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ALTA ENVIRONMENTAL SERVICES, INC.

July 21, 2005
Via Certified Mail

Mr. Robert Busby
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive, #200
Rancho Cordova, CA 95670

Re: Transmittal of Investigation for Pan Lysimeters PL-2.2A, 5.1A, and 5.1B Report, Norcal Waste Systems Hay Road Landfill Inc., Solano County

Dear Mr. Busby,

In response to your letter dated December 22, 2004 (*Conditional Approval of Investigation Workplan for Pan Lysimeters PL-2.2A and PL-5.1B*) and our letter dated February 14, 2005 requesting to include PL-5.1A in the investigation, Alta Environmental Services, on behalf of Norcal Waste Systems Hay Road Landfill, is transmitting the enclosed report titled *Investigation for Pan Lysimeters PL-2.2A, 5.1A, and 5.1B* prepared by Golder Associates.

If you have any questions, please call me at (707) 693-2108.

Sincerely,

Bryan Clarkson
Environmental Compliance Manager
Alta Environmental Services, Inc.

Enclosure

cc: Greg Pryor, Norcal Waste Systems Hay Road Landfill, Inc.
Stephanie Young, Alta Environmental Services, Inc.
Peter Bennett, Geomatrix Consultants

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Action Taken	<u>Letter sent on 8/24/05</u>

**INVESTIGATION FOR PAN LYSIMETERS
PL-2.2A, PL-5.1A, AND PL-5.1B
Norcal Waste Systems
Hay Road Landfill Inc.**

*Submitted to:
Norcal Waste Systems Hay Road Landfill Inc.
for Submittal to:
Regional Water Quality Control Board
Central Valley Region*

Prepared by:

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2580 Wyandotte Street, Suite G
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Distribution:

Stephanie Young, Alta Environmental Services
Bryan Clarkson, Alta Environmental Services

July 18, 2005

053-748





**INVESTIGATION FOR PAN LYSIMETERS
PL-2.2A, PL-5.1A, and PL-5.1B
Norcal Waste Systems Hay Road Landfill Inc.
Solano County, California**

Prepared for
Norcal Waste Systems Hay Road Landfill Inc.

Prepared by:
Golder Associates
2580 Wyandotte Street, Suite G
Mountain View, California

Golder Associates Inc.

A handwritten signature in black ink, appearing to read "Kris H. Johnson", written over a horizontal line.

Kris H. Johnson, C.E.G., 1763

Senior Consultant

July 18, 2005

053-7444

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1 INTRODUCTION

Golder Associates Inc. has prepared this investigation report for pan lysimeters PL-2.2A, PL-5.1A, and PL-5.1B at the Norcal Waste Systems Hay Road Landfill Inc. (Figures 1 and 2). The scope of work for this investigation was presented in a workplan dated October 29, 2004.¹ Conditional approval of the workplan was provided by the Regional Water Quality Control Board (RWQCB) by letter dated December 22, 2004.²

The workplan was submitted in lieu of preparing amendments to the Report of Waste Discharge (ROWD) establishing evaluation monitoring programs (EMPs). This approach was verbally approved by the RWQCB in a September 2004 telephone conversation between Ms. Stephanie Young of Alta Environmental Services and Mr. Rob Busby of the RWQCB.

1.1 Landfill Background

The landfill area consists of two Class III landfills (Landfill 1 and Landfill 2; referred to as LF-1 and LF-2, respectively), and a Class II landfill (Landfill 3; LF-3). LF-1 and LF-2 are each composed of one disposal module (DM-1 and DM-2.1, respectively). LF-3 is a partially constructed Class II Landfill, and includes DM-2.2, DM-11.1, DM-11.2, DM-4.1, DM-5.1, DM-5.2, and DM-9. DM-9 is used for stockpiling biosolids sludge during the wet season, where they are subsequently dried in the Land Treatment Unit (LTU) during the dry season. A borrow pit has been excavated west of LF-1 and DM-2.2. A green-waste composting area is operated east of DM-1, overlying a 15-acre concrete and asphalt pad. Figure 2 shows the locations of the borrow pit and disposal modules.

1.2 Site Hydrogeology

The sediments beneath the site consist of sandy clay and silt, hundreds of feet thick, which locally contain zones of fine sand. Hydraulically, the sediments behave as one low-permeability groundwater body. The top of the groundwater body (i.e., the water table) occurs at a depth ranging from 5 to 15 feet beneath most of the site. Generally, groundwater flows slowly from the northwest to the southeast, following the regional direction of groundwater flow. Horizontal groundwater flow is more dominant than vertical flow, due to the clayey interbedded nature of the sediments, and is demonstrated by the similar water levels exhibited by wells that monitor different depth ranges.³

Operation of a groundwater drain and dewatering of the borrow pit have significantly altered the movement of shallow groundwater beneath most of the site. Extraction of groundwater has created a cone of depression nearly a quarter of a mile in diameter. Figure 2 shows the altered pattern of groundwater movement and the locations of select disposal modules, the groundwater extraction trench, and the borrow pit. Based on recent water levels, the groundwater elevation beneath

¹ Conor Pacific. October 29, 2004. *Investigation Workplan for Pan Lysimeters PL-2.2A and PL-5.1B, Norcal Waste Systems Hay Road Landfill Inc.*

² RWQCB. December 22, 2004. Letter re: *Conditional Approval of Investigation Workplan for Pan Lysimeters PL-2.2A and PL-5.1B, Norcal Waste Systems Hay Road Landfill Inc.*

³ Einarson Geoscience, Inc. *Geology and Hydrogeology, B&J Drop Box Sanitary Landfill, Solano County.* February 1995.

DM-2.2A and DM-5.1 is approximately 4 and 8 feet, respectively, below the base of PL-2.2A and PL-5.1A and PL-5.1B.

1.3 Landfill Monitoring Program

The Landfill detection monitoring program consists of groundwater monitoring, unsaturated zone monitoring, landfill gas monitoring, leachate monitoring, leak detection monitoring, and surface water monitoring.

1.3.1 Groundwater Monitoring

The groundwater monitoring network consists of 24 shallow monitoring wells, sampled semi-annually. The wells are divided by the area of the landfill they monitor, western and eastern areas. In addition, there are four corrective action wells that are monitored quarterly.

Wells in the western area of the Landfill are used for monitoring modules in the western part of the site (DM-1, DM-2.1, DM-2.2, DM-11.1, and DM-11.2). Due to the spatial variability of groundwater beneath the site and the influence of the borrow pit dewatering, intrawell comparisons are used for statistical evaluation of monitoring data.

Wells in the eastern area of the Landfill are used for monitoring the eastern part of the site (DM-4.1, DM-5.1, DM-5.2, DM-9.1[WP-9.1], and LTU). Because the groundwater flow in the eastern area of the site is influenced by the regional gradient, interwell comparisons are used for statistical evaluation of monitoring data.

1.3.2 Unsaturated Zone Monitoring

Suction lysimeter VZ-2.1, the unsaturated zone monitoring point for LF-2, is sampled semi-annually. Pan lysimeters PL-2.2A, PL-2.2B, PL-5.1A, PL-5.1B, PL-9.1A, PL-9.1B, PL-11.1 and PL-11.2 provide monitoring access to the secondary drainage layer (capillary break) under the corresponding disposal modules. Pan lysimeters PL-4.1 and PL-5.2 provide monitoring access below the leak detection sumps. According to the MRP, most pan lysimeters, which are installed beneath leachate sumps, are checked for liquid semi-annually, and sampled if sufficient liquid is present. As part of corrective action monitoring, liquid levels in pan lysimeters PL-9.1A and PL-9.1B are monitored daily, and PL-11.1 and PL-11.2 are measured at least weekly by Landfill staff. Pan lysimeters PL-11.1 and PL-11.2 are also sampled twice a quarter and PL-9.1A and PL-9.1B are sampled once per quarter as required by the corrective action monitoring program in the amended MRP. Water that accumulates in the pan lysimeters is pumped out by landfill staff. The recorded volumes of water pumped from the pan lysimeters are cumulative volumes removed from the adjacent water storage tank. The incremental water volumes removed are not recorded. Pressure transducers, which can measure the height of water above the transducer, were installed in all remaining pan lysimeters in December (PL-9.1A and PL-9.1B have had transducers in them) to provide a more reliable measurement of the amount of water in each pan lysimeter.

1.3.3 Landfill Gas Monitoring

Landfill gas probes (GP-1 through GP-11), pan lysimeters, and leak detection sumps are sampled semi-annually and monitored for methane, carbon dioxide, oxygen, and organic vapors using field instruments. If organic vapors are detected (concentration >1 ppm on field instrument) a vapor sample is obtained and submitted for laboratory analysis of VOCs using EPA Method TO-15. Quarterly monitoring of methane, carbon dioxide, and oxygen from landfill gas probes is conducted in accordance with Title 27 §20919.5(b)(2).

1.3.4 Leachate Monitoring

Leachate is sampled semi-annually at each disposal module sump. COCs are monitored annually during the fourth quarter of each year. As part of corrective action monitoring, liquid levels in sumps S-9.1A and S-9.1B are measured daily, and S-11.1 and S-11.2 are measured at least weekly by Landfill staff. Pressure transducers, which can measure the height of water above the transducer, were installed in all remaining sumps in December (S-9.1A and S-9.1B have had transducers in them) to provide a more reliable measurement of the amount of water in each pan lysimeter.

1.3.5 Surface Water Monitoring

Upstream surface water location SW-4 and downstream locations SW-5, SW-6, and SW-7 are sampled semi-annually.

1.4 **Introduction to PL-2.2A, PL-5.1A, and PL-5.1B Indications of a Release**

The following provides a brief summary of the detection of water in the pan lysimeters, initial and subsequent water sampling of the pan lysimeters, and the RWQCB notifications.

1.4.1 Pan Lysimeter PL-2.2A

Water was detected in PL-2.2A on April 23, 2004 and a sample was collected for laboratory analysis. The RWQCB was notified of the occurrence of water by letter dated April 26, 2004 and the analytical results were transmitted to the RWQCB by letter dated June 18, 2004. Laboratory analytical results from PL-2.2A and the overlying leachate sump S-2.2A are summarized in Table 1.

Four VOCs were detected at trace concentrations in the PL-2.2A water sample (benzene, methyl tert-butyl ether [MtBE], tetrachloroethene, and toluene). The tetrachloroethene is attributed to sample contamination as it was also detected in the equipment blank. In accordance with Detection Monitoring Specification E.21 of WDR R5-2003-0118, PL-2.2A was re-sampled for VOCs on June 7, 2004. The analytical results confirmed the detections of benzene and MtBE, but not the tetrachloroethene and toluene detections. In addition, a trace concentration of 1,1-dichloroethane was detected in the re-sample. The RWQCB was notified of the re-sample results on July 15, 2004.

Water had been detected and sampled in PL-2.2A twice previously, in July 1999 and June 2002. No VOCs were detected in 1999, but four VOCs were detected at trace concentrations in 2002 (benzene, cis-1,2-dichloroethene, MtBE, and toluene). The 2002 VOCs were not confirmed, because the water in the pan lysimeter was pumped out and no water returned for verification re-sampling. The VOC concentrations in the April 2004 sample are lower than the previous VOC concentrations (benzene decreased from 1.3 $\mu\text{g/l}$ to 0.28 $\mu\text{g/l}$ and MtBE decreased from 4.5 $\mu\text{g/l}$ to 1.7 $\mu\text{g/l}$). The concentrations of inorganic parameters in the pan lysimeter water are much lower than the leachate concentrations, indicating that the source of the water in the pan lysimeter is not likely leachate.

Approximately 1,500 gallons of water were pumped out of PL-2.2A on July 5, 2004. The water level in PL-2.2A was checked weekly and remained at minimum levels the remainder of 2004. Following a period of heavy rainfall, the water level increased to 1.9 feet between December 27, 2004 and January 14, 2005. From January 14 to 19, 2005 approximately 6,000 gallons of water were pumped out of PL-2.2A. The water level rose to 1.1 feet from February 17 to 23, 2005, when approximately 5,000 gallons of water were removed from February 23 to 26, 2005. The water level increased to 1.2 feet between February 28, 2005 and March 14, 2005, when approximately 2,700 gallons of water were pumped out. The water level again rose to approximately 0.35 feet between March 24, 2005 and April 14, 2005, when approximately 1,000 gallons of water were pumped out. These data are presented on Landfill field forms in Appendix A.

1.4.2 Pan Lysimeter PL-5.1A

Water was detected in PL-5.1A on January 4, 2005 and a sample was collected for laboratory analysis on January 14, 2005. The RWQCB was notified of the occurrence of water by letter dated January 10, 2005 and the analytical results were transmitted to the RWQCB by letter dated February 14, 2005. Laboratory analytical results from PL-5.1A and the overlying leachate sump S-5.1A are summarized in Table 2.

This was the first occurrence of water in PL-5.1A. MtBE and methylene chloride were detected above the reporting limit in the initial water sample from PL-5.1A. The methylene chloride detection is likely the result of laboratory contamination, because it was also detected in the laboratory method blank. MtBE was also detected in the overlying leachate sump, S-5.1A. However, concentrations detected in the PL-5.1A water sample were roughly one-half of those detected in the leachate sample. The concentrations of inorganic parameters in the pan lysimeter water are much lower than the leachate concentrations, indicating that the source of the water in the pan lysimeter is not likely leachate.

PL-5.1B was re-sampled for COCs on May 3, 2005. The re-sample results confirmed the detection of MtBE, and additional VOCs were detected at trace concentrations (Table 2).

Following a period of heavy rainfall, the water level increased to 0.6 feet between December 27, 2004 and January 4, 2005. On February 14, 2005 a total cumulative volume of approximately 1,500 gallons of water had been pumped out of PL-5.1A. The water level rose to 0.3 feet on February 23, 2005, and approximately 700 gallons of water were subsequently removed. The water level was at

0.1 feet on April 14, 2005, when approximately 30 gallons of water were pumped out. Approximately 20 gallons of water were pumped out on April 20, 2005. These data are presented on Landfill field forms in Appendix A.

1.4.3 Pan Lysimeter PL-5.1B

Water was detected in PL-5.1B on April 21, 2004 and a sample was collected for laboratory analysis. The RWQCB was notified of the occurrence of water by letter dated April 26, 2004 and the analytical results were transmitted to the RWQCB by letter dated June 18, 2004. Laboratory analytical results from PL-5.1B and the overlying leachate sump S-5.1B are summarized in Table 2.

This was the first occurrence of water in PL-5.1B. MtBE was detected above the reporting limit and eight VOCs were detected at trace concentrations in the water sample from PL-5.1B. With the exception of tetrachloroethene, the VOCs detected in PL-5.1B were detected in the overlying leachate sump, S-5.1B. Concentrations detected in the PL-5.1B sample were roughly one-half of those detected in the leachate sample.

