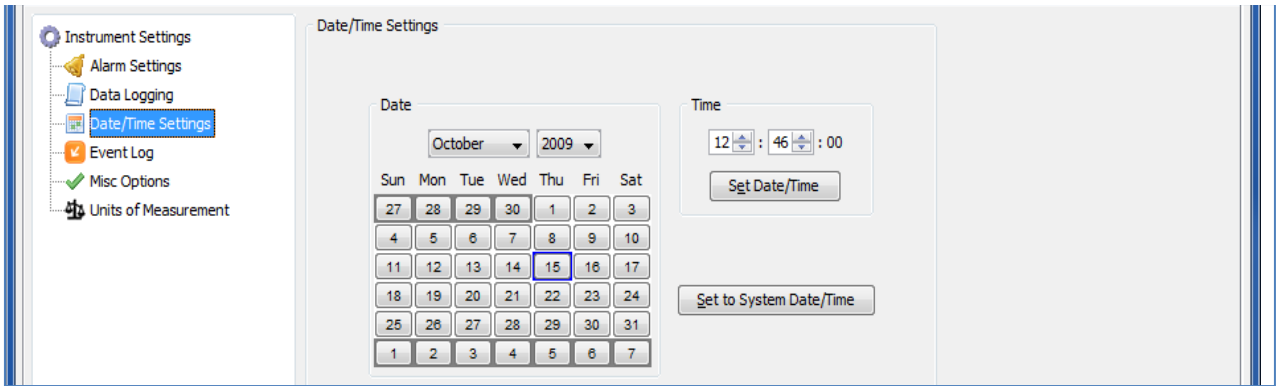
Note: This feature of the instrument is available in GA Operational Mode Only

Data Log ID
The Data Logging option allows the user to specify an ID to be associated to readings taken with the Auto-logging feature of the instrument.

Time Between Readings
This value indicates the time from when the pump stops running until the pump begins sampling.

Pump Running Time
This value indicates the duration the pump will be run for sampling.

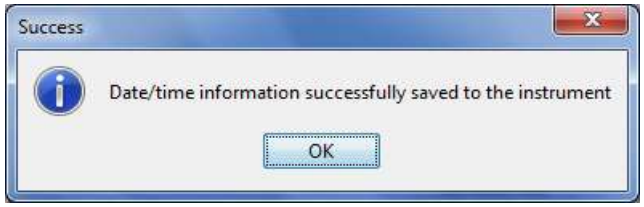
Date/Time Settings



The **Date/Time Settings** screen allows the user to set the date and time of the instrument.

Setting the Computer's Date and Time

To set the instrument's date and time to that of the computer, click on the Set to System Date/Time button.



Answer OK and the instrument's date/time will be set to that of the computer.

Date

Use the calendar options to select the desired date.

Time

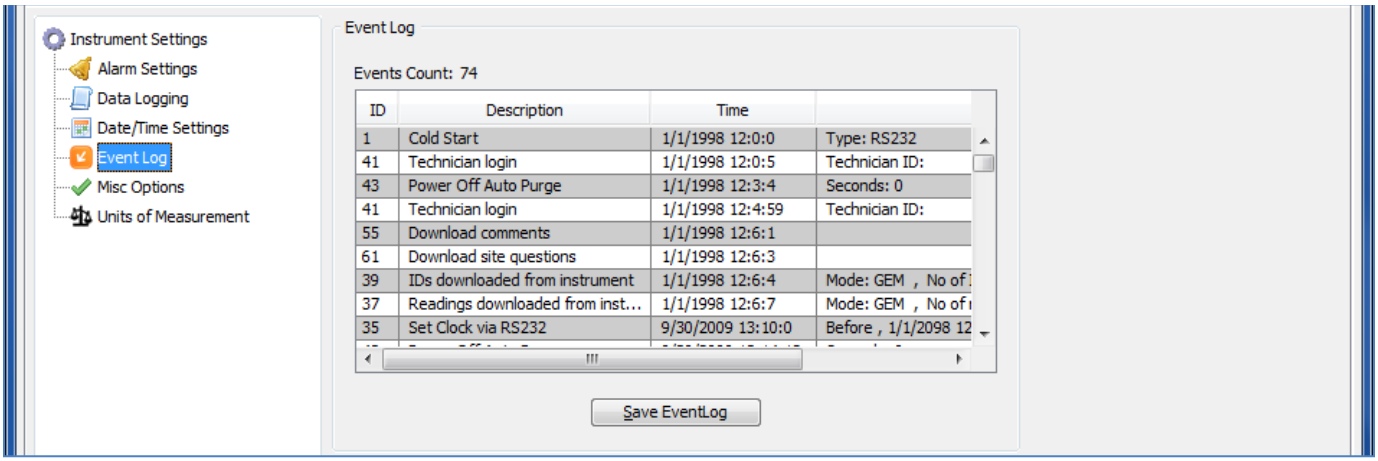
Use the up and down controls to select the desired hour and minutes.

Set Date/Time in the instrument

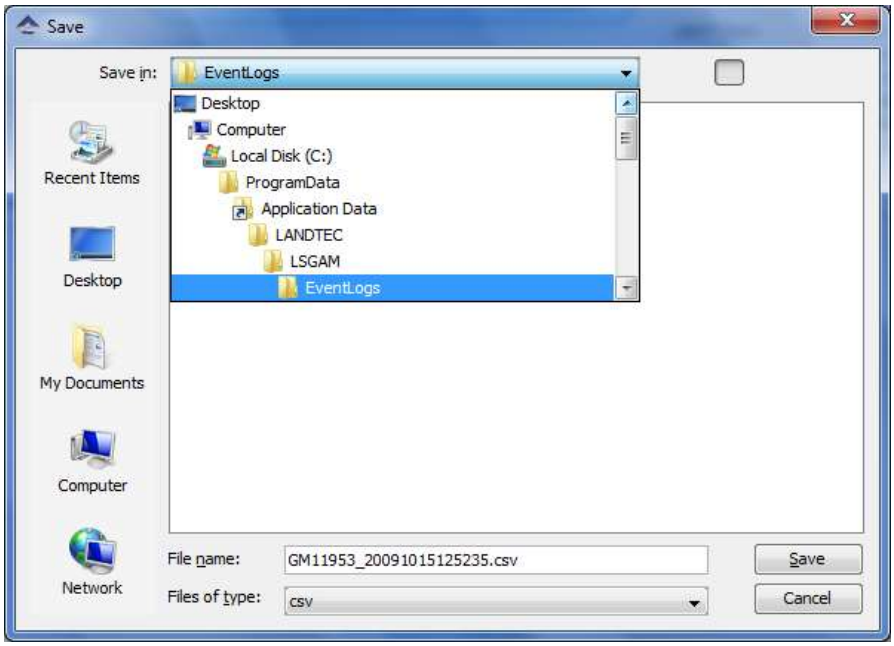
Click the Set Date/Time button to apply the settings to the instrument

Event Log

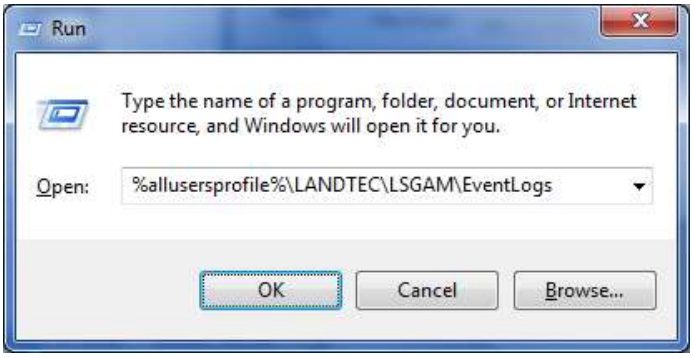
The instrument maintains an event log which records certain events that are not downloaded along with readings, IDs, or comments. In general, these events are useful for LANDTEC Service personnel when assisting in troubleshooting the instrument.



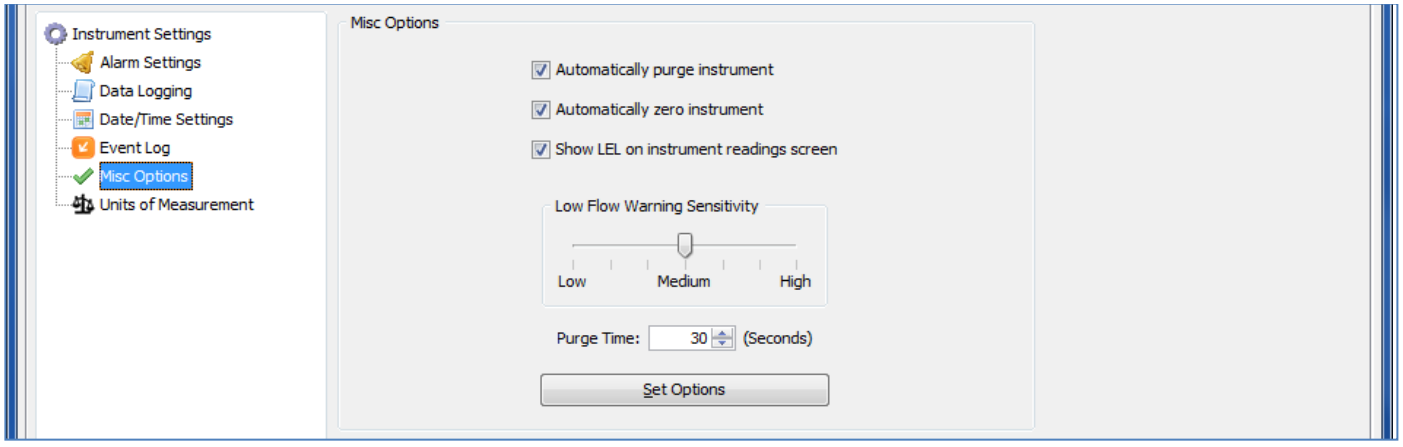
Clicking on the Save EventLog button will allow events to be saved from the instrument.



By default the location of the folder is the EventLogs for the data directory associated to LSGAM. This directory location changes depending upon your operating system but it can be found by typing the following in the Start Menu→Run box from windows.



2.10 Misc Options



Under the miscellaneous options interface the user can change the following instrument settings:

Automatically purge instrument
Activates and deactivates the automatic purge feature in the instrument

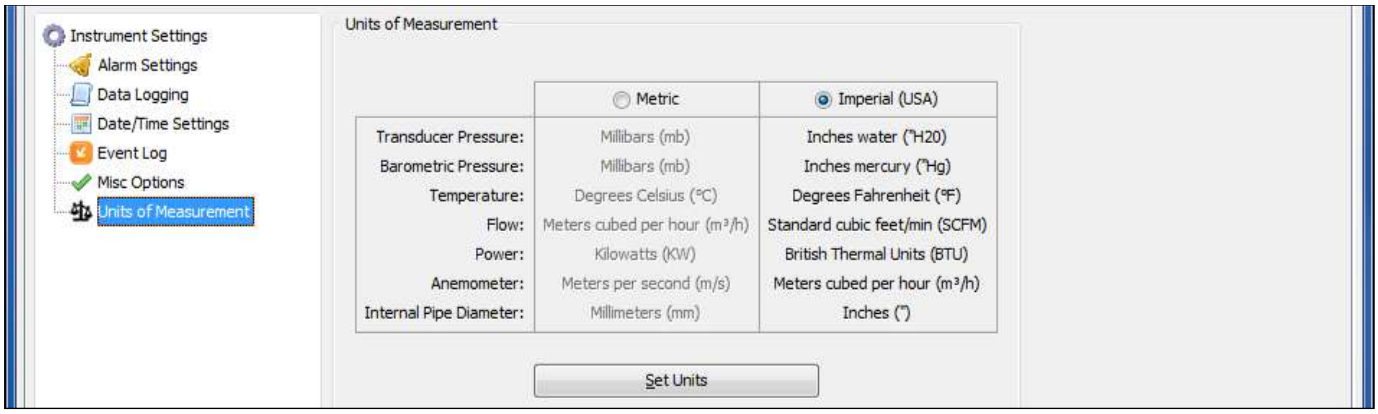
Automatically zero instrument
Activates and deactivates the automatic zero feature in the instrument

Show LEL on Instrument readings screen
Specifies whether or not Lower Explosive Limit (LEL) is displayed on screen, power instrument off and on for change to take effect.

