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PHASE I REPORT

HASSAYAMPA SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

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TABLE OF CONTENTS

Page

1. INTRODUCTION 1

1.1 Terms of Reference 1
1.2 Background and Objectives 1
1.3 Report Organization 2

2. SITE BACKGROUND 3

2.1 Site Location 3
2.2 Operational History 3
2.3 Regulatory Background 4
2.4 Investigation and Remedial Action Summary 6
2.4.1 General 6
2.4.2 Hydrogeologic Overview 6
2.4.3 Soil 6
2.4.4 Soil Vapor 7
2.4.5 Groundwater 8
2.4.6 Remedial Actions 10
2.4.6.1 General 10
2.4.6.2 Multilayer Cap 10
2.4.6.3 Groundwater 11
2.4.6.4 SVE System 11

3. PHASE I TASKS 13

3.1 Overview 13
3.2 Pit 1 Soil Investigation 13
3.3 Groundwater Well and Piezometer Installation 15
3.3.1 General 15
3.3.2 MW-18UA Installation 16
3.3.3 MW-19UA Installation 17
3.3.4 Piezometer MW-20UA Installation 17
3.3.5 Well Development 18

TABLE OF CONTENTS (continued)

Page

3.4 Aquifer Tests 18
3.5 Soil Vapor Extraction Re-Start 19
3.5.1 Soil Vapor Extraction Treatment Piping Installation 20
3.5.2 Treatment System Installation 21
3.5.3 Treatment System Startup 22
3.5.4 Operations and Maintenance 23
3.5.5 Vapor Plume Progress Monitoring 25

4. UPDATED SITE CONCEPTUAL MODEL 28

4.1 General 28
4.2 Hydrogeologic Setting 28
4.2.1 Location 28
4.2.2 Regional Hydrogeologic Setting 28
4.2.3 Local Hydrogeologic Setting 30
4.2.3.1 General 30
4.2.3.2 Vadose Zone 30
4.2.4 Local Groundwater Conditions 32
4.2.4.1 Overview 32
4.2.4.2 Unit A Groundwater Conditions 33
4.2.4.3 Unit B Groundwater Conditions 34
4.2.4.4 Vertical Head Differences 35
4.3 Contaminant Fate and Transport 36
4.3.1 General 36
4.3.2 Pit 1 Primary Source Area 37
4.3.3 Soil Vapor 40
4.3.4 Groundwater Unit A 43
4.3.5 Groundwater Unit B 44
4.3.6 Vertical Migration between A and B Units 44
4.3.7 GRS Capture Zone Analysis 46
4.3.8 Conclusions Regarding Chemical Transport 47

TABLE OF CONTENTS (continued)

Page

5. PHASE II RECOMMENDATIONS 49

5.1 Introduction 49
5.2 Groundwater Recovery System 49
5.3 SVE Modifications 50
5.3.1 Objective and Technical Approach 50
5.3.2 Wellfield Expansion 51
5.3.3 New Well Startup Testing 53
5.3.4 Treatment Technology 53
5.3.4.1 Objective and Technical Approach 53
5.3.4.2 System Design and Installation 55
5.3.4.3 Operations and Maintenance 56
5.4 Soil Vapor Monitoring 57
5.5 Shutdown Protocol 59
5.6 Soil Vapor Performance Standards 60

6. SUMMARY AND CONCLUSIONS 63

6.1 Summary 63
6.2 Phase I Work Tasks 63
6.3 Updated Site Conceptual Model 65
6.4 Phase II Scope of Work 66

REFERENCES

TABLE OF CONTENTS (continued)

LIST OF TABLES

Table 3-1: Field Measurement – Phase I Soil Borings
Table 3-2a: Summary of Laboratory Data – Boring B-1
Table 3-2b: Summary of Laboratory Data – Boring B-2
Table 3-2c: Summary of Laboratory Data – Boring B-3
Table 3-2d: Summary of Laboratory Data – Boring B-4
Table 3-2e: Summary of Laboratory Data – Boring B-5
Table 3-2f: Summary of Laboratory Data – Boring B-6
Table 3-2g: Summary of Laboratory Data – Boring B-7
Table 3-2h: Summary of Laboratory Data – Boring B-8
Table 3-2i: Summary of Laboratory Data – Boring B-9
Table 3-3: Soil Vapor Sampling Schedule
Table 3-4: Vadose Zone PID Measurements
Table 4-1: Groundwater Solubility Calculations – MW-18UA and MW-19UA
Table 4-2: Soil Vapor Equilibrium Calculations – February 2007

LIST OF FIGURES

Figure 2-1: Site Location Map
Figure 2-2: Site Layout
Figure 2-3: Detailed Site Layout

Figure 3-1: Phase I Soil Boring Locations
Figure 3-2: SVE Layout and Vapor Probes
Figure 3-3: Typical Wellhead Construction
Figure 3-4: Typical Temperature Expansion Loops
Figure 3-5: GEO System Process Flow Diagram
Figure 3-6: 1st Quarter 2006 Coarse-Grained Soil Vapor
Figure 3-7: 1st Quarter 2006 Fine-Grained Soil Vapor
Figure 3-8: 1st Quarter 2006 Sub-Basalt Soil Vapor
Figure 3-9: 1st Quarter 2007 Coarse-Grained Soil Vapor

TABLE OF CONTENTS (continued)

Figure 3-10: 1st Quarter 2007 Fine-Grained Soil Vapor
Figure 3-11: 1st Quarter 2007 Sub-Basalt Soil Vapor
Figure 3-12: 3rd Quarter 2006 Sub-Basalt Soil Vapor
Figure 3-13: 4th Quarter 2006 Sub-Basalt Soil Vapor
Figure 3-14: CGZ PID Readings
Figure 3-15: FGZ PID Readings
Figure 3-16: Sub-Basalt PID Readings

Figure 4-1: Elevation of Basalt
Figure 4-2: Vertical Head Potential Between Unit A and Unit B – July 2006
Figure 4-3: Vertical Head Potential Between Unit A and Unit B – February 2007
Figure 4-4: Plan View and Cross-Section Locations
Figure 4-5: Cross-Section A_1-A_1' – Vapor Data
Figure 4-6: Cross-Section A_2-A_2' – Soil Data
Figure 4-7: Cross-Section B-B′ and C-C′
Figure 4-8: Total VOC Concentrations in Soil Vapor and Groundwater – MW-01UA
Figure 4-9: Total VOC Concentrations in Soil Vapor and Groundwater – MW-04UA
Figure 4-10: Total VOC Concentrations in Soil Vapor and Groundwater – MW-06UA
Figure 4-11: Total VOC Concentrations in Soil Vapor and Groundwater – MW-07UA
Figure 4-12: Total VOC Concentrations in Soil Vapor and Groundwater – MW-11UA
Figure 4-13: Total VOC Concentrations in Soil Vapor and Groundwater – MW-12UA
Figure 4-14: Total VOC Concentrations in Soil Vapor and Groundwater – MW-18UA & VP-18UA
Figure 4-15: Total VOC Concentrations in Soil Vapor and Groundwater – MW-19UA & VP-19UA

Figure 4-16: VOC Fate & Transport, Updated Site Conceptual Model

Figure 5-1: Carbon System Process Flow Diagram

TABLE OF CONTENTS (continued)

LIST OF APPENDICES

Appendix A: Summary of Field Parameters and Laboratory Analytical Data
Appendix B: Phase I Borehole Logs / Well Construction Details
Appendix C: Aquifer Test
Appendix D: Soil Vapor Extraction Data
Appendix E: Capture Zone Analysis

1. INTRODUCTION

1.1 Terms of Reference

This Phase I Report (Report) documents Phase I investigation and remedial activities conducted at the Hassayampa Landfill Superfund site (the Site) located in Maricopa County, Arizona. This Report was prepared jointly by Geosyntec Consultants (Geosyntec) and Hargis + Associates (Hargis) for the Hassayampa Steering Committee (HSC). This Report has been prepared for submittal to the United States Environmental Protection Agency, Region 9 (USEPA) and the State of Arizona Department of Environmental Quality (ADEQ).

1.2 Background and Objectives

Historically, hazardous wastes were disposed of at the Site in a series of unlined pits. Early investigations of soil, soil vapor and groundwater quality identified impacts from volatile organic compounds (VOCs). An initial phase of remedial actions was conducted in the mid-1990s, including the construction of a geomembrane cover over the hazardous waste disposal area and the construction and operation of a soil vapor extraction (SVE) system and a groundwater pump and treat system. The SVE system was operated from 1996 until 1998. Operation of the groundwater pump and treat system began in 1994 and continues today.

Following the shutdown of the SVE system, monitoring data indicated upward trends in both the extent and concentration of the vadose zone vapor plume. In addition, VOC concentrations in several groundwater wells had exhibited increasing trends. Given these conditions, the HSC deemed it appropriate to evaluate the Site conditions and, as needed, implement corrective measures. The plan for evaluating the trends consisted of a phased approach. The Site Conceptual Model (SCM) and related data gaps were described in a Phase I Work Plan [Geosyntec / Hargis, 2005] which also included a scope of work for supplemental investigation and remedial activities intended to:

- control the lateral migration of vadose zone vapors;
- evaluate the depth and lateral extent of residual VOCs in the primary source area (i.e., Pit 1); and

- assess the capture zone of the groundwater extraction well network.

The Phase I Work Plan was subsequently implemented in 2006. Data collected from Phase I have been used to update the SCM and develop a recommended scope of work for Phase II. This Phase I report documents the Phase I activities and presents the updated SCM and Phase II recommendations.

1.3 Report Organization

The remainder of this Report is organized into the following sections:

- Section 2, *Site Background*, contains background information on the Site, including a brief description of the Site history, regulatory status and investigation and remedial work conducted prior to Phase I;

- Section 3, *Phase I Tasks*, documents the implementation of Phase I activities and presents summaries of collected data;

- Section 4, *Updated Site Conceptual Model*, presents a re-interpretation of the SCM with respect to contaminant fate and transport;

- Section 5, *Phase II Recommendations*, presents the recommended scope of work to address remaining impacts to soil and groundwater at the Site, with the objective of achieving Site closure; and

- Section 6, *Summary and Conclusions*.

2. SITE BACKGROUND

2.1 Site Location

The Site is approximately 40 miles west of Phoenix, Arizona, south of Interstate 10 and approximately 8 miles west of Buckeye in the SE1/4 of Section 3, T1S, R5W, of the Gila and Salt River Baseline and Meridian, in Maricopa County, near the intersection of 309th Avenue and Baseline Road (Figure 2-1). The Site, an approximate 10-acre parcel, is located on a portion of a 77-acre tract owned by Maricopa County. Within the 77-acre tract, 47 acres, south and west of the Site, were used for the disposal of municipal solid waste (MSW) (Figure 2-2).

2.2 Operational History

Maricopa County began operating the Hassayampa Landfill as an MSW landfill in 1961. MSW was disposed of in unlined trenches 30 to 50 feet in width, 300 to 600 feet in length, and 20 to 40 feet deep. Wastes reportedly were compacted on a daily basis and covered with an interim soil cover [EM/CRA, 1991].

On 15 February 1979, the Arizona Department of Health Services (ADHS) prohibited disposal of industrial and hazardous wastes into the City of Phoenix landfills. The City of Phoenix is within Maricopa County. ADHS subsequently arranged for Maricopa County to accept industrial and hazardous wastes on an interim basis on a 10-acre parcel (the Site) located adjacent to the Hassayampa Landfill. Maricopa County conditionally agreed to accept industrial and hazardous wastes at the Site for a 30-day period on 20 April 1979. ADHS subsequently arranged for several time extensions until 28 October 1980, when disposal of industrial hazardous wastes at this location ceased [EM/CRA, 1991].

During the 18-month period from 20 April 1979 to 28 October 1980, hazardous wastes were disposed of at the Site under a manifest program operated by ADHS. It is reported, based on evaluations of these manifests, that approximately 3.4 million gallons of hazardous liquid wastes and between 3,700 and 4,100 tons of solid wastes were disposed of at the Site [EM/CRA, 1991]. The hazardous wastes were disposed of in a series of five unlined disposal pits (Figure 2-3), each designated for a specific type of waste, as follows:

- Pit 1 – organic and oil wastes;
- Pit 2 – acids and acidic sludges;
- Pit 3 – alkaline and metallic sludges;
- Pit 4 – pesticide and alkaline sludges; and
- Special Pit – isolated cells of low-volume solid wastes, containerized wastes, or other wastes not accepted for disposal in the other pits.

The hazardous waste disposal pits were covered with native soil and restored to surrounding Site grade following the 18-month period.

Two additional pits, Pit A and Pit B, were designated for disposal of non-hazardous wastes and, therefore, were not included in the hazardous waste manifest program. Reportedly, cesspool and septic tank wastes were disposed of in Pit A. The contents of Pit B have not been reported in detail, although there are some reports of hydrate waste disposal [EM/CRA, 1991]. Disposal of MSW at the Hassayampa MSW Landfill ceased in June 1997. The MSW landfill was closed with a soil cover. The MSW landfill does not have an active gas extraction system.

2.3 Regulatory Background

In 1981, ADHS constructed three groundwater monitoring wells (HS-1, HS-2, and HS-3) at the Hassayampa Landfill to evaluate potential impacts from hazardous waste disposal activities. Samples collected from these wells were found to contain VOCs. In 1984, ADHS conducted a site inspection of the Hassayampa Landfill and the surrounding area. In response to ADHS findings, USEPA proposed adding Hassayampa to the National Priorities List (NPL) on 10 June 1986. The Site was added to the NPL on 22 July 1987, thus becoming a federal Superfund site [USEPA, 2005].

After the NPL listing, the USEPA and certain Respondents entered into an Administrative Consent Order (Docket No. 88-08) on 19 February 1988. The Order required the Respondents to conduct, under USEPA direction and oversight, a Remedial Investigation (RI) and Feasibility Study (FS) regarding potential impacts to soil and groundwater resulting from the disposal of hazardous wastes at the Site. The RI was conducted in the late 1980s, and hazardous substances were detected at concentrations above Arizona Health-Based Guidance Levels (HBGLs) in soil and above the Federal

Maximum Contaminant Levels (MCLs) or HBGLs in groundwater. The FS was completed in 1992 [EM/CRA, 1992].

The Record of Decision (ROD) for the Site was issued on 6 August 1992. The USEPA selected the federal and state MCLs as cleanup standards for groundwater. For constituents where MCLs had not been established, proposed MCLs or HBGLs identified by the ADEQ and ADHS were used. Soil vapor cleanup standards intended to be protective of groundwater quality also were developed using SESOIL computer modeling. The selected remedy for the Site, as specified in the ROD, consisted of the following:

- groundwater extraction and treatment;
- soil vapor extraction and treatment;
- a multilayer cap;
- continued groundwater and soil vapor monitoring; and
- deed and access restrictions.

Following issuance of the ROD, the USEPA and the Respondents commenced Consent Decree negotiations, and the Consent Decree ultimately was filed on 2 September 1994 [USEPA, 2005]. Pursuant to the ROD, a multilayer cap was constructed in 1994, and a pump and treat groundwater remediation system was constructed and began operation in March 1994. The groundwater system has been consistently operated since its construction. An SVE system also was constructed and started operation in early 1996. Operation of the SVE system terminated in September 1998. Following shutdown of the SVE system, monitoring data indicated upward trends in both the size and concentration of the vadose zone vapor plume. In addition, VOC concentrations in several groundwater wells had exhibited increasing trends. Based on these data, the HSC submitted a Phase I Work Plan for USEPA and ADEQ approval [Geosyntec / Hargis, 2005]. USEPA and ADEQ provided conditional approval of the Work Plan in a letter dated 22 December 2005.

2.4 Investigation and Remedial Action Summary

2.4.1 General

Environmental investigations at the Site began in 1981 when the ADHS installed and sampled three groundwater monitoring wells (HS-1, HS-2, and HS-3) [EM/CRA, 1991]. Since that time, numerous investigations of soil, soil vapor, and groundwater have been conducted. In addition, a groundwater extraction and treatment system, a multilayer cap, and an SVE system were constructed in the mid-1990s.

2.4.2 Hydrogeologic Overview

The vadose zone, as it existed at the Site at the time of the initial investigative work, was divided into two general units based on the predominant soil types identified: an upper coarse-grained zone and a lower fine-grained zone. The coarse-grained zone generally extends from ground surface to approximately 30 feet below ground surface (ft-bgs). The fine-grained zone generally extends from depths of approximately 30 to 60 ft-bgs. Beneath the fine-grained zone exists a basaltic lava flow unit that is variable in thickness. Additional vadose zone is currently present beneath the basalt unit. Two groundwater units, Unit A and Unit B, have been defined at depth beneath the basalt unit. Details regarding hydrogeologic conditions are provided in Section 3.

2.4.3 Soil

The presence of constituents of concern (COCs) in the soil was evaluated as part of the RI conducted in the late 1980s. Soil investigations for the RI consisted of drilling and sampling 18 soil borings and trenching in the vicinity of Pits 1, 2, 3, and 4 [EM/CRA, 1991]. Additional investigation of soil conditions around Pit 1 was conducted in 2006 as part of Phase I activities. Details regarding Phase I activities are presented in Section 3 of this Report.

As part of the RI conducted in the late 1980s, soil borings were drilled adjacent to the hazardous waste disposal pits as well as other locations across the Site. Samples were collected at various depth intervals for laboratory analyses of organic and inorganic constituents. As described in the RI report, significant detections of constituents were limited to VOCs. The highest concentrations of total VOCs were detected in samples

collected from Angle Boring AB-3 installed approximately beneath Pit 1. Within Boring AB-3, the greatest total VOC concentration at 4,700 milligrams per kilogram (mg/kg) was detected in the deepest sample, collected at a depth of 60 ft-bgs. VOC constituents detected in Boring AB-3 consisted primarily of 1,1,1-Trichloroethane (TCA) and Freon-113 (also known by its chemical name, 1,1,2-Trichloro-1,2,2-Trifluoroethane, or trichlorotrifluoroethane). Concentrations of VOCs in samples collected from other borings were significantly less than those detected in samples from Boring AB-3, leading to the conclusion that Pit 1 is the primary source area for VOCs at the Site. It has been reported based on an evaluation of operational information that Pit 1 was approximately 50 feet long, 50 feet wide and had a depth of approximately 20 ft [EM/CRA, 1991].

During the RI, trenches were excavated to define the approximate limits of the pits and evaluate pit contents. Trenches were excavated into the top of the waste in each pit; however, the excavation did not extend to the base of each pit. Generally, trenches did not penetrate more than one foot into the top of buried materials. Pit materials were observed visually, screened with an organic vapor analyzer (OVA) and sampled for laboratory analyses. Pit materials exhibiting the highest concentrations of VOCs were found in Pit 1, where total VOC concentrations ranged from 1,500 to 1,800 mg/kg. Materials exhibiting the highest concentrations of organic vapors, as measured by the OVA, also were found in Pit 1, where the material was described as slightly moist to moist, and in places where a black viscous liquid was observed. Significantly lower concentrations of VOCs were detected in waste samples collected from the other pits (e.g., up to 10 mg/kg in Pits 3b and 3c).

2.4.4 Soil Vapor

The first soil vapor survey at the Site was performed in October 1991, following completion of the RI report. In addition, a total of 33 soil vapor probes have been installed at the Site between 1991 and 2006 (Figure 2-3). With the exception of soil vapor probes VP-18UA and VP-19UA, soil vapor probes generally have been constructed as dual completion probes, where each probe is constructed with screened zones in both the coarse- and fine-grained geologic zones. Soil vapor probes VP-18UA and VP-19UA were constructed as single completion probes beneath the basalt in 2006

as part of Phase I activities (Section 3). Soil vapor probe construction details are provided as Appendix A of each Quarterly Progress report for the Site [NES, 2007].

Select soil vapor probes have been sampled and analyzed for VOCs on various occasions from 1991, when the initial probes were installed, through the most recent sampling event conducted in February 2007. For samples collected above the basalt, VOC concentrations typically are greater in vapor samples collected from the screen located in the fine-grained zone as compared to samples collected from the screen located in the overlying coarse-grained zone for the same probe. More recently, as part of Phase I activities, soil vapor samples have also been collected from the vadose zone below the basalt.

Historically, the greatest concentrations of VOCs in soil vapor have been found in and around Pit 1. Generally, the most predominant VOC constituents found in soil vapor consist of Freon-113 and 1,1-dichloroethene (Appendix A). As shown in the historical soil vapor data tables included as Appendix A-2, soil vapor concentrations were reduced as a result of the operation of the SVE system during 1996 through 1998. Over the years following the cessation of initial SVE operations in 1998, soil vapor VOC concentrations increased. Since Phase I activities were initiated in early 2006, soil vapor concentrations both above and below the basalt have exhibited decreases of up to an order of magnitude.

2.4.5 Groundwater

Groundwater quality within Unit A, the first groundwater underlying the Site, was first evaluated with the installation of monitoring wells HS-1, HS-2, and HS-3 by the ADHS in 1981. Groundwater well HS-1 was abandoned in 1988 during the RI due to concerns regarding the competency of the well seal. Groundwater wells HS-2 and HS-3 were also subsequently abandoned. Additional Unit A and Unit B groundwater wells were installed in 1988 and 1989 as part of the RI, including the following:

- MW-1UA/MW-1UB;
- MW-2UA/MW-2UB;
- MW-3UA/MW-3UB;
- MW-4UA/MW-4UB;
- MW-5UA;

- MW-6UA;
- MW-7UA; and
- MW-8UA.

Unit A groundwater wells generally were installed to depths of 95 ft-bgs, with 20- to 30-foot long screen intervals. Unit B groundwater wells (the second groundwater unit encountered beneath the Site) generally were installed to depths of 135 ft-bgs, with 30-foot long screens. Additional groundwater monitoring wells installed since the RI include the following:

- MW-6UB;
- MW-9UA/MW-9UB;
- MW-10UA/MW-10UB;
- MW-11UA;
- MW-12UA;
- MW-13UA;
- MW-14UA;
- MW-15UB;
- MW-16UA;
- MW-17UA;
- MW-18UA;
- MW-19UA; and
- MW-20UA.