In accordance with Detection Monitoring Specification E.21 of WDR R5-2003-0118, PL-5.1B was re-sampled for VOCs on June 7, 2004. The re-sample results confirmed the detection of all of the VOCs, and additional VOCs were detected. The RWQCB was notified of the re-sample results on July 15, 2004.

As part of routine monitoring, a water sample was obtained from PL-5.1B on November 3, 2004 for laboratory analysis. MtBE was detected above the reporting limit and 12 VOCs were detected at trace concentrations. All of the VOCs detected in PL-5.1B, except chloroform and tetrachloroethene, were detected in the overlying leachate sump, S-5.1B, at roughly one to three orders of magnitude lower than in the leachate sump. The concentrations of inorganic parameters in the pan lysimeter water are also much lower than the leachate concentrations.

During the previous monitoring event (April 2004), water had been detected in PL-5.1B and MtBE was detected above the reporting limit and eight VOCs were detected at trace concentrations. As a result of the VOC confirmations, a workplan to investigate the presence of water and VOCs in PL-5.1B was submitted to the RWQCB.⁵ This workplan was conditionally approved by the RWQCB by letter dated December 22, 2004.

A total of approximately 800 gallons of water was pumped out of PL-5.1B in July and August 2004. The water level in PL-5.1B was checked weekly and remained at minimum levels the remainder of 2004. Following a period of heavy rainfall, the water level increased to 0.8 feet between December 27, 2004 and January 18, 2005. By January 26, 2005 approximately 3,000 gallons of water had been pumped out of PL-5.1B. The water level rose to 0.5 feet from February 17 to 23, 2005, and approximately 3,000 gallons of water were subsequently removed. The water level was at 0.1 feet on March 14, March 15, April 14, and April 20, 2005, when approximately 150 gallons, 75 gallons, 600 gallons, and 425 gallons of water, respectively, were pumped out of PL-5.1B. These data are presented on Landfill field forms in Appendix A.

⁵ Conor Pacific, October 29, 2004, *Investigation Workplan for Pan Lysimeters PL-2.2A and PL-5.1B*, Norcal Waste Systems Hay Road Landfill Inc.

1.5 Unsaturated Zone Gas Monitoring

Field measurements of methane, carbon dioxide (CO₂), oxygen, and VOC concentrations in the unsaturated zone are routinely obtained semi-annually from the pan lysimeters (PL-2.2A, PL-2.2B, PL-5.1A, and PL-5.1B) and the gas probes located south of DM-2.2 (GP-3A and GP-3B). In addition, if the field VOC concentration exceeds 1 ppm, then an air sample is obtained for VOC speciation using EPA Method TO-15. These monitoring results are reported in the Landfill routine monitoring reports. The gas monitoring data are summarized in Tables 3 and 4.

In general, low concentrations (0.1% to 1%) of methane to no methane have been detected in these pan lysimeters, with one exception. Methane was detected in PL-2.2B at 19% in October 2004. CO₂ concentrations in the pan lysimeters are often higher than ambient air concentrations, and have ranged from 0.15% to 25.5%. Oxygen levels in the pan lysimeters are often below normal. Gas Probes GP-3A and GP-3B have relatively high methane concentrations, elevated CO₂ concentrations, and low oxygen. The field organic vapor measurements in the pan lysimeters and gas probes have ranged from non-detect to 12.5 ppm, and are usually less than 1 ppm. The landfill has been in communication with the LEA and RWQCB regarding the methane concentrations above the lower explosive limit (LEL = 5% methane) and the gas-phase VOC detections. Additional perimeter gas monitoring probes have been installed and additional perimeter probes are planned pending results of a proposed gas migration investigation.⁶

The initial gas-phase VOC analysis for PL-2.2B (June 2004) resulted in many VOCs detected at relatively high concentrations, but the subsequent sample (March 2005) had less detected VOCs and lower concentrations. Gas Probe GP-3A has been sampled for VOCs four times and has consistently had many VOCs detected at relatively higher concentrations. Several of these VOCs are typical of landfill gas, 1,1-dichloroethane, cis-1,2-dichloroethene, heptane, hexane, Freon 114, Freon 12, tetrachloroethene, trichloroethene, and vinyl chloride.

A gas-phase sample from PL-5.1B was analyzed for VOCs in June 2004 and several VOCs were detected at relatively high concentrations (1,1,1-trichloroethane, 1,1-dichloroethane, cis-1,2-dichloroethene, Freon 11, Freon 12, hexane, MtBE, tetrachloroethene, and trichloroethene). No gas-phase samples have been obtained from PL-5.1A for VOC analyses.

⁶ Geomatrix Consultants, May 31, 2005, *Amended Report of Waste Discharge Proposing Corrective Action, Hay Road Landfill, Vacaville, California*.

2 SCOPE OF WORK

The work performed in this investigation was influenced by additional conditions at the Landfill; water has previously been detected at two pan lysimeter pairs at Hay Road Landfill, PL-9.1A/PL-9.1B and PL-11.1/PL-11.2. The source of the water in these pan lysimeters has been attributed to infiltration of water along the edge of each disposal module.^{7,8} The inflow of water into these pan lysimeters has followed relatively large sustained rainfall at the Landfill. In the case of DM-9.1, along with surface water infiltration, the water, at one time, apparently included leachate that had flowed out the edge of the disposal module leachate drainage layer. In addition, landfill gas has been detected in landfill gas monitoring probes along the perimeter of portions of the Landfill and within the headspace of pan lysimeters.

The following outlines the scope of work to investigate pan lysimeters PL-2.2A, PL-5.1A, and PL-5.1B.

- Review the disposal module liner system design and as-built construction details,
- COC sampling of pan lysimeter water (if sufficient water is available),
- Review groundwater monitoring well analytical data to evaluate extent of impact,
- Install pressure transducers to monitor water levels in pan lysimeters and leachate sumps,
- Evaluate data collected through the rainy season,
- Evaluate potential for VOCs in landfill gas to impact water in the pan lysimeters.

Each task above is described in detail below.

Review Disposal Module Liner System Design and As-Built Construction Details

The disposal module liner system design and construction as-built details were reviewed with emphasis on areas where water can easily enter the pan lysimeter drainage system. In addition, the details were reviewed for potential landfill gas migration routes.

Constituent of Concern (COC) Concentrations

The water in all three pan lysimeters was sampled and analyzed for COCs. The Hay Road Landfill COCs include phosphate, fecal coliform, Total Organic Carbon, metals, cyanide, sulfide, phosphorous, volatile organic compounds, semi-volatile organic compounds, organophosphorus pesticides, chlorinated herbicides, and PCBs. The leachate sumps are routinely monitored for COCs annually during fourth quarter monitoring. These data were used to evaluate the nature of the water in the pan lysimeters and potential sources for the water.

⁷ Conor Pacific, May 3, 2002, *Revised Engineering Feasibility Study for Disposal Module 9.1, Norcal Waste Systems, Inc. Hay Road Landfill, Solano County, California*

⁸ Conor Pacific, May 31, 2001, *Engineering Feasibility Study for Disposal Modules 11.1 and 11.2, B&J Drop Box Sanitary Landfill, Solano County, California*

Review Groundwater Monitoring Well Analytical Data to Evaluate Extent of Impact

The monitoring data from groundwater monitoring wells located near PL-2.2A, PL-5.1A, and PL-5.1B were used to evaluate the extent of potential groundwater impact in the subsurface. Recent, as well as historical data were evaluated with respect to VOC detections and landfill leakage indicators. Leakage indicators include, but are not limited to, increases in bicarbonate alkalinity, pH changes, chloride or other dissolved solids increases, and/or changes in ionic ratios.

Install Pressure Transducers to Monitor Water Levels

Pressure transducers can measure the height of water above the transducer and can provide a more reliable measurement of the amount of water in each pan lysimeter and/or sump than periodic manual measurements. Transducers also can be connected to data loggers, which can record water levels automatically at specified time intervals for later downloading to a computer. A pressure transducer was installed in each pan lysimeter and leachate sump in mid-December 2004 (PL-5.1A, PL-5.1B, S-5.1A, and S-5.1B) and late December 2004 (PL-2.2A and S-2.2A). The pressure transducers in PL-2.2A, PL-5.1B, S-2.2A, and S-5.1B were connected to data loggers in mid-February 2005 and the loggers were set to automatically record water levels hourly. Daily rainfall data from a nearby weather monitoring station in Vacaville was obtained. The data loggers were used to record the water levels through the remainder of the rainy season. In addition, the landfill recorded manual transducer readings approximately once per week in each pan lysimeter and leachate sump.

Evaluate Data Collected Through the Rainy Season

The data logger was downloaded following significant rainfall events. The pan lysimeter and sump water levels recorded by the transducers and data logger were evaluated with the goal of detecting any possible correlation between rainfall, leachate levels, and any water level increases in the pan lysimeters. This information was used to evaluate potential pathways for the water to enter the pan lysimeters.

Evaluate potential for VOCs in landfill gas to impact water in the pan lysimeters

The gas-phase VOC analytical results were used to predict potential VOC concentrations in the water in each pan lysimeter using Henry's Law relationships. Standard phase transfer models can describe partitioning of VOCs between gas and water. A theoretical aqueous concentration was calculated for compounds for which a Henry's Law constant is available in literature, including most common VOCs. To help identify the source of the VOCs detected in the pan lysimeter water, theoretical aqueous VOC concentrations were calculated from the VOC concentrations detected in the gas samples.

The equilibrium water concentration is the maximum dissolved VOC concentration that could be observed by dissolution of VOCs from an overlying vapor phase,⁹ and is calculated as follows:

$$C_w = C_g / K_h$$

⁹ Kerfoot, H., 1996, *Effects of Landfill Gas on Water*, in: *Landfilling of Waste: Biogas*, Christenson, T. H., R. Cossu, and R. Steggman. E&FN Spon, London., p 162-185.

where C_w is the maximum water concentration that would be observed based on equilibration with gas containing a vapor concentration C_g in micrograms per liter ($\mu\text{g/L}$) of a specific VOC constituent. K_h is the dimensionless Henry's Law constant for the VOC constituent.

3 INVESTIGATION RESULTS

The following reviews the results of the investigation scope of work. The disposal module construction is summarized, the pan lysimeter water chemistry is evaluated, local groundwater monitoring results are reviewed to define the potential extent of impact, the water-level monitoring results are evaluated along with daily rainfall data, and gas-phase VOC data are used to predict potential water concentrations of VOCs.

3.1 Construction of DM-2.2A and DM-5.1

DM-2.2A was constructed in 1996 and DM-5.1 was constructed in 2001. The base of DM-2.2A is sloped toward the west and DM-5.1 is sloped toward the east, where the module's leachate sumps and pan lysimeters are located. DM 2.2's Class II liner system is tied into the Class III liner system of DM 2.1. Figure 3 presents the subgrade plan for DM-5.1 and DM-2.2A.

DM-2.2A and DM-5.1 are Class II disposal units and were constructed with an engineered alternative to the specified 5-foot separation between wastes and highest anticipated groundwater. A 12-inch thick capillary break gravel layer was constructed below the DM-2.2 base liner and a 6-inch thick capillary break gravel layer was constructed below the DM-5.1 base liner to provide this engineered alternative. Pan lysimeters PL-2.2A, PL-5.1A, and PL-5.1B were constructed to provide monitoring access to the secondary drainage layer (capillary break) under the disposal modules (Figure 3). A capillary break geocomposite drainage layer underlies the sideslope landfill lining system. The geocomposite drainage layer is connected to the capillary break gravel layer at the base of the module sideslope.

Each pan lysimeter is composed of a 2.5-foot thick layer of gravel, with a perforated high-density polyethylene (HDPE) pipe installed along the base. The lysimeters are lined with 60-mil HDPE, which overlies the subgrade (native or compacted fill) (Figure 3). Above the capillary break are 1.5 feet of compacted soil, which is overlain by the primary landfill lining system, a geosynthetic clay liner (GCL) and a 60-mil HDPE geomembrane liner. Above this is the LCRS perforated pipe and drainage gravel. On top of this lies the 1-foot thick operations layer.

Based on the potential for surface water to enter the capillary break gravel layer along the temporary module terminations at DM-9 and DM-11, the temporary module terminations at DM-5.1 were designed and constructed with the HDPE liner covering the edge of the capillary break layer (Figure 3). DM-2.2 was constructed prior to the recognition of this potential issue and the northern edge of the module capillary break layer has not been sealed. The edges of DM-5.1 are now permanently terminated with the lining system of DM-4.1 to the south (completed in 2003) and DM-5.2 to the west (completed in 2004), and no longer exposed to potential surface water infiltration. Note that DM-4.1 and DM-5.2 were constructed without a gravel capillary break layer underlying the modules and no capillary break geocomposite drainage layer underlying the sideslope landfill lining system. No water has been detected in the pan lysimeters for DM-4.1 and DM-5.2. The lack of water in PL-4.1 and PL-5.2 provides additional evidence that the capillary break drainage layers provide a pathway for infiltrating surface water to enter the pan lysimeters at at DM-2.2 and DM-5.1.

Leachate is extracted from DM-2.2A and DM-5.1 at leachate sumps S-2.2A, S-5.1A, and S-5.1B. Each sump is equipped with an automatic pumping system so that leachate is pumped out when the height of leachate exceeds one foot (30 centimeters) above the leachate pump. Leachate extraction records for each sump are included in Appendix A.

3.2 Nature of the Releases to Pan Lysimeters

The most recent sampling results for water in the pan lysimeters and overlying leachate sumps are presented in Tables 1, 2, 5, and 6.

3.2.1 Evaluation of General Water Chemistry

General water chemistry data (major ions) can be useful in determining water sources and mixing. Major ion data from each pan lysimeter, leachate sump, and the adjacent groundwater monitoring wells have been plotted on Piper diagrams for each area (Figures 4 and 5).

When evaluating changes in water quality due to mixing, absolute concentrations of ions can vary widely, but ratios of ionic constituents remain relatively constant. Graphical tools that use ratios instead of absolute concentrations, such as Piper diagrams are useful for providing a "fingerprint" of the ionic character of the water. Piper diagrams are also useful for interpreting relationships that exist between various samples including mixing trends and geochemical reactions (e.g., cation exchange, precipitation and dissolution reactions, and sulfate reduction). Data on a Piper diagram is plotted as percentages of the principal cations and anions in separate triangular fields. The resulting anion and cation percentages for each sample are then projected into a central diamond-shaped field. The intersection of these projections represents the composition of the water with respect to the combination of ions shown.

On the Piper diagram, the data from the eastern area groundwater monitoring wells (G-16, G-18, and G-20) shows a change in composition from western area wells (G-11, G-11R, and G-12). The west to east change in character is evidenced by a general increase in chloride and reduction in sodium. This change in composition from west to east is likely the result of natural spatial variability resulting from water chemistry differences that result from infiltration through younger alluvium.