Low Flow Warning
Specifies the point at which the instrument will "Flow Fail". If the instrument detects that it is not able to extract the appropriate gas flow for analysis the word "Flow" will flash in the upper left part of the screen where the pump timer is normally shown. If flow does not increase the pump will automatically be stopped. Adjusting the setting to "Low" will allow the pump to run with less flow going through the instrument. This may help avoid flow fail conditions when sampling from high vacuum systems.

Purge Time
Specifies the duration the pump will run when activated by the purge feature of the instrument.

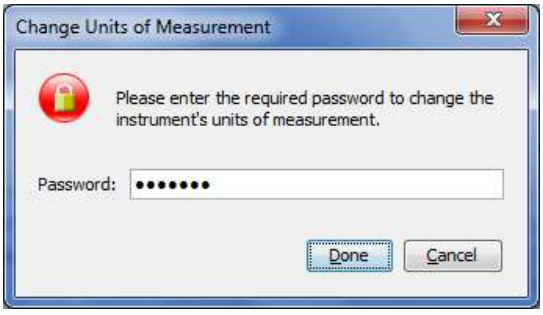
2.11 Units of Measurement



The Units of Measurement interface allows users to select whether to operate the instrument in metric or imperial units. The units for each parameter are displayed on the screen.

WARNING: *Units of Measure are as critical as the values of the readings stored. Be certain to verify the appropriate Units of Measure for your project prior to making a change to this option. Changing the Units of Measure will* ***NOT*** *convert any existing values stored in the instrument. To avoid confusion, download any stored readings prior the changing the Units of Measurement.*

Clicking on the Set Units button will bring up the Change Units Password box. I f you must change the units of measure please call LANDTEC's Software Support for a password.

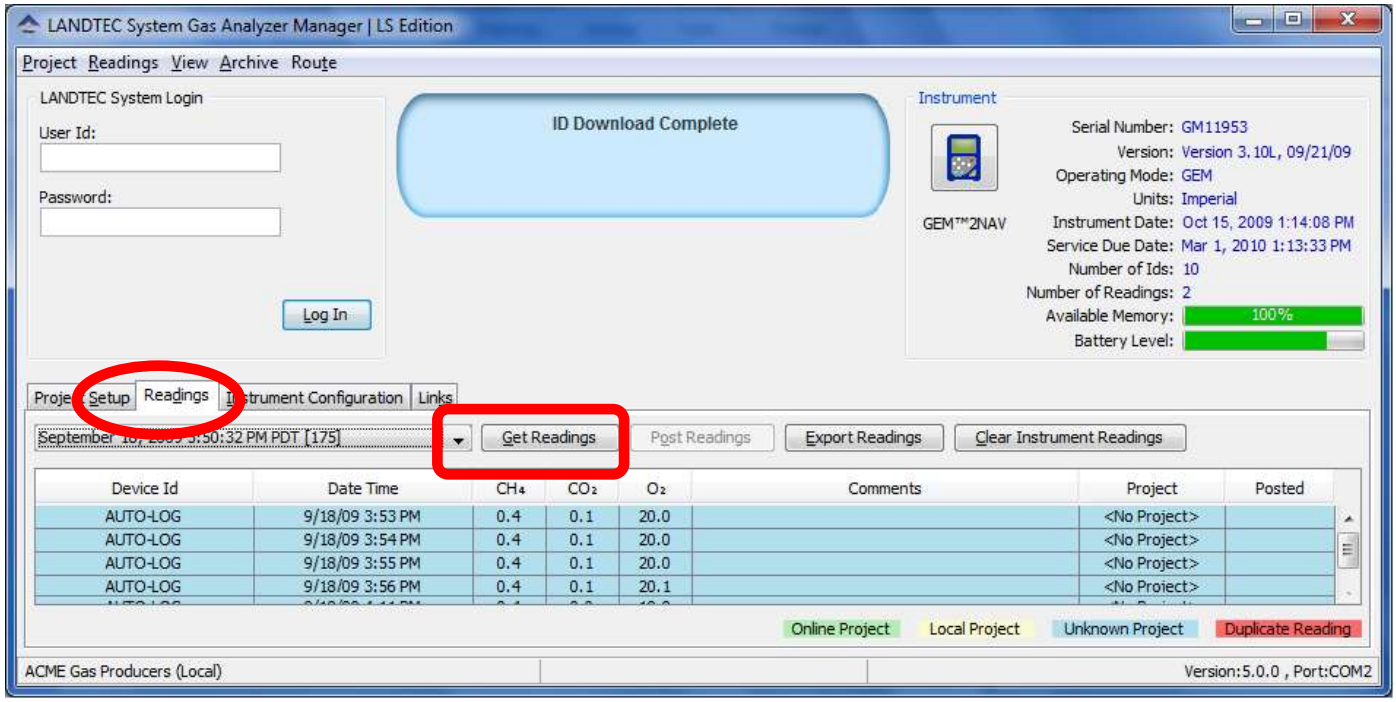


Upon entering the password you'll be prompted one last time to download your data from the instrument. If you have not downloaded your instrument press the No or Cancel buttons. Click Yes only if you have all data from your instrument as changing the units of measure must erase data that is in the instrument to ensure data integrity.

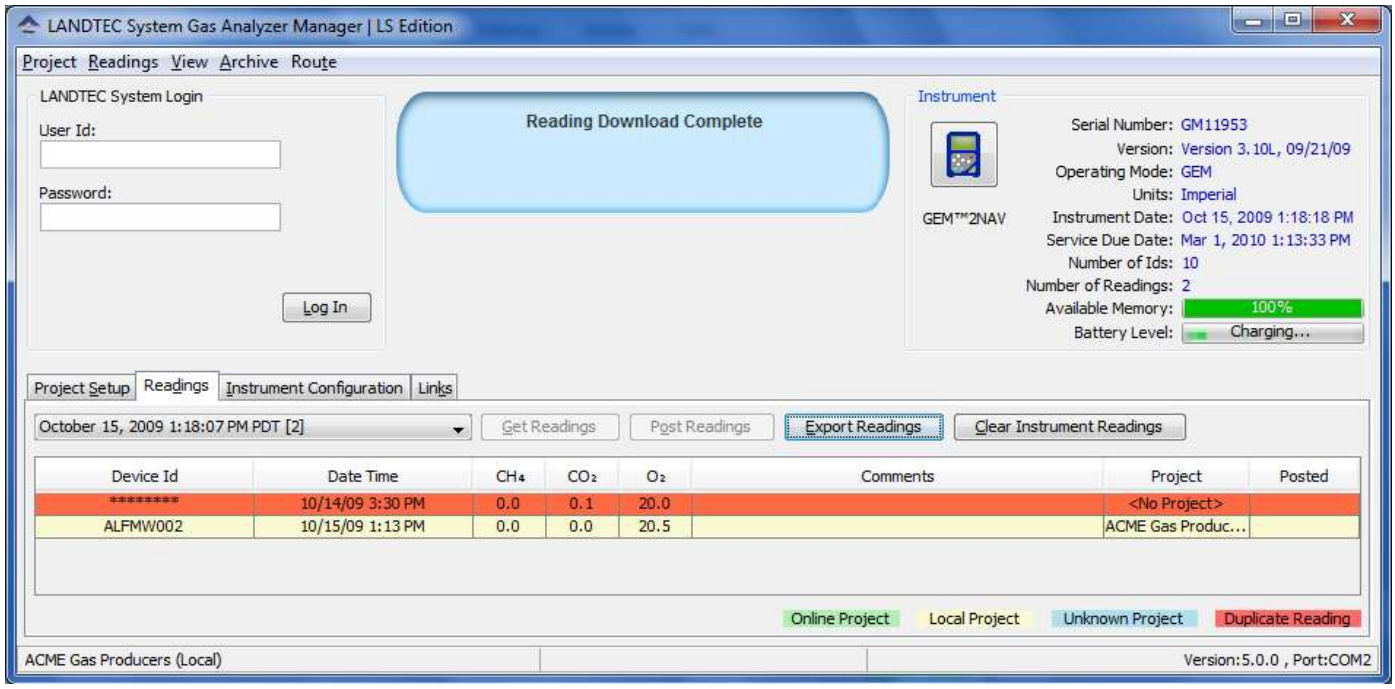
Downloading Readings

After successfully creating projects, IDs, and setting appropriate instrument settings, the instrument is ready for field use. When used in the field, ***readings*** are collected and stored within the instrument's memory. The readings consist of the measured, input, and calculated parameters such as CH_4, CO_2, O_2, Gas Temperature, Flow Rate, etc. These readings must be downloaded from the instrument to be reviewed on the computer and stored for review at a later time. This section of the Operation Manual reviews the process of downloading and storing readings from the instrument.

To view your readings from the instrument, select the Readings tab of the LANDTEC System Gas Analyzer Manager software. Then click on the Get Readings button

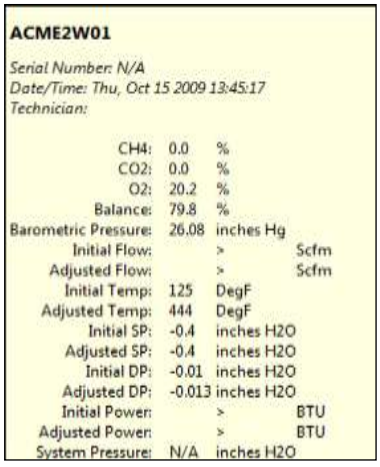


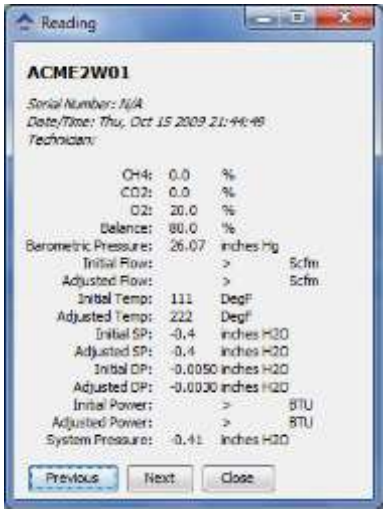
Note: Get Readings function only retrieves readings for the instrument's current mode of operation. If there are readings in both modes of operation (typically Probe Readings in GA mode and Well / Sample Port Readings in GEM mode) then Get Readings button will need to be pressed in each mode of operation to download all of the readings in the instrument.