It should be noted that Groundwater Monitoring Wells MW-18UA, MW-19UA, and MW-20UA were installed in 2006 as part of Phase I activities. Details regarding Phase I activities are presented in Section 3. In total, 19 Unit A and eight Unit B groundwater wells have been installed following the initial investigation performed by ADHS. The locations of these wells are shown on Figure 2-3. Groundwater well construction details are provided as Appendix A of each Quarterly Progress report for the Site [NES, 2007]. Site-related effects on groundwater have been limited to Unit A, and Site-related effects have not been detected historically in samples from Unit B groundwater wells. Appendix A-3 contains a summary of historical groundwater monitoring data, including time concentration plots for select wells and constituents.

Generally, the most predominant constituents detected in Unit A groundwater samples are 1,1-dichloroethene and Freon-113.

2.4.6 Remedial Actions

2.4.6.1 General

Remedial actions conducted at the Site to date have included the following:

- construction of a multi-layer cap over the former hazardous waste disposal areas in March 1994;
- construction and operation of a groundwater extraction and treatment system in March 1994 to the present;
- construction and operation of an SVE system from March 1996 until September 1998; and
- re-start of the SVE system in March 2006 and continued operation to the present.

Monitoring of the groundwater and soil vapor conditions is conducted routinely. In addition, access and deed restrictions have been imposed and maintained at the Site.

2.4.6.2 Multilayer Cap

The multi-layer cap was constructed over the former hazardous waste disposal areas in spring 1994. The multi-layer cap consists of the following major components, from top to bottom;

- approximately 18-inch thick vegetative soil layer;
- geotextile filter fabric;
- geonet drainage layer;
- 40-mil high-density polyethylene (HDPE) liner; and
- sand foundation layer.

The approximate limits of the cap are shown in Figure 2-3. Additional specifications and construction details for the multi-layer cap are contained in historical documents, including the Cap Design Report for the Hassayampa Landfill Superfund Site [EM/CRA, 1994] and its amendments and the Construction Inspection Report: Construction of the Soil Cap [EM/CRA, 1995].

2.4.6.3 Groundwater

Construction of a groundwater pump and treat system to capture VOC-impacted groundwater in Unit A, downgradient of the disposal pits, was completed in March 1994. Unit A groundwater is pumped from four extraction wells (EW-1UA through EW-4UA), piped to the treatment building, and treated by an air stripper. Treated groundwater is then re-injected to Unit B through upgradient well IW-1UB (Figure 2-3). The groundwater treatment system has been in relatively continuous operation since 1994. Details regarding the current status of the Unit A and Unit B groundwater monitoring well network are provided in Section 2.4.5.

2.4.6.4 SVE System

The SVE system was installed in 1995 / 1996 and initially operated intermittently from March 1996 until September 1998 (approximately 18 months). This SVE system consisted of the following elements:

- Eleven coarse- and fine-grained vadose zone extraction well pairs (SP-1 through SP-6, W-1, P-1, NW-2, NE-1, VB-2c, and VB-2f);
- Aboveground piping to a thermal oxidation treatment and condensate removal system;
- Eight dual completion (coarse- and fine-grained zone) passive air injection wells (V1 through V8) and one dual completion active injection well (V-9);
- Eight dual completion vadose zone piezometers (PZ-1 through PZ-8); and
- Twelve dual completion soil vapor monitoring wells (N-1, N-2, N-3, NE-3, NW-2, P-3, SE-1, SP-7, SP-8, VB-1, VB-3, and VB-4).

Informal estimates have been made that indicate that approximately 3,700 pounds of VOCs were removed by the SVE system between 1996 and 1998. More recently, as part of Phase I activities, a modified SVE system was re-started in March 2006, and operation has continued since then. Details regarding the re-started SVE system are provided in Section 3.

3. PHASE I TASKS

3.1 Overview

Phase I work tasks were designed to address the data gaps identified in the Phase I Work Plan [Geosyntec / Hargis, 2005] so that the HSC could critically review the original conceptual model developed for the Site. In general, the Phase I tasks were conducted to:

- evaluate the extent of residual source material at Pit 1, the primary source area;
- evaluate the groundwater extraction system capture zone; and
- re-start the SVE system to control the vapor plume emanating from Pit 1.

As part of the conditional approval for the Phase I Work Plan, the USEPA and ADEQ also required the installation of two Unit A groundwater wells and sub-basalt vapor probes. The conditional requirements also included conducting short-term drawdown and recovery aquifer tests of the newly installed wells.

Specific Phase I work tasks included:

- Pit 1 Soil Investigation;
- Groundwater Well and Piezometer Installation;
- Aquifer Tests; and
- SVE Re-Start.

3.2 Pit 1 Soil Investigation

As presented in the approved Phase I Work Plan, the focus of Phase I investigation was solely on VOCs related to Pit 1, the primary VOC source area at the Site. The RoD references previous site-wide investigations, including a detailed Remedial Investigation (RI) / Feasibility Study (FS) that was conducted, with full agency oversight and approval. For example, the RoD on page 41 states "As described in Section II-E of this RoD, 'Summary of Site Characteristics' Pit 1 was the only location where contaminants in waste or soil exceeded ADEQs proposed HBGLs or EPA's

TCLP or EP Tox levels for organic chemicals." As a result of the historical and current knowledge base related to the distribution of Site-related constituents, the approved Work Plan focused additional investigation on the Pit 1 area only.

A subsurface investigation was conducted within and around Pit 1 to collect soil samples for field and laboratory analysis of VOCs to assess the magnitude and extent of residual source material around Pit 1. Nine hollow-stem auger boreholes were drilled between 25 January and 9 February 2006 (Figure 3-1). Boreholes were drilled using a CME 75 drill rig equipped with 6-inch diameter augers. Prior to drilling activities, Arizona Blue Stake was contacted to mark utilities leading into the Site. Existing facility drawings were reviewed to confirm that drilling locations were not planned in areas containing underground facilities.

Boreholes were sampled and logged continuously using an 18-inch California-modified split spoon sampler from depths of approximately 10 ft-bgs to the top of the basalt. The drilling cuttings and split-spoon samples were used by the geologist in the field to prepare lithologic logs for each borehole in general accordance with the Unified Soil Classification System (USCS). Competent basalt was encountered in each boring except B-6 and B-9; in these borings, auger drilling was ceased at depths of 79 and 65 ft-bgs, respectively. Borehole logs are included in Appendix B.

Soil samples were collected in 2.5-inch by 6-inch driven brass tubes. After collection, select soil samples were tested using non-aqueous phase liquid (NAPL) sensitive tape. NAPL tape field measurements are summarized on Table 3-1. A positive color change reaction of NAPL tape was observed in borehole B-1 at a depth of 57 ft-bgs and borehole B-5 at a depth of 31.6 ft-bgs. For each recovered split spoon sample, an aliquot of the soil sample was placed in a plastic storage bag, and the bag was sealed. The head space in the bag was screened using a photo-ionization detector (PID) after waiting a minimum of 15 minutes. PID data are summarized in Table 3-1.

Based on field observations and PID measurements, soils from select locations were submitted for laboratory analysis; samples were collected from the brass tubes using Encore samplers (USEPA Method 5035). Additional soil samples were also collected for laboratory analysis at targeted zones, including just above and below the contact of the coarse- and fined-grained zones and at the top of basalt. Soil samples were stored on ice pending shipment under standard chain-of-custody protocols to the analytical

laboratory at the end of each day of drilling activities. A trip blank accompanied the primary samples. Samples were submitted to Del Mar Analytical, Phoenix, Arizona (DHS certification number AZ0426). The primary soil matrix samples and quality control samples were analyzed for VOCs using USEPA Method 5035/8260B. Table 3-2 includes a summary of VOC constituents detected in soil samples.

The hollow stem augers were decontaminated by steam cleaning between boreholes. The California-modified split spoon sampler was decontaminated between samples using a three-stage decontamination wash. Equipment blanks were collected approximately daily by pouring deionized water over the decontaminated sampler and collecting the rinsate in a VOA vial. The PID was calibrated at the start of each work day using isobutylene calibration gas.

After completion of each soil boring, the boring was abandoned with neat cement grout using a pressure tremmie from the bottom of the boring to the approximate ground surface. For boreholes installed through the engineered cap, the geomembrane was repaired by installing a heat-bonded patch and replacing compacted soil fill. Soil cuttings were consolidated in piles adjacent to the borehole locations.

3.3 Groundwater Well and Piezometer Installation

3.3.1 General

Two dual completion groundwater well and vapor probes, (MW-18UA/VP-18UA and MW-19UA/VP-19UA) and one piezometer (MW-20UA) were drilled and installed in February 2006. Each of the monitoring wells consists of a two-inch diameter groundwater monitoring well and a one-inch diameter soil vapor probe. The installations of MW-18UA and MW-19UA were added to the Phase I scope of work at the request of EPA and ADEQ. At the time, ADEQ required that the two wells be drilled using a RotoSonic drilling rig to obtain continuous core, which precluded drilling a borehole large enough to install a 4-inch diameter groundwater well casing and a vapor probe. A proposed well installation diagram indicating that the wells would be constructed of 2-inch diameter casing was provided to EPA and ADEQ as part of the revised Phase I Work Plan submitted on 8 December 2005. In a letter dated 22 December 2005, conditional approval of the revised Phase I Work Plan was provided by EPA.

Groundwater Well and Vapor Probe MW-18UA/VP-18UA was drilled as a continuation of hollow stem auger Boring B-6. MW-19UA/VP-19UA was drilled as a continuation of Boring B-2. These boreholes were then completed to total depth using a RotoSonic drill rig. MW-20UA was drilled solely with RotoSonic. The locations of MW-18UA/VP-18UA and MW-19UA/VP-19UA and piezometer MW-20UA are shown in Figure 2-3. As-built diagrams are included in Appendix B.

The RotoSonic cores samples were used by the geologist in the field to complete the lithologic logs for the boreholes in general accordance with the USCS. Select intervals of the cores were screened for the presence of VOCs with a PID, following the procedure described in Section 3.2. These data are presented in the boring logs included in Appendix B.

3.3.2 MW-18UA Installation

Groundwater Well MW-18UA and Soil Vapor Probe VP-18UA were installed in borehole B-6 drilled as part of the Pit 1 soil investigation. In an effort to reduce the potential for creating a vertical conduit for chemical migration during the installation of MW-18UA, a bentonite plug approximately 5 ft thick was emplaced and hydrated at the base of the hollow stem auger borehole. The 9-inch RotoSonic drive casing was then lifted and re-emplaced several times to smear the bentonite and help create a seal between the drive casing and surrounding formation in the last few feet of the borehole. After the bentonite seal was achieved, an 8-inch steel drive casing was installed within the 9-inch casing. The borehole was then advanced to target depth. As the cores were retrieved from the borehole, they were evaluated for the lithologic contact between Unit A and Unit B. The groundwater monitoring wells were screened solely in Unit A.

The basalt layer was not encountered at this location. The well was constructed by installing 78.5 ft of 2-inch ID blank steel casing and 15 ft of 2-inch 0.020 slot PVC screen. The annular space surrounding the well screen was filled with a 10 × 20 silica sand filter pack, to a depth of 4 ft above the top of the screened interval. A 3-ft bentonite seal was installed above the well filter pack to separate the well-screened interval from the vapor probe. A 1-inch ID PVC vapor probe was installed above the bentonite seal, with a screened interval from 66.5 to 71.5 ft-bgs. Approximately 3.5 ft of bentonite pellet seal was installed on top of the vapor probe filter pack to prevent the cement-bentonite annular seal from penetrating the filter pack. The bentonite pellet seal

was allowed to hydrate for at least one hour. A cement-bentonite seal was placed in the annular space between the steel casing and the borehole, from the top of the bentonite pellet seal to ground surface (approximately 62 ft).

3.3.3 MW-19UA Installation

Groundwater Monitoring Well MW-19UA and Soil Vapor Probe VP-19UA were installed in Borehole B-2 drilled as part of the Pit 1 investigation. In an effort to reduce the potential for creating a vertical conduit for chemical migration, the RotoSonic drill rig was used to first advance a nominal 9-inch diameter drive casing approximately 1 ft into the basalt unit. Then, a bentonite plug approximately 5 ft thick was emplaced and hydrated inside the drive casing at the bottom of the borehole. The 9-inch drive casing was then lifted and re-emplaced several times to smear the bentonite and help create a seal between the drive casing and surrounding basalt in the last few feet of the borehole. After the bentonite seal was achieved, an 8-inch steel drive casing was installed in the borehole.

The borehole for groundwater Monitoring Well MW-19UA and Vapor Probe VP-19UA was drilled to a total depth of 95 ft-bgs. The approximate top of the basalt unit at this location was 60.5 ft-bgs. Eighty feet of 2-inch ID blank steel casing and 15 ft of 2-inch 0.020 slot PVC screen were installed to complete the monitoring well. The annular space surrounding the well screen was filled with a 10×20 silica sand filter pack to a depth of 1 ft above the top of the screened interval. A 3-ft bentonite seal was installed above the well filter pack to separate the vapor probe screen from the well screen. A 1-inch ID PVC vapor probe was installed above the bentonite seal with 5 ft of screen. The vapor probe filter pack was installed to 1 ft above the screen. Approximately 5 feet of bentonite pellet seal was installed on top of the vapor probe filter pack to prevent the cement-bentonite annular seal from penetrating the filter pack. The bentonite pellet seal was allowed to hydrate for at least one hour. A cement-bentonite seal was placed in the annular space between the steel casing and the borehole, from the top of the bentonite pellet seal to ground surface, which was 65 feet.

3.3.4 Piezometer MW-20UA Installation

A piezometer, MW-20UA, was installed approximately 90 ft south of groundwater Monitoring Well MW-12UA to obtain data to perform a detailed Unit A capture zone

analysis (Figure 2-3). The borehole for piezometer MW-20UA was drilled to 100 ft-bgs using a RotoSonic drill rig. The diameter of the borehole is 8 inches from land surface to 55 ft-bgs, the approximate depth at which the basalt layer was encountered. The diameter of the borehole is 6.5 inches from 55 to 94 feet and 5.5 inches to the total depth of 100 ft-bgs. The borehole was back-filled to 96 ft-bgs with bentonite pellets. Seventy-one ft of 2-inch ID blank steel casing and 25 ft of 0.020-slot PVC screen were installed in piezometer MW-20UA. The annular space surrounding the well screen was filled with a 10 × 20 silica sand filter pack to a depth of 3 ft above the top of the screened interval. Approximately 4.5 ft of bentonite pellet seal was installed on top of the filter pack to prevent the cement-bentonite annular seal from penetrating the filter pack. The bentonite pellet seal was allowed to hydrate for at least one hour. A cement-bentonite seal was placed in the annular space between the steel casing and the borehole, from the top of the bentonite pellet seal to ground surface, totaling a distance of approximately 63.5 ft.

3.3.5 Well Development

Following installation, the groundwater monitoring wells and piezometer were developed by pumping each well for a period of several hours and/or until the water was clear and free of formation materials.

3.4 Aquifer Tests

The aquifer testing program consisted of two 12-hour constant rate aquifer tests conducted in June 2006. The aquifer tests were conducted on the two newly installed monitoring wells: MW-18UA and MW-19UA. Monitoring Well MW-06UA was used as an observation well for each test. Monitoring Well MW-19UA was also used as an observation well during the testing of MW-18UA, and MW-18UA was used as an observation well while testing Monitoring Well MW-19UA.

Transducers connected to a data logger were installed in the three wells involved in the testing. The data logger recorded the water level drawdown in the three wells being tested. Well discharge rates were measured, and keeping the discharge constant was a primary goal. As would be expected, minor variations in pumping rates were recorded, but none of the minor variations was judged to impact the test results significantly. Upon cessation of the pumping portion of the test, water level recovery data were

recorded by the data logger. Three of the four extraction wells compromising the groundwater recovery system were not shut down during the testing period in order to continue to provide capture of affected groundwater. Only Extraction Well EW-04UA was shut off during the period of the aquifer tests.

Tests were analyzed for both dynamic and recovery conditions using several methods typically used in Arizona alluvial sediments and also in wide use in the public domain. In summary, the data derived from the testing of the small-diameter Monitoring Wells MW-18UA and 19UA do not compare well with data previously collected from seven larger-diameter monitor wells stressed at higher pumpage rates. The data are considered semi-quantitative in nature and may, if valid, apply only locally near the wells. Also, based on previously collected data from seven Unit A wells, the newly derived data are not representative of conditions across the Site. Detailed data and analyses of the aquifer tests are included in Appendix C.

3.5 Soil Vapor Extraction Re-Start

In an effort to control the lateral migration of vapors in the vadose zone, SVE activities were resumed at the Site in March 2006. The re-started SVE system included construction of the following:

- well head assemblies and conveyance piping;
- manifold and header piping;
- lined equipment pad; and
- vapor treatment unit.

Following construction, startup testing was conducted, including a pressure distance test and individual extraction well vacuum versus flow step tests. The SVE system was officially re-started on 28 March 2006, at which time pressure monitoring was conducted at regular intervals at select vapor wells. The system is operated in accordance with an operating permit obtained from the Maricopa Air Quality Department.

3.5.1 Soil Vapor Extraction Treatment Piping Installation

A total of 11 existing fine-grained zone vapor probes were converted to SVE wells. These wells included N-01, NE-01, NW-02, P-01, V-08, V-09, V-10, V-11, V-12, VB-02, and W-01 (Figure 3-2). Each of the extraction wells were fitted with a well head assembly, which was then connected to a central manifold using two-inch diameter PVC pipe. The number of wells operating at one time and the flow rates from individual wells are occasionally adjusted during operation to improve efficiency.

Each extraction well head was constructed to include a sampling port, a location to monitor individual well flow, and a valve to control well flow. The flow monitoring location, consisting of a Pitot access tube port, is located in a straight section of 1-inch PVC pipe with a minimum of straight pipe equal to eight pipe diameters upflow and six pipe diameters downflow, to reduce turbulent flow effects on the well flow measurements (Figure 3-3).

The SVE wells were piped using 2-inch Schedule (Sch) 40 PVC to a central manifold. The manifold was constructed of 2-inch Sch 40 PVC, with ball valves isolating specific pipe runs and sample ports on the existing concrete pad and upright metal supports just north of Pit 1. The 4-inch header was installed at the ground surface in a generally straight run from the manifold to the treatment system area using 4-inch Sch 40 PVC piping (Figure 3-2). Two temperature expansion loops were installed along the header between the treatment system and the manifold (Figure 3-4). The temperature expansion loops provide the appropriate spacing to allow the PVC piping to expand and contract with changes in temperature without damaging the PVC connections and/or fittings. The 2-inch and 4-inch PVC piping was supported approximately three to four inches off the ground surface by placing on 4-inch by 4-inch wooden blocks and securing with metal straps.

Once the well heads, 2-inch, 4-inch, and manifold piping were constructed and the adhesive was allowed to cure for eight hours, the SVE piping system was pressure-tested for leaks. The piping system was pressurized with an air compressor to 20 pounds per square inch (psi). While pressurized, joints in the piping were evaluated for leaks using a liquid soap solution. When evidence of bubbles was observed, joints were repaired and retested until no leaks were observed.

An additional modification to the re-started SVE system consisted of connecting Sub-Basalt Well VP-19UA to the SVE system on 5 December 2006. VP-19UA was connected via a 2-inch "T" fitting at the SVE manifold to the well N-01 pipe run. A well head similar in design to the other fine-grained zone extraction wells was constructed for VP-19UA.

3.5.2 Treatment System Installation

Prior to system installation, an approximate 40-foot by 40-foot containment pad was constructed to house the aboveground treatment system and included the following components from bottom to top:

- graded soil berm and corner sump;
- 60-mil HDPE liner;
- 16-ounce cushion geotextile; and
- four to 6 inches of crushed rock.

The treatment system and associated equipment were placed on top of the containment pad. The system is a compression / condensation system that consists of three steps: an extraction / pressurization step, a condensation step, and a polishing step. The system itself consists of three main pieces of equipment: a skid, a trailer, and carbon vessels (Figure 3-5). The skid consists of the compressors / blowers and the air-to-air heat exchanger. The trailer portion of the unit consists of the condensation system and the first polishing step, a proprietary regenerative adsorber. The final polishing step consists of carbon vessels that are filled with vapor-phase granular-activated carbon (VGAC). The treatment system is the proprietary technology of GEO Inc.

The GEO System includes a positive displacement blower capable of extracting 200 standard cubic feet per minute (scfm) at a vacuum of approximately 100 inches of water column (in W.C.). The overall extraction rate for the SVE system is limited by the blower and compressors of the GEO system. The blower used with the GEO system is capable of extracting a maximum of 200 scfm under low vacuum conditions. Approximately equal vacuums are applied to each extraction well, which result in varying flow rates from the wells due to differences in well construction and local geologic conditions.

Following extraction of the soil vapor by the blower, the extracted vapors are pressurized to 10 atm (the extraction / pressurization step). The vapor stream then is cooled to -40 degrees Fahrenheit. At the high pressure and low temperature, the majority of VOCs change phase from vapor to the liquid phase (the condensation step). The vapor stream then is polished using the proprietary regenerative adsorber and VGAC prior to discharge to the atmosphere (the polishing step). The GEO vapor compressor / condensation unit produces two primary recovered liquid streams: an organic-based liquid solvent waste (solvent waste) and an aqueous-based condensate waste (condensate waste). The solvent waste is stored in a 2,400-gallon pressure vessel, and the condensate waste is stored in a 750-gallon polyethylene tank located within the containment pad.

3.5.3 Treatment System Startup

Startup testing for the SVE system re-start included the following activities:

- pressure versus distance testing at Extraction Well V-11;
- single extraction well step tests at several wells; and
- pressure monitoring measurements at select monitoring probes during full system startup.

Vapor pressure transducers and data loggers were used for pressure monitoring at select probe and well locations during these tests.