3.2.1.1 PL-2.2A Area

The Piper diagram shows that the cation compositions of the PL-2.2A water and overlying leachate in S-2.2A are different, with more sodium apparent in PL-2.2A water. The anion composition of the PL-2.2A water is distinct when compared to the leachate sump composition, containing relatively greater amounts of bicarbonate alkalinity and lower chloride. The differences in anion and cation compositions are reflected in the projected compositions shown in the upper diamond-shaped area of the Piper diagram, and again show the overall ionic composition of the S-2.2A leachate and pan lysimeter PL-2.2A water to be different. The increased sodium ratio in the pan lysimeter water

*No. increase.
Younger alluvium
is more sodium
saturated to
depth.*

samples may be the result of water contact with the bentonite in the landfill module lining system, where sodium-bentonite is a key component of the geocomposite lining system.

On the Piper diagram, the cation and anion compositions of the S-2.2A leachate and nearby groundwater samples are similar. This is the result of the natural spatial variability of the groundwater and the naturally high chloride concentrations of eastern area groundwater. The apparent relative increase of bicarbonate alkalinity in PL-2.2A water may be the result of the interaction of carbon dioxide in landfill gas and the water in the pan lysimeter. A major component of landfill gas is CO₂, generally ranging from 40 to 50 percent by volume. If landfill gas is migrating from the landfill, it will contain substantial amounts of CO₂. Gas monitoring of PL-2.2A has shown methane concentrations up to 0.1% and CO₂ concentrations to range from 1 to 11%. When CO₂ comes into contact with water, it can dissolve into the water, forming carbonic acid (CO₂ + H₂O → H₂CO₃), which forms bicarbonate (HCO₃⁻) and carbonate.¹¹ The CO₂ in contact with water can increase bicarbonate concentrations in the water substantially.

The elevated bicarbonate concentration and VOCs in the PL-2.2A water are likely from landfill gas. The elevated bicarbonate concentration, in combination with a relatively low chloride concentration, is indicative of a landfill gas source for the VOCs in PL-2.2A water, rather than a leachate source.

3.2.1.2 PL-5.1A and PL-5.1B Area

The Piper diagram shows that the cation compositions of the PL-5.1A and PL-5.1B water and overlying leachate in S-5.1A and S-5.1B are distinct, with more sodium apparent in the leachate sumps. The anion compositions of PL-5.1A and PL-5.1B are distinct when compared to the overlying leachate sump compositions, containing relatively greater amounts of bicarbonate alkalinity and lower chloride. The differences in ionic compositions are reflected in the projected compositions shown in the upper diamond-shaped area of the Piper diagram, and again show the overall ionic composition of the leachate and pan lysimeter water to be different.

On the Piper diagram, the cation compositions of the pan lysimeter, leachate, and nearby groundwater samples are similar. The anionic compositions of the groundwater samples show relatively more chloride than in the pan lysimeter water and are likely the result of naturally high chloride in the local groundwater.

The apparent relative increase of bicarbonate alkalinity in the pan lysimeter water may be the result of the interaction of carbon dioxide in landfill gas and the water in the pan lysimeter, as described above. Gas monitoring of PL-5.1A and PL-5.1B has shown methane concentrations up to 1% and CO₂ concentrations to range from 3 to 22%. The elevated bicarbonate concentrations and VOCs in the pan lysimeters are likely from landfill gas. The elevated bicarbonate concentration, in combination with a relatively low chloride concentration, is indicative of a landfill gas source for the VOCs in the pan lysimeter waters, rather than a leachate source.

¹¹ Krauskopf, K.B., 1967, Introduction to Geochemistry, McGraw-Hill, Inc., pp. 9-10.

3.3 Constituent of Concern Analytical Results

The water in each pan lysimeter was sampled for COCs to fulfill the requirements in Title 27 CCR Section 20420[k][6]. The pan lysimeter COC analytical results are compared to the routine fourth quarter 2004 COC results from each overlying leachate sump to evaluate leachate as a potential source (Tables 5 and 6).

3.3.1 Pan Lysimeter PL-2.2A COC Analytical Results

Six dissolved metals were detected in the PL-2.2A water sample, arsenic, barium, iron, manganese, nickel, and thallium (Table 5). In the leachate sample from S-2.2A, the same dissolved metals except thallium were detected. In addition, selenium was detected in the leachate sample from S-2.2A. The concentrations of the dissolved metals in the leachate sump were two to thirty times higher than in the water sample from PL-2.2A.

Of the other COCs, ammonia, fecal coliforms, total Kjeldahl nitrogen (TKN), and total organic carbon (TOC) were detected in the water sample from PL-2.2A. The concentrations of these COCs were 2 to 170 times higher in the leachate sample from S-2.2A. No semi-volatile organic compounds (SVOCs), polychlorinated biphenyls, organophosphorus pesticides, or chlorinated herbicides were detected in either the pan lysimeter water sample or leachate sample.

None of the detected COCs are present at sufficient concentrations in the pan lysimeter to provide definitive evidence of a release.

3.3.2 Pan Lysimeters PL-5.1A and PL-5.1B COC Analytical Results

Three dissolved metals were detected in the PL-5.1A water sample (arsenic, barium, and manganese), and five dissolved metals were detected in the PL-5.1B water sample (arsenic, barium, iron, manganese, and nickel) [Table 6]. In the leachate samples from S-5.1A and S-5.1B, the same dissolved metals were detected. In addition, chromium, cobalt, and vanadium were detected in the leachate samples. The concentrations of the dissolved metals in the leachate sumps were lower, equivalent, or up to twenty times higher than in the water samples from PL-5.1A and PL-5.1B.

Of the other COCs, ammonia, fecal coliforms, phosphorous, TKN, and TOC were detected in the water samples from PL-5.1A and PL-5.1B. The concentrations of these COCs were 2 to 20 times higher in the leachate samples. Phenol was detected in PL-5.1B; however, phenol is a common sample contaminant. No other semi-volatile organic compounds (SVOCs), polychlorinated biphenyls, organophosphorus pesticides, or chlorinated herbicides were detected in either the pan lysimeter water sample or leachate sample.

None of the detected COCs are present at sufficient concentrations in the pan lysimeter to provide definitive evidence of a release.

3.4 Groundwater Monitoring Results

The extent of a potential impact to groundwater from the VOCs detected in the pan lysimeter water samples was investigated using groundwater analytical results from adjacent monitoring wells. Each pan lysimeter location is discussed below.

3.4.1 PL-2.2A Area

April 2005 analytical results from monitoring wells G-11, G-11R, and G-12 were used to determine if there was an observable impact to groundwater adjacent to DM-2.2A. Wells G-11 and G-11R are adjacent to and downgradient from PL-2.2A, and well G-12 is adjacent to PL-2.2B (Figure 2).

Table 7 presents a summary of the analytical results from groundwater monitoring wells G-11, G-11R, and G-12. Groundwater monitoring well G-11 originally was installed west of landfill module DM-2.2 to monitor downgradient groundwater quality (Figure 2). The well became dry because of dewatering conducted in the borrow pit area, immediately to the west. A deeper well was installed to supplement well G-11. Well G-11R was installed in April 2001 according to a January 2001 work plan.¹² Over the past 2 years, modified dewatering of the borrow pit has resulted in higher groundwater levels and well G-11 is no longer routinely dry.

No VOCs were detected in well G-11, two VOCs were detected at trace concentrations in well G-11R (acetone and ethanol), and one VOC was detected at a trace concentration in well G-12 (acetone). Both of the detected VOCs are common laboratory and sample contaminants and are not considered to be indicative of VOC impact to groundwater. In addition, no VOCs were detected in groundwater samples obtained from either G-11, G-11R, or G-12 in October 2004. There is no evidence of groundwater impacts from the VOCs detected in PL-2.2A.

3.4.2 PL-5.1A and PL-5.1B Area

April 2005 analytical results from monitoring wells G-16, G-18, and G-20 were used to determine if there was an observable impact to groundwater adjacent to DM-5.1. Wells G-16 and G-20 are adjacent to and downgradient from PL-5.1B and PL-5.1A, respectively, and well G-18 is adjacent to and upgradient of DM-5.1 (Figure 2). Table 8 presents a summary of the analytical results from groundwater monitoring wells G-16, G-18, and G-20.

No VOCs were detected in well G-20 and one VOC was detected at a trace concentration in wells G-16 and G-18 (acetone). Acetone is a common laboratory contaminant and is not considered to be indicative of VOC impact to groundwater. In addition, no VOCs were detected in groundwater samples obtained from G-16, G-18, or G-20 in October 2004. There is no evidence of groundwater impacts from the VOCs detected in PL-5.1A and PL-5.1B.

¹² Conor Pacific. *Workplan for Replacement Wells, B&J Sanitary Landfill, Solano County, California*. May 14, 2001.

3.5 Water Level Monitoring Results

Water levels were monitored in each pan lysimeter and overlying leachate sump throughout the rainy season (October through May), either by (1) weekly manual depth to water measurements using a water-level meter (until transducers were installed), (2) weekly manual readings from pressure transducers, and (3) hourly data logger readings from pressure transducers. The data logger used to record measurements in PL-5.1B and S-5.1B failed during operation and useful data was not recovered. The data logger used at PL-2.2A and S-2.2A successfully recorded water levels from mid-February through April 2005. The manual transducer measurements adequately supplement the data logger measurements in PL-2.2A and S-2.2A, such that the failure of the data logger at DM-5.1A does not impact the interpretation of the data (Appendix A).

Figure 6 shows the hourly data logger recorded water levels and the weekly manually recorded water levels in PL-2.2A. The data logger and manual measurements are similar. In addition, on Figure 6, the daily rainfall measurements are shown. Note that sustained rainfall events of February 15 through February 21 (total of approximately 4 inches), February 27 through March 4 (total of approximately 1.2 inches), and March 18 through 22 (total of approximately 3 inches) were followed by a rise in water level in PL-2.2A. The water in the pan lysimeter was pumped out in between the rainfall events and the water level was reduced to a minimum level before the next sustained rainfall event. The leachate levels measured in the overlying leachate sump S-2.2A did not show an indication that leachate accumulated above minimal levels. During the time shown in Figure 6 (February through April 2005), the average leachate extraction rate from S-2.2A was approximately 450 gallons per day. Apparently the leachate pump in S-2.2A was able to keep up with any increase in leachate generation in the landfill module during the rainy season.

Figure 7 shows the weekly manual water level measurements in PL-2.2A, PL-5.1A, and PL-5.1B from December 2004 through May 2005 and daily rainfall throughout the rainy season (October 2004 through May 2005). The water level measurements in PL-5.1A and PL-5.1B show a similar pattern to the water levels in PL-2.2A. The three sustained rainfall events in February, March, and April were followed by water level increases in the pan lysimeters. In addition, sustained rainfall events of December 26 through January 11 (total of over 7 inches) and January 24 through January 28 (total of over 1 inch) also were followed by water level rises in the pan lysimeters. The water in the pan lysimeters was pumped out between rainfall events. Again, there were no indications in the weekly leachate level measurements that leachate accumulated above routine levels (not shown on Figure 7, see measurements in Appendix A).

These data show that the early season rainfall (from October through most of December) likely leads to saturation of the site soils to the point where additional rainfall results in drainage from the soils. This saturated state is referred to as the field capacity of the soil. After the soils are saturated, subsequent sustained rainfall events cannot be absorbed by the site soils and excess water drains from the soil. The nearest drainage point for water that falls adjacent to the landfill modules is the side-slope capillary break drainage layer (geocomposite). Water from the adjacent soils that enters the geocomposite can run downslope to the gravel capillary break layer underlying the landfill modules and accumulate in the HDPE-lined pan lysimeters.

The water volume capacity of the lined portion of each pan lysimeter is approximately 3,500 gallons (assuming a porosity of 0.33 for the gravel). The amount of water removed from PL-5.1A and PL-5.1B did not exceed the pan lysimeter capacity. The incremental water volumes removed from PL-

2.2A in January and February, while totaling a greater volume than the pan lysimeter capacity, likely did not exceed the pan lysimeter capacity, based on the maximum water depth reading of 1.9 feet, which is lower than the total thickness of the lined portion of the pan lysimeter.

3.6 Evaluate Potential for VOCs in Landfill Gas to Impact Water in the Pan Lysimeters

The gas-phase VOC analytical results were used to predict potential VOC concentrations in the pan lysimeter water using Henry's Law relationships. Gas-phase VOC data from PL-2.2B, GP-3, and PL-5.1B were used to predict equilibrium water concentrations and compared to the water concentrations found in PL-2.2A, PL-5.1A, and PL-5.1B. This analysis assumes that the gas-phase VOC concentrations in PL-2.2B would be similar to those in PL-2.2A, and that the gas-phase VOC concentrations in PL-5.1B would be similar to those in PL-5.1A. The results are presented in Tables 9, 10, and 11.

The partitioning calculations for the PL-2.2B gas-phase VOCs predict relatively low concentrations of VOCs in water, 0.3 ug/l total VOCs. These predicted water concentrations are similar to those found in PL-2.2A, where the total VOC concentrations have ranged from 3 to 6.8 ug/l. Using gas-phase VOC data from gas probe GP-3 yields slightly higher predicted water concentrations, 1.2 ug/l total VOCs. These predicted water concentrations may be biased, because the gas samples and the water sample came from different locations.

The partitioning calculations for the PL-5.1B gas-phase VOCs predict relatively higher concentrations of VOCs in water, 56 ug/l total VOCs. These predicted water concentrations are similar to those found in PL-5.1B, where the total VOC concentrations have ranged from 9 to 127 ug/l. The predicted VOC water concentrations using PL-5.1B are an order of magnitude higher than the water concentrations in PL-5.1A, which have ranged from 4.3 to 9.5 ug/l.

Although the predicted VOC water concentrations are not equal to the measured water concentrations, given the assumptions made for these calculations, results within orders of magnitude are considered comparable. The results are not conclusive, but most of the VOCs detected in the pan lysimeter water have been detected in the gas-phase samples. Partitioning of VOCs from the gas phase to water in the pan lysimeter is the most likely explanation for the concentrations of VOCs detected.

3.6.1 Potential Landfill Gas Migration Pathways

Potential landfill gas migration pathways for DM-2.2 and DM-5.1 and possible explanations for detections of landfill gas constituents in gas probes GP-3A and GP-3B are described below.

- Landfill gas migration to the anchor trench, then along the side-slope liner, via the geocomposite drainage layer, to the capillary break gravel and the pan lysimeters (Figure 3).
- Landfill gas migration through a side-slope liner leak. Class III module DM-1 is partially unlined, and therefore gas migration from this module could occur via

the vadose zone/waste interface (this explanation does not apply to DM-5.1, which is ½-mile from DM-1).