When the instrument is initially detected by the LSGAM software, the Get Readings button will activate if there are readings in the instrument in the current mode of operation to be downloaded.

Placing your mouse over a reading will display additional parameters of the reading. As shown below on the left. Clicking on a reading will open a Reading details window and allow you to click through the readings one-by-one in detail by clicking the Previous and Next buttons.





Clear Readings

To clear the readings from your instrument, after the readings are downloaded successfully, click the ***Clear Instrument Readings*** button 

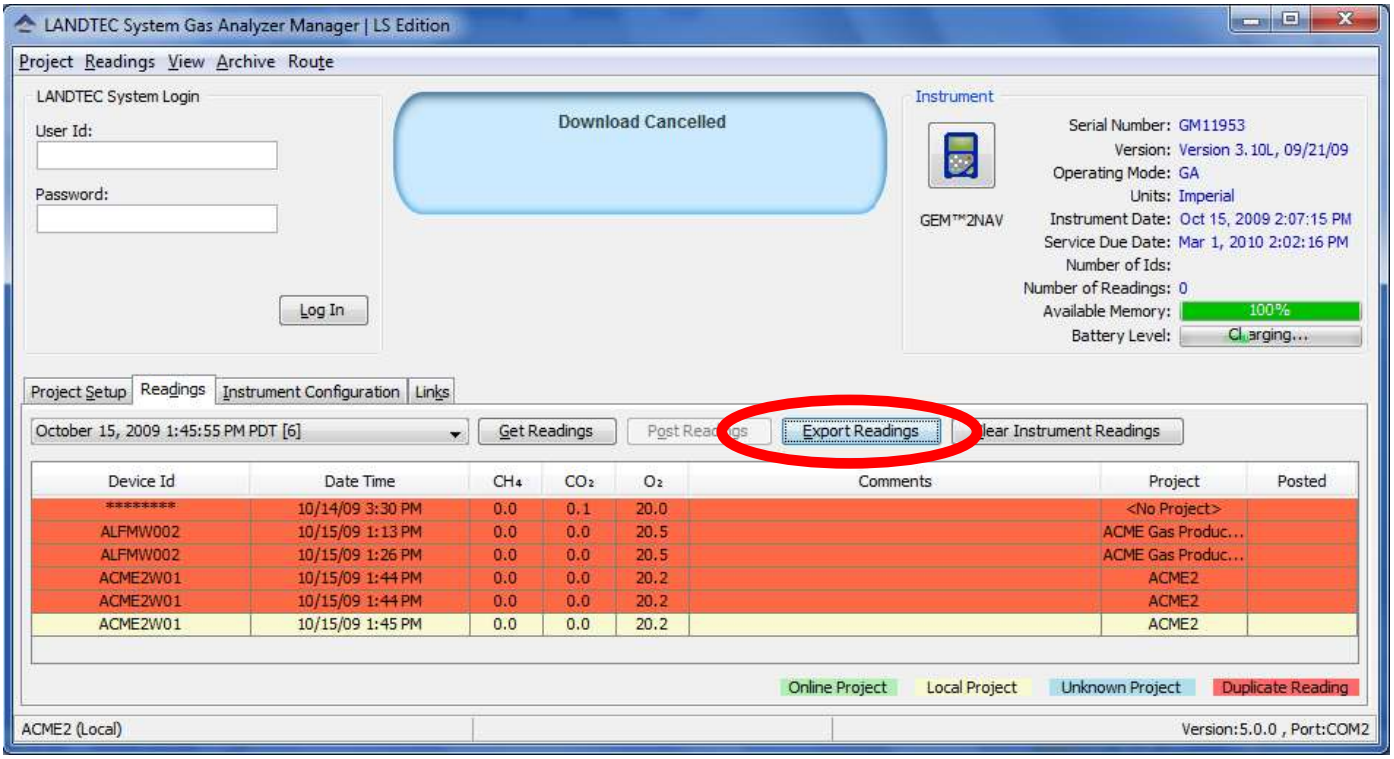
. A prompt will verify the permanent deletion of the readings from the instrument.

This will clear information within the GEM and GA Mode **simultaneously**.

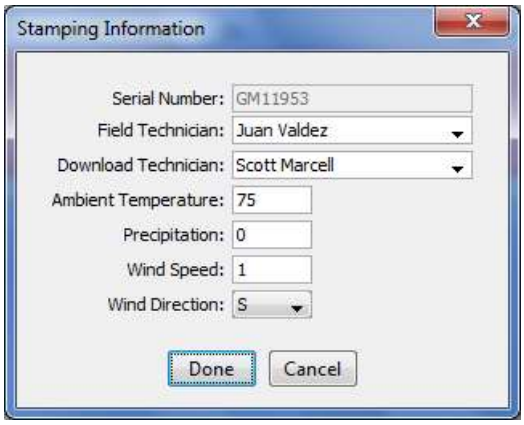
Note: Clicking yes will NOT check to ensure all data is saved from the instrument. If you plug in a GEM2xxx and click the Clear Instrument Readings button without first performing a Get Readings operation, data not previously downloaded will be lost!

Exporting Readings

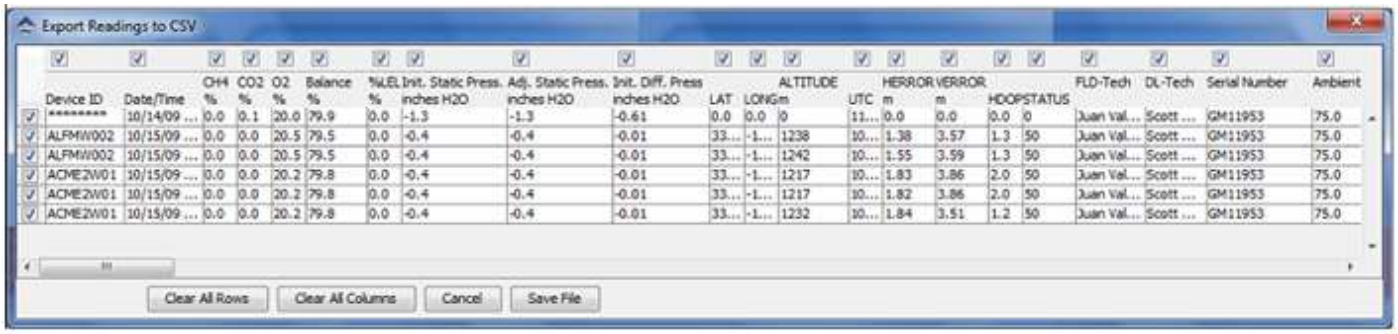
To export readings to a file, click the ***Export Readings*** button.



This will open the Stamping Information Screen. Stamping information are details that are most often stored with the historical data but not directly stored by the instrument. Detailed historical Stamping Information can assist when reviewing the data as atmospheric conditions do impact a gas system's production performance.



Clicking on Done will open the ***Export Readings to CSV*** screen.



Note: Depending upon your specific GEM2xxx Instrument model you will see additional fields specific to the instrument. For example GEM2NAV has the fields of Latitude, Longitude, Altitude, Herror, Verror, and HDOP Status that the other GEM2xxx models do not have.

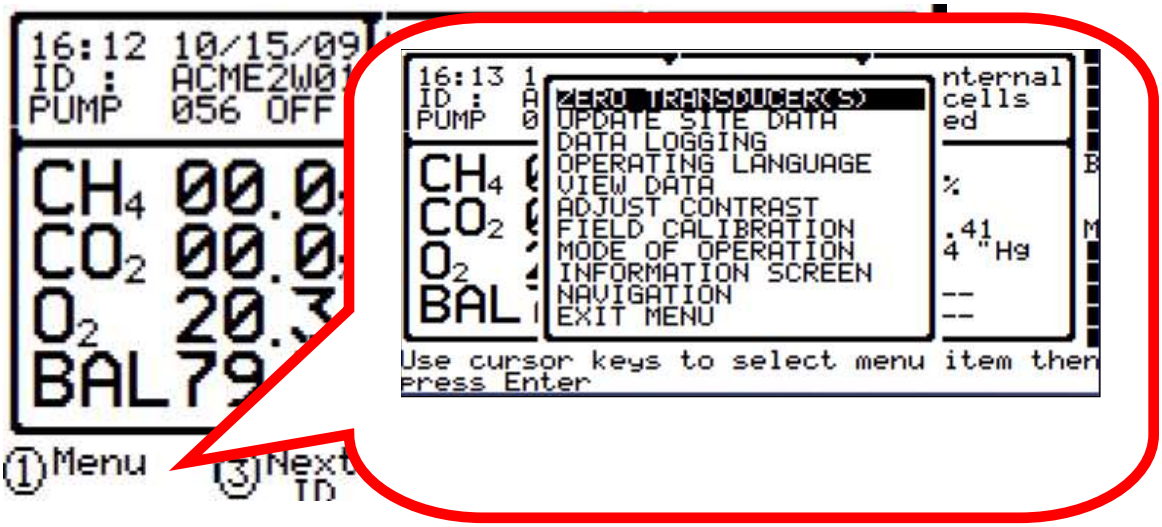
This interface provides several options described below.

- To add or remove a single reading from export, uncheck the checkbox in the leftmost column.
- To add or remove a specific parameter from export, uncheck the corresponding checkbox across the top.
- To clear all rows click the ***Clear All Rows*** button at the bottom of the screen. After Clearing all Rows you can the button will change and you can ***Set all Rows***
- To clear all column selections, click on the ***Clear All Columns*** button at the bottom of the screen. After Clearing All Columns the button will change and you can then choose ***Set All Columns***
- To exit the operation without saving, click the ***Cancel*** button.
- To specify a filename and save the selection to a file, click the ***Save File*** button. Clicking this button will open a Save window.

The save file dialog will open and default to the My Documents of the user who is currently logged in on the computer. Specify a filename and location then click the Save button. The selected readings will be saved in comma separated value (.CSV) format. The .CSV file may now be opened in another application such as Microsoft Office Excel or Open Office Calc.

General Operations Menu

The following features and functions are selectable from the main menu via key '① **Menu**' from the read gas levels screen. Navigation through the list is via the  and  cursor keys. Selection of the feature is by pressing the '↵' key.



2.12 Zero Transducers

This function allows the user to zero the pressure transducer(s). Upon selection, the current pressure reading is displayed. The operation will be carried out when the '↵' is pressed. When zeroing transducers it is important to allow them to stabilize first so an accurate zero is achieved. If ① is pressed the instrument will return to the gas reading screen without zeroing.

NOTE: Zeroing Transducers may take a few extra minutes in the field, but is a recommended step to

ensure the best possible accuracy.

2.13 Update Site Data

Allows the user to answer questions (pre-defined in LSGAM software) relating to the site (e.g. name of operator, weather conditions, etc.). Site Questions are different than ID Questions. Once answered, site answers to site questions will be associated with all subsequent readings until the instrument is turned off or the question answers are updated.

This is covered in detail in section 3.2 of this manual.

2.14 Data Logging (GA mode only)

Enables the user to leave the Instrument unattended to take samples at pre-determined intervals. The reading interval and pump run time may be edited prior to commencing the logging cycle. The ID code may ONLY be set in LSGAM communication software.