A pressure versus distance test was performed at Extraction Well V-11. A vacuum of approximately 130 in W.C. was applied to the well head, producing a flow of approximately 19 scfm. Adjacent Monitoring Probes V-9, V-10, and P-1 were monitored for pressure responses until readings stabilized. The resulting data from the pressure versus distance test was used to calculate a radius of influence, which was estimated to be approximately 50 ft.[1]

[1] The data from the pressure versus distance test is presented on the figure titled "Pressure Versus Distance Test – Extraction Well V-11" in Appendix D. For this test, an applied well head vacuum of approximately 130 inches of water was used to create vapor flow at well V-11. The resulting steady-state vacuum

Step tests were performed at the fine-grained zone SVE wells. The step tests involved applying vacuums ranging from 30 to 200 in W.C. to each of the well heads, resulting in a range of flow rates between the wells for given applied vacuums. Variations in flow for a given applied vacuum between wells may be due to differences in a combination of factors, including well construction specifications, installation procedures, or local surrounding geologic conditions. Graphs of vacuum versus flow relationships for each of the extraction wells tested are included in Appendix D.

At full system startup on 28 March 2006, pressure transducers with data loggers were used for pressure monitoring at fine-grained zone Vapor Probe V-12 (located approximately 25 feet from the nearest SVE well) and sub-basalt Vapor Probe VP-19UA (located approximately 35 feet from the nearest SVE well). In addition, manual vacuum gauge measurements were recorded at approximately 15-minute intervals from additional soil vapor probes for 3-1/2 hours after system startup. A vacuum response of about 1 in W.C. was recorded in sub-basalt Vapor Probe VP-19UA screened beneath the basalt, indicating that some degree of advective vapor flow may be induced from beneath the basalt in this area due to extraction in the overlying fine-grained zone. Vacuum versus time data graphs are included in Appendix D. Manual vacuum gauge measurements summarized in tabular format are also included in Appendix D.

3.5.4 Operations and Maintenance

Re-start of the SVE system occurred on 28 March 2006. The O&M of the system typically includes routine Site visits, during which the following tasks typically are conducted:

- Inspection and maintenance, as needed, of system components (e.g., piping, blower oil, belts / hoses);
- Monitoring of system flow rates / vacuum;

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measurements at probes V-9, V-10, and P-1 located at radial distances of approximately 24, 26 and 34 feet from Well V-11, respectively, are plotted on a log scale on the figure. A trend line through these data points intercepts the X-axis (zero vacuum) at a value between 50 and 60 feet distance from V-11.

- Monitoring concentrations of VOCs at the system influent and between carbon vessels;
- Collection of samples from the system effluent for laboratory analysis, if necessary;
- Flow, vacuum, and total VOC measurements using a PID at each extraction well; and
- Monitoring the rate of solvent waste and condensate waste recovery.

During the Phase I period, soil vapor flow rates from each extraction well ranged between approximately 5 and 20 scfm, resulting in a combined flow rate to the GEO treatment system of approximately 150 scfm. Differences in flow rates are expected based on the results of the individual well step tests. Periodically, slight adjustments to individual well flow rates are made in an attempt to increase VOC mass removal rates. On 5 December 2006, Sub-Basalt Well VP-19UA was connected to the SVE system. Due to the small inside diameter of VP-19UA (3/4-in) only a flow rate of approximately 1 scfm was estimated to have been achieved. Summaries of system operational data are included in Appendix D.

At startup, the rate of solvent waste recovery was initially estimated at approximately 2.0 gallons per hour. Subsequently, the rate declined to approximately 0.26 gallons per hour by the end of March 2007. It is estimated that a total of approximately 3,350 gallons, or 36,850 pounds, of solvent waste were recovered between 28 March 2006 and 31 March 2007. During the same period, approximately 2,720 gallons of condensate waste were recovered, and it is estimated that the condensate waste contained an additional 68 pounds of VOCs. From 28 March 2006 to 31 March 2007, the GEO system was operational for approximately 7,628 hours, representing an approximate 86 percent run time. System downtime is primarily attributed to routine operations and maintenance (O&M) activities and the seven-day shutdown for the annual soil vapor sampling event in February 2007. Downtime for O&M includes downtime related to carbon change-outs and shipment of the recovered solvent waste and condensate waste for off-Site disposal at a permitted facility.

The recovered solvent waste and condensate waste are transported for off-Site disposal to the ROMIC Southwest facility located in Chandler, Arizona. Both solvent waste and condensate waste are shipped in the same event using a double hull tanker provided by ROMIC. Solvent waste and condensate waste were shipped for disposal under waste manifest by ROMIC on the following dates:

- 26 June 2006;
- 11 September 2006;
- 5 December 2006; and
- 12 March 2007.

Both drums of vapor-phase carbon were changed out and shipped under manifest by US Filter / Siemens Water Technology on the following dates;

- 14 April 2006;
- 7 September 2006; and
- 18 December 2006.

3.5.5 Vapor Plume Progress Monitoring

Concentrations of VOCs in the soil vapor from the coarse- and fine-grained zones and the vadose zone beneath the basalt have been monitored during the Phase I period. Specific soil vapor monitoring events included:

- Annual monitoring events that included the collection of soil vapor samples in SUMMA™ canisters for fixed laboratory testing of VOCs;

- Quarterly sampling events that included collection of soil vapor samples for testing of VOCs by a mobile laboratory; and

- Monthly measurements of total VOC concentrations of probes using a PID.

Annual monitoring events occurred just prior to the SVE re-start (in February 2006) and following one year of SVE operation (in February 2007). In February 2007, the SVE system was shut down approximately one week prior to the sampling event to allow for static soil vapor conditions. Soil vapor samples were collected in SUMMA canisters

after purging each vapor probe of approximately three casing volumes of vapor. The SUMMA™ canister samples were analyzed by Columbia Analytical Laboratory, of Simi Valley, California, using USEPA Method TO-15 for VOCs.

Concentrations of total VOCs measured in the 1st quarter of 2006 from the coarse-grained zone, fine-grained zone, and sub-basalt area are presented in Figures 3-6, 3-7, and 3-8, respectively. Following approximately one year of SVE operation in the fine-grained zone around Pit 1, an annual soil vapor sampling event was conducted in the 1st quarter of 2007. Concentrations of total VOCs measured in the 1st quarter of 2007 from the coarse-grained zone, fine-grained zone, and sub-basalt areas are presented in Figures 3-9, 3-10, 3-11, respectively. The specific vapor probes sampled for the annual events are listed in Table 3-3. Laboratory data of the annual sampling events are summarized in Appendix A.

Soil vapor samples were collected from select probes for analysis by a mobile laboratory during the 3rd and 4th quarters of 2006. A mobile laboratory sampling event was not conducted in the second quarter of 2006 due to the close spacing of the SVE re-start (28 March) and the 2nd quarter monitoring event during the 1st week of April. For quarterly events, samples were collected following a three-volume purge in airtight syringes and analyzed on-Site by a mobile laboratory by USEPA Method 8260, according to California Department of Toxic Substances Control (DTSC) guidelines. These guidelines include protocols to identify problems with sampling if they occur (e.g., short circuiting, detection protocols) [DTSC / RWQCB, 2003]. Duplicate samples were collected in SUMMA™ canisters at 10 percent of the sampling locations to confirm the results of the mobile laboratory. The duplicate samples were analyzed by Columbia Analytical Laboratory using USEPA Method TO-15 for VOCs. Total VOC contours of soil vapor in sub-basalt were prepared for the third and fourth quarters of 2006 (Figures 3-12 and 3-13). Total VOC soil vapor contours were not prepared for the coarse- and fine-grained zones due to the pressure effects caused by the active SVE system. The specific vapor probes sampled for the quarterly events are listed in Table 3-3. Laboratory data of the quarterly sampling events are included in Appendix A.

During operation of the SVE system, soil vapor probes were monitored on a monthly basis using a PID. Monthly monitoring was conducted during the months that annual and quarterly sampling was not conducted. Monthly PID data is presented in Table 3-4. PID data collected in January 2007 is suspect due to a field instrument malfunction. Time-series graphs of the monthly (excluding January 2007) PID readings from the coarse-grained zone, fine-grained zone, and sub-basalt vapor probes are shown in Figures 3-14, 3-15, and 3-16, respectively. The specific vapor probes that were monitored monthly using a PID are listed in Table 3-3.

4. UPDATED SITE CONCEPTUAL MODEL

4.1 General

The original SCM was updated and a revised SCM was first discussed in the Phase I Work Plan [Geosyntec / Hargis, 2005]. That revised SCM was developed based on a review and interpretation of published regional geologic and hydrogeologic reports for the Lower Hassayampa sub-basin of the Phoenix Active Management Area, information from the Arizona Department of Water Resources and U.S. Geological Survey data bases, and data collected from previous investigations and remedial actions conducted at the Site.

Based on data gaps identified through analysis of the revised SCM, a Phase I scope of work was developed to collect additional data intended to fill these data gaps. Using the data obtained through the implementation of the Phase I Work Plan, the SCM has been updated again. This section provides information on the regional and local hydrogeologic setting of the Site as well as updated conclusions regarding the fate and transport of chemicals originally disposed of at the Site.

4.2 Hydrogeologic Setting

4.2.1 Location

The Site is located in the Southeast ¼ of Section 3 of Township 1 South and Range 5 West in Maricopa County, Arizona, near the intersection of 309th Avenue and Baseline Road (Figure 2-1). The Site is located in the Lower Hassayampa Area (LHA) of the sub-basin, near the east-central boundary of the Hassayampa sub-basin of the Phoenix Active Management Area.

4.2.2 Regional Hydrogeologic Setting

The Hassayampa sub-basin includes approximately 1,200 square miles in west-central Arizona [ADWR, 1983]. The sub-basin is an alluvial plain bounded on the north by the Vulture and Wickenburg Mountains, on the east by the White Tank Mountains, on the south by the Buckeye Hills and Gila Bend Mountains, and on the west by the Belmont and Big Horn Mountains and Palo Verde Hills. The Hassayampa sub-basin is drained

by the Hassayampa River, Jack Rabbit Wash and Centennial Wash [ADWR, 1983]. These three streams are ephemeral and flow only after heavy rains. The LHA is a sediment-filled structural basin. Groundwater occurs regionally in the basin-fill sediments, which locally include volcanic rocks. Regional aquifer conditions in the basin-fill sediments are predominantly unconfined. Unconfined conditions predominate in the Tonopah Desert, along the Hassayampa River, along the Arlington Valley, and, possibly, in parts of the area along Centennial Wash. Groundwater occurs under both confined and perched conditions south of the Palo Verde Hills, in the area around the Palo Verde Nuclear Generating Station [ADWR, 1983].

The basin-fill sediments in the LHA are divided into three major hydrogeologic units and include the upper, middle, and lower alluvium (U.S. Bureau of Reclamation, 1976). The upper alluvium is unsaturated in most of the area; it contains groundwater only in the areas along the Hassayampa and Gila Rivers [ADWR, 1983]. The middle and lower alluvium, and locally the volcanic and sedimentary bedrock, are the main water-bearing units that comprise the regional aquifer. The hydrogeology of the LHA was defined further during investigations for the Palo Verde Nuclear Generating Station. These investigations indicate that the upper alluvium is 30 to 60 feet thick and consists of silty sand and gravelly sand with discontinuous lenses of clay and silty clay. The middle alluvium is 230 to 300 feet thick and is predominantly clay and silty clay interbedded with discontinuous lenses of clayey silt, clayey sand, and silty sand [ADWR, 1982]. The lower alluvium consists of less than 100 to more than 1,000 feet of unconsolidated silty sand, sand, and gravelly sand and, locally, moderately to well-consolidated alluvial fan deposits. Most of the large-diameter, highly productive wells in the LHA are completed in the lower alluvium or the underlying volcanic and sedimentary rocks [ADWR, 1983].

Groundwater flow in the LHA historically has been generally from north to south along the Hassayampa River toward the Gila River (Figure 2-1) and from northwest to southeast in the Tonopah area to the Gila River. However, since the late 1940s, groundwater pumping for agricultural purposes in the Tonopah area and south of the Palo Verde Hills in the Centennial Wash area has caused the formation of large cones of depression. By 1982, groundwater levels declined more than 70 feet in the Tonopah area and more than 40 feet in the Centennial Wash area. These declines altered groundwater flow directions in these areas; groundwater generally flows toward these

cones of depression. Groundwater flow near the Hassayampa River, however, has remained generally to the south-southeast toward the Gila River near Arlington, at a gradient of approximately 0.005 (approximately 26 feet per mile).

4.2.3 Local Hydrogeologic Setting

4.2.3.1 General

The local geologic setting near the Site is indicative of the regional geologic conditions. The Site is located along the west-central boundary of the LHA, near the juncture of the Hassayampa and Gila Rivers. The Site is just north of the Arlington Flow, which is a small shield volcano composed of basalt. The Arlington shield volcano erupted in the late Pliocene to early Pleistocene era and is located approximately 40 miles west of Phoenix. The lava flows from the Arlington volcano flowed into the Gila River channel. At Arlington, the channel was shifted to the south. The northern margin of Arlington is mantled by alluvium, and basalt flows from the volcano are interbedded with the basin fill alluvial sediments.

In the Site vicinity, the geology includes basin-fill deposits. Investigations to date indicate that the basin-fill deposits are composed of upper and middle basin-fill alluvium interbedded with basalt. The basin-fill alluvium overlying the basalt includes an upper coarse-grained zone and a lower fine-grained zone. The sediments underlying the basalt also have been subdivided into two zones based on texture and hydraulic characteristics. These subunits locally are called Unit A and Unit B. The coarse-grained zone is roughly comparable to the upper alluvium, and the fine-grained zone and Units A and B correspond to the middle alluvium, as described by the Army Corps of Engineers [U.S. Bureau of Reclamation, 1976].

4.2.3.2 Vadose Zone

The vadose zone in the Site vicinity includes the basin-fill alluvium above the basalt, the basalt unit and the upper portion of the basin-fill alluvium beneath the basalt.

4.2.3.2.1 Coarse-Grained Zone

The uppermost sub-unit recognized in the Site area is the coarse-grained zone. The coarse-grained zone is composed predominantly of interbedded silty sand, gravelly sand, and sandy gravel. Typically, the coarse-grained zone is composed of 60 to more than 90 percent sand, gravel, cobbles, and boulders with silt. The silt content of the coarse-grained zone ranges from trace amounts to approximately 40 percent. The coarse-grained zone is described as loose to weakly cemented, with local caliche horizons. The sand, gravel, cobbles, and boulders are typically sub-angular to angular and are derived predominantly from local volcanic and granitic bedrock with some quartz and quartzite clasts. The coarse-grained zone ranges in thickness from approximately 24 to 50 feet. The coarse-grained zone is underlain by the fine-grained zone portion of the upper basin-fill alluvium, and descriptions of the lower part of the coarse-grained zone and the upper part of the fine-grained zone indicate that the contact of the two sub-units is gradational.

4.2.3.2.2 Fine-Grained Zone

The fine-grained zone sub-unit of the basin-fill alluvium is composed of silt and clay units with varying amounts of sand and gravel. The fine-grained zone includes gravelly-sandy silt, sandy-clayey silt, sandy-silty clay, and silty clay. The fine-grained zone is typically brown to red in color and contains from 60 to 95 percent silt and clay. These fine-grained units are typically described as slightly to moderately lithified with carbonate cement. In many instances, hard silty-clay and clayey-silt spheroids and fragments are noted. The fine-grained zone overlies the basalt unit. Typically, the lower portions of the fine-grained zone contain basalt fragments. Borehole data from the Site indicate that the thickness of the fine-grained zone ranges from as little as 7 feet to approximately 36 feet.

4.2.3.2.3 Basalt

The basalt, as described from drill cuttings and cores collected at Site Borings EX-1, EX-2, and EX-4 [EM/CRA, 1991] and MW-19UA and MW-20UA installed as part of the Phase I Investigation, is a black to dark gray, vesicular olivine basalt. Vesicles range from 0.1 to 0.4 inches in diameter and are filled partially with calcite. The basalt also is generally described as non-fractured. However, some partially filled and

completely filled fractures are noted in the logs for Boring EX-2. The fractures are filled with calcium carbonate and clay. In addition, reports of basalt interbedded with silty-clay and claystone are noted in some logs, such as the log for Monitoring Well MW-5UA.

Previous investigations in the Site vicinity indicate that the basalt is encountered between approximately 52 and 74 ft-bgs. The top of the basalt is encountered at elevations between 847 to 871 feet above mean sea level (ft-msl, Figure 4-1). During the Phase I soil boring investigation, basalt was encountered in the hollow stem borings, with the exception of Borings B-6 and B-9. Based on data collected to date, the basalt beneath the Site varies in thickness from zero feet just north of Pit 1 to a maximum of 29 feet on the southern boundary of the Site at Monitoring Well MW-10UB. Although variable in thickness, the basalt generally thins from south to north and was not encountered north of the Site at Monitoring Well and Vapor Probe MW-18UA/VP-18UA or hollow stem auger Borehole B-9. Based on these data, the limits and elevation of basalt in the vicinity of Pit 1 have been redrawn (Figure 4-1). As shown in Figure 4-1, the upper surface of the basalt appears irregular and undulated, creating localized channels, pockets, and depressions in the surface of the unit.

4.2.3.2.4 Sub-Basalt Units

Unit A is described as sandy, clayey-silt, or clayey silt comprising 85 to 95 percent silt and clay, with minor fine sand and gravel interbeds. This sub-unit typically is brown to red-brown in color and non-lithified to weakly lithified with carbonate cement.

Unit B, although fine-grained, generally contains more sand and sandy interbeds than Unit A and typically is described as interbedded sandy, clayey-silt, and silty-sand and sand. This sub-unit is typically red-brown and non-lithified to weakly lithified with carbonate cement.

4.2.4 Local Groundwater Conditions

4.2.4.1 Overview

Groundwater occurs in the Unit A and Unit B portions of the basin-fill alluvium that compose the regional aquifer in the LHA. However, at the present time the upper 7 to

12 feet of Unit A beneath the Site is unsaturated. Groundwater in Unit A occurs under unconfined conditions. Units A and B are differentiated based on differences in texture, hydraulic conditions, and water quality. These units are hydraulically connected, and the potential exists for groundwater to migrate vertically between the units where a vertical head difference exists between the units. However, the rate of movement and degree of connection between the units are limited by the vertical permeability difference between the units.

The groundwater conditions described below are based on data collected as part of the groundwater monitoring program and reported in the 2006 Annual Monitoring Report [Geosyntec / Hargis, 2007] and monitoring data collected for the 1st quarter of 2007. Descriptions of the depth to groundwater, groundwater elevations, direction of groundwater flow and groundwater gradient, and groundwater quality are provided in the following sections.

4.2.4.2 Unit A Groundwater Conditions

4.2.4.2.1 Flow Direction and Gradient

Estimates of the flow direction and groundwater gradient in Unit A are based on water level measurements collected in February 2007 (Appendix A). Depths to groundwater measured in monitoring wells screened in Unit A in February 2007 ranged from 830 to 837 ft-msl. During 2006, water level elevations in Unit A monitoring wells ranged from approximately 830 to 842 ft-msl. However, Unit A groundwater elevations are influenced by operation of the groundwater extraction system at the Site. The groundwater extraction system includes pumping from four extraction wells screened in Unit A with a combined pumping rate of approximately 5.5 gpm. The groundwater extraction system was designed to capture and contain VOC contamination in groundwater in Unit A. Water level elevations in the extraction wells ranged from approximately 827 to 829 ft-msl in February 2007 and 826 to 832 ft-msl in 2006. The direction of groundwater flow in Unit A currently is toward the cones of depression caused by on-Site pumping (Appendix E). The hydraulic gradient of Unit A at the Site is variable and is controlled by extraction well pumping. The apparent direction of Unit A groundwater flow outside of the influence of the extraction system is south-southeast.

Unit A water level elevations measured in monitoring wells did not change significantly at the Site in 2006 as compared to previous years (Appendix A) [Geosyntec / Hargis, 2007].

4.2.4.2.2 Current Chemical Concentrations in Groundwater

Unit A groundwater constituents of potential concern at the Site include the VOCs 1,1-Dichloroethene (1,1-DCE), 1,2-Dichloropropane, tetrachloroethene (PCE), and trichloroethene (TCE). Another significant VOC, in terms of concentration, in the Unit A groundwater is Freon-113. Although the groundwater concentrations of this constituent are a significant component of the total VOC concentration, Freon is not a COC at the Site.

Historically, groundwater samples have been collected from Unit A groundwater wells using a three-casing volume purge technique. However, as approved by the USEPA and ADEQ, the sampling technique for Unit A groundwater wells was changed from three-casing volume purge to the use of passive diffusion bags (PDBs) by April 2006. PDBs are now routinely placed in Unit A groundwater wells to be sampled as part of each quarterly monitoring event. Quarterly Progress Letter Reports and the Annual Report provide additional detailed information on PDB placement depths [NES, 2007]. In general, analytical results of PDB samples yielded equivalent, if not higher, concentrations of VOCs as compared to pumped samples. A review of the analytical data for the Unit A groundwater samples collected in February 2007 indicates that VOC concentrations were detected in groundwater samples collected from several groundwater monitoring wells located near and downgradient of Pit 1 but upgradient of extraction wells. VOCs have been detected at concentrations greater than the groundwater performance standards in samples collected from these monitoring and extraction wells (Appendix A).

4.2.4.3 Unit B Groundwater Conditions

4.2.4.3.1 Flow Direction and Gradient

Estimates of the flow direction and groundwater gradient in Unit B are based on water level measurements collected in 2006 and February 2007. Depths to groundwater measured in monitoring wells screened only in Unit B in 2006 and February 2007 range

from 99 to 110 ft-bgs. During 2006 and February 2007, water level elevations in the Unit B monitoring wells ranged from approximately 813 to 822 ft-msl. During this time period, the horizontal hydraulic gradient and flow direction in Unit B was approximately 0.007 toward the south (Appendix E). These values are consistent with historical Unit B elevation and gradient data.