The potential migration pathway(s) for landfill gas constituents require further delineation and therefore, identification of subsurface gas migration pathways along the perimeter of DM-2.2 and DM-5.1 is proposed. The landfill gas delineation in the area of DM-2.2 has been previously proposed.¹³ Additional investigation is proposed herein for DM-5.1.

¹³ Geomatrix Consultants, May 31, 2005, *Amended Report of Waste Discharge Proposing Corrective Action, Hay Road Landfill, Vacaville, California.*

4 PROPOSED ADDITIONAL INVESTIGATIONS

Additional investigations are proposed to delineate the potential landfill gas migration pathways. Following this delineation, the information obtained will be utilized when implementing the proposed landfill gas corrective actions for DM-1-1 (Geomatrix Consultants).¹⁴ Minor modifications to the Landfill monitoring program are proposed.

4.1 Proposed Subsurface Landfill Gas Investigation

The following scope of work follows that proposed by Geomatrix Consultants and expands the scope to include DM-5.1. A subsurface landfill gas investigation will be conducted to further delineate landfill gas migration pathways. This investigation will target areas inside the slurry wall adjacent to DM-2.2 by collecting soil gas samples adjacent to the edge of the liner (which is assumed to be inside the slurry wall). In addition, the area adjacent to DM-5.1 will be targeted. Before conducting this investigation, the location of the liner will be determined by exposing the liner termination along the anchor trench. The presence of landfill gas inside the anchor trench will be assessed at this time, using field measurements of methane, carbon dioxide, oxygen, and organic vapors.

The field investigation will include real-time measurements of methane, carbon dioxide, oxygen (using a landfill gas meter), and organic vapors (using a PID) collected through temporary soil gas probes advanced along the extent of the liner termination for DM-2.2 and DM-5.1. Gas samples will be collected for analysis of VOCs using EPA Method TO-15 at locations where PID readings exceed 1 ppmv as benzene equivalents, and at a minimum of three locations where the highest methane concentrations are encountered if PID measurements are less than 1 ppmv.

The preliminary area of investigation is shown on Figure 8, although this area may change as real-time information is collected during the field program. Borings will be advanced within three feet outside of the liner termination. A direct-push drilling rig equipped with a Soil Conductivity Probe (SCP) will be used to profile lithology of the vadose zone to depths of approximately 10 to 15 feet bgs and to identify coarse-grained intervals which may act as preferential pathways for gas migration. The drilling rig will then advance a temporary soil gas probe to the targeted depth interval at a location adjacent to the SCP boring, to withdraw and analyze soil gas for methane, carbon dioxide, and oxygen content using a landfill gas meter, and organic vapors using a PID. SCP and soil gas probe borings will be grouted with neat cement slurry after the SCP or soil gas probe is removed. It is estimated that up to 20 SCP borings and 20 to 40 gas samples will be collected during this delineation program.

¹⁴ Geomatrix Consultants, May 31, 2005, *Amended Report of Waste Discharge Proposing Corrective Action, Hay Road Landfill, Vacaville, California.*

5 PROPOSED CORRECTIVE ACTION MEASURES

The regulatory requirements specify that the Landfill must address implementing corrective action measures to remediate a release, ensuring that COCs achieve their respective concentration limits, preventing noncompliance with the COC limits, and establishing and implementing a water quality monitoring program to demonstrate the effectiveness of the corrective action program. These items are addressed below.

5.1 Removal of Potentially Impacted Water from Pan Lysimeters

The releases detected in PL-2.2A, PL-5.1A, and PL-5.1B were confined to the lined pan lysimeters and the VOC-impacted water has been removed from the pan lysimeter to the extent feasible. If water is observed in the pan lysimeter, it will be sampled for routine laboratory analyses and subsequently removed. These actions will prevent any potentially VOC-impacted water detected in the pan lysimeter from leaking out of the lined lysimeter and potentially impacting the vadose zone underlying the landfill.

5.2 Proposed Corrective Action Plan

The requirements for landfill gas control are specified in Title 27 of the California Code of Regulations. Title 27 specifies that landfill-gas control is a part of corrective action, if the release involves landfill gas:

§20425 (d)(3) states that if information indicates that the release likely involves landfill gas then the corrective action program should include the design, installation, and operation of the landfill-gas control and monitoring systems.

Landfill gas has been indicated as a possible source of VOCs detected in water samples obtained from PL-2.2A, PL-5.1A, and PL-5.1B.

A corrective action plan for similar VOC detections in PL-11.1 and PL-11.2 was prepared by Geomatrix Consultants.¹⁵ The corrective action plan evaluated potential gas control strategies:

- Full-scale landfill gas extraction;
- Focused landfill gas extraction at areas where migration is occurring;
- Air injection into the capillary break (with vapor recovery).

¹⁵ Geomatrix Consultants, May 31, 2005, *Amended Report of Waste Discharge Proposing Corrective Action, Hay Road Landfill, Vacaville, California.*

Geomatrix concluded that the relatively low concentrations of methane and VOCs detected did not warrant a full-scale landfill gas extraction. A focused landfill gas extraction system based on the results of the proposed subsurface landfill gas investigation was proposed. In addition, injection of air into the leak detection layer via the pan lysimeter riser was proposed as the corrective action measure for Class II modules to prevent migration of VOCs from waste into the pan lysimeter (leak detection layer). A pilot test was proposed to be conducted at DM-11 to test injection rates and monitor pressures within the underlying capillary break.

Because this work is in progress, no additional action for PL-2.2A, PL-5.1A, and PL-5.1B will be taken until the proposed pilot test for DM-11 is completed.

5.3 Proposed Changes to Monitoring Program

At this time, there are two changes proposed to the water quality monitoring system, (1) more frequent water level measurements in PL-2.2A, PL-5.1A, and PL-5.1B, and (2) installation of additional groundwater monitoring wells near DM-2.2.¹⁶ The VOCs detected in PL-2.2A, PL-5.1A, and PL-5.1B water can be effectively evaluated with the monitoring wells in place or proposed for installation at the Landfill. Groundwater monitoring wells G-11 and G-11R are located adjacent to and downgradient of PL-2.2A, and an additional well, G-11M, has been proposed for installation adjacent to G-11 and G-11R. Well G-11M will monitor groundwater at a depth between well G-11 (shallow) and well G-11R (deep). Groundwater monitoring wells G-16 and G-20 are located adjacent to and downgradient of PL-5.1A and PL-5.1B.

Currently, landfill staff check for liquid weekly in PL-2.2A, PL-5.1A, and PL-5.1B. This frequency will continue during the wet season (October to May). Otherwise water levels will be measured at least monthly during the dry season. Sampling of PL-2.2A, PL-5.1A, and PL-5.1B will be attempted each semi-annual monitoring event, or will be initiated by an observed increase in water level during the weekly monitoring. If a water-level increase is observed the lysimeter will be sampled and pumped; there is no need to perform water sampling more than once per quarter. The detection monitoring wells are monitored semi-annually.

Because shallow infiltrating water may continue to enter PL-2.2A, PL-5.1A, and PL-5.1B, the detection of water in the pan lysimeters is not an indication of a release. Samples will be obtained when water is detected in the pan lysimeters and chemical analyses will be performed and the analytical results will be used to determine if there is an indication of a release from the landfill.

¹⁶ Golder Associates Inc. May 31, 2005, *Amended ROWD Proposing Changes to the Detection Monitoring Program, Norcal Waste Systems Hay Road Landfill Inc.*

6 SUMMARY AND CONCLUSIONS

The source of water in PL-2.2A, PL-5.1A, and PL-5.1B is likely from infiltrating rainfall that drains from saturated soil into the sideslope capillary break geocomposite drainage layer. Landfill gas is the most likely source for the VOCs detected in the pan lysimeter water based on the module construction, VOC concentrations, and VOC partitioning calculations. Concentrations of VOCs are very low and there are no indications that the VOC-impacted water in the pan lysimeters has impacted groundwater.

A subsurface landfill gas investigation is proposed to further delineate the nature and extent of landfill gas constituents along the perimeter of DM-2.2 and DM 5.1. Gas control measures will be implemented based on the results of the landfill gas investigation and the results of the proposed DM-11 air injection pilot test.¹⁷

Routine monitoring of the pan lysimeters and adjacent groundwater monitoring wells is proposed to continue as specified in the Landfill monitoring program and removal of water that accumulates in the pan lysimeters will continue.

¹⁷ Geomatrix Consultants, May 31, 2005, *Amended Report of Waste Discharge Proposing Corrective Action, Hay Road Landfill, Vacaville, California.*

Table 1
Pan Lysimeter 2.2A and Leachate Sump 2.2A
Routine Monitoring Parameters and VOCs
NWS Hay Road Landfill

Sample Designation Sampling Date	PL-2.2A				S-2.2A		
	4/21/04	6/7/04	01/14/05	04/29/05	11/03/04	04/29/05	
<i>General Water Quality Parameters</i>		<i>Units</i>					
pH	std. units	7.12	7.24	7.06	7.99	6.57	6.57
Specific Conductance	µmhos/cm	3,820	3,740	3,310	2,990	7,090	5,660
Temperature	°C	21.3	25.1	20.6	24.0	22.1	24.2
Turbidity	NTU	482	218	55	483	43	162
<i>Monitoring Parameters</i>							
Bicarbonate Alkalinity	mg/l	1,300	NR	1,100	930	950	na
Calcium, dissolved	mg/l	68	NR	70	26	280	na
Carbonate Alkalinity	mg/l	<20	NR	<5.0	<5.0	<20	na
Chloride	mg/l	580	NR	570	100	2,000	1,500
Magnesium, dissolved	mg/l	81	NR	80	55	390	na
Nitrate/Nitrite as N	mg/l	0.084	NR	<0.100	1.3	<0.05	<1.0
Potassium, dissolved	mg/l	4.6	NR	4.6	<2.0	40	na
Sodium, dissolved	mg/l	740	NR	670	550	620	na
Sulfate as SO ₄	mg/l	24	NR	190	100	11	14
Total Dissolved Solids	mg/l	2,000	NR	2,100	1,700	3,800	3,000
<i>Volatile Organic Compounds by EPA Method 8260</i>							
1,1-Dichloroethane	µg/l	<0.2	0.15 t	0.35 t	<0.040	0.47 t	0.51 t
1,2-Dichloroethane	µg/l	<0.4	<0.05	<0.05	<0.05	<0.4	<0.4
1,2-Dichloropropane	µg/l	<0.35	<0.7	<0.7	<0.7	<0.35	<0.35
1,2,4-Trimethylbenzene	µg/l	<0.55	<0.11	<0.11	1.5	0.91 t	0.71 t
1,4-Dichlorobenzene	µg/l	<0.55	<0.11	<0.11	<0.11	2.4 t	2.5 t
2-Butanone	µg/l	<3.5	<0.7	<0.7	<0.7	<3.5	<3.5
Acetone	µg/l	<9	4.2 t	4.6 t	4.4 t	25 t	18 t
Benzene	µg/l	0.25 t	0.28 t	0.41 t	<0.050	1.9 t	1.9 t
Chloroethane	µg/l	<0.55	<0.11	<0.11	<0.11	<0.55	<0.55
Chloromethane	µg/l	<0.7	<0.14	0.24 t	<0.14	1.1 t	<0.7
cis-1,2-Dichloroethene	µg/l	<0.45	<0.09	0.21 t	<0.090	<0.45	<0.45
Di-isopropyl ether	µg/l	<1.5	<0.3	0.63 t	<0.30	<1.5	<1.5
Ethyl tert-butyl ether	µg/l	<1.4	<0.28	<0.28	<0.28	<1.4	<1.4
Ethylbenzene	µg/l	<0.5	<0.1	<0.10	0.24 t	1.9 t	1.9 t
Methyl tert-butyl ether	µg/l	1.8 t	1.7	3.5	0.15 t	15	17
Methylene chloride	µg/l	<0.3	<0.06	1.5	<0.060	0.46 t*	<0.3
m,p-Xylene	µg/l	<1	<0.21	<0.21	<0.21	4 t	3.1 t
Naphthalene	µg/l	<0.5	<0.10	<0.10	0.29 t	40	32
n-Propylbenzene	µg/l	<0.55	<0.11	<0.11	0.21 t	<0.55	<0.55
o-Xylene	µg/l	<0.35	<0.07	<0.070	<0.070	2.2 t	1.9 t
Tert-butyl alcohol	µg/l	<2	<0.39	<18	<18	590	430
Tetrachloroethene	µg/l	0.44 t	<0.08	<0.080	<0.080	<0.40	<0.40
Toluene	µg/l	0.50 t	<0.07	0.070 t	<0.070	1.6 t	0.97 t
Trichloroethene	µg/l	<0.3	<0.06	0.074 t	<0.060	<0.3	<0.3
Trichlorofluoromethane	µg/l	<0.35	<0.07	<0.070	<0.070	0.57 t	<0.35
Vinyl chloride	µg/l	<0.3	<0.06	<0.060	<0.060	1.1 t	1.4 t

t - Trace concentrations detected between the reporting limit and the detection limit. Results should be considered estimates only.
 * detected in associated method blank
 mg/l - milligrams per liter (parts per million)
 µg/l - micrograms per liter (parts per billion)
 NTU - Nephelometric Turbidity Units
 µmhos/cm - micromhos per centimeter at 25 °C
 na - not analyzed; not required by MRP.