Once the logging function is activated, the instrument will carry out a 30 second 'Warm-up' countdown (displayed bottom right) and begin the first sample. After each sample, the unit will automatically sleep to conserve power if the time between the pump ending and the next sample is greater than 30 seconds.

The instrument is reactivated (awakened) during a logging cycle, the LANDTEC logo will be displayed for a few seconds and the Gas Reading screen will be displayed. This will initiate a 30 second countdown to the next sample being taken unless the operator stops the logging function. The data will be logged against the ID setup through LSGAM for the Data Logging function

2.15 Operating Language

The operating language of the instrument can be set to English, German, Spanish, French, Italian or Brazilian Portuguese through this option.

2.16 View Data

The view data allows the user to see the readings that are in the GEM2xxx memory. Often the amount of data stored is more than can be displayed adequately on one screen so pressing the ⑤ key will allow the user to see additional screens with stored data. The 2 '∧', 4 '**<**', 6 '**>**' and 8 '∨' cursor keys will move forward or backwards through the instruments memory. Pressing the ① key will exit to the Gas Reading screen.

2.17 Adjust Contrast

The GEM2xxx automatically adjusts the screen contrast according to the ambient temperature to maintain normal viewing.

The contrast can be manually adjusted by using the 4 '<' and 6 '>' cursor keys. The manual contrast setting is stored when the '↵' key is pressed.

2.18 Field Calibration

Whenever carrying out a user calibration function it is important to ensure the correct values are entered. Additionally, in the case of a zeroing function, ensure only certified gas or ambient air is used and no connection is made to a probe or wellhead fitting. Additionally, ensure the instrument is purged of any residual gas that may be inside the instrument prior to zeroing. Calibration cylinders are sold by LANDTEC. The regulator, sold by LANDTEC, is set to 0.5 liters per minute and 15 psig maximum. A normal field calibration usually requires the gas to be running for about two minutes.

Upon selecting this option, the Field Calibration screen is displayed. A brief description of the user span calibration procedure and the current reading (row '**a**') and user span calibration gas values (row '**b**') are

displayed.

The span gas values may be changed via the '③ **Edit Target Concentrations**' option. Once this option has been selected, **all** the gas values will require entry. Each entry is to be confirmed by pressing the '↵' key. It is important to confirm the concentration of the calibration gas(es) used and enter the value(s) properly.

The calibration menu has the following menu options:

2.18.1 Zero Channels

Selected from the '**Field Calibration**' - '↵**-Calibration Menu**' allows the relevant reading to be zeroed. When selected, a list of the available options will be displayed, this usually includes CH_4, and O_2, also the Gas Pod (if fitted).

Supply a zero gas mixture to the instrument for the gas to be zeroed. Ensure the reading for the selected gas has settled to its lowest value before selecting the zero function. When the required option is selected, the user zero function will be carried out automatically. The operation will be carried out when the '↵' key is pressed.

2.18.2 Span Channels

Spanning Channels should be carried out prior to use or when the ambient operating temperature changes greater than +/- 20 degrees Fahrenheit. Selected from the '**Field Calibration**' - '↵**-Calibration Menu**', allows the relevant reading to be span calibrated (in accordance with the calibration value entered). When selected, a list of the available options will be displayed, which includes CH_4, CO_2, O_2, (CO & H_2S internally for the Plus) and if an external Gas Pod is fitted (H2S, CO, SO2, H2, NO2, Cl2, or HCN).

When the required option is selected from the list, the span calibration function will be carried out automatically. When carrying out this procedure, ensure the span calibration procedure (as outlined below) is followed:

1. Apply the relevant known certified gas concentration through the inlet port of the Instrument.
2. Wait until the current gas reading has stabilized.
3. Select the required calibration option via the '↵**-Calibration Menu**'.

2.18.3 Factory Settings

This will clear any user zero and span calibration data. It will also restore the pre-programmed factory settings for **ALL** channels – CH_4, CO_2, O_2 (CO & H_2S for the Plus) or Gas Pod (if fitted) and pressure transducers.

2.18.4 Last Field Cal

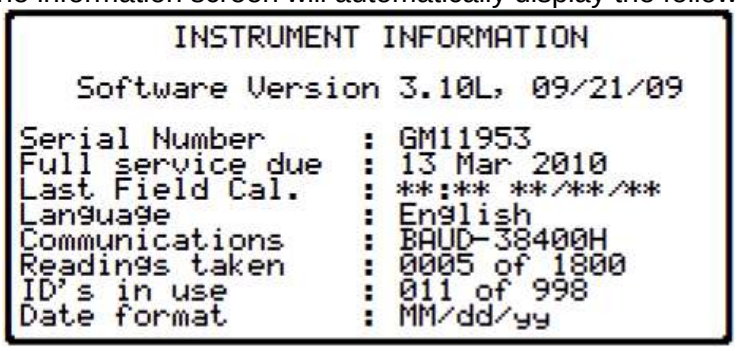
Displays the date the last field calibration was carried out (zero or span).

2.19 Mode of Operation

Allows changing instrument between GA mode and GEM mode of operation.

2.20 Information Screen

The information screen will automatically display the following information:



Navigation

Note: This menu item is specific to GEM2NAV instrument models.

This feature has two options Navigation Screen ON and Navigation Screen OFF. If the Navigation is turned ON, a navigation screen will appear after selecting a well ID. If the Navigation screen is OFF you will skip entering through the navigation screen. If all well locations are known, the user may choose to turn this feature off. Even if this feature is turned off, the GPS will record the related information with readings.

2.21 Exit Menu

The Exit Menu simply exits the main menu screen and returns to the gas reading screen.

3 Taking Probe Readings (GA Mode)

LANDTEC classifies non-extraction wells as Probes when **NOT** connected to an active vacuum extraction system. Probes, (commonly known as migration probes), are typically placed on the perimeter of the landfill in natural soil to test for sub-surface gas migration or may be placed next to a building or road to test for the presence of Methane. The GEM2xxx instruments may be configured as a Gas Analyzer (GA mode) for sampling probes. To access this function from the gas read screen press '①' for menu and scroll down to **Mode of Operation**, press the '↵' key and highlight **Landfill Gas Analyzer**, pressing the '↵' key again will select GA mode of operation.

3.1 Preliminary Checks

Prior to going to the test site, it is good practice to ensure:

- All necessary ID codes have been uploaded via LSGAM software.
- The time and date are correct.
- The water trap has a clean and dry filter fitted.
- The inlet-port particulate filter is clean and dry.
- A supply of spare filters is available in case of accidental water blockage or contamination.
- The battery has a good charge (minimum 25% charge, even if only a few readings are required).
- The memory has sufficient space available.
- The CH_4, CO_2, and O_2 (CO & H_2S for the Plus or Gas Pod if fitted) readings have been zeroed, without gas concentration present.
- Check the span calibration with a known concentration calibration gas.

Travel to the site with the analyzer in the vehicle's interior - not in the trunk or truck bed, where it may be subjected to extremes of temperature and possible shock damage. Do not place the analyzer against anything hot (e.g. gas extraction pipe, car body or in an unattended car during the summer). This may cause erroneous readings.

When moving around a site, protect the instrument from strong direct sunlight, heavy rain or wind-chill. Strong direct sunlight can raise the temperature of the instrument beyond its operating range. If this occurs, the LCD display will appear almost black and the contrast setting cannot alter the contrast. Typically no permanent damage is done and after the instrument cools the screen will become readable again.

Always use the water trap! If the water trap becomes flooded, change the filter immediately and ensure all tubes are clear before re-use.

3.2 Update Site Data

Prior to taking the readings at a particular site, the Site Questions and Technician Login should be updated. This is accessed via the General Menu '①' then **'Update Site Data'**. This function removes the need for the site conditions to be recorded manually.

A series of up to five questions can be pre-programmed using LSGAM, see Section 3.7. If Site Questions were uploaded to the instrument, they should be answered at this time. The answers are stored and appended to each reading stored thereafter, until the Site Data is updated for another site.

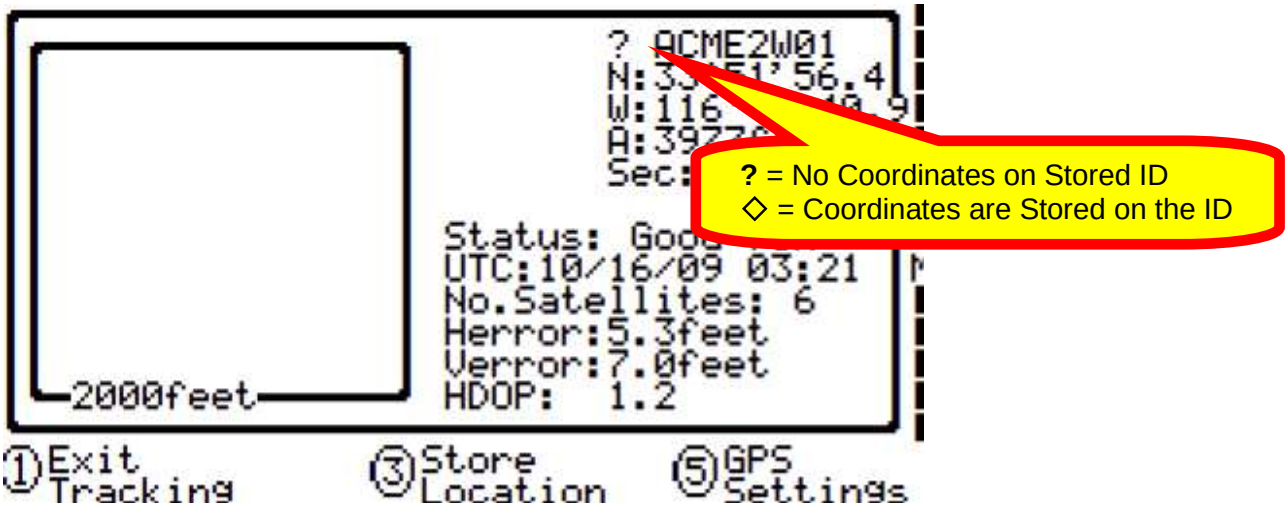
3.3 Taking Readings – With ID

For this function to be used it is essential that the relevant ID be previously uploaded to the Instrument using LSGAM, see Chapter 2 An ID **cannot** be created by the Instrument alone.

1. When the Read Gas Levels screen is displayed, option **'③ Next ID'** should be selected. A list of stored IDs is displayed for selection via the '∧' and '∨' cursor keys, the 'next' ID on the list is

automatically highlighted. To confirm selection, press the '↵ **Select ID**' key. The display may be toggled using the **'③ View ID Details'** to display any relevant ID information available; such as a description of the probe location, etc.

2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (default is 30 seconds). Once the '↵ **Start Purge**' key is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the '①**EXIT**' key.
3. The ID number selected and the pump runtime is displayed in the upper left corner of the read gas levels display.
4. On GEM2NAV models a Warning screen may appear before going to the GPS Tracking screen



If coordinates were stored with the ID in LSGAM, then a diamond symbol ('◇**'**) will appear before the ID. In front of the ID, a compass with an arrow will appear indicating the direction of the ID that you have selected. ⑤ **GPS Settings** will allow you to change the GPS Units of measure indicator and scaling values.