Unit B water level elevations measured in monitoring wells generally declined in the spring and summer and rose during the fall and winter of 2006. This pattern of the decline and rise of water levels has been observed historically and is believed to be related to seasonal recharge and pumping of groundwater for irrigation use and domestic and industrial water supply in the vicinity of the Site [Geosyntec / Hargis, 2007].

4.2.4.3.2 Current Chemical Concentrations in Groundwater

Analytical results for groundwater samples collected from Unit B groundwater monitoring wells during the Phase I period indicate that VOCs were not detected. VOCs have never been detected in samples collected from Unit B groundwater wells in the history of groundwater monitoring at the Site. Unit B groundwater samples are collected using submersible pumps and a three-casing volume purge technique.

4.2.4.4 Vertical Head Differences

Water elevation data from paired Unit A and Unit B groundwater monitoring wells located outside the extraction area were compared to asses the ambient head potential between Units A and B. Data from 2006 and 2007 show that Unit A potentiometric levels are between 8 and 17 feet higher than those of Unit B. However, in the area where VOCs are present, active pumping within Unit A lowers the water levels and further reduces their vertical head potential.

A comparison of 2006 and 2007 elevation data from Unit A extraction wells located within the active pumping area indicate elevations in Unit A ranged from 4 to 8 feet higher than water elevations in Unit B (Figures 4-2 and 4-3). These data demonstrate that pumping reduces the vertical head potential near-field to pumping wells where VOCs are present. Thus, pumping further reduces forces driving the potential for contaminant migration from Unit A to Unit B (Section 4.3.6). At the request of EPA

and ADEQ, further evaluation of the vertical migration potential from Unit A to Unit B will be conducted as part of Phase II scope of work.

4.3 Contaminant Fate and Transport

4.3.1 General

This section provides an updated evaluation of the migration and fate of contaminants at the Site. Of particular importance are the transport mechanisms that describe how contaminants migrated from the source area into the surrounding vadose zone and within groundwater. Key findings regarding the distribution and fate and transport of contaminants at the Site are summarized below, and detailed supporting information is included in subsequent sections:

- Liquids migrated downward to the basalt layer underneath Pit 1. Available data suggest that there are no significant quantities of liquids currently pooled on top of the basalt. Some liquids migrated to the edge of the basalt at a depth where the Unit A groundwater elevation was estimated to exist at the time of waste disposal (Section 4.3.2). Some quantity of liquids may also have migrated into, through or around the basalt.

- Data from samples collected below the basalt indicate much lower concentrations of VOCs in soils at this depth. Concentrations of VOCs in Unit A groundwater immediately adjacent to the Pit suggest that only limited quantities of organic liquids may be in direct contact with groundwater (Section 4.3.2).

- VOC vapors are generated in the vadose zone due to the volatilization of residual VOC mass in the vadose zone beneath Pit 1. Over several years, the extent of vapors in the coarse- and fine-grained zones extended well beyond the area of Pit 1 (Section 4.3.3).

- Although some quantity of liquid may have migrated to Unit A groundwater in the Pit 1 area, data trends from the Phase I period and related analyses indicate that sub-basalt concentrations of VOCs in vapor have contributed to Unit A groundwater VOC impacts (Section 4.3.3).

- A limited potential exists for vertical migration of VOCs from Unit A groundwater to Unit B groundwater (Section 4.3.6).

This understanding forms the basis for providing the recommendations for Phase II Work Tasks (Section 5). The extent of VOCs within the soil, soil vapor, and Unit A groundwater matrices and the potential for migration from and between these media are discussed in additional detail in the following sections.

4.3.2 Pit 1 Primary Source Area

As discussed in Section 2.2, Pit 1 received organic and oily wastes, and the area surrounding and beneath Pit 1 is the primary location of soil VOC impacts (Section 2.4.4). Pit 1 is the primary source area or origin of VOC impacts to Unit A groundwater. Therefore, Pit 1 (the primary source area) is the focus of this source area discussion.

High organic concentration liquids and/or dense non-aqueous phase liquid (DNAPL) historically deposited into Pit 1 (liquids) are considered to be the primary sources of VOCs detected at the Site. VOC concentrations in soil and soil gas samples surrounding and beneath Pit 1 are consistent with these high organic content liquids migrating predominantly vertically downward from Pit 1. Prior to conducting the Phase I investigation, there was insufficient data to characterize the distribution of residual organic liquids that may have migrated from Pit 1, especially laterally.

As described in Section 3.2, a total of nine boreholes were drilled in and around Pit 1. Boreholes were continuously sampled from depths of approximately 10 ft-bgs until basalt was encountered. Significant findings from the Pit 1 soil boring investigation include:

- Based on the absence of basalt in Borings B-6 and B-9, the edge of the basalt unit is much closer to Pit 1 than previously estimated (Figure 4-1);
- The highest concentrations of residual VOCs in soils remain in close proximity to the footprint of Pit 1 above the basalt unit; and
- Liquids migrated vertically downward from Pit 1 to the edge of the basalt.

As described in Section 3.2, each hollow stem auger soil boring was either advanced to the top of the basalt or to a depth sufficiently below the expected contact (Borings B-6 and B-9). These data on the depth to basalt in the Pit 1 area were used together with data collected from previous investigations to update the elevation and extent of the basalt unit (Figure 4-1). As shown on Figure 4-1, the edge of the basalt is now known to form a notch that extends to the south approximately 15 feet from the northeast corner of Pit 1. Control on the edge of the basalt to the east and the west of Pit 1 is provided by the drilling of vapor probes at locations N-01, N-02, V-09, V-10, V-11, NE-01, and VP-19UA, as well as Boring B-9.

Several cross-sections, the locations of which are shown on Figure 4-4, were developed to graphically depict the investigative findings. Cross-Section A_1-A_1' (Figure 4-5) is drawn in a north-south orientation extending from the southern boundary of the Site north through Groundwater Monitoring Well MW-17UA. Also included on Cross-Section A_1-A_1' are the February 2007 total VOC soil vapor concentrations and associated iso-concentration contours of 1,000, 10,000, and 50,000 ug/l. As shown, the highest area of remaining VOC vapor concentrations is found immediately around Pit 1 in the sub-basalt vadose zone. Vadose zone areas outside the footprint of Pit 1 are shown to contain much lower total VOC concentrations.

Cross-Section A_2-A_2' (Figure 4-6) is drawn in the same north-south plane as Cross-Section A_1-A_1' but encompasses only a quarter of the section to focus on the details of the soil boring VOC data around Pit 1. Soil VOC data on Cross-Section A_2-A_2' illustrate that the highest concentrations of VOCs (20,000,000 ug/kg) were detected in Boring B-1 beneath Pit 1 near, but not directly on top of the basalt, suggesting that significant quantities of liquids did not pool on top of the basalt in this location. Relatively high (8,000,000 ug/kg) VOC concentrations were also detected about 16 feet west on top of the basalt in Boring B-5, again indicating that liquids remained localized within the footprint of Pit 1. Limited lateral migration is indicated by the fact that VOCs were detected at concentrations less than 50,000 ug/kg near the basalt in Borings B-2, B-3 and B-8, which were each outside Pit 1 but drilled within 25 feet of the pit edge.

Figure 4-7 includes Cross-Sections B-B′ and C-C′, drawn at a scale similar to Cross-Section A_2-A_2′. Cross-Section B-B′ drawn in an approximate west to east direction crosses the notch in the edge of the basalt. Cross-Section B-B′ shows that VOCs were detected at a concentration of approximately 800,000 ug/kg in Boring B-6 (at approximately 70 ft-bgs) drilled at the edge of the basalt. However, VOC concentrations of samples collected at deeper depths below the basalt edge ranged from non-detectable to 1,800 ug/kg, indicating limited downward migration at this location. Sample results from other borings, specifically B-7, B-8, and B-9, indicate relatively low VOC soil concentrations at distances of 25 to 50 feet away from the Pit in these directions.

Cross-Section C-C′, drawn in a southwest-northeast direction through the notch in the basalt, also shows the highest detected VOC concentrations in Boring B-1 (at approximately 57 ft-bgs) beneath Pit 1, near but not directly on top of the basalt. Boring data also suggest a localized high spot in the elevation of the basalt beneath Pit 1, where, if liquids migrated to depth in this location, they may have migrated south to a depression in the basalt or toward the edge of the basalt to the north. Data from Boring B-6 also suggest the migration of some liquids to the edge of the basalt, where it may have come into contact with the water table projected to exist near that depth at that time. Data from deeper samples in Boring B-6 indicate that liquids did not migrate downward significantly below the projected 1980 Unit A groundwater surface in this location. The VOC concentration of 11,000 ug/kg reported in the sample collected at the basalt in Boring B-3 also suggests that liquids did not pool in significant quantities in the localized depression in the basalt south of the pit.

Overall, the distribution of VOCs detected in soil samples suggests that liquid migration from Pit 1 was primarily downward with limited lateral spreading. Soils data do not suggest that liquids migrated downward from the Pit to the basalt in saturated conditions over a wide area. Although organic liquids appear to have reached the basalt beneath Pit-1, the pattern of soil VOC data suggests migration along fractures in areas of higher permeability in quantities that limited the potential for significant pooling or accumulation of liquids on top of the basalt.

Furthermore, no direct or indirect evidence has been found that shows significant quantities of liquid waste directly contacted Unit A groundwater in the vicinity of Pit 1.

A comparison of February 2007 concentrations of detected VOCs from samples collected from Wells MW-18UA and MW-19UA indicates that, with the exception of Freon-113, concentrations of individual VOCs are mostly less than 0.05 percent of their respective solubilites (Table 4-1). Detected concentrations of Freon-133 in Unit A groundwater are believed to be related to the relatively high concentrations of Freon-113 in sub-basalt soil vapor. Freon-113 has a relatively high vapor pressure and low aqueous solubility. Generally, concentrations between 1 and 10 percent of solubilities have been used to indicate the potential presence of DNAPL in contact with groundwater. The fact that groundwater contamination has not been detected in Unit B below the basalt (Section 3.2.4.3) also suggests that liquids did not migrate through Unit A and continue vertically into Unit B.

4.3.3 Soil Vapor

VOC vapors are generated in the vadose zone from the volatilization of residual organic liquids associated with Pit 1. VOC vapors then migrate by diffusion due to concentration gradients, density gradients for high molecular weight VOC compounds (e.g., Freon), and/or advection. Vapor migration also may be influenced to some degree by the presence of the geomembrane that is part of the multi-layer cap constructed over a majority of the former hazardous waste disposal area. The geomembrane will act to limit vapor flux at the surface, thus enhancing lateral migration of vapor. A combination of these transport processes over time led to the configuration and magnitude of the soil vapor plume that existed in the vadose zone prior to implementing the Phase I Work Plan.

During the Phase I period, soil vapor data were collected from the coarse-grained, fine-grained, and sub-basalt vadose zones. The change in the size and magnitude of the soil vapor plume during the Phase I period is illustrated by the data collected from the February 2006 and February 2007 monitoring events (Figures 3-6 to 3-11, Section 3.5.5).

As shown on these figures, soil vapor VOC concentrations from the coarse-grained, fine-grained and sub-basalt zones have decreased by an approximate order of magnitude during the one-year operation of the SVE system. Soil vapor VOC concentrations in the vadose zone below the basalt were observed to steadily decrease during the 3rd and 4th quarters of 2006 without active extraction from this zone. Between March 2006 and

December 2006, the SVE system was only operated in the fine-grained vadose zone. As shown on Figures 3-8, 3-12, and 3-13, the size of the sub-basalt soil vapor VOC plume steadily decreased during this period. Some VOC concentrations at individual wells may fluctuate, but the overall trend is for decreasing concentrations and size of the soil vapor plume.[2] Following the December 2006 connection of Sub-Basalt Well VP-19UA to the SVE system, the reduction of VOC concentrations below the basalt appears to have greatly accelerated even with the low estimated vapor flow rate of 1 scfm achieved from the small diameter of VP-19UA.

Historically, there has been evidence that VOCs in soil vapor have affected Unit A groundwater concentrations at the Site. Further evaluation of this potential relationship using Unit A groundwater and sub-basalt soil vapor data collected during the Phase I period identified the following:

- For several groundwater wells located near Pit 1, decreases in Unit A groundwater VOC concentrations were measured coincident with decreases in sub-basalt VOC vapor concentrations;

- Prior to SVE startup, sub-basalt vapor VOC concentrations in wells near Pit 1 were high enough to cause the VOC concentrations measured in Unit A groundwater at the same location; and

- Following a year of SVE operation, VOC vapor concentrations in the sub-basalt vadose zone were reduced by approximately an order of magnitude. However, sub-basalt vapor concentrations in wells adjacent to Pit 1 are still high enough to cause the measured impacts to Unit A groundwater in this area.

[2] For instance, concentrations in vapor probe VP-19UA have fluctuated over time; this is in part due to the differences between data collected while the system is running (quarterly events) versus when the system is turned off for a brief rebound period (annual snapshot event). Other factors that may influence the concentrations include the method of sample collection (e.g., Tedlar® bags versus SUMMA canisters) and the laboratory equipment (mobile laboratory versus fixed laboratory).

Based on these findings, it can be concluded that although some quantity of liquid may have migrated down from Pit 1 to Unit A groundwater, soil vapor is the major contributor to the concentrations of VOCs detected in the Unit A groundwater.

Figures 4-8 through 4-15 consist of plots of total VOC concentrations measured in sub-basalt soil vapor and Unit A groundwater between February 2006 and February 2007 at the following select groundwater wells:

- MW-01UA;
- MW-04UA;
- MW-06UA;
- MW-07UA;
- MW-11UA;
- MW-12UA;
- MW-18UA; and
- MW-19UA.

With the exception of groundwater wells MW-12UA and MW-19UA, total VOC concentrations in Unit A groundwater wells have generally decreased during the Phase 1 period. As shown in the plots for Wells MW-04UA, MW-06UA, MW-07UA, and MW-11UA, located outside the footprint of Pit 1, a correlation between vapor and groundwater VOC concentrations appears to exist, where a decrease in soil vapor VOC concentrations is observed to occur with a decrease in Unit A groundwater VOC concentrations. Also worth noting is the sudden change in MW-19UA vapor and groundwater VOC concentrations during the 1st quarter of 2007 (Figure 4-15). It is believed this change is a direct result of piping sub-basalt Vapor Probe VP-19UA to the SVE system in early December 2006. Table 4-2 includes a comparison of February 2007 measured Unit A groundwater VOC concentrations with predicted groundwater concentrations using sub-basalt soil vapor data. As shown in Table 4-2, the predicted groundwater concentrations are greater than measured Unit A groundwater VOC concentrations in Wells MW-18UA and MW-19UA, indicating the continued potential for vapor to have impacts on groundwater quality in this area. For wells located in areas where the magnitude of sub-basalt vapor plume has been reduced (MW-04UA, MW-06UA, and MW-07UA), measured concentrations of several VOCs in groundwater exceed those predicted at equilibrium from vapor data. This trend may

indicate a reversal of the partitioning gradient due to operation of the SVE, which should result in further decreases in Unit A groundwater VOC concentrations. Although some quantity of liquid may have migrated down from Pit 1 to Unit A groundwater, these data indicate that soil vapor contributes to the concentrations of VOCs detected in groundwater.

4.3.4 Groundwater Unit A

During the Phase I period, concentrations of VOCs greater than performance standards were limited to Wells EW-03UA, EW-04UA, MW-01UA, MW-04UA, MW-06UA, MW-07UA, MW-12UA, MW-18UA, and MW-19UA. With the exception of Groundwater Wells MW-12UA and MW-19UA, total VOC concentrations in Unit A groundwater wells have decreased during the Phase 1 period.

Characteristics of Unit A groundwater contamination of the most relevance to the discussion of contaminant fate and transport include the decreasing concentration of Freon-113 in upgradient Wells MW-11UA and the increasing concentrations of Freon-113 and 1,1-DCE in Well MW-12UA. As discussed in the previous section, the trend in MW-11UA is related to the reduction in soil vapor concentrations. This concept of vapor-phase impacts at MW-11UA is also supported by the fact that MW-11UA is located hydraulically upgradient of Pit 1, creating limited potential for liquid phase impacts.

- Total VOC concentrations detected in samples collected from groundwater monitoring well MW-12UA have continued to exhibit an increasing trend during the Phase I period. The trend began in 2001 with initial detections of VOCs (primarily Freon 113) in pumped samples.

- Based on historical Unit A water level measurements, MW-12UA is located hydraulically side gradient of Pit 1. However, in the 1st Quarter 2006, MW-12UA appears to have been hydraulically downgradient of a portion of the sub-basalt VOC soil vapor plume (Figure 3-8).

Because MW-12UA is not downgradient of Pit 1, the hypothesis is that the observed changes in VOC concentrations at MW-12UA are vapor driven. This is supported by the data showing that Freon was the first VOC detected in groundwater samples from

MW-12UA and that this first detection occurred over 20 years after the wastes were disposed of. Furthermore, monitoring data from other wells at the Site have exhibited periods of rising and declining VOC concentrations which have been attributed to changing vapor conditions as the vapor plume expanded and shifted. Historically, MW-06UA was observed to exhibit a rise and subsequent decline in VOC concentrations. MW-06UA is located hydraulically side-gradient of MW-12UA. Lastly, since sub-basalt vapor monitoring was not conducted prior to, during or after the initial SVE system was operated from 1996-1998, the historical trends in the magnitude and extent of the sub-basalt VOC vapor plume and its reaction to vapor extraction is not known. This lack of data makes future predictions on time lags between groundwater and soil vapor trends difficult. Groundwater and soil vapor monitoring data will continue to be evaluated for a correlation.

However, based on the results of the capture zone analysis (Section 4.3.7), it can be concluded that VOCs detected in well MW-12UA are being captured by the extraction system. Also, VOCs have historically not been detected in well MW-16UA located east of MW-12UA.

4.3.5 Groundwater Unit B

Consistent with historical data, VOCs were not detected in samples collected from Unit B groundwater monitoring wells [Geosyntec / Hargis 2007].

4.3.6 Vertical Migration between A and B Units

The following four lines of evidence were used to evaluate the potential vertical migration of VOCs from groundwater in Unit A to groundwater in Unit B.

- The anisotropic relationship between horizontal and vertical hydraulic conductivities;
- The vertical head potential within the area of VOC distribution;
- Unit-specific response to aquifer stress; and
- The lack of VOC detections in Unit B groundwater.

As discussed in Appendix E, the estimated vertical hydraulic conductivity in Unit A is approximately 0.0001 ft/day. When compared to the estimated Unit A horizontal hydraulic conductivity of 100 ft/day, the vertical hydraulic conductivity is six orders of magnitude lower. This anisotropic hydraulic conductivity relationship significantly inhibits vertical flow and therefore results in a very low vertical migration potential from the Unit A groundwater to the Unit B groundwater.

As discussed in Section 2, the on-Site groundwater treatment system used to extract groundwater from Unit A has been operating since 1994. The vertical head potential between Unit A and Unit B groundwater is reduced from 8 to 17 feet outside the area of predominant VOC impacts to 4 to 8 feet within the area of VOC distribution at the extraction wells. A lowered vertical head potential indicates a decrease in the potential driving force required for the downward migration of VOCs from Unit A into Unit B.

Unit B is observed to be influenced by regional stresses on the aquifer due to groundwater withdrawal (Appendix E). Unit A does not appear to be similarly influenced. The trends in Unit A water levels before the onset of remedial pumping (1994) showed very little seasonal fluctuation, whereas water levels in Unit B wells showed considerable fluctuations, which are interpreted to be in response to regional stresses. After pumping from the Site extraction wells began, Unit A water levels showed a steady and persistent decline, whereas water levels in Unit B wells fluctuated within the same range as measured prior to startup of the extraction system. This observation suggests that the regional stresses on Unit B have a greater effect on water levels than does extraction from Unit A. Based on the observation that neither influence is seen on the other Unit, it appears that there is a significant dampening of stresses between the Units that is consistent with the anisotropy discussed above. This suggests poor communication between the Units.

Finally, the lack of VOC detections in groundwater sampled from the Unit B wells corroborates the findings described above. There is limited potential for VOC migration and little hydraulic communication between Units A and B. Although a difference in groundwater elevation potential exists between the units, there is limited evidence of flow between them. At the request of EPA and ADEQ, further evaluation of the vertical migration potential between these units will be conducted as part of Phase II work.

4.3.7 GRS Capture Zone Analysis

A data gap identified in the Phase I Work Plan was whether the current Groundwater Recovery System is providing capture of impacted groundwater, particularly in the area of groundwater Monitoring Well MW-12UA. Piezometer MW-20UA was installed as part of Phase I field activities to collect groundwater elevation data for use in a capture zone analysis. Details of the capture zone analysis are provided in Appendix E.

The capture zone analysis was performed in general accordance with the information presented in a USEPA short course (May 2005) and draft guidance document titled "A Systematic Approach for Evaluation of Capture Zone at Pump and Treat Systems." In summary, the capture zone analysis indicates that the groundwater affected by VOCs is intercepted by the extraction wells. A minor exception is the area east of Extraction Well EW-04UA near piezometer MW-20UA. However, analyses indicate that an increase of 25 percent in the pumping rate of EW-04UA would be sufficient to achieve capture of impacted groundwater near MW-20UA (Appendix E). Additional conclusions from the capture zone analysis related to optimization of the GRS include:

- Removing groundwater monitoring wells MW-08UA and MW-09UA from the water quality monitoring (sample collection) portion of the groundwater monitoring program as these wells monitor groundwater in areas where VOCs are not present. The location of these groundwater monitoring wells is included on Figure 2-3.

- Ceasing operation of extraction well EW-01UA, as this well extracts water without detectable concentrations of VOCs. Well EW-01UA will be added to the groundwater monitoring program where samples will be collected quarterly and water level measurements will be made monthly.

- Increasing the pumping rate of extraction well EW-02UA by 60% to achieve capture of groundwater with VOCs in the area of monitoring well MW-01UA.

This approach in operating the extraction wells is proposed as it is expected that the effects of increased pumping rates will be observed faster if the pumping rate of EW-02UA is increased as compared to EW-01. Also, because EW-01UA is located on the western margin of the Site, essentially outside the area of VOC impacted groundwater, it is

preferred to pump from EW-02UA which is located closer to the center of the Site. Details regarding the capture zone analyses and conclusions are contained in the detailed capture zone analysis appendix (Appendix E).