Table 2
 Pan Lysimeters 5.1A & 5.1B and Leachate Sumps S-5.1A & 5.1B
 Routine Monitoring Parameters and VOCs
 NWS Hay Road Landfill

Sample Designation	Unit	PL-5.1A 01/14/05 05/03/05	PL-5.1B 04/21/04 06/07/04 11/03/04 01/19/05 05/03/05	S-5.1A 11/03/04 05/03/05	S-5.1B 11/03/04 #####
<i>General Water Quality Parameters</i>					
pH	std. unit	7.40	7.74	7.41	6.92
Specific Conductance	µmhos/c	2,880	2,060	9806	10,300
Temperature	°C	13.2	24.9	19.9	23.5
Turbidity	NTU	185	152	28	49
<i>Monitoring Parameters</i>					
Bicarbonate Alkalinity	mg/l	1,100	750	4,000	2,700
Calcium, dissolved	mg/l	150	96	110	120
Carbonate Alkalinity	mg/l	ND	<5.0	<20	<20
Chloride	mg/l	150	100	860	970
Magnesium, dissolved	mg/l	180	120	210	260
Nitrate/Nitrite as N	mg/l	74	0.13	0.2	<0.050
Potassium, dissolved	mg/l	6.1	4.3	79	82
Sodium, dissolved	mg/l	270	230	620	650
Sulfate as SO ₄	mg/l	400	220	<10	1,200
Total Dissolved Solids	mg/l	2,100	1,200	2,800	4,100
<i>Volatile Organic Compounds by EPA Method 8260 (results on next page)</i>					

Table 2 (continued)
 Pan Lysimeters 5.1A & 5.1B and Leachate Sumps S-5.1A & 5.1B
 Routine Monitoring Parameters and VOCs
 NWS Hay Road Landfill

Sample Designation	Unit	PL-5.1A 01/14/05 05/03/05	PL-5.1B 04/21/04 06/07/04 11/03/04 01/19/05 05/03/05	S-5.1A 11/03/04 05/03/05	S-5.1B 11/03/04 #####
<i>Volatile Organic Compounds by EPA Method 8260</i>					
1,1-Dichloroethane	µg/l	<0.2	0.053 t	<0.20	<0.40
1,2-Dichloroethane	µg/l	<0.40	<0.080	<0.40	<0.80
1,2-Dichloropropane	µg/l	<0.35	<0.07	<0.35	<0.7
1,2,4-Trimethylbenzene	µg/l	<0.55	<0.11	<0.55	<1.1
2-Butanone	µg/l	<3.5	<0.70	<3.5	<7.0
Acetone	µg/l	<9.0	7.9 t*	29 t*	37 t*
Benzene	µg/l	<0.25	<0.05	<0.25	1.8 t
Carbon disulfide	µg/l	<6.8	1.6	7.1 t	<14
Chloroethane	µg/l	<0.55	<0.11	<0.55	<1.1
Chloroform	µg/l	<0.35	<0.07	<0.35	<0.70
Chloromethane	µg/l	<0.70	<0.14	<0.70	<1.4
cis-1,2-Dichloroethane	µg/l	<0.45	0.12 t	<0.45	1.5 t
Dichlorodifluoromethane	µg/l	<0.45	<0.09	<0.45	<0.90
Di-isopropyl ether	µg/l	<1.5	<0.30	<1.5	<3.0
Ethanol	µg/l	<70	<14	<70	<140
Ethyl tert-butyl ether	µg/l	<1.4	<0.28	<1.4	<2.8
Ethylbenzene	µg/l	<0.50	<0.1	<0.50	<1.0
Methyl tert-butyl ether	µg/l	9.5	2.5	15	150
Methylene chloride	µg/l	8.6*	<0.06	<0.30	0.64 t*
m,p-Xylene	µg/l	<1.0	<0.21	<1.0	<2.1
Naphthalene	µg/l	<0.50	<0.1	<0.50	<1.0
o-Xylene	µg/l	<0.35	<0.07	<0.35	<0.70
Tert-amyl methyl ether	µg/l	<2.0	<0.39	<2.0	<3.9
Tert-butyl alcohol	µg/l	<88	<18	<88	<33
Tetrachloroethene	µg/l	<0.40	<0.08	<0.40	<0.80
Toluene	µg/l	<0.35	<0.07	<0.35	1.0 t
Trichloroethene	µg/l	<0.30	<0.06	<0.30	<0.60
Trichlorofluoromethane	µg/l	<0.35	<0.07	<0.35	<0.70
Vinyl chloride	µg/l	<0.30	<0.06	0.36 t	<0.60

t - Trace concentrations detected between the reporting limit and the detection limit. Results should be considered estimates only.

* detected in associated method blank

NTU - Nephelometric Turbidity Units

µg/l - milligrams per liter (parts per million)

µg/l - micrograms per liter (parts per billion)

Table 3
Landfill Gas Monitoring - DM 2.2
2003, 2004, 2005
NWS Hay Road Landfill

Sample Designation Sampling Date	GP-3A				PL-2.2B		
	09/30/03	06/09/04	10/18/04	03/28/05	06/09/04	03/28/05	
<i>Field Measurements</i>		<i>Units</i>					
Methane	%	1.2	8	4.4	3	0.2	0
Carbon Dioxide	%	4.1	4.5	4.7	0.15	5	0.15
Oxygen	%	2	0.5	0.8	5.4	15.8	20.9
Organic Vapors	ppm	12.5	1.1	1.3	0.6	1.2	0.1
<i>Volatile Organic Compounds by EPA Method TO-15</i>							
1,1,1-Trichloroethane	ppbv	<0.10	<1.6	<0.20	<0.78	1.8	<0.68
1,1-Dichloroethane	ppbv	8.3	26	16	19	18	0.73
1,1-Dichloroethene	ppbv	<0.10	<1.6	0.49	<0.78	<0.74	<0.68
1,2,4-Trimethylbenzene	ppbv	<0.10	<1.6	0.43	<0.78	2.5	1.1
1,3,5-Trimethylbenzene	ppbv	<0.10	<1.6	0.2	<0.78	1.8	<0.68
1,4-Dichlorobenzene	ppbv	<0.10	<1.6	<0.20	<0.78	1.7	<0.68
2,2,4-Trimethylpentane	ppbv	NA	45	NA	7	1	<0.68
2-Butanone	ppbv	<1.0	1.8	<0.98	<0.78	6.2	1
4-Ethyltoluene	ppbv	<0.10	<1.6	<0.98	<0.78	1.8	0.83
Acetone	ppbv	<1.0	<6.6	4.8	<3.1	18	4.8
Benzene	ppbv	4	9.3	5.8	6.6	0.8	<0.68
Carbon Disulfide	ppbv	0.38	3	2	4.5	<0.74	<0.68
Chloroethane	ppbv	6.8	<1.6	17	13	<0.74	<0.68
Chloroform	ppbv	2	<1.6	<0.20	<0.78	39	<0.68
cis-1,2-Dichloroethene	ppbv	<0.10	5.8	4	4.9	<0.74	<0.68
Cumene	ppbv	NA	<1.6	<0.98	<0.78	1.5	<0.68
Cyclohexane	ppbv	<0.10	120	51	45	2.6	<0.68
Ethylbenzene	ppbv	<0.10	<1.6	0.87	0.97	4.2	0.7
Freon 11	ppbv	<0.10	<1.6	0.28 t	<0.78	<0.74	<0.68
Freon 114	ppbv	<0.10	22	12	9.2	4.2	<0.68
Freon 12	ppbv	<0.10	59	23	22	19	<0.68
Heptane	ppbv	<0.10	17	6.6	4.4	1.8	<0.68
Hexane	ppbv	<0.10	34	9.3	6.9	4.9	<0.68
m,p-Xylene	ppbv	1	4	2.6	3.4	7.7	1.7
Methyl tert-butyl ether	ppbv	<0.10	<1.6	<0.98	<0.78	6.1	<0.68
Methylene Chloride	ppbv	6.2	10	4.4	5	<0.74	<0.68
o-Xylene	ppbv	0.59	<1.6	0.56	0.91	3.1	<0.68
Tetrachloroethene	ppbv	<0.1	3.1	2.7	2.2	2.6	<0.68
Tetrahydrofuran	ppbv	1.3	<1.6	<0.98	<0.78	<0.74	<0.68
Toluene	ppbv	0.78	<1.6	3.7	0.92	1.9	1.7
Trichloroethene	ppbv	3.5	16	11	12	0.74	<0.68
Vinyl Chloride	ppbv	21	71	30	30	1	<0.68

ppm - parts per million
ppbv - parts per billion by volume

Table 4
 Landfill Gas Monitoring - DM 5.1
 2004
 NWS Hay Road Landfill

Sample Designation	PL-5.1B	
Sampling Date	06/09/04	
<i>Field Measurements</i>		
	<i>Units</i>	
Methane	%	0.6
Carbon Dioxide	%	nm
Oxygen	%	3.2
Oganic Vapors	ppm	2.2
<i>Volatile Organic Compounds by EPA Method TO-15</i>		
1,1,1-Trichloroethane	ppbv	17
1,1-Dichloroethane	ppbv	190
1,1-Dichloroethene	ppbv	<5.4
1,2,4-Trimethylbenzene	ppbv	<5.4
1,3,5-Trimethylbenzene	ppbv	<5.4
1,4-Dichlorobenzene	ppbv	<5.4
2,2,4-Trimethylpentane	ppbv	54
2-Butanone	ppbv	<5.4
2-Propanol	ppbv	<21
4-Ethyltoluene	ppbv	<5.4
Acetone	ppbv	<21
Benzene	ppbv	<5.4
Carbon Disulfide	ppbv	<5.4
Chloroethane	ppbv	<5.4
Chloroform	ppbv	<5.4
cis-1,2-Dichloroethene	ppbv	24
Cumene	ppbv	<5.4
Cyclohexane	ppbv	400
Ethylbenzene	ppbv	<5.4
Freon 11	ppbv	300
Freon 113	ppbv	<5.4
Freon 114	ppbv	29
Freon 12	ppbv	2000
Heptane	ppbv	<5.4
Hexane	ppbv	38
m,p-Xylene	ppbv	9.3
Methyl tert-butyl ether	ppbv	200
Methylene Chloride	ppbv	6.8
o-Xylene	ppbv	<5.4
Tetrachloroethene	ppbv	74
Tetrahydrofuran	ppbv	18
Toluene	ppbv	<5.4
trans-1,2-Dichloroethene	ppbv	<5.4
Trichloroethene	ppbv	65
Vinyl Chloride	ppbv	<5.4

nm - not measured
 ppm - parts per million
 ppbv - parts per billion by volume

Table 5
 Pan Lysimeter 2.2A and Leachate Sump 2.2A
 Constituent of Concern Monitoring Parameters
 Fourth Quarter 2004 and First Quarter 2005
 NWS Hay Road Landfill

Sample Designation		PL-2.2A	S-2.2A
Sampling Date		01/14/05	11/03/04
<i><u>Inorganic Parameters</u></i>			
	<i><u>Units</u></i>		
Ammonia as N	mg/l	0.130	19
Cyanide	mg/l	<0.0050	0.0057
Fecal Coliforms	mpn/100ml	2.0	340
Nitrite as N	mg/l	<0.30	<0.05
Phosphate	mg/l	<5.0	<0.25
Phosphorus	mg/l	<0.10	0.068
Sulfide	mg/l	<0.10	<20
Total Alkalinity	mg/l	1100	950
Total Kjeldahl Nitrogen	mg/l	2.24	21
Total Organic Carbon	mg/l	20	49
<i><u>Metals, dissolved</u></i>			
Aluminum	mg/l	<0.050	<0.20
Antimony	mg/l	<0.010	<0.060
Arsenic	mg/l	0.0075	0.014
Barium	mg/l	0.16	5.1
Beryllium	mg/l	<0.0040	<0.0010
Cadmium	mg/l	<0.0050	<0.010
Chromium	mg/l	<0.0050	<0.010
Cobalt	mg/l	<0.010	<0.0070
Copper	mg/l	<0.010	<0.010
Iron	mg/l	0.76	9.8
Lead	mg/l	<0.0050	<0.0050
Manganese	mg/l	4.1	7.4
Mercury	mg/l	<0.00020	<0.00020
Nickel	mg/l	0.036	0.094
Selenium	mg/l	<0.0050	0.0065
Silver	mg/l	<0.010	<0.0070
Thallium	mg/l	0.0058	<0.0050
Tin	mg/l	<0.10	<0.25
Vanadium	mg/l	<0.010	<0.010
Zinc	mg/l	<0.020	<0.020
<i><u>Organic Compounds</u></i>			
All compounds	µg/l	ND	ND

mg/l - milligrams per liter (parts per million)

mpn - most probable number

µg/l - micrograms per liter (parts per billion)

ND - not detected at or above the reporting limit.

Table 6
 Pan Lysimeters 5.1A & 5.1B and Leachate Sumps S-5.1A & 5.1B
 Constituent of Concern Monitoring Parameters
 Fourth Quarter 2004 through Second Quarter 2005
 NWS Hay Road Landfill

Sample Designation Sampling Date		PL-5.1A 05/03/05	PL-5.1B 01/19/05	S-5.1A 11/03/04	S-5.1B 11/03/04
<i><u>Inorganic Parameters</u></i>					
	<i><u>Unit</u></i>				
Ammonia as N	mg/l	<0.25	40.4	900	860
Cyanide	mg/l	<0.0050	<0.025	0.005	-
Fecal Coliforms	mpn/100ml	300	1600	140	>16,000
Nitrite as N	mg/l	<0.1	<0.30	0.58	<3
Phosphate	mg/l	<1.6	<5.0	3	1.7
Phosphorus	mg/l	0.067	3.18	2.6	1.9
Sulfide	mg/l	<1.0	5.8	3.5	16
Total Alkalinity	mg/l	750	1300	4000	2700
Total Kjeldahl Nitrogen	mg/l	1.4	57	790	800
Total Organic Carbon	mg/l	25	140	470	1200
<i><u>Metals, dissolved</u></i>					
Aluminum	mg/l	<0.10	<0.050	<0.20	<0.20
Antimony	mg/l	<0.10	<0.010	<0.060	<0.060
Arsenic	mg/l	0.15	0.0093	0.034	0.032
Barium	mg/l	0.15	0.45	1.6	0.24
Beryllium	mg/l	<0.010	<0.0040	<0.0010	<0.0010
Cadmium	mg/l	<0.010	<0.0050	<0.010	<0.010
Chromium	mg/l	<0.010	<0.0050	0.012	0.028
Cobalt	mg/l	<0.050	<0.010	0.016	0.022
Copper	mg/l	<0.010	<0.010	<0.010	<0.010
Iron	mg/l	<0.10	0.19	4.8	<0.0050
Lead	mg/l	<0.10	<0.0050	<0.0050	<0.0050
Manganese	mg/l	2.1	5.4	2.5	1.9
Mercury	mg/l	<0.00020	<0.00020	<0.00020	<0.00020
Nickel	mg/l	<0.050	0.037	0.094	0.17
Selenium	mg/l	<0.10	<0.0050	<0.0050	<0.25
Silver	mg/l	<0.020	<0.010	<0.0070	<0.007
Thallium	mg/l	<0.10	<0.0050	<0.0050	<0.25
Tin	mg/l	<0.10	<0.10	<0.25	<0.25
Vanadium	mg/l	<0.050	<0.010	0.021	0.023
Zinc	mg/l	<0.050	<0.020	<0.020	<0.020
<i><u>Organic Compounds</u></i>					
Phenol	µg/l	<9.6	300	<10	<9.8
All other compounds	µg/l	ND	ND	ND	ND

mpn - most probable number
 mg/l - milligrams per liter (parts per million)
 µg/l - micrograms per liter (parts per billion)
 ND - not detected at or above the reporting limit.