Once you have navigated to the well device you can press ① **Exit Tracking** to proceed to the gas reading screen.

5. At this point, connect the sample tube (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' into place. Then connect the sample tube to the probe sample port. **Do not connect the sample tube to the probe port before connecting to the instrument as this will cause any pressure in the probe to dissipate and a proper pressure reading will not be taken.**
6. As soon as the connection is made, the relative/static pressure reading will be displayed. No sample is taken from the probe at this time. Let the relative pressure reading stabilizes. When the pump starts, the relative/static pressure reading is stored. The relative/static reading will remain displayed as the pressure last taken.
7. The pump will run for the pre-programmed time and a countdown timer will be displayed. The pump may be stopped or started at anytime by way of the '✕' (pump) key. The reading may be stored at anytime with the use of the '↵' key. When the pump automatically stops this should be used as a prompt to store the reading.
8. Upon storing the reading, any pre-programmed questions will be displayed for response. This may require a numeric, alphanumeric selectable comment, or exclusive comment answer. A maximum of eight selectable and exclusive comments may be entered.
9. Disconnect the sample tubing from the probe and start again at Step 1 for the next probe.

For each reading, the following information will be stored:

- ID code.
- Current time/date.

- Site data (if entered).
- All gas readings and balance (CH_4, CO_2, O_2 (, CO and H_2S for the Plus)).
- LEL CH_4.
- Barometric Pressure.
- Relative Pressure.
- Questions/comments.
- Temperature (if temperature probe is connected).
- Gas Pod (if connected).
- Latitude (for GEM2NAV)
- Longitude (for GEM2NAV)
- Elevation (for GEM2NAV)
- UTC (for GEM2NAV)
- Herror (for GEM2NAV)
- Verror (for GEM2NAV)
- Number of Satellites (for GEM2NAV)

When the instrument is switched off, a clean air purge is automatically started for a pre-determined period. This may be aborted with the use of the '↵' key, although it is not recommended.

A tone will sound and a flashing bell will be displayed next to the appropriate gas reading value if a preset alarm condition has been exceeded.

3.4 Taking Readings – Without ID

Gas Readings can be taken without an ID in the instrument by following the instructions below. To create and uploaded IDs to the instrument using LSGAM, see Chapter 2. An ID **cannot** be created by the Instrument alone.

1. From the Gas Reading Screen first select **'③ Next ID'** then press **'⑤ Select No ID**' or, if ID information has not been uploaded to the instrument, an ID list will not be available. In either case, the ID will be displayed and stored as '**- - - - - - - -**'.
2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (default is 30 seconds). Once '↵' is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the '①**EXIT**' key.
3. On GEM2NAV instrument models the Tracking screen will appear if the Navigation Menu option is turned on. Since the reading will be taken without an ID you will not have coordinates for the device and the navigation compass will not be displayed. Press '①**EXIT Tracking**' key to continue to the gas reading screen.
4. At this point, connect the sample tube (with water trap) from the sample point to the inlet port of the instrument, ensuring the connector 'clicks' in to place.
5. Now connect the sample tube to the probe sample port. **Do not connect the sample tube to the probe port before connecting to the instrument as this will cause any pressure in the probe to dissipate and a proper pressure reading will not be taken.**
6. The pump may be started or stopped at anytime by way of the '✇' (pump) key and a 'time-on' timer will be displayed. The pump should always be stopped using the '↵' key, before storing a reading.
7. Upon storing the reading, a virtual keyboard will be displayed for any alphanumeric comments to be entered.
8. Disconnect the sample tubing from the probe and proceed from step 1 for the next probe.

Except for the ID code information, which will be stored as '**- - - - - - - -**', and probe questions, for each reading the information stored will be the same as that for a reading with an ID.

While taking a reading, a tone will sound and a flashing bell will be displayed next to the appropriate gas reading value if a preset alarm condition has been exceeded.

3.5 Temperature Probe Reading

The GEM2xxx has the facility to automatically display and record the probe temperature via an optional Temperature Probe (TP-2000). When the Temperature Probe is fitted to the Communication Socket, the temperature will be displayed in the read gas levels screen and recorded with all other data. The temperature probe is part of the GEM2xxx UL certification and is therefore certified for use under the same conditions as the instrument.

3.6 Cross-Gas Effects

3.6.1 Methane, Carbon Dioxide and Oxygen

Methane is measured using dual beam infrared absorption. The Methane reading is filtered to an absorption frequency of 3.41μm (nominal). Instruments are calibrated using certified Methane mixtures and will give correct readings provided there are no other hydrocarbon gasses present within the sample (e.g. ethane, propane, butane, etc.). If there are other hydrocarbons present, the Methane reading will be higher (never lower) than the actual Methane concentration being monitored.

The extent to which the Methane reading is affected depends upon the concentration of the Methane in the sample and the concentration of the other hydrocarbons. The effect is non-linear and difficult to predict. The instrument does not read total hydrocarbons. If other hydrocarbons are present in the sample gas a filter should be used to remove them and mitigate the cross gas effects. Typically trace levels of other hydrocarbons (<100ppm) will not induce a cross gas effect and do not require filtering.

The Carbon Dioxide reading is filtered to an infrared absorption frequency of 4.29μm (nominal), the frequency specific to Carbon Dioxide. Therefore, any other gases usually found on landfill sites will not affect the Carbon Dioxide reading.

The Oxygen sensor is a galvanic cell type and suffers virtually no influence from CO_2, CO, H_2S, SO_2 or H_2, unlike many other types of Oxygen cell.

The infrared sensors will not be "poisoned" by cross gas effects. Normal operation will resume as soon as the gas sample has been purged.

Note - there has been one reported incident of a high reading due to the presence of Carbon Disulfide, which has a similar absorption frequency to Carbon Dioxide.

3.6.2 H_2S, CO and other Optional Gas Pods

The Gas Pods used to measure H_2S and CO do suffer from cross-gas effects. Such effects are not accurately specified. However, the following table may be useful as a guide. This table represents how many ppm would be read by a Gas Pod if 100ppm of the interfering gas was applied, (with no other cross-contaminates being present in the sample).

Cell	CO	H_2S	SO_2	H_2	CH_4	CO_2
CO	100	<3/~300*	0	<40	0	0
H_2S	<0.5	100	~20	~0.1	0	0

* Indicates reading from pod not fitted with internal filter or after internal filter is saturated.

NOTE: All readings are given in parts per million (ppm). The life of an electrochemical cell is determined by exposure to gasses, typical life being one to two years. It is recommended that Gas Pods be field calibrated at regular intervals. Purge gas pods in the same manner as the instrument to help preserve their life.

NOTE: Cross-gas effects can be mitigated by employing a filter for the gas not being tested.

3.6.3 GEM2xxx Plus Internal Electrochemical Cells for Measuring H_2S and CO

The GEM2xxx Plus employs two internal electrochemical cells to measure Hydrogen Sulfide (H_2S) and Carbon Monoxide (CO). Electrochemical cells which measure CO are typically susceptible to cross gas interference by Hydrogen (H_2) and Hydrogen Sulfide (H_2S). Two components that may be present in the Landfill Gas sample. This means that if H_2 and/or H_2S are/is present in the Landfill Gas sample a normal CO electrochemical cell would give an artificially high reading.

The GEM2xxx Plus uses a 'hydrogen compensated' CO cell to counteract the interference by H_2. This is why the instrument displays an H_2 channel. H_2 is not directly measured, although a rough value, which is shown as LO, MED or HI, can be interpreted. If the H_2 value is displayed as LO or MED the H_2 compensation will mitigate the H_2 effect on the CO reading, however if the H_2 value is shown as high it is possible that there is more H_2 present than the compensation is capable of adjusting for. If that is the case the CO value may be artificially high due to cross gas interference by the H_2. Additionally, if a HI level of H_2 is encountered then a longer than normal purge time will typically be necessary to clear all the H_2 from the electrochemical cell. It is recommended that after encountering a HI level of H_2 the instrument be purged with clean air until the H_2 channel displays LO. This could take as long as five or ten minutes (if the H_2 channel was over ranged) but is necessary to ensure the subsequent readings are accurate.

The CO cell used in the GEM2xxx Plus also utilizes an internal H_2S filter to eliminate H_2S cross gas interference. However, the filter does have a finite capacity. If the filter's capacity is exceeded then the CO cell will be susceptible to cross gas interference by any H_2S that is present in the gas sample. It is quite easy to determine if the capacity of the filter has been exceeded. After all the sample gas has been purged from the instrument, with clean air, and the CO reading is zero, run a certified gas that contains H_2S but not CO (the H_2S calibration gas) through the instrument. If the CO reading remains zero while the H_2S reading increases to the certified value then the internal H_2S filter has remaining capacity. If the CO reading increases with the H_2S reading then the internal filter's capacity has been exceeded and the cell will need to be replaced.

The GEM2xxx Plus was designed to read a maximum H_2S concentration of 500ppm and a maximum CO reading of 2000ppm. If the gas sample contains more than the maximum concentration the instrument will be over ranged and display >>> as the reading. If the instrument is over ranged the readings typically stay artificially high for several minutes and will not go back to zero with a normal purge. While over ranging the instrument is not recommended and will slightly shorten the life span of the electrochemical cells the resulting high readings are not permanent. If one of the channels is over ranged it is recommended to purge the instrument, with clean air, until the reading returns to zero. This may take as long as five or ten minutes. The cell may need to be recalibrated but normally the extra long purge is all that is necessary.

4 Taking Extraction Well Readings (GEM Mode)

LANDTEC classifies gas-producing penetrations on landfills as wells when used with vacuum extraction systems and flow determining devices such as the ACCU-FLO wellheads, orifice plates or pitot tubes. The GEM2xxx instruments may be configured as a Gas Extraction Monitor (GEM mode) for the purpose of sampling wells and obtaining flow measurements. To access this function from the gas read screen press '①' and scroll down to **Mode of Operation**, press the '↵' key and highlight **Gas Extraction Monitor**, pressing the '↵' key again will select GEM mode of operation.

LANDTEC classifies monitoring points on the gas conveyance system not otherwise classified as a Well. Sample ports may have a flow device associated with them. For this reason, Sample ports are monitored in the same manner as well readings.

4.1 Preliminary Checks

Prior to going on site, it is good practice to ensure:

- All necessary ID codes and readings have been uploaded via LSGAM software
- The time and date are correct
- The water trap has a clean and dry filter fitted
- The inlet-port particulate filter is clean and dry
- A supply of spare filters is available in case of accidental water blockage or contamination
- The battery has a good charge (minimum 25% charge, even if only a few readings are required)
- The memory has sufficient space available
- The CH_4, CO_2 and O_2 (CO & H_2S for the Plus or Gas Pod if fitted) readings have been auto-zeroed without gas concentration present
- Check the span calibration with a known concentration calibration gas

Travel to the site with the analyzer in the vehicle's interior - not in the trunk or truck bed, where it may be subjected to extremes of temperature and possible shock damage. Do not place the analyzer against anything hot (e.g. gas extraction pipe, car body or in an unattended car during the summer). This may cause erroneous readings.