4.3.8 Conclusions Regarding Chemical Transport

Organic and oil wastes were disposed of in Pit 1, causing it to be the primary source of VOC impacts to soil and Unit A groundwater at the Site. Figure 4-16 illustrates the fate and transport of VOCs based on the updated Site Conceptual Model. Results of soil investigations around Pit 1 suggest that liquid migration was primarily downward in an area localized to the Pit 1 footprint. Data suggest that liquids did migrate downward to the basalt layer underneath Pit 1. Results of soil samples also indicate that some liquids migrated to the edge of the basalt at a depth where the projected Unit A groundwater elevation existed at the time of waste disposal. Data from samples collected below the basalt do not indicate significant quantities of liquid migrated to these depths in a saturated condition over a wide area. Data also do not suggest that significant quantities of liquids or DNAPL are pooled on top of the basalt. However, it is acknowledged that some quantity of VOCs may have migrated into, through, or around the basalt. While limited evidence of current DNAPL was identified, results of soil and soil vapor sample analyses indicate that residual ganglia or areas of high soil VOC concentrations likely exist within the footprint of Pit 1.

Equilibrium calculations using co-located sub-basalt soil vapor and Unit A groundwater data from February 2007 indicate that soil vapor currently has the potential to cause the measured Unit A groundwater impacts in the area immediately adjacent to Pit 1. Further, results of solubility calculations at MW-18UA and MW-19UA and the lack of VOCs in Unit B groundwater suggest that liquids did not migrate through or around the basalt in significant volumes to have migrated through A Unit and continue vertically into Unit B. VOC vapors are generated in the vadose zone due to the volatilization of residual organic or aqueous-phase solvents in the vadose zone beneath Pit 1. The generated VOC vapors then migrate over time by diffusion, due to concentration gradients and density gradients, or advection. Over several years, the extent of vapors in the coarse- and fine-grained zones extended well beyond the area of Pit 1. The re-start of the SVE has acted to capture and draw back a majority of the expanded vapor plume and remove a portion of the residual mass beneath the Pit 1 area (Figures 3-6 to

3-13). Vapor monitoring during the Phase I period has also included collection of samples from the sub-basalt vadose zone, which has led to an understanding of the vapor concentration trend in this area, a portion of the vadose zone not well understood prior to Phase I.

In summary, although some quantity of liquid may have migrated to Unit A groundwater in the Pit 1 area, data trends from the Phase I period and related analyses indicate that concentrations of VOCs in soil vapor have contributed to Unit A groundwater impacts and that reductions in soil vapor VOC concentrations will result in reductions in groundwater concentrations. These conclusions regarding the updated SCM have been used to develop the Phase II recommendations presented in Section 5.

5. PHASE II RECOMMENDATIONS

5.1 Introduction

Studies undertaken as part of Phase I Investigation have advanced the understanding of the SCM. Data collected from the Phase I period indicate that concentrations of VOCs in soil vapor have contributed to Unit A groundwater impacts and that a reduction in soil vapor VOC concentrations will result in reductions in groundwater concentrations. The re-start of the SVE has acted to capture and draw back a majority of the expanded vapor plume and remove a portion of the residual mass beneath the Pit 1 area.

The Phase II recommendations include the continued operation of the GRS and SVE. The GRS will continue to be operated in a manner consistent with the past several years, with the exception of increasing the pumping rate of Extraction Well EW-04UA by approximately 25 percent, as described in Section 4.3.7. Operation of the SVE will be in accordance with a modified design, as described in the following sections. Operation of the GRS will continue to provide capture of groundwater with concentrations of COCs greater than performance standards while the SVE removes VOC mass from the vadose zone, reducing the potential for additional Unit A groundwater impacts. At the request of EPA and ADEQ, Phase II work will also include further evaluation of the vertical migration potential between Unit A and Unit B groundwater.

5.2 Groundwater Recovery System

Based on the results of the capture zone analysis (Appendix E), several recommendations are made with the objective of achieving complete downgradient capture of VOC containing groundwater and optimization of the GRS. Continued operation of the GRS while increasing the pumping rate of Extraction Well EW-04UA by approximately 25 percent, will provide sufficient capture of impacted groundwater at the Site. Additional modifications related to optimization of the GRS include:

- Removing groundwater monitoring wells MW-08UA and MW-09UA from the water quality monitoring (sample collection) portion of the groundwater monitoring program as these wells monitor groundwater in areas where VOCs are not present. Also, piezometer MW-20UA will be added to the water

quality monitoring (sample collection) portion of the groundwater monitoring program.

- Ceasing operation of extraction well EW-01UA as this well extracts water without detectable concentrations of VOCs. Well EW-01UA will be added to the groundwater monitoring program where samples will be collected quarterly and water level measurements will be made monthly.

- Increasing the pumping rate of extraction well EW-02UA by 60% to achieve capture of groundwater with VOCs in the area of monitoring well MW-01UA.

5.3 SVE Modifications

5.3.1 Objective and Technical Approach

The objective of the SVE remedy is to remove VOC mass from the vadose zone beneath the Site, encompassing the coarse-grained, fine-grained, and sub-basalt zones, to levels that are protective of groundwater quality. The following sections present:

- Modifications to the SVE wellfield and treatment technology;

- The conceptual design and operation of the vapor-phase carbon SVE portion of the remedy;

- Details of the approach to be used for monitoring the remaining soil vapor plume; and

- A re-evaluation of soil vapor performance standards.

As described previously, the Phase I SVE system extracted approximately 37,000 pounds of VOCs from the subsurface between March 2006 and March 2007. As demonstrated by soil vapor data collected during the 1st quarter of 2007, this SVE system has made significant progress toward reducing the size and concentration of the VOC vapor plume present in the coarse-grained, fine-grained, and sub-basalt vadose zone areas. Groundwater data further indicate that the remediation of the vadose zone may be causing a measurable improvement in groundwater quality near Pit 1. However, 1st-quarter 2007 data indicate that the highest concentrations of VOCs

remaining in the vadose zone are located in the sub-basalt zone in the immediate area of Pit 1. Given these data, Phase II will include expanding the GEO SVE system to directly target more of the sub-basalt vadose zone near Pit 1.

5.3.2 Wellfield Expansion

The SVE system will be expanded in addition to the 11 fine-grained zone wells currently piped in above the basalt. The proposed expansion includes the following three sub-basalt wells:

- MW-06UA – a 4-inch diameter groundwater monitoring well with an unsaturated screen interval of approximately 12 feet extending from the base of the basalt to the Unit A groundwater table. MW-06UA is located approximately 100 feet southeast of Pit 1 (Figure 2-3).

- MW-18UA – a 2-inch diameter groundwater monitoring well with an unsaturated screen interval of approximately 6 feet extending upward from the Unit A groundwater table. MW-18UA is constructed in the same borehole as its companion, Vapor Monitoring Probe VP-18UA. MW-18UA/VP-18UA is located approximately 15 feet northeast of Pit 1 (Figure 2-3).

- MW-19UA – a 2-inch diameter groundwater monitoring well with an unsaturated screen interval of approximately 6 feet extending upward from the Unit A groundwater table. MW-19UA is constructed in the same borehole as its companion, Vapor Monitoring Probe VP-19UA. MW-19UA/VP-19UA is located approximately 5 feet south of Pit 1 (Figure 2-3).

The existing wellhead at VP-19UA will be removed, and VP-19UA will be converted back to a vapor monitoring point. Based on an estimated radius of influence of 50 feet measured in the fine-grained zone immediately above the basalt and a distance of approximately 95 feet between MW-18UA and MW-19UA, the spacing between these sub-basalt wells for vapor extraction is ideal. Also, given the no-flow boundary of the groundwater table and the close proximity of the overlying basalt, the actual radius of influence may be much larger. The total flow rate from the SVE extraction well network will be kept relatively constant even after the expansion to include MW-06UA, MW-18UA, and MW-19UA. This will be accomplished by reducing the extraction

flow rate from fine-grained zone vapor extraction wells NE-1 and VB-2. 1st-Quarter 2007 data indicate that total VOC concentrations in the coarse-grained and fine-grained zones around these extraction wells have been decreased to less than approximately 200 ug/l.

New wellheads will be fabricated at MW-06UA, MW-18UA, and MW-19UA. The wellheads will consist of Schedule 40 PVC components, including:

- Flow control valve;
- Vacuum measurement port;
- Pitot-type flow measurement equipment (includes a clear section of piping that also functions as a sight glass); and
- A threaded cap that can be removed to access the inside of the well for continued groundwater monitoring.

Conveyance piping will also be 2-inch diameter Schedule 40 PVC. The conveyance piping will run aboveground until it connects with the existing SVE piping network.

The wellheads are designed to facilitate continued groundwater monitoring from these points as well as SVE. The top of the wellhead may be accessed for continued placement of PDB bags via the 2-inch threaded cap. This wellhead construction is consistent with existing SVE wells (Figure 3-3). Prior to placement of PDB bags in the wells, the flow control value will be closed. After placement of the PDB bag and securing of the threaded cap, the valve will be opened, restoring vapor flow through the well. Vapor flowing through the exposed (unsaturated) well screen will have little, if any, effect on the PDB left suspended several feet into the water column. For PBD bag retrieval, the valve can again be closed, and the PDB bag can be accessed through the threaded cap at the top of the well head. Also for continued groundwater monitoring, the flow control valves will be closed for approximately 1 hour prior to collecting depth to water measurements in these wells.

5.3.3 New Well Startup Testing

The following field tests will be performed during startup of the expanded SVE system:

- Measurement of flows over a range of applied vacuums at Wells MW-06UA, MW-18UA, and MW-19UA;
- Measurement of groundwater elevations in Groundwater Monitoring Wells MW-06UB, MW-18UA, and MW-19UA to observe possible mounding during a range of operating conditions;
- Monitoring of total VOC concentrations in the extracted gas streams from MW-06UA, MW-18UA, and MW-19UA, as measured using a PID, and monitoring of vacuum from monitoring points VB-2C, VP-18UA, and VP-19UA. Vacuum and flow will also be monitored from fine-grained zone NE-1 and VB-2 fine-grained extraction wells.

Data from these field tests will be used to estimate the radii of influence of the additional Sub-Basalt Extraction Wells MW-06UA, MW-18UA, and MW-19UA. Data from these field tests will also be used to select the flow rates at MW-06UA, MW-18UA, MW-19UA, and fine-grained wells at NE-1 and VB-2 to maximize efficient VOC mass removal.

Routine O&M will be conducted as described in Section 5.2.3.3.

5.3.4 Treatment Technology

5.3.4.1 Objective and Technical Approach

During Phase I, the re-started SVE system utilized the GEO Inc. pressure condensation treatment unit and focused vapor extraction in fine-grained zone wells at and nearby Pit 1, the primary VOC source area at the Site. As part of the Phase I scope of work, it was proposed to change the off-gas treatment technology from the GEO Inc. system to vapor-phase carbon once VOC vapor concentrations were reduced to levels that would make use of carbon feasible from a cost perspective. An advantage of the GEO Inc. treatment unit is the system's ability to treat high concentrations of VOCs that would

not be practical to treat using vapor-phase carbon. However, the GEO Inc. units are currently limited in blower capacity due to overall system constraints. Conversely, use of vapor-phase carbon for off-gas treatment is more practical at relatively lower concentrations of VOCs but can be scaled up to utilize blowers of much larger size.

Given the advantages and limitations of the GEO Inc. and carbon systems, it is proposed to continue using the GEO Inc. unit currently operating at the Site to extract vapors from areas of the fine-grained zone and sub-basalt vadose zone areas that contain the highest VOC concentrations. At the point VOC concentrations are reduced to levels that are economically treated by carbon, the GEO Inc. system will be replaced with a vapor-phase carbon system. The Carbon System will then be designed with an appropriately sized blower to extract vapor from areas of the vadose zone (coarse-grained, fine-grained, or sub-basalt) that are determined to pose a risk to groundwater quality at that time. As areas with the highest vapor concentrations will have already been reduced to levels that will be economical for vapor-phase carbon treatment, the primary objective of the Carbon System will be to remove remaining VOC mass from areas of the vadose zone that pose a threat to groundwater quality, as discussed in Section 4.3.8.

As part of developing the final design for the Carbon System, soil vapor monitoring data will be used to evaluate which fine-grained zone soil vapor probes or sub-basalt vapor monitoring points will be used for extraction. Trends in soil vapor data toward the end of GEO System's operation will be used to assess where areas of residual VOC mass reside within the vadose zone. This evaluation will be provided with other details of the carbon adsorption treatment system final design to the USEPA and ADEQ for approval prior to conversion of the treatment technology to carbon.

The Carbon System will be operated in a continuous mode until continuous operation becomes impractical due to asymptotic mass removal, after which the system will be operated in a pulsed mode. Shutdown of the SVE system will be considered after asymptotic mass removal is achieved and residual concentrations of VOCs in soil vapor are decided to no longer pose a threat to groundwater quality. Procedures for evaluating asymptotic mass removal are presented in Section 5.5.

5.3.4.2 System Design and Installation

The Carbon System will be sized based on the data collected during the final months of operation of the GEO System and an evaluation of vadose areas where residual mass resides that poses a threat to groundwater quality. The key design data that will be used to size the Carbon System will include the following:

- Number and location of extraction wells;
- Individual well and treatment system flow rate;
- Required vacuum at wellheads;
- Influent chemical concentrations; and
- Estimated carbon usage rates.

The Carbon System will consist of the following components:

- Condensate knockout pot;
- Particulate air filters;
- A minimum of two vapor-phase carbon vessels;
- Vacuum blower; and
- Associated instrumentation.

A generalized process flow diagram of a typical carbon adsorption treatment system is shown on Figure 5-1. The Carbon System will consist of a skid (knockout pot, blower, and control panel) and the carbon adsorption vessels. The appropriate connections will be made between the skid and the carbon vessels. The existing 4–in. PVC header piping will be connected to the influent of the Carbon System. The Carbon System will be located on the lined equipment pad, in the same location occupied by the GEO System.

The Carbon System is expected to be 230 or 480 V, with much lower amperage requirements than required for the current Carbon System; therefore, the required electrical service for the Carbon System exists at the Site. Should the electrical service at the Site require modification for the treatment system to operate, the services of an electrical contractor will be procured.

The Carbon System will be permitted with the Maricopa Air Quality Department (MCAQD). Depending on the requirements of the MCAQD, the existing permit will be modified or a new permit will be filed. Startup of the Carbon System will be conducted over a one- to two-week period. Following the startup period, it is anticipated that the treatment system will be fully operational and will be purposefully shut down only for routine O&M.

5.3.4.3 Operations and Maintenance

Routine O&M of the Carbon System will be conducted in accordance with the manufacturer specifications. The O&M of the Carbon System will typically include regular Site visits, during which the following tasks will be conducted:

- Inspection and maintenance, as needed, of system components (e.g., piping, blower oil, belts / hoses);
- Monitoring of system and extraction well flow rates / vacuum;
- Monitoring concentrations of VOCs at extraction wells, the system influent, between carbon vessels, and at the effluent using a PID;
- Collection of samples for laboratory analysis, if necessary; and
- Monitoring condensate recovery.

Liquids from the Carbon System will be disposed of per applicable requirements. Spent carbon will be disposed of under manifest by a licensed carbon vendor.

Operational data will be used to evaluate the performance of the SVE treatment system. Adjustments will be made to the system configuration to increase soil vapor extraction and treatment of VOCs from the subsurface. Adjustments may include:

- Decreasing the amount of dilution air entering the system over time as influent VOC concentrations decrease; or

- Decreasing or increasing the extraction flow rate from individual extraction wells to increase the treatment system's efficiency at removing VOCs from the subsurface.

5.4 Soil Vapor Monitoring

The vapor plume will be monitored to assess the progress of the SVE system. Soil vapor monitoring will be conducted in accordance with a quarterly and annual program. Modifications may be proposed to either the quarterly or annual sampling events due to changes in soil vapor conditions.

For quarterly monitoring events, soil vapor samples will be collected and analyzed by a mobile laboratory to monitor areas of residual soil vapor VOCs outside the influence of the extraction wells operating in the Pit 1 area. Quarterly monitoring events will be conducted in a dynamic condition unless the SVE system is in a rebound period. Soil vapor data from the 1st-quarter 2007 monitoring event was evaluated to select the monitoring points within these areas. The specific coarse- and fine-grained zone soil vapor probes and sub-basalt monitoring points for quarterly monitoring include the following:

Coarse- and fine-grained zone points

- N-02;
- NE-03;
- NW-01;
- V-02;
- V-14;
- V-15;
- SP-01;
- SP-02;
- SP-05; and
- SP-08

Sub-basalt monitoring points

- MW-04UA;
- MW-07UA;
- MW-11UA;
- MW-12UA;
- VP-18UA; and
- VP-19UA.

Monitoring points will first be purged of three-casing volumes of soil vapor prior to sample collection. The mobile laboratory samples will be collected in airtight syringes and analyzed on-Site by a mobile laboratory by USEPA Method 8260 and in general accordance with California DTSC guidelines. These guidelines include protocols to identify problems with sampling if they occur (e.g., short circuiting, detection protocols). Each soil vapor sample will analyzed for a 25-compound target analyte list of VOCs [DTSC / RWQCB, 2003].

For quarterly mobile laboratory sampling events, duplicate samples will be collected in SUMMA™ canisters at 10 percent of the sampling locations as a quality control check on the results of the mobile laboratory. The duplicate samples will be analyzed by USEPA Method TO-15 for VOCs. The SUMMA™ canister analyses will be performed by Columbia Analytical of Simi Valley, California. The probes to be monitored will be reassessed following each monitoring event.

Annual soil vapor sampling events will be conducted in the first quarter of each year to provide a more detailed evaluation of remedial progress and residual soil vapor conditions. Annual soil vapor sampling events include the collection of soil vapor samples from a larger number of monitoring points in SUMMA™ canisters for fixed laboratory analysis of VOCs by USEPA Method TO-15. The monitoring points to be sampled will be consistent with those sampled for the annual events conducted in February 2006 and February 2007. Annual soil vapor sampling events will be conducted under static conditions following a brief rebound period of approximately one week. The rebound period may be extended for annual soil vapor sampling events if mass removal rates have significantly decreased or if the SVE system is in pulsed operation mode.

5.5 Shutdown Protocol

Operational data will be used to estimate the mass of VOCs being extracted and treated and evaluate the overall trend in VOC concentrations of the extracted gas stream. Pulsed operation of the entire system or of individual extraction wells will be initiated when the mass removal rate and overall VOC concentrations in influent reach asymptotic levels. Pulsed operation will be conducted until remaining concentrations of VOCs in the vadose zone no longer pose a threat to groundwater quality or until continued operation becomes technically impractical (defined below). Procedures for pulsed operation and shutdown of SVE systems is described in several guidance documents, including *How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide For Corrective Action Plan Reviewers* [USEPA, 2004] and *Development of Recommendations and Methods to Support Assessment of Soil Venting Performance and Closure* [USEPA, 2001]. These documents and other documents referenced below were used to develop the procedures that will be used for this Site, which are described below.

- Asymptotic behavior of the total VOC mass removal rate will cause the SVE system to shift from continuous operation mode to pulsed operation mode. Asymptotic behavior for this Site will be considered to be when the overall VOC mass removal rate remains relatively constant over the course of three consecutive months.

- Pulsed operation will initially be operated on a cycle of one-month operational time followed by one month of downtime. Each time the system is re-started, the "rebound" total VOC concentration will be measured in the influent [USCOE, 2002]. Asymptotic behavior of the rebound concentration will be considered to be when the rebound VOC concentration remains relatively constant over the course of three consecutive re-starts. The length of the operational period will be decreased and/or the length of the downtime will be increased when rebound concentrations reach asymptotic levels.

- Pulsed operation will occur until rebound concentrations demonstrate asymptotic behavior after a minimum of six months of downtime [USEPA, 2004]. Continued operation when asymptotic behavior is observed after six months of downtime is defined as technically impractical.

- Asymptotic behavior of rebound VOC concentrations at individual vapor extraction wells will result in those locations being taken off-line for a rebound period. Conversely, the flow and/or operational time periods from individual extraction wells will be increased if significant rebound concentrations are observed. Asymptotic behavior will be considered to be when the total rebound VOC concentrations remain relatively constant over the course of three consecutive re-starts. As stated in AFCEE [2001], the rebound concentrations are useful for measuring remediation progress and assessing whether specific areas of the Site require more aggressive remediation.

Data used for the evaluation of asymptotic conditions may consist of either laboratory analytical data or measurements made with a PID. Evaluation of distillation effects at individual extraction wells will also be conducted in addition to the rebound evaluation procedures described above. The composition of VOC vapors will be analyzed to evaluate whether the fraction of more volatile VOC constituents such as Freon-113 and 1,DCE in the vapor phase reaches a relatively steady state. This evaluation is intended to limit the potential for individual wells to be taken off-line before the VOC constituents remaining in the subsurface have been decreased to a residue with limited soil vapor migration potential [USCOE, 2002].

5.6 Soil Vapor Performance Standards

Prior to construction and operation of the SVE system, soil vapor performance standards were initially developed in 1994 using a model. The modeling conducted in 1994 and in subsequent revisions used the modeling program SESOIL coupled with a groundwater mixing cell model MIXMODEL and the HELP model [EM, 2001]. The SVE system was subsequently constructed and operated intermittently from March 1996 until September 1998. Following shutdown of the SVE system, the soil vapor performance standards were re-evaluated in modeling reiterations performed in

2000 and 2001 [EM, 2001]. Changes in the modeling between iterations included the inclusion of the geomembrane liner installed over the hazardous waste disposal area and the use of updated coarse- and fine-grained soil vapor concentrations obtained after the initial 1994 model.