Table 7
DM 2.2A Monitoring Wells
Routine Monitoring Parameters and VOCs
Second Quarter 2005
NWS Hay Road Landfill

Sample Designation Sampling Date		G-11 04/20/05	G-11R 04/20/05	G-12 04/21/05
<i>Field Parameters</i>				
	<i>Units</i>			
pH	std. units	7.33	7.60	7.46
Specific Conductance	µmhos/cm	1250	957	1320
Temperature	°C	18.7	19.0	19.0
Turbidity	NTU	225	>999	208
<i>Routine Parameters</i>				
Arsenic, Dissolved	mg/l	<0.10	<0.10	<0.10
Bicarbonate Alkalinity	mg/l	400	290	610
Calcium, dissolved	mg/l	53	38	51
Carbonate Alkalinity	mg/l	<5.0	<5.0	<5.0
Chloride	mg/l	120	97	190
Chromium, dissolved	mg/l	<0.010	<0.010	<0.010
Magnesium, dissolved	mg/l	52	50	69
Nitrate/Nitrite as N	mg/l	2.6	2.3	1.8
Phosphate	mg/l	<5.0	<5.0	0.056
Potassium, dissolved	mg/l	<2.0	<2.0	<2.0
Sodium, dissolved	mg/l	150	86	120
Sulfate as SO ₄	mg/l	47	34	69
Total Dissolved Solids	mg/l	670	490	720
<i>Volatile Organic Compounds by EPA Method 8260</i>				
Acetone	µg/l	<1.8	2.2 t	3.8 t
Ethanol	µg/l	<14	25 t	<14
All other compounds non-detect.				

NTU - Nephelometric Turbidity Units

µmhos/cm - micromhos per centimeter at 25 °C

mg/l - milligrams per liter (parts per million)

µg/l - micrograms per liter (parts per billion)

t - Trace concentrations detected between the reporting limit and the detection limit. Results should be considered estimates only.

Table 8
DM 5.1 Monitoring Well Analytical Results
Routine Monitoring Parameters and VOCs
Second Quarter 2005
NWS Hay Road Landfill

Sample Designation		G-16	G-18	G-20
Sampling Date		04/22/05	04/22/05	04/22/05
<i>Field Parameters</i>				
	<i>Units</i>			
pH	std. units	7.37	7.43	7.45
Specific Conductance	µmhos/cm	3520	2770	2240
Temperature	°C	18.9	17.3	19.3
Turbidity	NTU	226	433	237
<i>Routine Parameters</i>				
Ammonia as N	mg/l	<0.25	<0.25	<0.25
Arsenic, Dissolved	mg/l	<0.10	<0.10	<0.10
Bicarbonate Alkalinity	mg/l	290	320	340
Calcium, dissolved	mg/l	84	78	65
Carbonate Alkalinity	mg/l	<5.0	<5.0	<5.0
Chloride	mg/l	920	700	530
Chromium, dissolved	mg/l	0.012	<0.010	<0.010
Lead, dissolved	mg/l	<0.10	<0.10	<0.10
Magnesium, dissolved	mg/l	210	150	130
Nitrate/Nitrite as N	mg/l	3.3	3.6	2.0
Potassium, dissolved	mg/l	<2.0	<2.0	<2.0
Sodium, dissolved	mg/l	300	220	200
Sulfate as SO ₄	mg/l	270	150	110
Total Dissolved Solids	mg/l	1900	1400	1100
Total Kjeldahl Nitrogen	mg/l	21	2.0	4.5
<i>Volatile Organic Compounds by EPA Method 8260</i>				
Acetone	µg/l	1.9 t	2.0 t	<1.8
All other compounds non-detect.				

NTU - Nephelometric Turbidity Units

µmhos/cm - micromhos per centimeter at 25 °C

mg/l - milligrams per liter (parts per million)

µg/l - micrograms per liter (parts per billion)

t - Trace concentrations detected between the reporting limit and the detection limit. Results should be considered estimates only.

Table 9
Theoretical Partitioning of VOCs From Landfill Gas to Water
PL-2.2B and PL-2.2A
Hay Road Landfill

Constituent	Gas	Henry's Law	Predicted Water	Measured Water Concentration		
	Concentrations	Constant	Concentration			
	PL-2.2B			PL-2.2A		
	6/9/2004			4/21/2004	6/7/2004	4/29/05
	(ug/m3)	(atm-m3/mol)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
	Cg	H	Cw			
1,1-Dichloroethane	--	0.0056	--	<0.2	0.15	--
1,3,5-Trimethylbenzene	--	0.0077	--	--	--	1.5
Acetone	--	0.00004	--	<9	4.2	4.4
Benzene	0.8	0.0056	0.003	0.25	0.28	--
Ethylbenzene	--	0.0079	--	<0.5	<0.1	0.24
Methyl <i>tert</i> -butyl ether	6.5	0.00059	0.265	1.8	1.7	0.15
Naphthalene	--	0.0197	--	--	--	0.29
n-Propylbenzene	--	0.0075	--	--	--	0.21
Tetrachloroethene	3.0	0.018	0.004	0.44	<0.08	--
Toluene	1.9	0.0066	0.007	0.5	<0.07	--
Total quantified VOCs			0.3	3.0	6.3	6.8

Notes:

J = Trace concentration

ND = analyte not detected

NA = not analyzed, analyte not on TO-14 compound list

Henry's Law: $C_w = (C_g \times 0.024) / 1000 / H$

C_w = liquid phase concentration (ug/L)

C_g = vapor phase concentration (ug/m³)

H = Henry's law coefficient (atm-m³/mol)

0.024 = the value for R x T, where R is the Universal Gas Constant and T is degrees Kelvin

1000 = conversion factor for cubic meters to liters

Predicted concentrations in groundwater are calculated at standard temperature (25 degrees C) and pressure (1 atmosphere) conditions.

Table 10
Theoretical Partitioning of VOCs From Landfill Gas to Water
GP-3A and PL-2.2A
Hay Road Landfill

Constituent	Landfill Gas	Henry's Law	Predicted Water	Measured Water Concentration		
	Concentrations	Constant		Concentration	PL-2.2A	
	in GP-3A 3/28/2005 (ug/m3) Cg	(atm-m3/mol) H	(ug/L) Cw	4/21/04 (ug/L)	6/7/04 (ug/L)	4/29/05 (ug/L)
1,1-Dichloroethane	77	0.0056	0.33	--	0.15	--
1,2-Dichlorotetrafluoroethane (Freon 114)	64	2.8	0.001	--	--	--
1,3,5-Trimethylbenzene	--	0.0077	--	--	--	1.5
Acetone	--	0.00004	--	--	4.2	4.4
Benzene	21	0.0056	0.09	0.25	0.28	--
Carbon Disulfide	14	0.0144	0.02	--	--	--
Chloroethane	35	0.011	0.08	--	--	--
cis-1,2-Dichloroethene	19	0.0041	0.11	--	--	--
Cyclohexane	155	0.15	0.02	--	--	--
Dichlorodifluoromethane (Freon 12)	109	0.10	0.03	--	--	--
Ethylbenzene	4	0.0079	0.01	--	--	0.24
Heptane	18	2	0.000	--	--	--
Hexane	24	1.802	0.000	--	--	--
m,p-Xylenes	15	0.0075	0.05	--	--	--
Methyl tert-butyl ether	--	0.00059	--	1.8	1.7	0.15
Methylene Chloride	17	0.0022	0.19	--	--	--
Naphthalene	--	0.0197	--	--	--	0.29
n-Propylbenzene	--	0.0075	--	--	--	0.21
o-Xylenes	4	0.0052	0.02	--	--	--
Tetrachloroethene	15	0.018	0.02	0.44	--	--
Toluene	3	0.0066	0.01	0.5	--	--
Trichloroethene	64	0.01	0.15	--	--	--
Vinyl Chloride	77	0.027	0.07	--	--	--
Total quantified VOCs			1.2	3.0	6.3	6.8

Notes:

J = Trace concentration

ND = analyte not detected

Henry's Law: $C_w = (C_g \times 0.024) / 1000 / H$

C_w = liquid phase concentration (ug/L)

C_g = vapor phase concentration (ug/m3)

H = Henry's law coefficient (atm-m3/mol)

0.024 = the value for R x T, where R is the Universal Gas Constant and T is degrees Kelvin

1000 = conversion factor for cubic meters to liters

Predicted concentrations in groundwater are calculated at standard temperature (25 degrees C) and pressure (1 atmosphere) conditions.

Table 11
Theoretical Partitioning of VOCs From Landfill Gas to Water
PL-5.1A and PL-5.1B
Hay Road Landfill

Constituent	Gas Concentrations		Henry's Law Constant (atm-m ³ /mol) H	Predicted Water Concentration (ug/L) C _w	Measured Water Concentration						
	PL-5.1B 6/9/04 (ug/m ³) C _g				PL-5.1B			PL-5.1A			
			4/21/04 (ug/L)	6/7/04 (ug/L)	11/3/04 (ug/L)	1/19/05 (ug/L)	5/3/05 (ug/L)	1/14/05 (ug/L)	5/3/05 (ug/L)		
1,1,1-Trichloroethane	92	0.0170	0.13	-	-	-	-	-	-	-	-
1,1-Dichloroethane	769	0.0056	3.3	2.9	4.1	0.52	1.4	<0.20	<0.2	0.053	
1,2-Dichloroethane	--	0.00098	--	-	0.74	-	-	-	-	-	
1,2-Dichloropropane	--	0.0028	--	-	0.087	-	-	-	-	-	
1,2-Dichlorotetrafluoroethane (Freon 114)	203	2.8	0.002	-	-	-	-	-	-	-	
2-Butanone (MEK)	--	0.00003	--	-	-	-	28	<0.25	-	<0.05	
Acetone	--	0.00004	--	14	5.3	3.9	44	-	-	-	
Benzene	--	0.0056	--	0.48	0.58	0.11	0.5	-	-	-	
Chloroethane	--	0.011	--	-	0.63	-	-	<0.35	-	<0.07	
Chloroform	--	0.00367	--	-	-	0.083	-	-	-	-	
Chloromethane	--	0.00700	--	-	-	-	2.1	<0.70	-	<0.14	
<i>cis</i> -1,2-Dichloroethene	95	0.0041	0.56	1.4	5.2	0.42	-	<0.45	-	0.12	
Cyclohexane	1,376	0.15	0.22	-	-	-	-	-	-	-	
Dichlorodifluoromethane (Freon 12)	9,894	0.10	2.4	-	-	0.16	-	<0.45	-	<0.09	
Ethanol	--	0.000005	--	-	-	-	-	<70	-	<14	
Ethylbenzene	--	0.0079	--	-	0.14	-	-	<0.50	-	<0.1	
<i>m,p</i> -Xylenes	40	0.0075	0.13	-	-	-	-	-	-	-	
Methyl <i>tert</i> -butyl ether	721	0.00059	29	28	43	2.9	48	15	9.5	2.5	
Methylene Chloride	24	0.0022	0.26	2.1	0.81	0.06	2	<0.30	8.6 b	<0.06	
n-Hexane	134	1.802	0.002	-	-	-	-	-	-	-	
<i>o</i> -Xylenes	--	0.0052	--	-	0.32	0.082	-	<0.35	-	<0.07	
Tetrachloroethene	502	0.018	0.67	0.48	0.2	0.48	-	<0.40	-	<0.08	
Tetrahydrofuran	53	0.000071	18	-	4	-	-	-	-	-	
Toluene	--	0.0066	--	0.48	0.61	0.18	0.77	<0.35	-	<0.07	
Trichloroethene	348	0.01	0.84	1.1	0.76	0.13	-	-	-	-	
Trichlorofluoromethane (Freon 11)	1,680	0.097	0.42	-	0.12	0.15	-	<0.35	-	<0.07	
Vinyl Chloride	--	0.027	--	-	-	-	-	0.36	-	<0.06	
Total quantified VOCs			56	51	67	9.2	127	15	9.5	4.3	

Notes:

italics = Trace concentration

ND = analyte not detected

ug/m³ = 0.001 ug/L

Henry's Law: $C_w = (C_g \times 0.024) / 1000 / H$

C_w = liquid phase concentration (ug/L)

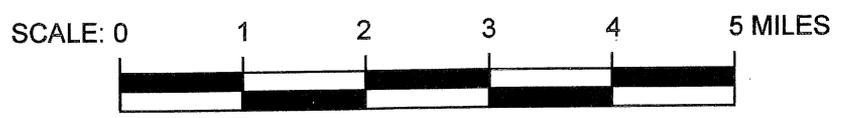
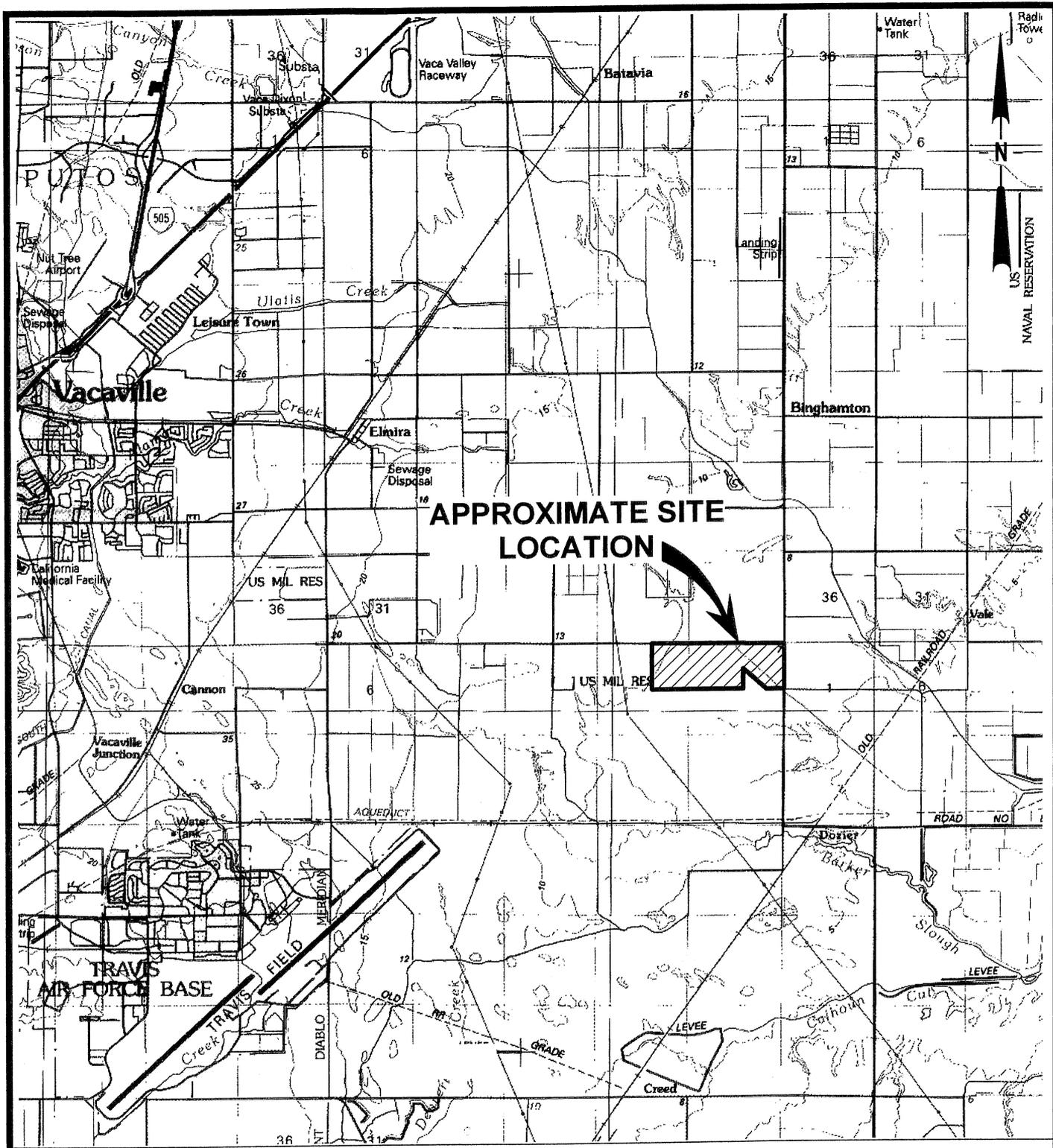
C_g = vapor phase concentration (ug/m³)

H = Henry's law coefficient (atm-m³/mol)

0.024 = the value for $R \times T$, where R is the Universal Gas Constant and T is degrees Kelvin

1000 = conversion factor for cubic meters to liters

Predicted concentrations in groundwater are calculated at standard temperature (25 degrees C) and pressure (1 atmosphere) conditions.