When moving around a site, protect the instrument from strong direct sunlight, heavy rain or wind-chill. Strong direct sunlight can raise the temperature of the instrument beyond its operating range. If this occurs, the LCD display will appear almost black and the contrast setting cannot alter the contrast. Typically no permanent damage is done and after the instrument cools the screen will become readable again.

Always use the water trap! If the water trap becomes flooded, change the filter immediately and ensure all tubes are clear before re-use.

4.2 Update Site Data

Prior to taking the readings at a particular site, the Site Data and technician login should be updated (if programmed). This is accessed via the General Menu '①'. This function removes the need for the site conditions to be recorded manually. A series of up to five questions can be pre-programmed with the use of LSGAM and answered at this time. The answers to these questions are stored and appended to each reading stored thereafter, until the site data is updated for another site.

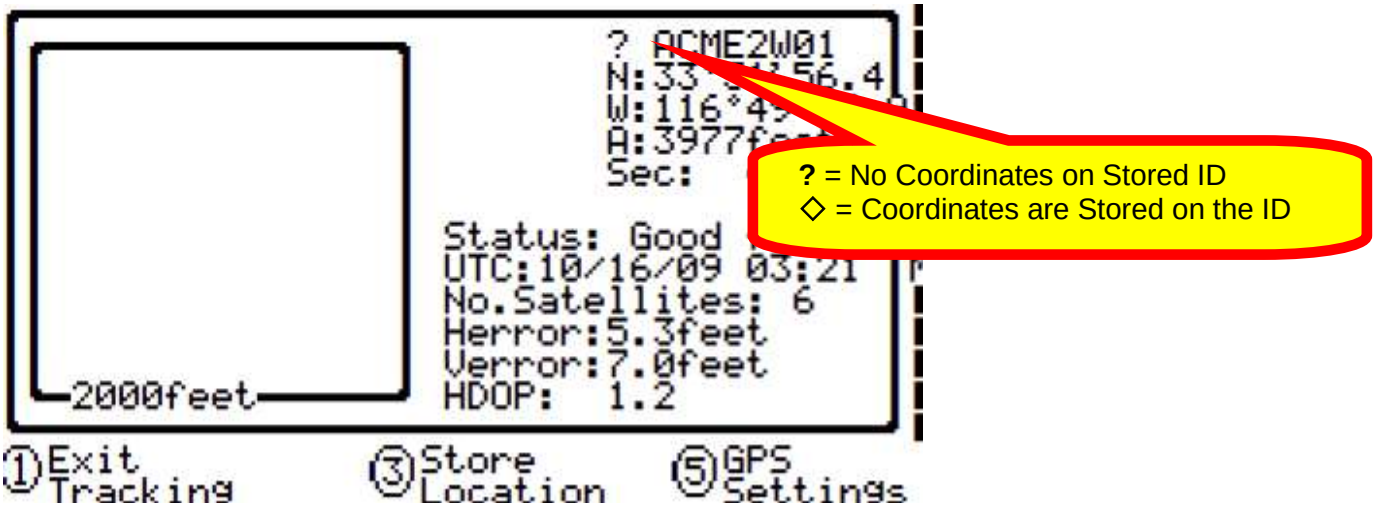
4.3 Taking Gas and Flow Readings (GEM Mode)

The GEM mode of operation is designed to allow for gas flow (SCFM) and energy measurements (BTU) to be calculated at the wellhead. This function requires the use of an ID that has been uploaded from LSGAM software with the correct type of flow device defined. **Gas flow and BTU will not be calculated if this action has not been performed.**

1. When the gas read screen is displayed select **'③ Next ID'**. A list of stored IDs will be displayed for

selection via the '∧' and '∨' cursor keys, the 'next' ID is automatically highlighted, to confirm the selection press the '↵' key. The screen may be toggled to display any relevant ID information such as a description of the well location, work to be carried out, etc.

2. A reminder is displayed to disconnect sample tubes, as a clean air purge will automatically remove the previous sample from the instrument. Purge time may be set via LSGAM (default is 30 seconds). Once the '↵' key is pressed, purge will begin and the Read Gas Levels screen will be displayed upon completion. The purge may be aborted by pressing the '①**EXIT**' key.
3. On GEM2NAV models a Warning screen may appear before going to the GPS Tracking screen



If coordinates were stored with the ID in LSGAM, then an diamond symbol ('◇') will appear before the ID. In front of the ID, a compass with an arrow will appear indicating the direction of the ID that you have selected. ⑤ **GPS Settings** will allow you to change the GPS Units of measure indicator and scaling values.

Once you have navigated to the well device you can press ① **Exit Tracking** to proceed to the gas reading screen.

4. Connect the sample tubes (with water trap filter) to the wellhead ensuring the gas sample tube and impact pressure tubes are properly oriented. Insert the temperature probe if used. *Note; a flashing bell will be displayed next to the appropriate gas and a beeping tone will be heard, if a preset alarm condition has been exceeded.*
5. Press the '⁂' key to start the sample pump; a countdown timer will be displayed in the upper left area of the display. The pump may be stopped and restarted and any time by pressing the '⁂' key. The pump run time is set in LSGAM software. Allow the gas readings to stabilize and press '⑤**Measure Flow**' key, this will store the gas level readings.
6. If a temperature probe is plugged in the temperature will automatically be recorded, otherwise a screen will appear prompting you to enter the gas temperature. Enter in the gas temperature manually if necessary and press the '↤**When Complete**' key.
7. If the flow device is set to user input then a screen prompting input of the flow will be displayed. Enter in the flow and then press the '↤**When Complete**' key.
8. The '**PRESSURE READINGS**' screen will now appear and prompt the user to disconnect the sample tubes and allow the pressure to stabilize. Once the pressure has stabilized press '↵ **Zero Transducers**'. Press '①' to continue. *Note: if ACCU-FLO wellheads are used this zero function may be performed prior to connecting the sample tubes to the well head by selecting '④ **MENU**' and highlighting '**ZERO TRANSDUCERS'.** This eliminates the need to disconnect and re-connect the sample tubes on the same wellhead.*
9. If a temperature probe is not connected, the user is prompted to manually input the gas temperature, press the '↵' key when entry is finished.
10. The gas flow and energy screen is now displayed showing all the gas level readings taken in the gas

read screen as well as the level of gas flow (SCFM) and power (BTU). In addition, Adjusted, Current and Previous (if not previously cleared from the instrument) readings are displayed so modifications may be made to the well if required.

11. If a device is setup containing "system pressure" then the System Pressure Readings screen will appear and prompt you to connect the instrument's static pressure hose to the sample port on the gas system side of the valve. Once the pressure is stored, press then '① **Continue'** key.
12. Pressing '↵ **STORE'** will save the readings to memory.
13. If questions were associated to the device, the questions/comments screen(s) will display and allow you to answer questions or select comments about the condition of the well. A total of seven comments and one exclusive comment may be stored with each ID.
14. Press '③ **NEXT ID**' and proceed to the next wellhead. An automatic purge will be performed at this time to ensure the sample has been exhausted from the instrument.

For each reading, the following information will be stored:

- Device ID code
- Current time/date
- Site Questions and Comments (if entered)
- All gas readings and balance gas (CH_4, CO_2, O_2 (CO & H_2S for the Plus Models))
- Barometric Pressure
- Temperature
- Gas Pod (if connected)
- Gas flow (SCFM)
- Power (BTU)
- Comments, Exclusive comments and Answers to Questions
- For GEM2NAV Models Only Relevant GPS information
    - Latitude
    - Longitude
    - Altitude
    - UTC
    - Herror
    - Verror
    - Number of Satellites

Upon switching the Instrument off, a clean air purge is automatically started for a pre-determined time period. This may be aborted by pressing the '↵' key, although this action is not recommend.

5 Field Operations

5.1 Landfill Gas Generation

A brief overview of the theory of landfill gas generation and Methane recovery follows. Initially, when decomposable refuse is placed into a solid waste landfill, the refuse is entrained with air from the surrounding atmosphere. Through a natural process of bacterial decomposition, the Oxygen from the air is consumed and an anaerobic (Oxygen free) environment is created within the landfill. This anaerobic environment is one of several conditions necessary for the formation of Methane-CH_4.

If Oxygen is reintroduced into the landfill, those areas are returned to an aerobic (Oxygen present) state and the Methane-producing bacteria population is destroyed. A period of time must pass before the productive capacity is returned to normal. Since there is some Methane of a given quality within the landfill void space, a decline in Methane quality is only gradually apparent depending upon the size of the landfill.

Carbon Dioxide is also produced under either an aerobic or anaerobic condition. Under static conditions, the landfill gas will be composed of roughly half Methane and half Carbon Dioxide with a little Nitrogen.

As air is introduced into the landfill, the Oxygen is initially converted to Carbon Dioxide and residual Nitrogen remains. Measurement of residual Nitrogen is usually a good indicator of the anaerobic state of the landfill; however, it cannot be directly measured. It can, however, be assumed and estimated using a subtraction basis as the balance gas. Hence, the measurement of Carbon Dioxide is an intermediary step. Because Carbon Dioxide levels may fluctuate depending on the changing concentrations of the other constituent gases, Carbon Dioxide levels are not evaluated directly but are considered in light of other data.

In evaluation of residual Nitrogen, allowances must be made if there has been any air leakage into the gas collection system or if there has been serious over pull. If enough air is drawn into the landfill, not all Oxygen is converted into Carbon Dioxide and the Oxygen is apparent in the sample. It is ideal to perform routine analysis of individual wells, as well as an overall well field composite sample, by a gas chromatography. This is not always practical at every landfill.

Under some conditions there may be a small amount of hydrogen in the LFG, (about 1 percent, usually much less). This may affect field monitoring response factors, but otherwise it can be ignored.

5.2 Subsurface Fires

If very large quantities of air are introduced into the landfill, either through natural occurrence or overly aggressive operation of the LFG system, a partly unsupported subsurface combustion of the buried refuse may be initiated. Subsurface fire situations are difficult to control or extinguish once started, present health and safety hazards, and can be quite costly. Therefore, prevention by good operation of the collection system and maintenance of the landfill cover is the best course of action. The presence of Carbon Monoxide, Carbon Dioxide, and Hydrogen Sulfide are indicators of poorly supported combustion within the landfill.

5.3 Techniques for Controlling Landfill Gas

There are many techniques for controlling landfill gas extraction. These techniques represent tools, which are used together to control landfill gas. The ACCU-FLO wellhead is designed to work with all of these techniques. Below is a discussion of the individual techniques, how to use them, and their limitations. Reliance on only a few of the techniques discussed can lead to misinterpretation of field data and improper operation of the well field. Later the best use of these techniques to optimize landfill gas control will be discussed.

5.3.1 Controlling by Wellhead Valve Position

Unless the valve handle is calibrated for a given flow rate, this method is unreliable. The position of the valve handle alone does not provide sufficient information about the well to control it. It is useful to note the relative position of the valve, and essential to know which valves are fully open or fully closed.

5.3.2 Controlling by Wellhead Vacuum

This technique relies on the relationship of well pressure/vacuum to flow for a given well. Reliance upon this method, however, can be misleading. This is because the square root relationship between flow and pressure is difficult to affect while performing day-to-day well field adjustments. As decomposition, moisture, and other conditions change, this method shows itself to be inadequate and imprecise.