Following shutdown of the SVE system, monitoring data indicated upward trends in both the size and concentration of the vadose zone vapor plume. Based on these data trends, the HSC deemed it appropriate to conduct supplemental investigations and interim corrective measures as part of a Phase I Work Plan [Geosyntec / Hargis, 2005]. As documented in this report, data collected from Phase I have furthered the understanding of the SCM, particularly with respect to contaminant fate and transport. Findings from Phase I that would likely alter the approach used previously for development of soil vapor performance standards include:

- The basalt is absent just to the north of Pit 1;
- Residual VOC mass was found in soil beneath Pit 1, which caused the vapor plume to significantly increase in both magnitude and size with time following initial shutdown of the SVE in 1998;
- Soil vapor concentrations measured beneath the basalt were found to be higher than in the fine-grained zone overlying the basalt; and
- Although some quantity of liquid may have migrated down from Pit 1 to Unit A groundwater, soil vapor is contributing to the concentrations of VOCs detected in groundwater.

Given these Phase I findings and the fact that VOC concentrations in several Unit A groundwater wells had exhibited increasing trends prior to the re-start of the SVE, it can be concluded that the existing soil vapor standards are inappropriate.

Given the new data obtained from Phase I and the development of the updated SCM, it can be concluded that soil vapors in the sub-basalt vadose zone have been in direct contact with Unit A groundwater, reducing the need for groundwater transport modeling. Previously the potential effects of soil vapor VOCs on groundwater was evaluated by simulating VOC vapor transport using a computer model. As no data on sub-

basalt soil vapor VOC concentrations were available at the time the initial standards were modeled, the computer model simulated VOC transport from the fine-grained vadose zone down to groundwater. Now that sub-basalt soil vapor VOCs have been characterized and found to be in direct contact with groundwater, transport modeling of VOC vapors through the vadose zone to groundwater is not needed, since direct data are available. Given this understanding, the potential threat to groundwater from soil vapors in the sub-basalt vadose zone can be evaluated using more direct quantitative methods. Analytical models can be used that consider both the equilibrium partitioning relationships of vapor and groundwater to quantify potential VOC concentrations that may result in effects on groundwater and the transport limiting process of advection or diffusion that will occur in groundwater once dissolution occurs at the water surface.

Since concentrations of VOCs in the vadose zone will be further reduced through continued operation of the SVE remedy and additional data on the Site-specific relationship between soil vapor and groundwater VOC concentrations will be collected, it is proposed to utilize a more performance-based approach and perform a quantitative evaluation only once asymptotic mass removal of the SVE has been achieved or when further mass removal becomes technically impracticable.

6. SUMMARY AND CONCLUSIONS

6.1 Summary

Historically, hazardous wastes were disposed of at the Site in a series of unlined pits. Early investigations of soil, soil vapor, and groundwater identified impacts from VOCs. An initial phase of remedial actions was conducted in the mid-1990s, including the construction of a geomembrane cover over the hazardous waste disposal area and construction and operation of an SVE system and a groundwater pump and treat system. The SVE system was operated from 1996 until 1998. Operation of the groundwater pump and treat system began in 1994 and continues today.

Following shutdown of the SVE system in 1998, monitoring data indicated upward trends in both the size and concentration of the vadose zone vapor plume. In addition, VOC concentrations in several Unit A groundwater wells began to exhibit increasing trends. Given these conditions, the HSC has deemed it appropriate to evaluate the Site conditions and implement corrective measures as needed. The plan for evaluating the trends consisted of a phased approach. The first phase consisted of the definition of an SCM and identification of related data gaps, which were described in a Phase I Work Plan. Phase I was subsequently implemented in 2006. Data collected from Phase I have been used to update the SCM and develop a recommended scope of work for Phase II.

6.2 Phase I Work Tasks

Phase I work tasks were designed to address remaining data gaps identified in the SCM and to control the soil vapor plume. Specific Phase I work tasks included:

- Pit 1 Soil Investigation;
- Groundwater Well and Piezometer Installation;
- Aquifer Tests; and
- SVE Re-Start.

The Pit 1 soil investigation was conducted within and around Pit 1 to collect soil samples for field and laboratory analysis of VOCs to assess the magnitude and extent of residual source material around Pit 1. Subsurface investigation activities also included

the installation of two dual completion groundwater monitoring wells / vadose zone monitoring probes and a Unit A piezometer. The dual completion wells were installed in close proximity to Pit 1 to provided additional characterization of groundwater and sub-basalt vapor conditions in the primary source area. The piezometer was installed to collect supplemental Unit A groundwater elevation data in support of a capture zone analysis of the existing groundwater recovery system. The newly installed monitoring wells were subjected to aquifer testing and the data incorporated into the capture zone analysis.

SVE activities were resumed at the Site in March 2006. Vapor treatment is performed using a GEO Inc. pressure-condensation system. The GEO Inc. treatment unit consists of two skid-mounted blowers and compressors, a treatment trailer where the condensation process occurs, and two 400-lb. vapor-phase carbon canisters for final polishing of the vapor prior to discharge. The GEO Inc. vapor compressor / condensation unit produces two primary recovered liquid streams: an aqueous-based condensate (condensate waste) and an organic-based liquid waste solvent (waste solvent).

Eleven fine-grained zone vadose probes are operated as SVE wells in and around the Pit 1 area. Sub-basalt vapor probe VP-19UA was added as an extraction well to the system in early December 2006. It is estimated that a total of approximately 3,350 gallons, or 36,850 pounds, of liquid waste solvents were recovered between March 2006 and March 2007. The recovered wastes are transported for off-Site disposal at the ROMIC Southwest facility located in Chandler, Arizona.

Concentrations of VOCs in the soil vapor from the coarse- and fine-grained zones and the vadose zone beneath the basalt have been monitored during the Phase I period as part of several monitoring tasks, including:

- Annual monitoring of soil vapor samples for fixed laboratory testing of VOCs;
- Quarterly sampling events of soil vapor samples for testing of VOCs by a mobile laboratory; and

- Monthly measurements of total VOC concentrations in soil vapor by using a PID.

6.3 Updated Site Conceptual Model

The original SCM was updated and a revised SCM was discussed in the Phase I Work Plan. Using the data obtained through the implementation of the Phase I Work Plan, the revised SCM has been updated again. Significant updates to the SCM based on the results of the Pit 1 soil investigation include the following:

- Based on the absence of basalt in Borings B-6 and B-9, the edge of the basalt unit is much closer to Pit 1 than previously estimated;

- The highest concentrations of residual VOCs in soils are located in close proximity to the footprint of Pit 1;

- Some liquids have migrated vertically downward from Pit 1 to the top of the basalt, although there is an absence of significant pooling on the surface of the basalt. Some quantity of liquids may also have migrated into, through or around the basalt.;

- While limited evidence of current DNAPL was identified, results of soil and soil vapor sample analyses indicate that residual ganglia or areas of high soil VOC concentrations likely exist in soil within the footprint of Pit 1; and

- Although some quantity of liquid may have migrated down from Pit 1 to Unit A groundwater, soil vapor is contributing to the concentrations of VOCs detected in Unit A groundwater.

Although VOC concentrations have fluctuated between sampling events at some monitoring locations, monitoring data collected during the Phase I period indicate that soil vapor VOC concentrations from the coarse-grained, fine-grained, and sub-basalt zones have overall decreased by an approximate order of magnitude during the one-year operation of the re-started SVE system.

Soil vapor VOC concentrations in the vadose zone below the basalt were observed to steadily decrease without active extraction in this zone. Following the December 2006 connection of Sub-Basalt Well VP-19UA to the SVE system, the reduction of VOC concentrations below the basalt appears to have greatly accelerated.

Historically, there has been evidence that VOCs in soil vapor have affected Unit A groundwater concentrations at the Site. Data collected during the Phase I period indicate that for several Unit A groundwater wells located within the Pit 1 area, an overall reduction in groundwater VOC concentrations was observed coincident with reductions in sub-basalt VOC soil vapor concentrations. In summary, although some quantity of liquid may have migrated to Unit A groundwater in the Pit 1 area, analyses of data and trends from the Phase I period indicate that concentrations of VOCs in soil vapor have contributed to Unit A groundwater impacts and that further reductions in soil vapor VOC concentrations will result in additional reductions in groundwater concentrations.

6.4 Phase II Scope of Work

Given the findings of the Phase I scope of work and related updated SCM, the Phase II recommendations include continued operation of the GRS and SVE. The GRS will continue to be operated in a manner consistent with past operations with the exception of increasing the pumping rate of Extraction Wells EW-04UA and EW-02UA by approximately 25 and 60 percent, respectively while ceasing extraction from well EW-01UA. Changes to the groundwater monitoring program include adding wells EW-01UA and MW-20UA and removing groundwater wells MW-08UA and MW-09UA. These modifications to the operation of the GRS will enable it to provide capture of groundwater with concentrations of chemicals greater than performance standards while the SVE removes additional VOC mass from the vadose zone. At the request of EPA and ADEQ, Phase II work will also include further evaluation and calculations regarding the vertical migration potential between Unit A and Unit B groundwater.

The SVE extraction network will be modified by adding MW-18UA, MW-19UA, and MW-06UA to enhance VOC removal from the vadose zone beneath the basalt. SVE will continue using the existing GEO Inc. unit operating at the Site to extract vapors from areas of the fine-grained zone and sub-basalt vadose zone areas that

contain the highest VOC concentrations. When VOC concentrations are reduced to levels that make the use of activated carbon more economical than the GEO Inc. system for treatment of extracted vapors, the GEO Inc. system will be replaced with a carbon system. At that time, the design of the wellfield for extraction will be modified to extract vapor from areas of the vadose zone (coarse-grained, fine-grained, or sub-basalt) that pose a risk to groundwater quality at that time. The Carbon System will be operated in a continuous mode until the recovery of extracted vapors declines to a near asymptotic condition. At that time, system operation will be switched to a pulsed mode when operation will be balanced between periodic shutdowns and active extraction, when rebound concentrations will be measured. Shutdown of the SVE system will be considered after asymptotic mass removal is achieved and residual (rebound) concentrations of VOCs in soil vapor no longer pose a threat to groundwater quality.

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Figures

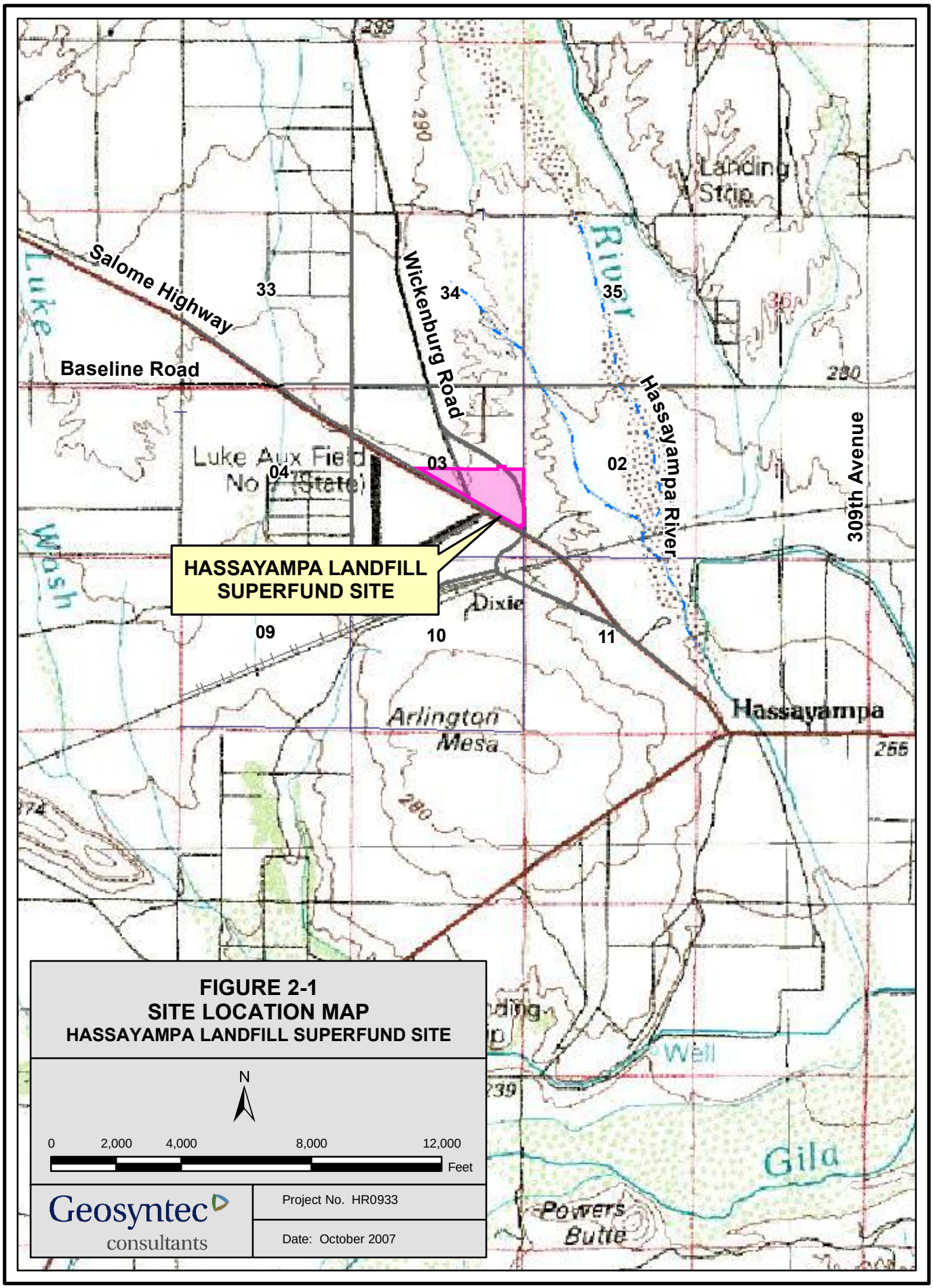

FIGURE 2-1
SITE LOCATION MAP
HASSAYAMPA LANDFILL SUPERFUND SITE

S:\GIS\HR0933\GIS\GIS files\Projects\Location_2007.mxd sn 20071030

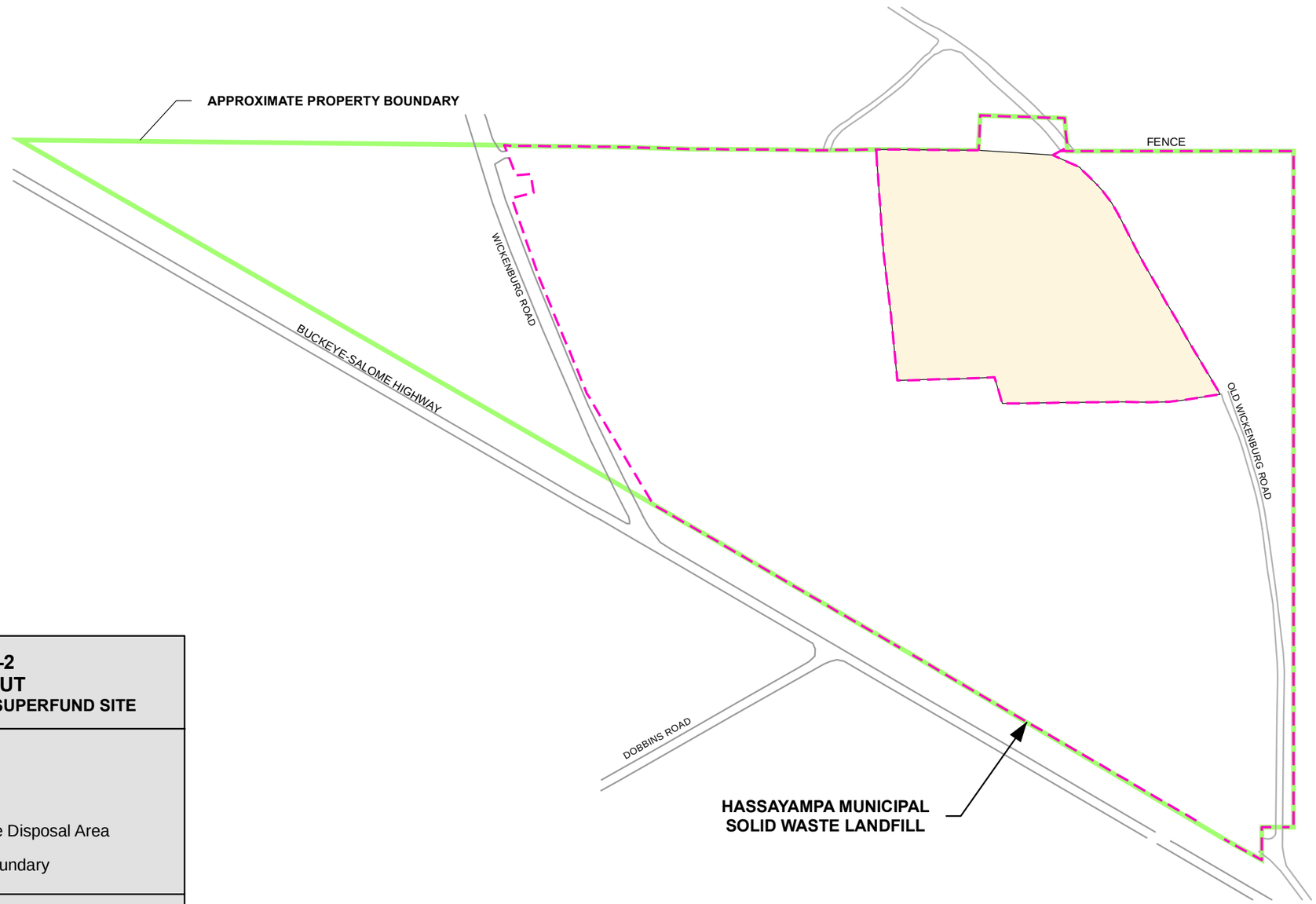

FIGURE 2-2
SITE LAYOUT
HASSAYAMPA LANDFILL SUPERFUND SITE

Explanation

- Fence
- Former Hazardous Waste Disposal Area
- Approximate Property Boundary

N

0 150 300 600 900 Feet

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Project No. HR0933

Date: October 2007

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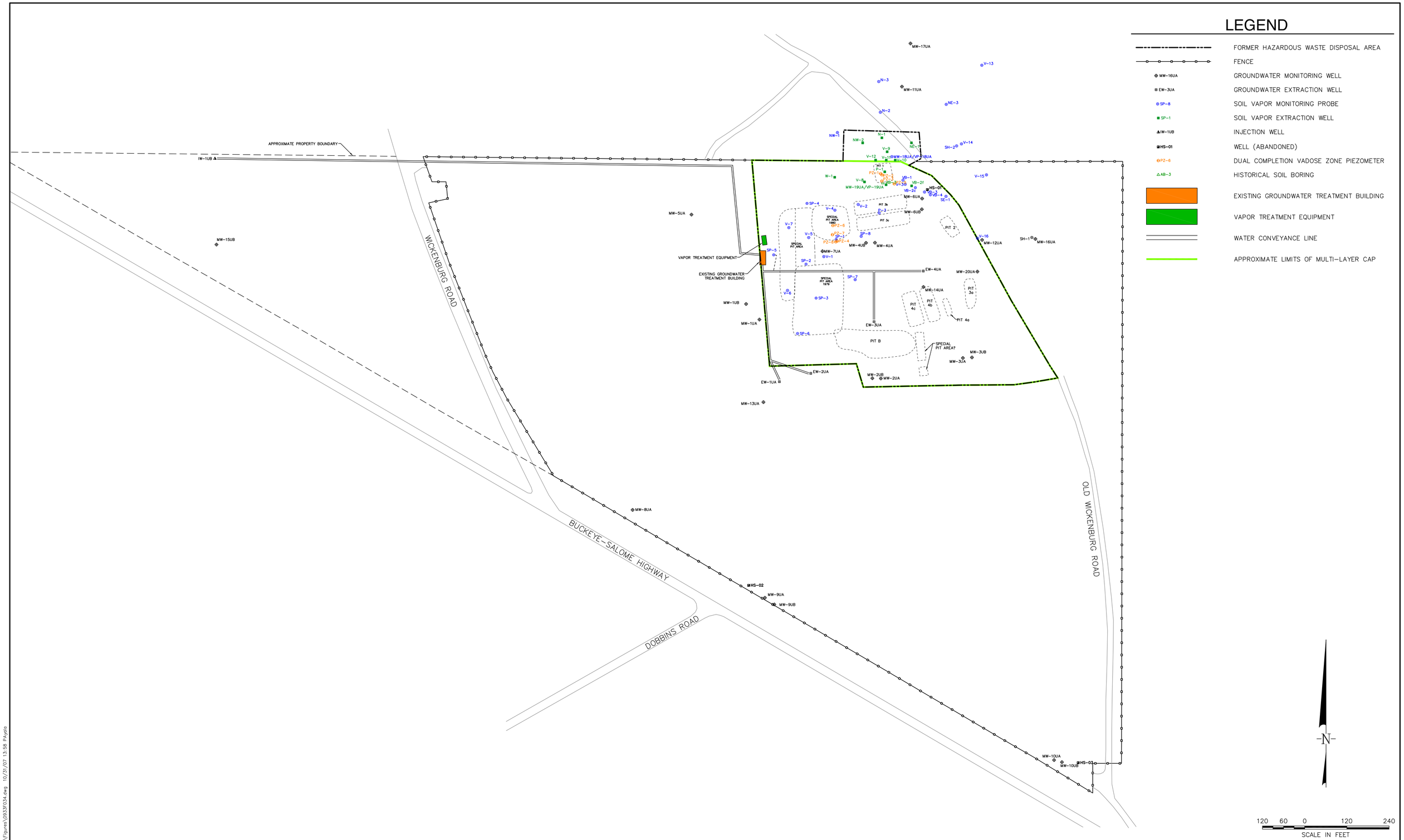

SOURCE: ERROL MONTGOMERY & ASSOCIATES, 30 MARCH 2004.

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DETAILED SITE LAYOUT
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	2-3
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

SOURCE: ERROL MONTGOMERY & ASSOCIATES, 30 MARCH 2004.