Base map from USGS 1:100,000 Metric Topographic Map: Lodi, Calif. (1993).

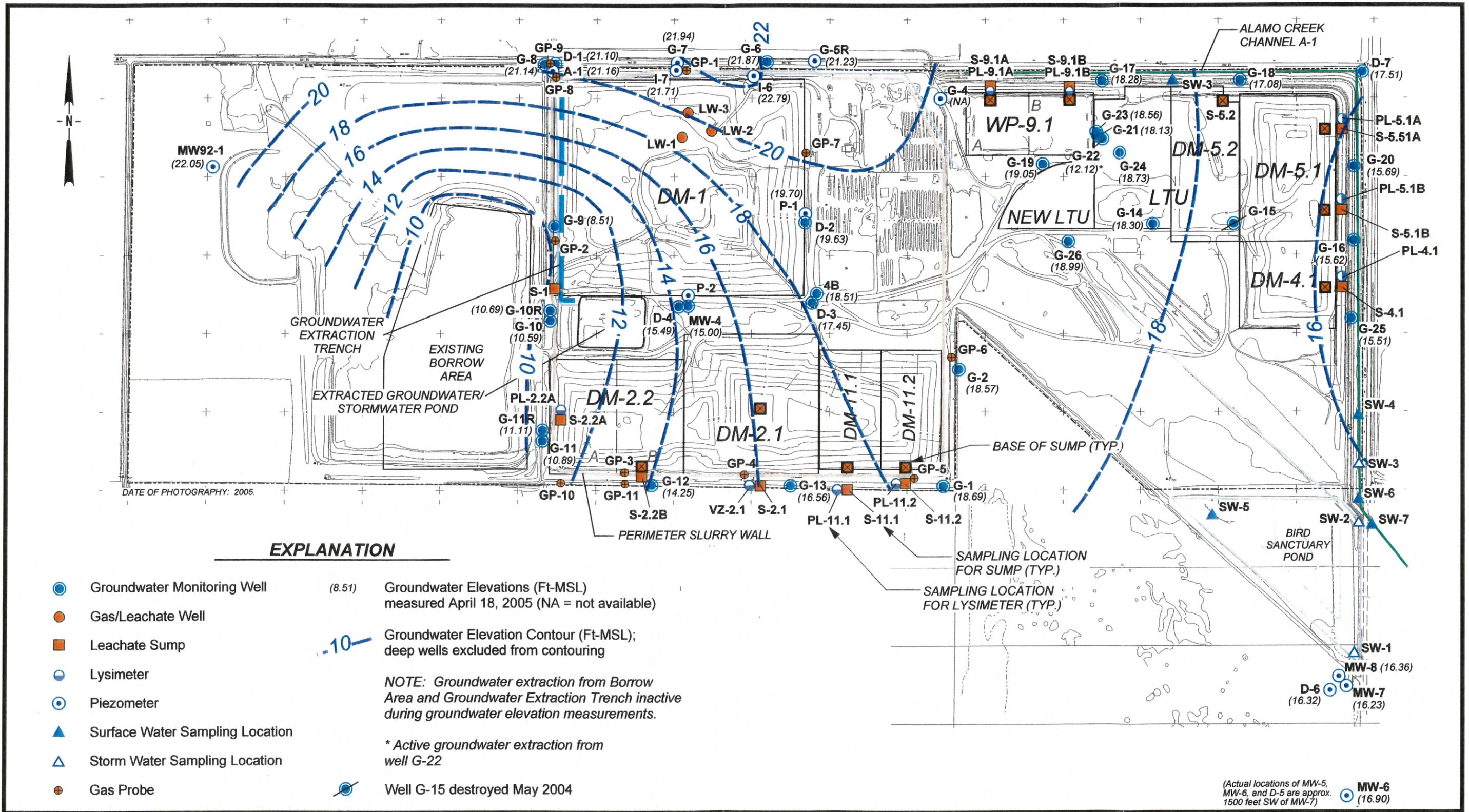


MONITORING AND REPORTING PROGRAM
 HAY ROAD LANDFILL
 SOLANO COUNTY, CALIFORNIA

FIGURE
1

SITE LOCATION

PROJECT NO.
 053-7444



EXPLANATION

- Groundwater Monitoring Well
- Gas/Leachate Well
- Leachate Sump
- Lysimeter
- Piezometer
- ▲ Surface Water Sampling Location
- ▲ Storm Water Sampling Location
- Gas Probe
- (8.51) Groundwater Elevations (Ft-MSL) measured April 18, 2005 (NA = not available)
- 10- Groundwater Elevation Contour (Ft-MSL); deep wells excluded from contouring
- NOTE: Groundwater extraction from Borrow Area and Groundwater Extraction Trench inactive during groundwater elevation measurements.
- * Active groundwater extraction from well G-22
- Well G-15 destroyed May 2004

(Actual locations of MW-5, MW-6, and D-5 are approx. 1500 feet SW of MW-7)

MW-6 (16.90)