5.3.3 Controlling by Gas Composition

This method determines Methane, Nitrogen (balance gas) and other gas composition parameters at wellheads and at recovery facilities using portable field instruments and, sometimes, analytical laboratory equipment. Complete knowledge of gas composition (i.e., major fixed gases: Methane, Carbon Dioxide, Oxygen and Nitrogen) is desirable. It is also necessary to check other gas parameters, such as Carbon Monoxide, to fully evaluate the condition of the well field. Reliance on this information can lead to improper operation of the well field. Indications of excessive extraction often do not show up right away. This method often leads to a cycle of damage to the Methane producing bacteria population and then to over-correction. This cycling of the well and producing area of the landfill is not a good practice. It leads to further misinterpretation of the condition of the well field and has a disruptive effect on the operation of the well field. The use of analytical laboratory instrumentation such as a gas chromatograph is a valuable supplementary tool to verify gas composition. This normally requires collection of samples at the wellhead and analysis at some fixed location where the equipment is located. The drawbacks of this method as a primary means of obtaining information for well field adjustment are the time expended, cost, and probably most important, responsiveness to the needs of the well field for timely adjustment. The laboratory equipment required is also very costly. Some analysis is recommended for verification of field readings from time to time. It is recommended a monthly sample of the composite gas be taken at the inlet to the flare or gas recovery facility.

5.3.4 Controlling by Flow Rate

This is a more exacting technique for determining and adjusting gas flow at individual wells. It requires using a fixed or portable flow measurement device at each wellhead to obtain the data needed to calculate volumetric (or mass) flow rates. It is normally convenient to use cubic feet per minute or per day, as a standard unit of measure for volumetric flow. It is important to distinguish between the volumetric quantity of landfill gas and the volumetric quantity of Methane extracted from each well and the landfill in total. The two variables are somewhat independent of each other and it is the total quantity of Methane extracted we are interested in. It is possible for the total quantity of landfill gas extracted to increase while the total quantity of Methane extracted decreases. To monitor this, the quantity of Methane extracted (LFG flow x percent Methane) or the quantity of BTUs recovered per hour (LFG flow x percent Methane x BTUs per cubic foot of Methane x 60 minutes per hour) can be calculated. It is conventional to measure BTUs per hour as a unit of time. There are approximately 1012 BTUs of heat per cubic foot of pure Methane (like natural gas), although this figure varies a little among reference texts.

Measuring flow is an essential part of monitoring and adjusting a well field. The well should be adjusted until the amount of Methane recovered is maximized for the long term. A greater amount of Methane or energy can usually be recovered over the short term; however, this ultimately leads to diminishing returns. This is seen in stages as increased CO_2 and gas temperature and later as increased Oxygen from well over-pull. In time, the Methane will also decline. This is the result of a portion of the landfill, usually at the surface, being driven aerobic. In this portion of the landfill, the Methane-producing bacteria will have been destroyed (due to the presence of Oxygen). With the Methane-producing capacity of the landfill reduced, the pore space in the area no longer producing may become filled with landfill gas equilibrating (moving in) from an unaffected producing area. This leaves the impression that more gas can be recovered from this

area, and may lead to the operator opening the well or increasing flow.

5.4 Well field Monitoring

The frequency of LFG well field monitoring varies depending upon field requirements and conditions. Normal monitoring frequency for a complete field monitoring session with full field readings (suggested normal and abbreviated field readings list follows) will vary from typically once a month to once a week. Well field monitoring should not normally be extended beyond one month. The importance of regular, timely monitoring cannot be overemphasized.

5.5 Typical Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Carbon Dioxide (CO_2)
- Balance Gas (primarily Nitrogen N_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM2xxx or magnehelic) or other device(anemometer/velometer)
- Velocity head (P or PT) (from GEM2xxx or pitot tube and magnehelic)
- Wellhead gas flow (from GEM2xxx, or pitot tube & magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Calculation of each well's LFG and Methane flow and sum total
- Observations/comments

Additionally, Carbon Monoxide (CO) or Hydrogen Sulfide (H_2S) readings may be taken if problems are suspected. Supplementary monitoring once to several times a week may be performed using an abbreviated form of field readings.

5.6 Abbreviated Field Readings

- Name of person taking readings
- Date/time of each reading
- Methane (CH_4)
- Oxygen (O_2)
- Wellhead gas temperature (flowing)
- Ambient air temperature
- Static pressure (PS) (from GEM2xxx or magnehelic)
- Velocity head (P or Pt) (from GEM2xxx or pitot tube and magnehelic)
- Wellhead gas flow (from GEM2xxx, or pitot tube and magnehelic, or anemometer/velometer)
- Wellhead adjustment valve position (initial and adjusted)
- New wellhead vacuum and flow information after adjustment
- Observations/comments

Line vacuums and gas quality may be taken at key points along the main gas collection header and at subordinate branches. This helps to identify locations of poor performance, excessive pressure drop, or leakage. Perform systematic monitoring of the well field, taking and logging measurements at each wellhead and major branch junction in the collection system.

During monitoring, examine landfill and gas collection system for maintenance issues. Record needed maintenance or unusual conditions. Examples of unusual occurrences or conditions are unusual

settlement, signs of subsurface fires, cracks and fissures, liquid ponding, condensate/leachate weeping from side slopes, surface emissions and hot spots, and liquid surging and blockage in the gas collection system. Field readings should be kept in a chronological log and submitted to management on a timely basis.

5.7 Well Field Adjustment Criteria

There are several criteria used in well field adjustment. The primary criterion is Methane quality. Methane quality is an indicator of the healthy anaerobic state of the landfill and thus proper operation of the LFG collection system. However, a decline in the healthy productive state of the landfill is usually not immediately apparent from Methane quality. Due to this, several criteria must be considered at once.

Conditions within the landfill favor Methane production. Following are well field adjustment criteria and typical conditions for consideration:

- Methane quality (ranging from 26 percent upwards)
- pH
- Temperature
- General overall quality
- Moisture conditions
- Waste stream characteristics
- Placement chronology
- Insulation characteristics
- Oxygen quality (ranging below 1 percent, preferably less then ½ percent)
- Landfill cover porosity and depth in the proximity of the well
- Landfill construction factors including:
- Type of fill
- Size and shape of refuse mass
- Depth of fill
- Compaction
- Leachate control methods
- Seasonal, climatic, geographical, and recent weather, or other considerations, including seasonally arid or wet conditions, precipitation, drainage, groundwater
- Surrounding topography and geologic conditions
- Proximity of the well to side slopes (within 150 to 200 feet and less may require conservative operation of the well)
- Nitrogen (typically 8 to 12 percent and less)
- Temperature (between ambient and about 130 °F)
- LFG and Methane flow from the wellhead
- Design of the gas collection system
- Landfill perimeter gas migration and surface emission control, or energy recovery objectives
- Diurnal fluctuation (day to night) of atmospheric pressure

5.8 Establishing Target Flows

The goal is to establish a target flow which will likely produce the best possible Methane quality and minimum Oxygen levels while maximizing the recovery of landfill gas. Typically, small adjustments are made in flow to achieve and maintain quality objectives. The well must not be allowed to over pull. High well temperatures, (130° to 140°F and greater), are an indication of aerobic activity and, thus, well over-pull. These effects may not be immediately apparent.

Well adjustment should be made in as small an increment as possible, preferably an increment of ten percent of the existing flow or less. There may be obvious conditions when this is not appropriate, such as

when first opening up a well or when serious over-pull is recognized. Every effort should be made to make adjustments and operations as smooth as possible. Dramatic adjustments, or operating while switching between a high flow mode and a well shutoff mode, should be avoided.

5.9 Well Field Optimization

Every effort should be made to continuously locate and correct or eliminate conditions (e.g., gas condensate, surging and blockage, settlement, etc.), which inhibit efficient operation of the gas collection system. This allows well monitoring and adjustment to be significantly more effective.

5.10 Migration Control—Dealing with Poor Methane Quality

If Methane and Oxygen quality objectives cannot be maintained at a given well, such as a perimeter migration control well, then an attempt should be made to stabilize the well as closely as is practical, avoiding significant or rapid down trending of Methane or up trending of Oxygen.

It is not uncommon for perimeter migration control wells to be operated at less than 40 percent Methane or greater than one-percent Oxygen. It should be recognized that these wells are likely in a zone where some aerobic action is being induced, and that there is some risk of introducing or enhancing the spread of a subsurface fire. Sometimes a judicious compromise is necessary to achieve critical migration control objectives or because existing conditions do not allow otherwise. Such situations should be monitored closely.

5.11 Well Field Adjustment—Purpose and Objectives

The objective of well field adjustment is to achieve a steady state of operation of the gas collection system by stabilizing the rate and quality of extracted LFG in order to achieve one or several goals. Typical reasons for recovery of LFG and close control of the well field are:

- Achieve and maintain effective subsurface gas migration control.
- Achieve and maintain effective surface gas emissions control.
- Assist with proper operation of control and recovery equipment.
- Avoid well “over-pull” and maintain of a healthy anaerobic state within the landfill.
- Optimize LFG recovery for energy recovery purposes.
- Control nuisance landfill gas odors.
- Prevent or control subsurface LFG fires.
- Protect structures on and near the landfill.
- Meet environmental and regulatory compliance requirements.

Well field adjustment is partly subjective and can be confusing because it involves judgment calls based on simultaneous evaluation of several variables, as well a general knowledge of site specific field conditions and historical trends. Well field evaluation and adjustment consist of a collection of techniques, which may be used, in combination, to achieve a steady state of well field operation.

6 Troubleshooting

Problem	Corrective Action/Reason
Unit does not turn on or operation is erratic	Battery charge is too low-recharge batteries. Unit is too hot - cool down unit and try again. Contact Factory Service.
"Flow Fail" is displayed and an audible alarm is heard	The inlet is blocked. Remove blockage and retry. The particulate filter or water trap filter needs replacing.
Readings taken are not what was expected	Unit may be out of calibration. Calibrate unit with known gas concentration. Water trap or particulate filters are clogged. Replace filter(s).
Readings swing up or down wildly as they are being taken	Cell phones and other sources of RF interference can affect Methane readings. Don't use your cell phone while taking readings.
Unit displays***** or >>>>>	These symbols are substituted when the measured reading is out of range of the instruments capabilities in some fields or when a value needs to be entered manually such as temperature.
Oxygen reading is high on all wells	Check that the water trap housing is screwed on tight. Check or replace O-rings on the water trap and instrument inlet. Check the wellhead inset for cracks, replace O-ring on insert. Field calibrate Oxygen channel.
Unit will not download readings or an error occurs while downloading.	Verify that the communications software is the right version for the instrument being used. Check that the proper serial port is selected in the software. Contact Factory Service.
Methane and Carbon Dioxide readings drift	Perform a field calibration and check well again. Verify cal gas is flowing when regulator is turned on. Verify all connections are tight and filters are not clogged. Contact Factory Service.
Oxygen readings drift	Perform a field calibration - zero and span. Contact Factory Service.
Black screen displayed when unit turned On	Charge unit over night and try again. Unit too hot - cool down and try again. Try adjusting contrast level. Contact Factory Service.
Nothing happens when the Gas Pod is installed	Remove and re-seat the Gas Pod. Contact Factory Service.
Temperature does not update when temperature probe is installed	Check the probe fitting is fully seated. Check the probe plug is screwed together tightly. Contact Factory Service.