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PHASE I SOIL BORING LOCATIONS
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	3-1
PROJECT NO.	HR0933-07
DATE:	OCTOBER 2007

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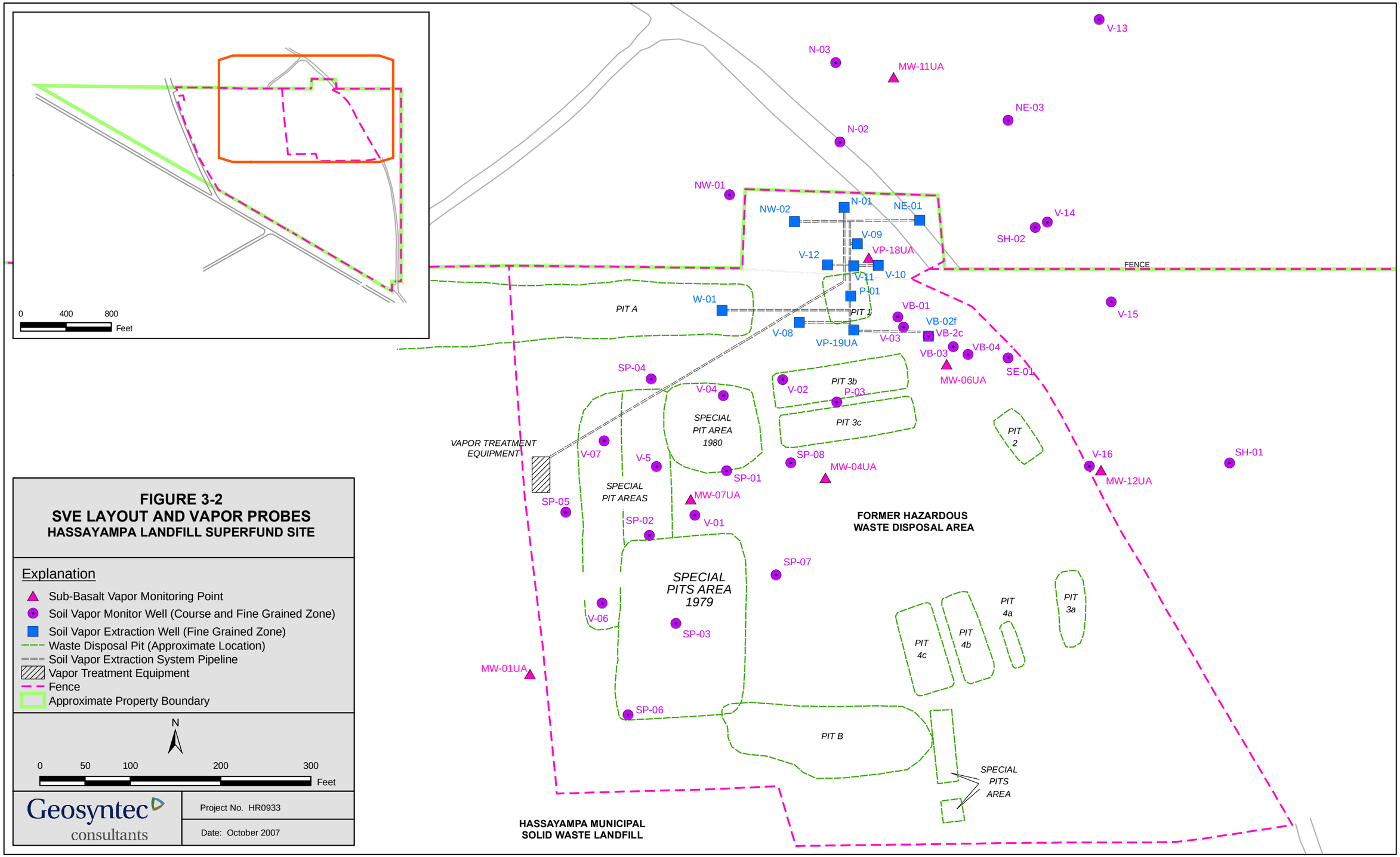

FIGURE 3-2
SVE LAYOUT AND VAPOR PROBES
HASSAYAMPA LANDFILL SUPERFUND SITE

Explanation

- Sub-Basalt Vapor Monitoring Point
- Soil Vapor Monitor Well (Course and Fine Grained Zone)
- Soil Vapor Extraction Well (Fine Grained Zone)
- Waste Disposal Pit (Approximate Location)
- Soil Vapor Extraction System Pipeline
- Vapor Treatment Equipment
- Fence
- Approximate Property Boundary

N

0 50 100 200 300 Feet

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Project No. HR0933

Date: October 2007

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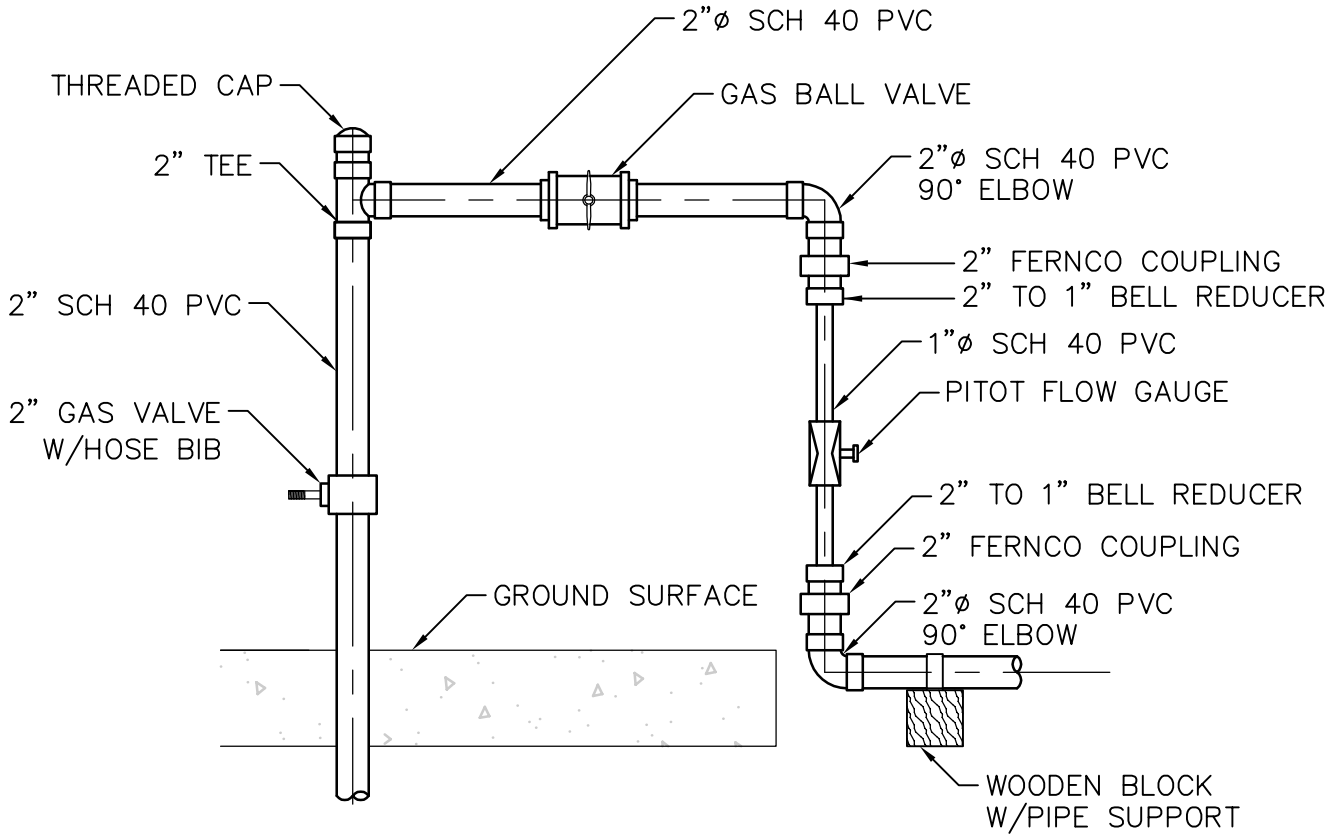

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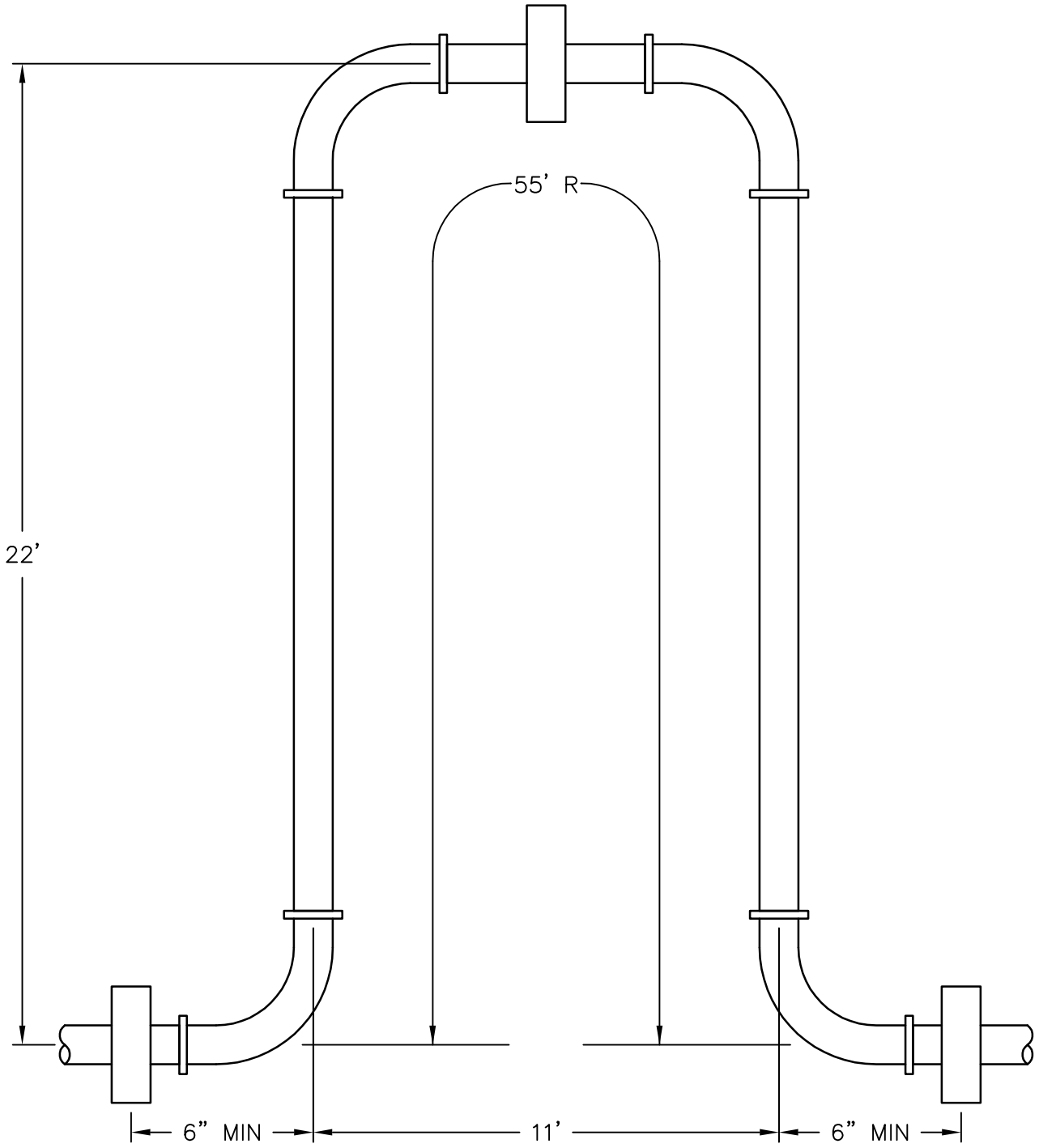
TYPICAL WELL HEAD CONSTRUCTION
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F036
PROJECT NO.	HR0933-07	FIGURE NO.	3-3



NOT TO SCALE

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TYPICAL TEMPERATURE EXPANSION LOOP
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F029
PROJECT NO.	HR0933-07	FIGURE NO.	3-4

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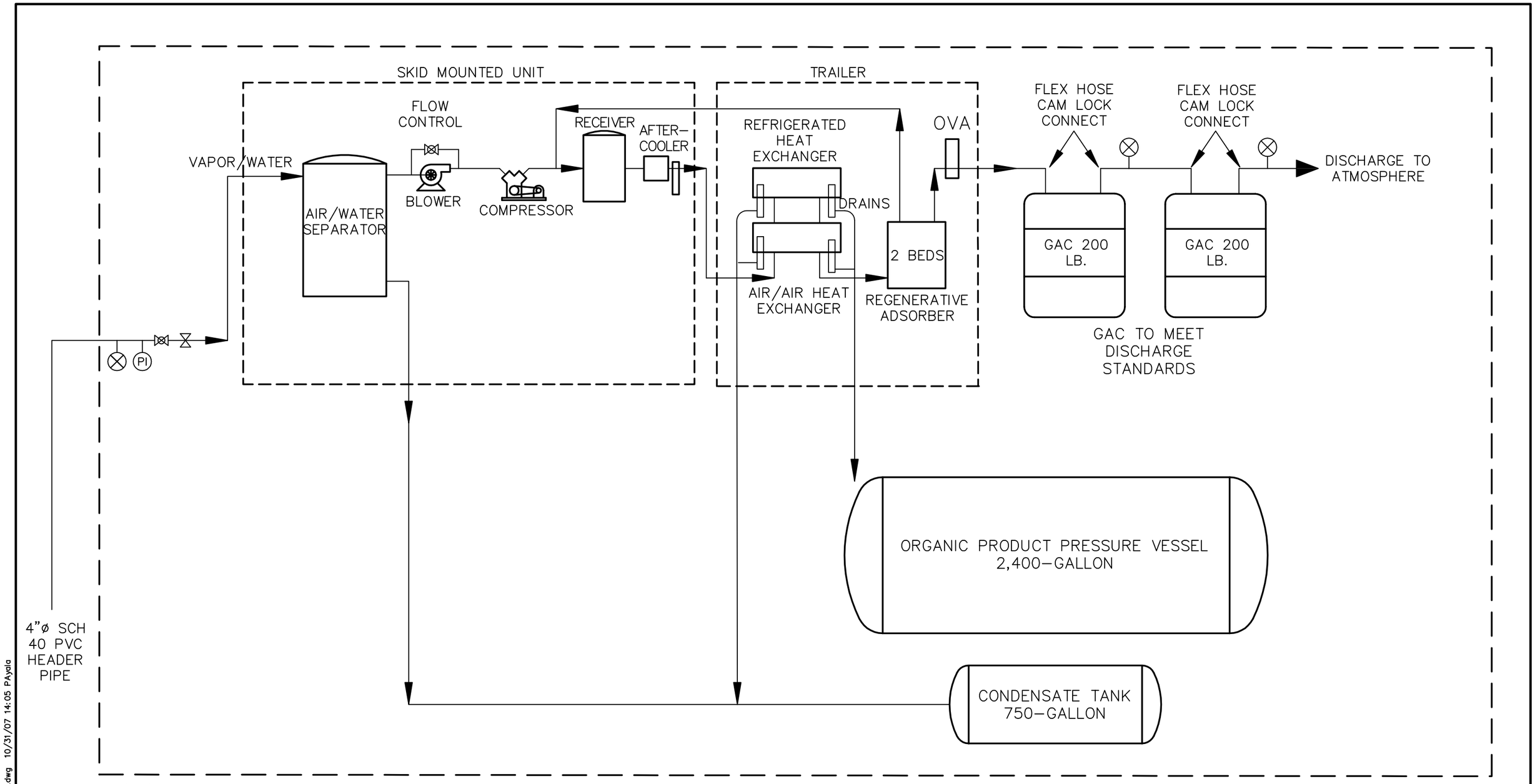

LEGEND

⊠	BALL VALVE	————	SYSTEM PIPING
⧖	CONTROL VALVE	- - - - -	PACKAGED SKID OUTLINE
⊗	SAMPLE PORT	— — —	ENCLOSURE PAD OUTLINE
(PI)	PRESSURE INDICATOR		

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GEO SYSTEM PROCESS FLOW DIAGRAM
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F035
PROJECT NO.	HR0933	FIGURE NO.	3-5

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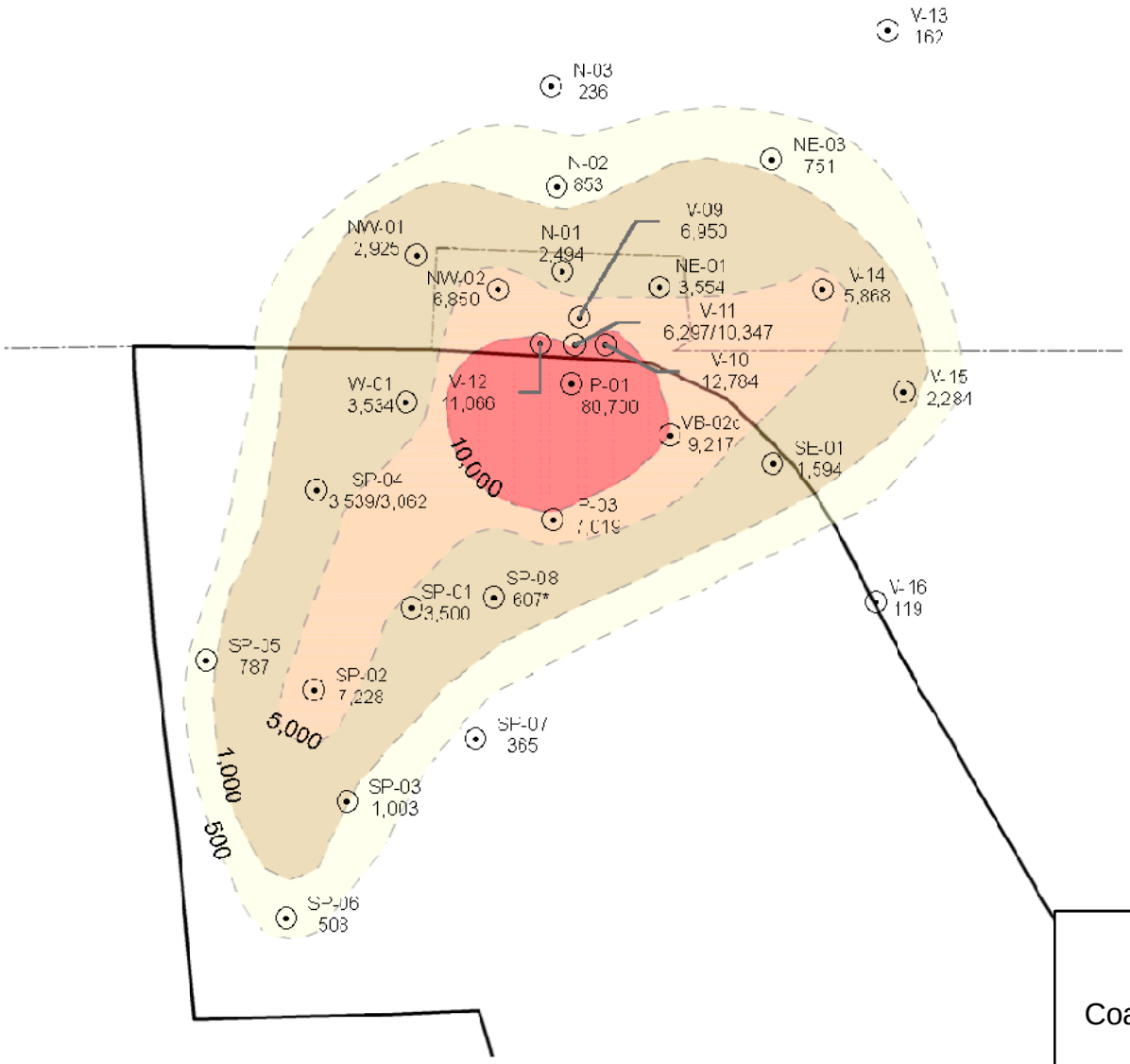


Note: Total VOC Concentration in Micrograms per Liter (ug/L)

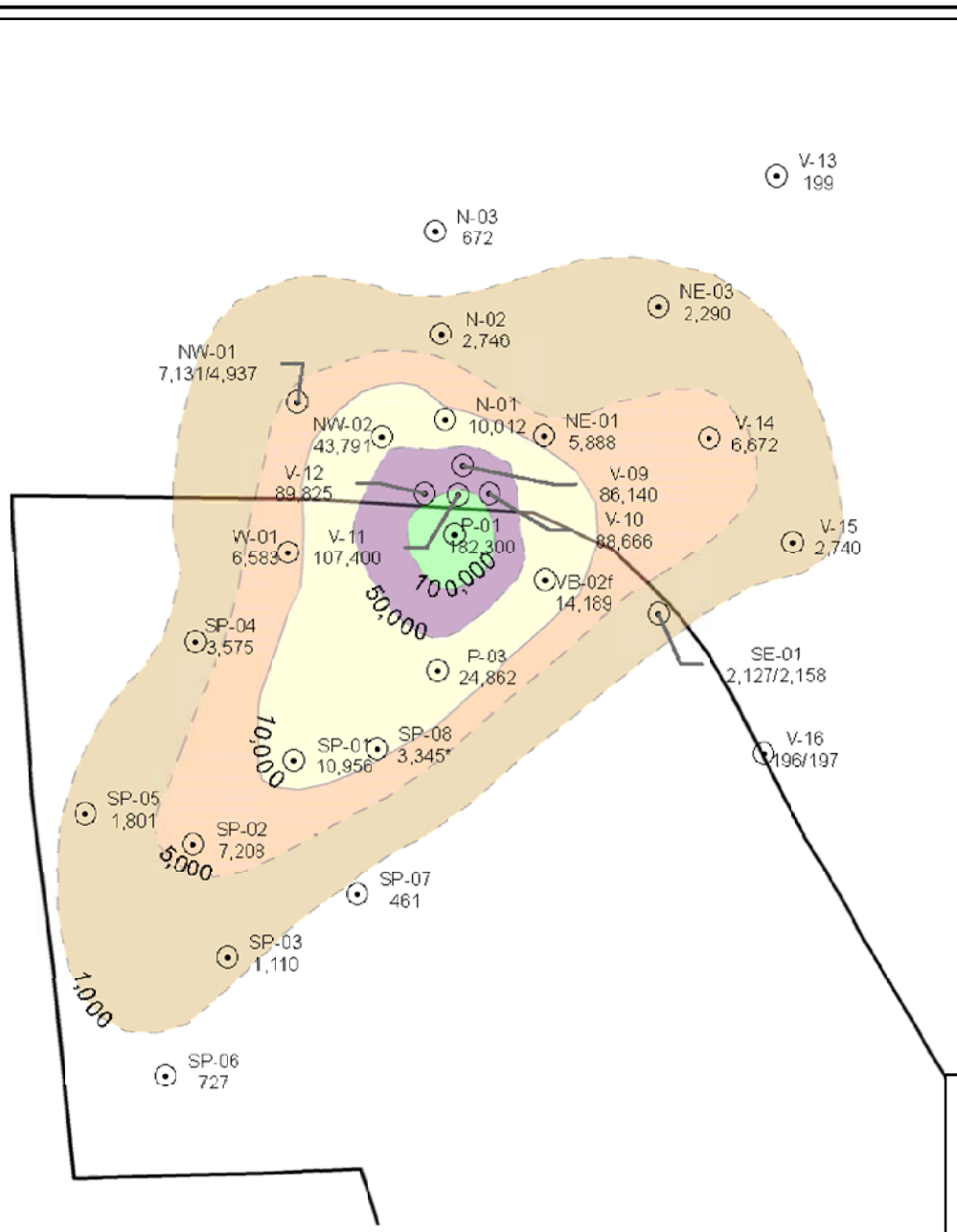
FIGURE 3-6
1st Quarter 2006
Coarse-Grained Zone Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