SCALE: 0 600 1,200 1,800 FEET



HAY ROAD LANDFILL
SOLANO COUNTY, CALIFORNIA

SITE PLAN

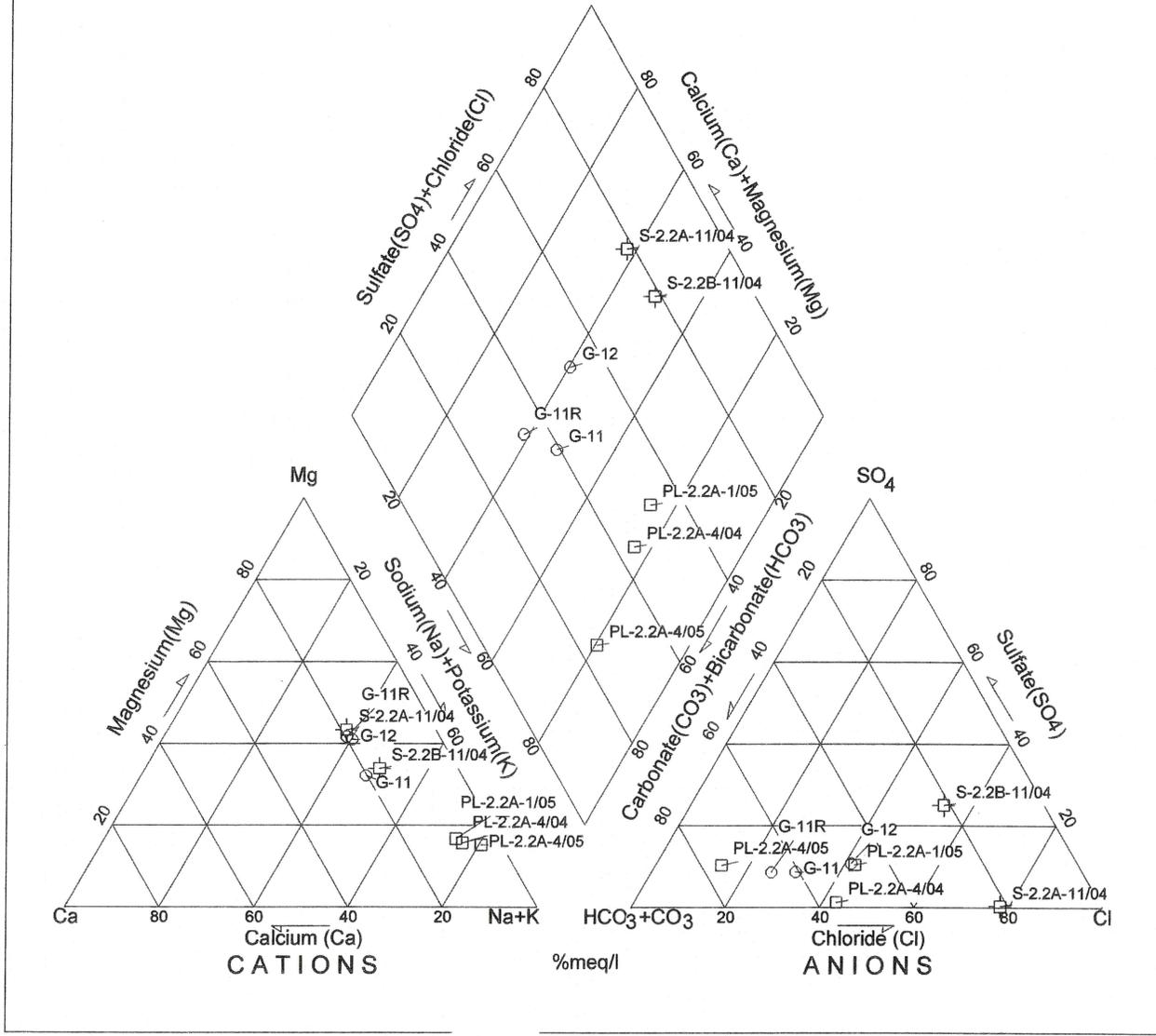
FIGURE

2

PROJECT NO.
053-7484

PL2.2A

Hay Road Landfill



HAY ROAD LANDFILL
 SOLANO COUNTY, CALIFORNIA

PL-2.2A AREA PIPER DIAGRAM

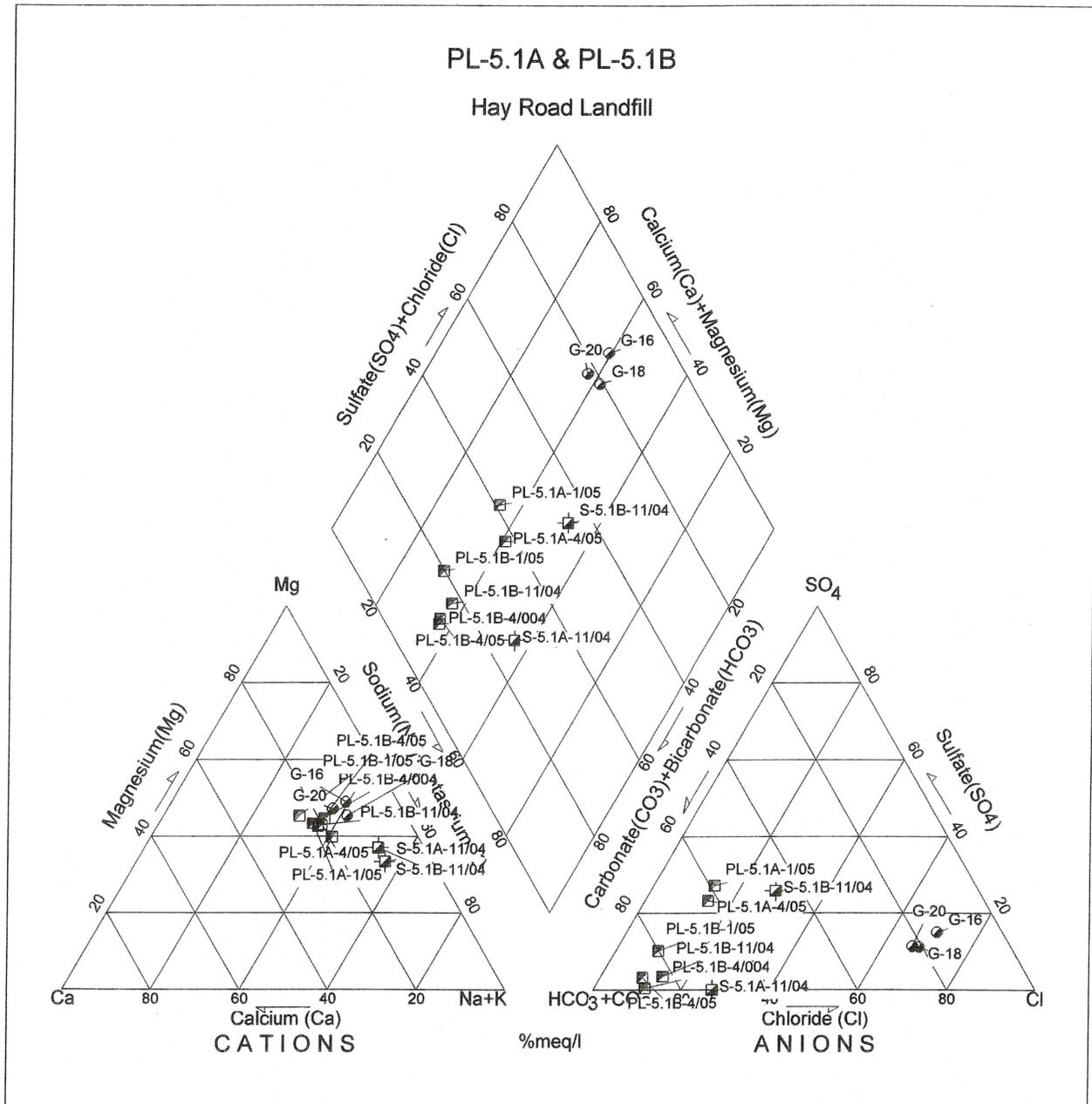
FIGURE

4

PROJECT NO.
 053-7484

PL-5.1A & PL-5.1B

Hay Road Landfill



HAY ROAD LANDFILL
SOLANO COUNTY, CALIFORNIA

PL-5.1A AND PL.5.1B AREA PIPER DIAGRAM

FIGURE

5

PROJECT NO.
053-7484

Figure 6
Hourly Sump S-2.2A and Pan Lysimeter PL-2.2A Liquid Levels and Rainfall

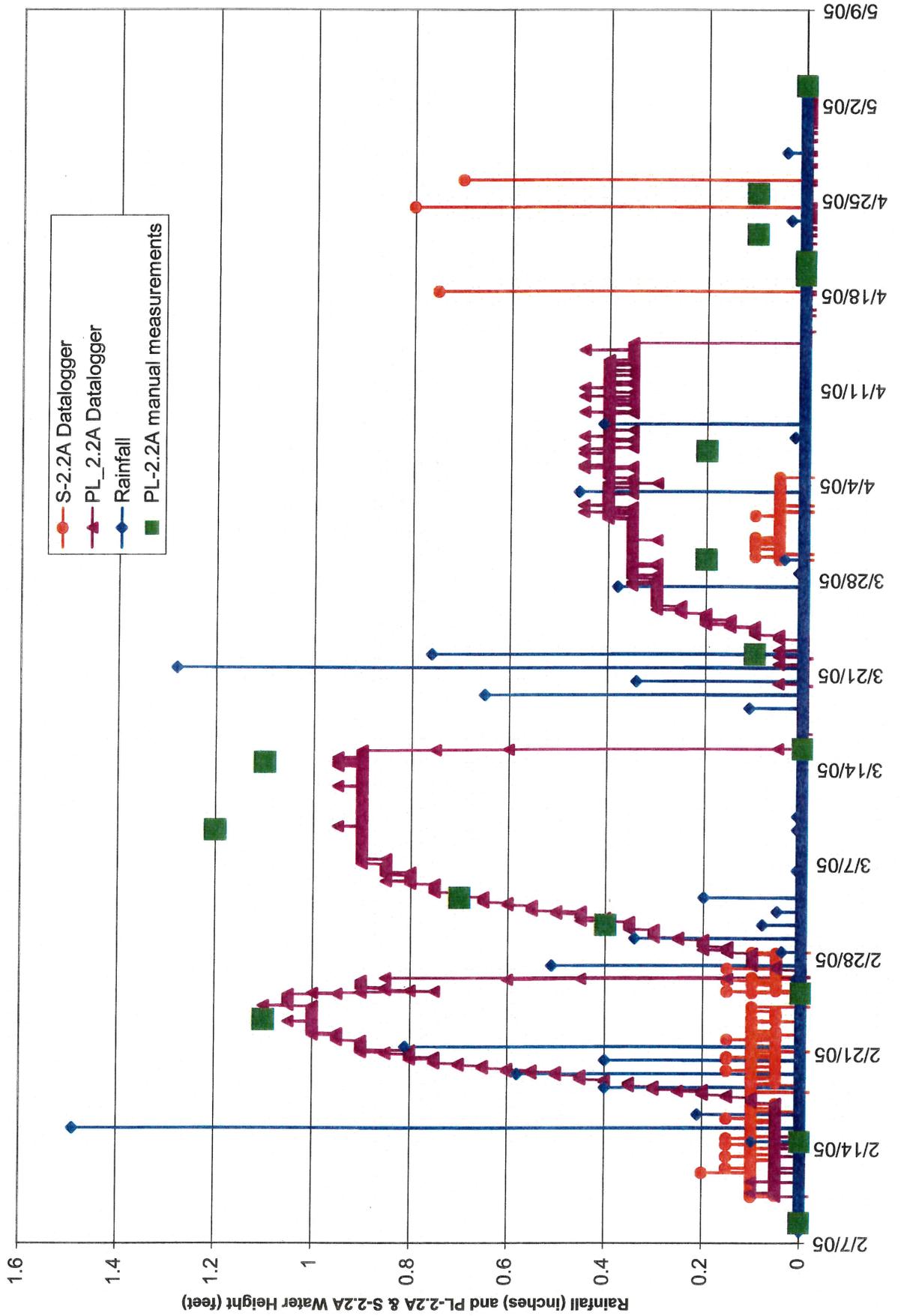
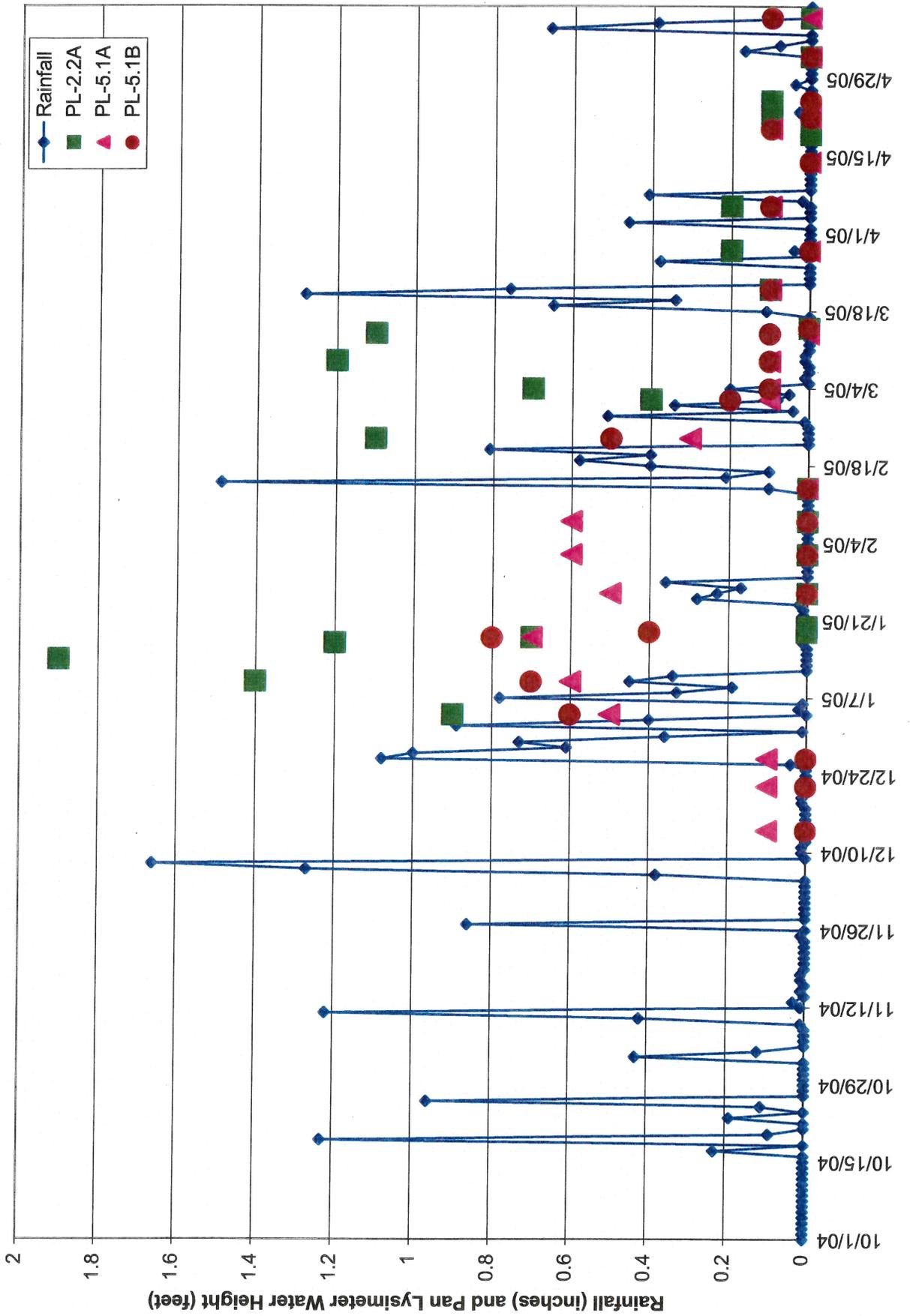
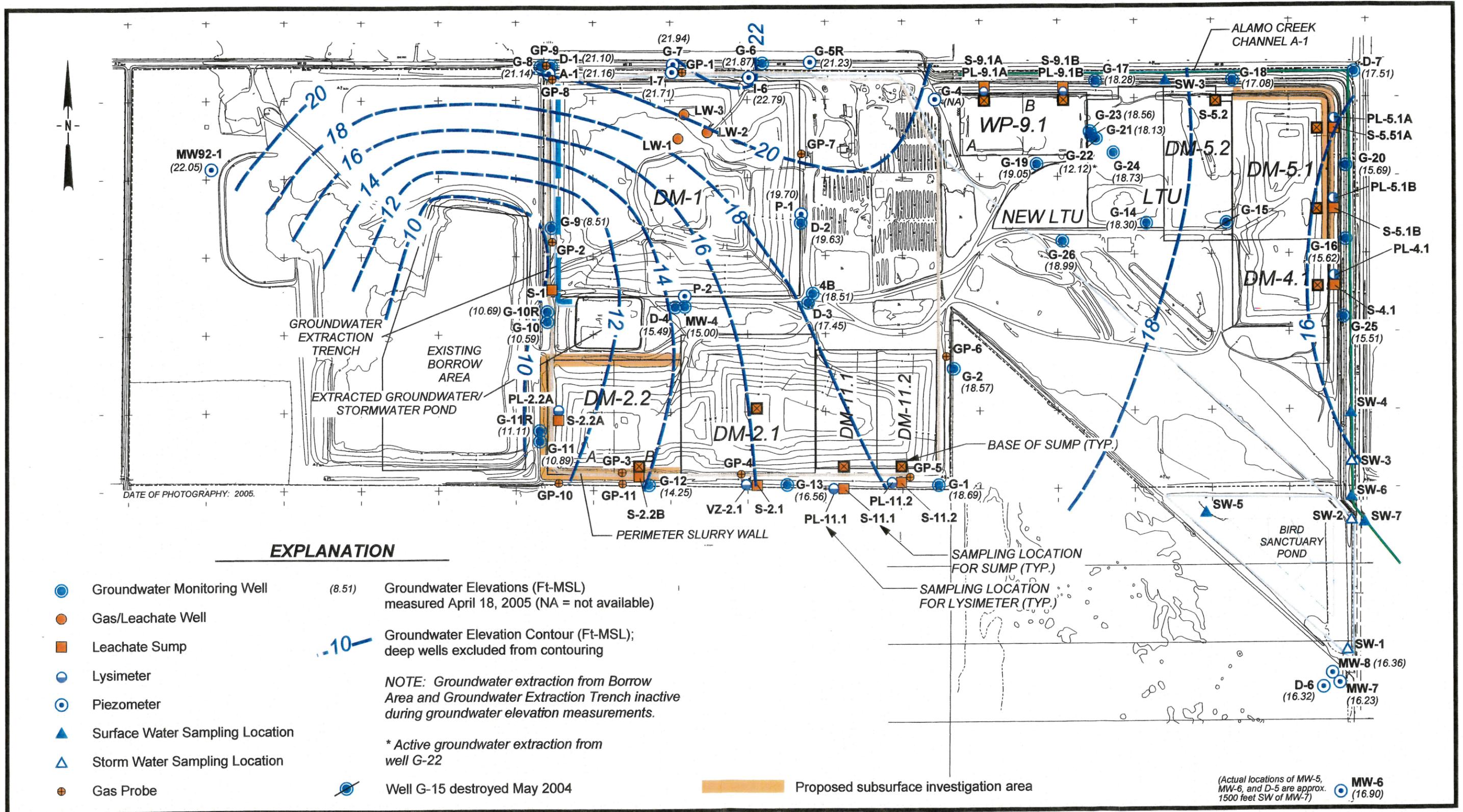


Figure 7
Weekly Pan Lysimeters PL-2.2A, PL-5.1A, and PL-5.1B Liquid Levels and Rainfall





HAY ROAD LANDFILL
 SOLANO COUNTY, CALIFORNIA
 PROPOSED SUBSURFACE INVESTIGATION AREA

FIGURE
 8
 PROJECT NO.
 053-7484

APPENDIX A

2.2A Pumping Data

Leachate Sump

Top of Riser Elevation 42.0' MSL
 Sump Elevation 26.1' MSL
 Target Depth to Leachate 30.00'

Sump | *Parlysimh*

Date	Depth to Leachate	Reading	Gallons Pumped/Reading
1-4-05	.10	.90	
1-10-05	.10	1.40	
1-14-05	.10	1.90	
1-17-05	.10	1.20	
1-18-05	.10	.70	
1-19-05	.10	.00	Est 6000 gal
1-20-05	.10	.00	
1-24-05	.0	.0	
2-2-05	.10	.0	
2-8-05	.10	.0	
2-14-05	.10	.0	
2-23-05	.0	1.10	Est 5000
2-2-05	.10	.40	
3-4-05	.10	.70	
3-9-05	.0	1.20	
3-14-05	.10	1.10	
3-15-05	.0	.0	Pumped 4 1/2 hrs est 2700 gal
3-22-05	.20	.10	
3-29-05	.0	.20	
4-6-05	.20	.20	
4-19-05	.20	.0	Pumped 1000 gal est
4-20-05	.30	.0	
4-22-05	.0	.10	
4-25-05	.0	.10	
5-3-05	.10	.0	
5-10-05	.20	.0	

5.1A Pumping Data

Leachate Sump
 Length of Riser 40.90'
 Target Depth 40.90'

Lysimeter
 Length of Riser

Sump			Lysimeter		
Date	Depth to Leachate	Gallons Pumped/Reading	Date	Depth to Water (ft)	Gallons Pumped
1-4-05	.70			.50	
1-10-05	.60			.60	
1-19-05	.50			.70	
1-26-05	.30			.50	
2-2-05	.50			.60	
2-8-05	.50			.60	
2-14-05	.50			.0	1500 gal/est
2-23	.30			.30	est 700 gal.
3-2-05	.40			.10	
3-4-05	.50			.10	
3-7-05	.60			.10	
3-14-05	.50			.0	
3-22-05	.40			.10	
3-29-05	.30			.0	
4-6-05	.40			.10	
4-14-05	.30			.0	20 gal
4-20-05	.80			.10	20 gal
4-22-05	.70			.0	
4-23-05	.90			.0	
5-3-05	.20			.0	
5-10-05	.20			.0	

5.1B Pumping Data

Leachate Sump
 Length of Riser 40.90'
 Target Depth 40.90'

Lysimeter
 Length of Riser

Sump			Lysimeter		
Date	Depth to Leachate	Gallons Pumped/Reading	Date	Depth to Water (ft)	Gallons Pumped
1-4-05	.40			.60	
1-10-05	.10			.70	
1-18-05	.10			.80	
1-19-05	.10			.40	
1-26-05	.10			.00	Est 3000 gal
2-2-05	.20			.0	
2-8-05	.20			.0	
2-14-05	.10			.0	
2-23-05	.0			.50	Est 3000 gal
3-2-05	.40			.20	
3-4-05	.20			.10	
3-9-05	.10			.10	
3-14-05	.10			.10	Est 150 gal
3-15-05	.0			.0	Est 75 gal
3-22-05	.20			.10	
3-29-05	.0			.0	
4-6-05	.20			.10	
4-14-05	.10			.0	Est 600 gal
4-20-05	.30			.10	Est 425
4-22-05	.40			.0	
4-28-05	.30			.0	
5-3-05	.30			.0	
5-10-05	.30			.10	