7 Service & Maintenance

7.1 Factory Service

LANDTEC Facilities are the ONLY authorized service centers for the GEM™ Family of instruments. LANDTEC offers a several service plans to facilitate your bi-annual Factory Servicing of the instrument. Please contact your LANDTEC representative for more information on the service plan that best fits your specific needs. Factory Service includes but is not limited to the following;

General operations
The main functions of the gas analyzers operation are checked to ensure that they are within specification.

Barometric pressure reading
The barometric pressure reading is checked to ensure it is within specification. This is carried out by way of comparing the atmospheric reading against a known standard. If necessary, reprogramming is quoted.

Static and differential pressure readings
The static and differential pressure transducers are checked to ensure they are within specifications. This is carried out by comparing instrument readings to a known standard, applying a known pressure and noting both readings. If necessary, reprogramming will be quoted.

Pump functionality (flow and vacuum)
All flow and vacuum functions of the internal pump are checked to ensure the operation is within specification.

Water ingress/blockage
The internal filters are checked for cleanliness and moisture ingress to ensure they are not contaminated.

Flow fail setting
The flow fail function is checked to ensure proper operation within the specified limits.

Gas pod and Temperature probe connectivity reading
The connectivity of the gas analyzer is checked to ensure correct operation and reading performance with accessories.

Computer controlled gas check
Inward and outward gas checks are carried out by way of connecting the gas analyzer to a custom built computer controlled calibration chamber and proprietary software. At the inward stage, two sets of readings are taken - one using the customer's calibration settings and a second set using factory calibration settings. During this process a range of gases are used that span the reading range of the gas analyzer.

Structural and aesthetics check
The instrument is checked for cracks, scratches and broken or missing pieces.

7.2 Factory Service Facilities

LANDTEC North America
850 S. Via Lata, Suite 112
Colton, CA 92324
USA
Sales Tel: +1 (800) 821-0496 or +1 (909) 783-3636
Service Tel: 1 (909) 783-3636 x6141
Web: www.LANDTECNA.com

LANDTEC Europe
Formerly Geotechnical Instruments
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Tel: +44(0)1926 338111
Web: www.geotech.co.uk

LANDTEC South America
LANDTEC Produtos e Servicos Ambientais Ltda.
Rua Pedroso de Carmargo, 237 - Chácara
Santo Antonio - SP/SP CEP 0417-010
Brazil
Phone: +55(11) 5181-6591
Web: www.landtecbrazil.com.br

7.3 User Maintenance

This instrument is designed to be low maintenance and rugged. However, field calibrations are recommended prior to use or when the ambient operating temperature of the instrument changes more than +/- 20 degrees Fahrenheit. See section 2.18 for further information on field calibrations. Additionally, it may be necessary to change the user accessible filters and o-rings from time to time.

There are two user accessible filters, the particulate filter is located in the back of the instrument, see section 1.1 for location, and the water trap filter which is part of the included hose kit. There are four user changeable o-rings, one on the particulate filter cover, one on the outside of the water trap filter housing, one on the inside of the water trap filter housing, and one on the ends of each male quick connect fitting included on the hose kits.

Note: The o-rings on the male quick connect fittings should be routinely checked as dust and dirt from the various wells they connect to can be abrasive. A damaged or leaky o-ring may allow air intrusion into your gas sample. This intrusion of air may not be noticed when calibrating the instrument because the calibration does not occur under vacuum.

Technical Specifications

7.4 Physical

Weight	4.4 lbs.
Size	L 2.48" x W 7.48'' x D 9.92".
Case material	Anti-static ABS.
Keys	Membrane panel.
Display	Liquid Crystal Display 40 x 16 characters. Fiber optic woven backlight for low light conditions.
Filters	User replaceable integral fiber filter at inlet port and external PTFE water trap filter.

7.5 General

Certifications	UL Certified to Class 1, Zone 1, AEx Ib d IIa T1
Temperature measurement	With optional probe 14°F to 167°F.
Temperature accuracy	±0.4ºF (± probe accuracy).
Visual and audible alarm	User selectable CO_2, CH_4 and O_2 Min/Max levels via LSGAM CS software.
Communications	RS232 protocol via download lead with variable baud rate.
Relative pressure	±250 mbar from calibration pressure

7.6 Power supply

Battery type	Rechargeable Nickel Metal Hydride battery pack containing six 4AH cells. **Not user replaceable**. Lithium Manganese battery for data retention.
Battery life	Typical use 10 hours from fully charged condition.
Battery charger	Separate intelligent 2A battery charger powered from AC voltage supply (110-230V).
Charge time	Approximately 2 hours from complete discharge.
Alternative power	Can be powered externally for fixed-in-place applications only. Contact LANDTEC for further information.
Battery lifetime	Up to 1,000 charge/discharge cycles.

7.7 Gas Ranges

Detection principle	CO_2 and CH_4 by dual wavelength infrared cell with reference channel. O_2 (and CO & H_2S in Plus) by internal electrochemical cell. The gas sample is not dried or adjusted for Gas Humidity and therefore is on a wet basis.
Oxygen cell lifetime	Approximately 18 months in air.

<table>
<tr><td>Typical Accuracy
0 - Full Scale</td><td>
<table>
<tr><th>Gas</th><th>0-5% volume</th><th>5-15% volume</th><th>15%-FS</th></tr>
<tr><td>CH_4</td><td>±0.3%</td><td>±1%</td><td>±3%</td></tr>
<tr><td>CO_2</td><td>±0.3%</td><td>±1%</td><td>±3%</td></tr>
<tr><td>O_2</td><td>±1%</td><td>±1%</td><td>±1%</td></tr>
<tr><td colspan="4">H_2S in Plus Instruments ±10%FS from 0-Full Scale</td></tr>
<tr><td colspan="4">CO in Plus Instruments ±10% of reading or 15ppm whichever is greater</td></tr>
</table>
</td></tr>
<tr><td>Response time, T90</td><td>CH_4 ≤20 seconds
CO_2 ≤20 seconds
O_2 ≤20 seconds</td></tr>
<tr><td>Range</td><td>CH_4 0-100% reading.
CO_2 0-100% reading.
O_2 0-25%
CO (in Plus Instruments) 0-2000ppm
H_2S (in Plus Instruments) 0-500ppm</td></tr>
</table>

7.8 Pump

Typical flow	300 cc/min.
Flow fail point	Adjustable, approximately 50 – 250 cc/min.
Flow with 200 mbar vacuum	250 cc/min approximately.
Vacuum	100 inches H_20.

7.9 Operating Conditions

Operating temp range	32°F to 104°F.
Relative humidity	0-95% non-condensing.
Atmospheric pressure range	700-1200 mbar. Displayed in Inches of Mercury (5.9 – 35.4“Hg). Not corrected for sea level.
Atmospheric pressure accuracy	±5 mbar approximately.
Case seal	IP65.

7.10 Optional Gas Pods

<table>
<tr><td>Typical Accuracy
(Subject to User calibration).</td><td>Gas 0-Full Scale
CO ±10% FS
H_2S ±10% FS
SO_2 ±10% FS
H_2 ±10% FS
HCN ±10% FS</td></tr>
<tr><td>Response time, T90</td><td>CO ≤60 seconds
H_2S ≤60 seconds
SO_2 ≤60 seconds
H_2 ≤60 seconds
HCN ≤60 seconds</td></tr>
</table>

Range	CO	0-500ppm
	H_2S	0-50 or 0-200ppm
	SO_2	0-20 or 0-100ppm
	H_2	0-1000ppm
	HCN	0-100ppm

7.11 Regulatory Compliance Labels and Statements

The device has the following safety and non-hazardous parameters:

Terminal Nos	Ui	Ii
Connector A:	6V	
Connector B	14 V	100 mA
or	11 V	2.25 A

Underwriters Laboratories Inc. (UL) has not tested the performance or reliability of the Global Positioning System (GPS) hardware, GPS operating software or other GPS-related aspects of this product. UL has only tested for the explosion, fire, shock and casualty hazards required by the applicable hazardous locations standards. UL certification does not cover the performance or reliability of the GPS hardware, GPS operating software or other GPS-related aspects of this product.

UL MAKES NO REPRESENTATIONS, WARRANTIES OR CERTIFICATIONS WHATSOEVER REGARDING THE PERFORMANCE OR RELIABILITY OF ANY GPS RELATED FUNCTIONS OF THIS PRODUCT

Appendix B. Field Forms

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Daily Field Report

Project No. 14-05904-000

(1) Day _____ Date | | | | | | | Work Period _____ AM to _____ PM Report No. _____

Weather _____ Temp. Max. _____ °F Min. _____ °F Precipitation _____

(2) Number and Class of Personnel Employed

(3) Major Equipment on Project and Amount of Use

No.	Description	Size/Capacity	Hrs. Oper.

(4) Work Accomplished Today

(5) Action Items:

(6)

Signature Date

HERRERA
2200 Sixth Avenue | Suite 1100
Seattle, Washington | 98121
p 206 441 9080 | f 206 441 9108
PORTLAND, OR | MISSOULA, MT | OLYMPIA, WA
WINTHROP, WA | GUANGZHOU, CHINA

STSII Gas Probe Data Sheet

Gas Probe ID: GP-

Sample ID: NA

Date and Time:

Total Casing Volume (cc):

Canister ID:

Initial Canister Pressure:

Final Canister Pressure

Field Personnel

Casing Volume Purged	Volume Purged (cc)	Purge Rate (ml/min)	PURGE TIME				CH_4 (% Volume)	$C0_2$ (% Volume)	0_2 (% Volume)	H2S (% Volume)	CO (% Volume)
0			0	min	0	sec					
1/4				min		sec					
1/2				min		sec					
3/4				min		sec					
1				min		sec					
1-1/4				min		sec					
1-1/2				min		sec					
1-3/4				min		sec					
2				min		sec					
2-1/4				min		sec					
2-1/2				min		sec					
2-3/4				min		sec					
3				min		sec					

Comments/Special Instructions:

Barometric Pressure: GP-

Well head Pressure: NA

Well Diameter: 0.75”

Water Level/Well Bottom: Screen:

Equipment Used: Gem 2000 (Plus), Water Level Meter

HERRERA
2200 Sixth Avenue | Suite 1100
Seattle, Washington | 98121
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PORTLAND, OR | MISSOULA, MT | OLYMPIA, WA
WINTHROP, WA | GUANGZHOU, CHINA

Chain of Custody Record

Project Name:	Project Number:	Client:
Report To:		Copy To:
Sampled By:		Delivery Method:
Laboratory:	Requested Completion Date:	Total No. of Containers:

Lab Use:			Sample Type (see codes)	Preserv-ative? (Y/N)	Matrix (see codes)	Number of Containers	Analyses Requested										Lab ID No.
Sample ID	Date	Time															

Comments/Special Instructions:

Relinquished by (Name/CO/	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time
Relinquished by (Name/CO/	Signature	Date/Time	Received By (Name/CO)	Signature	Date/Time

Sample Type: G=Grab C=Composite **Matrix Codes:** A=Air GW=Groundwater SE=Sediment SO=Soil SW=Surface Water W=Water (blanks) M=Material O=Other (specify)