S:\GIS\HR0933\GIS\GIS files\Projects\1stQtr2006_CGZ.mxd sn 20071030



Note: Total VOC Concentration in Micrograms per Liter (ug/L)

FIGURE 3-7
1st Quarter 2006
Fine-Grained Zone Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

S:\GIS\HR0933\GIS\GIS files\Projects\1stQtr2006_FGZ.mxd sn 20071030

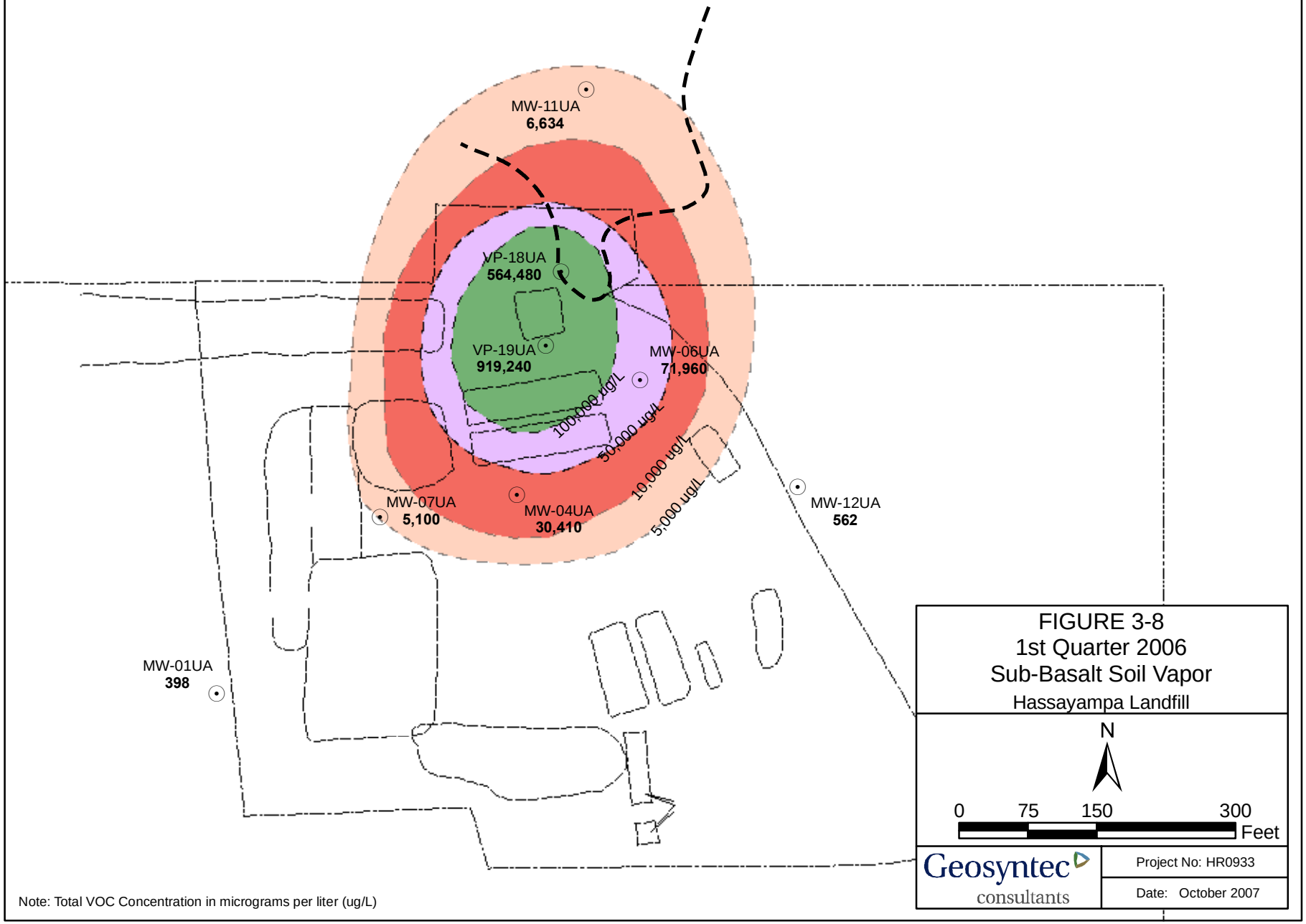


FIGURE 3-8
1st Quarter 2006
Sub-Basalt Soil Vapor
Hassayampa Landfill

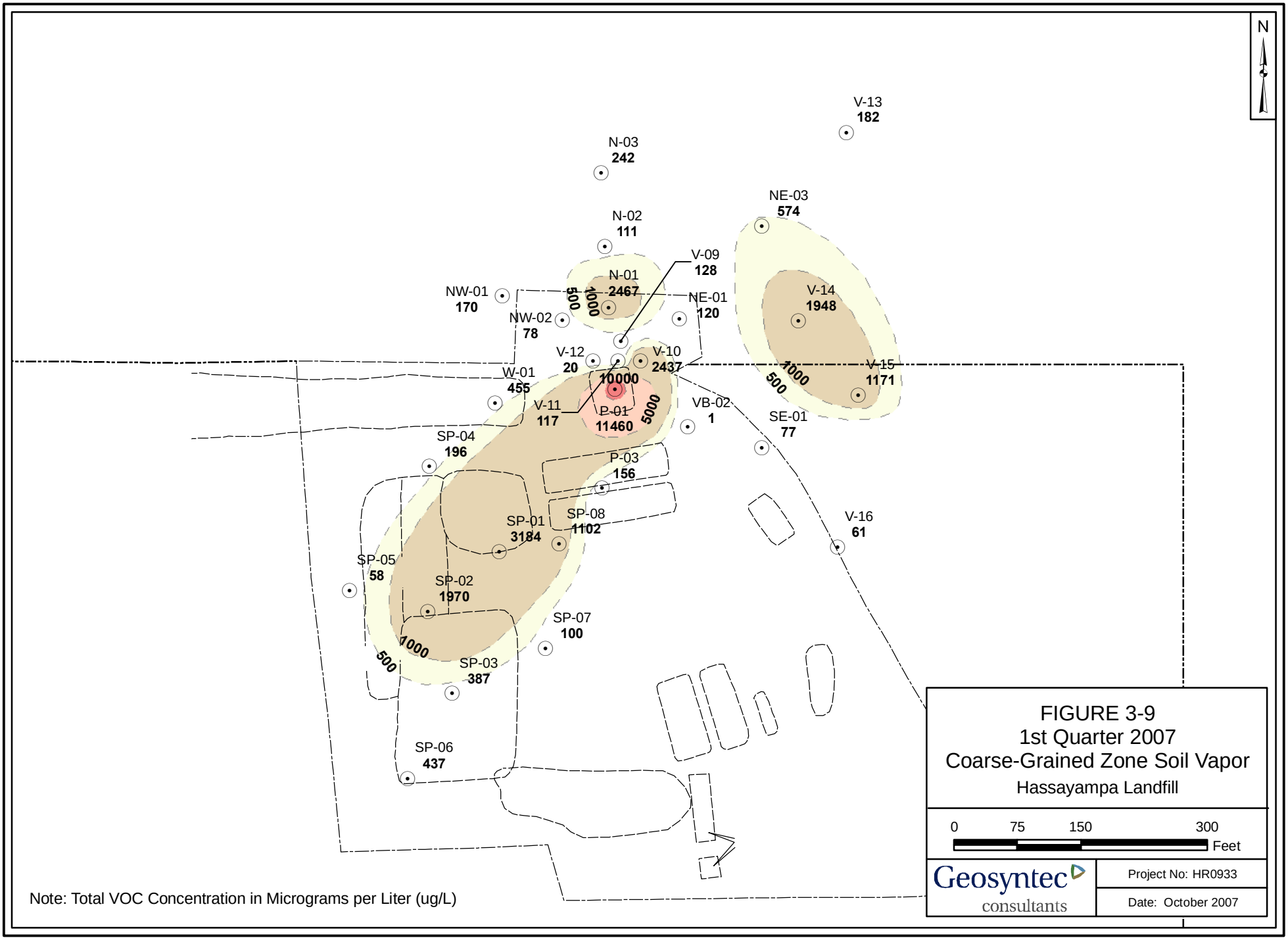
Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

S:\GIS\HR0933\GIS\GIS files\Projects\1stqtr_2006TotalVOCs_20060817.mxd sn 20071030



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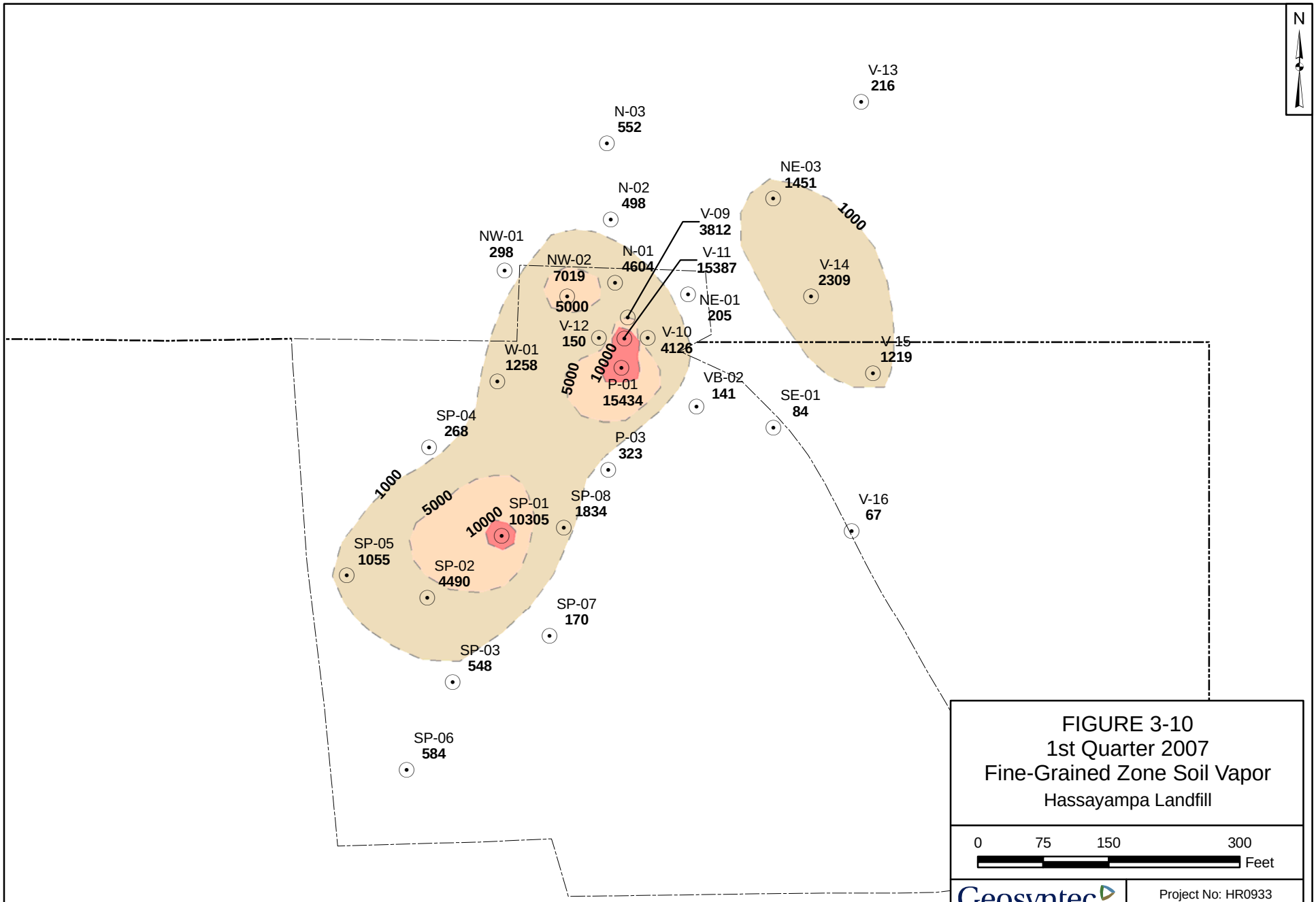

Note: Total VOC Concentration in Micrograms per Liter (ug/L)

FIGURE 3-10
1st Quarter 2007
Fine-Grained Zone Soil Vapor
Hassayampa Landfill

0 75 150 300 Feet

Geosyntec consultants

Project No: HR0933

Date: October 2007

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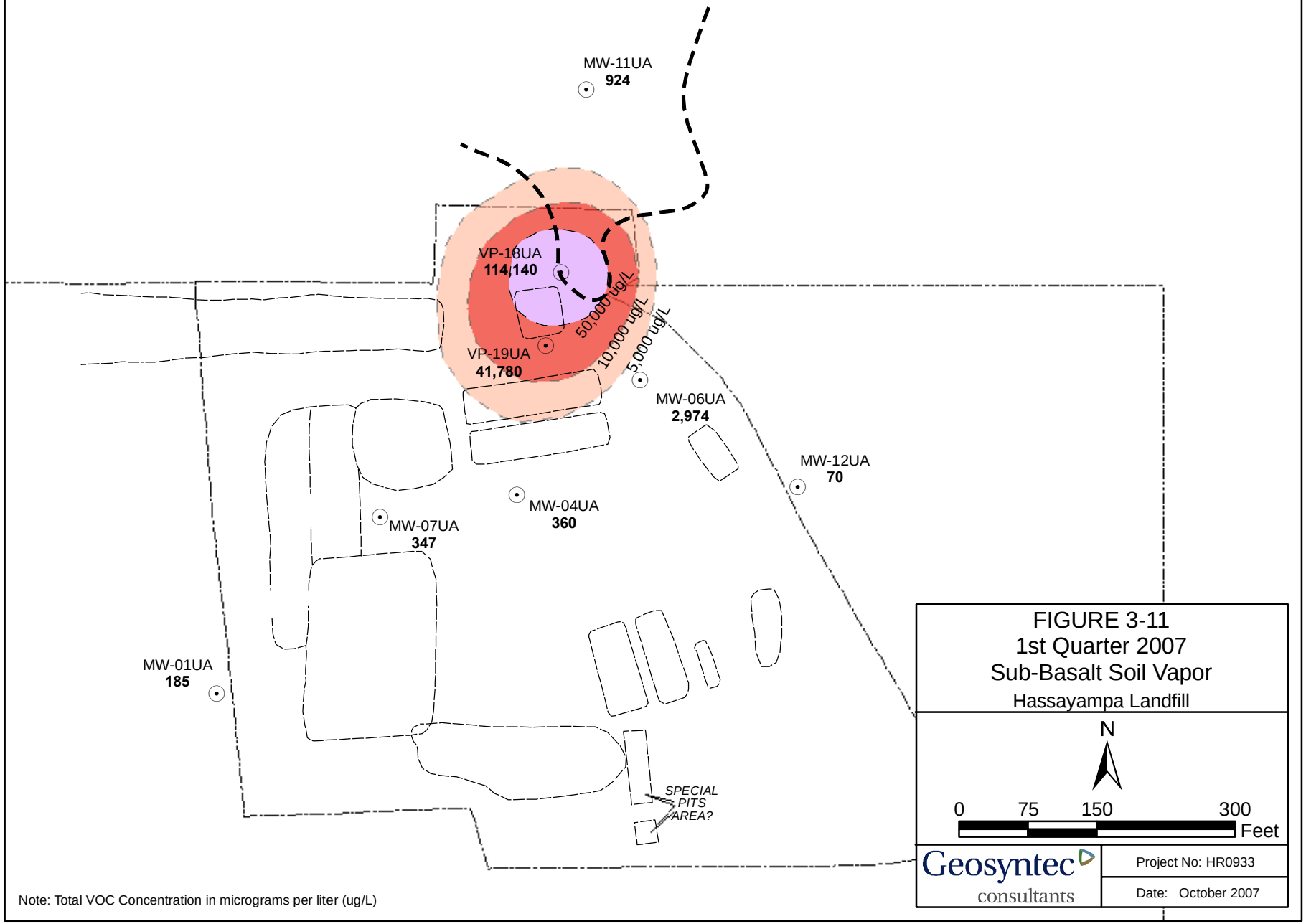

FIGURE 3-11
1st Quarter 2007
Sub-Basalt Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

S:\GIS\HR0933\GIS\GIS files\Projects\1stQTR_2007TotalVOCs_20070403.mxd sn 20071030

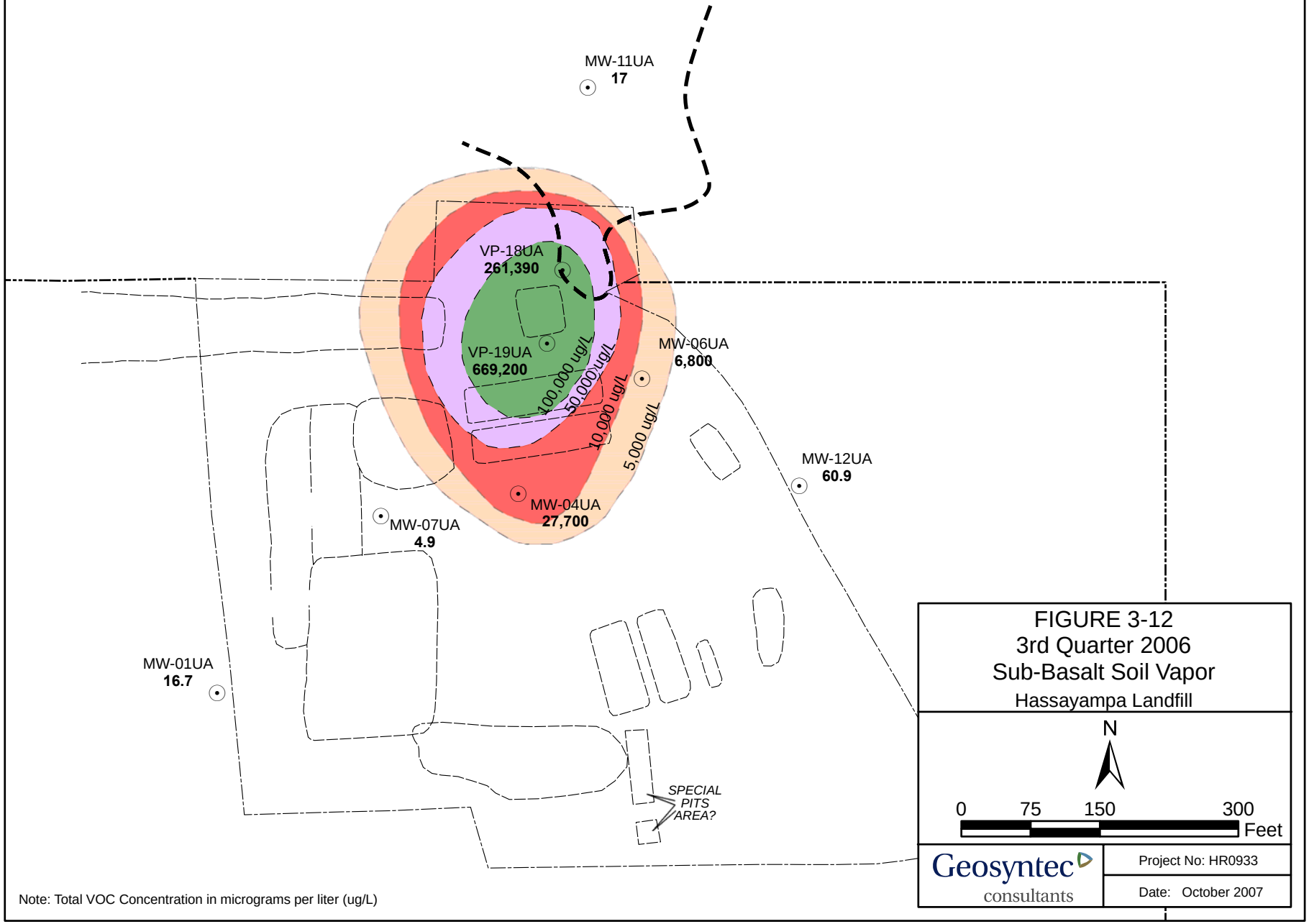

FIGURE 3-12
3rd Quarter 2006
Sub-Basalt Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

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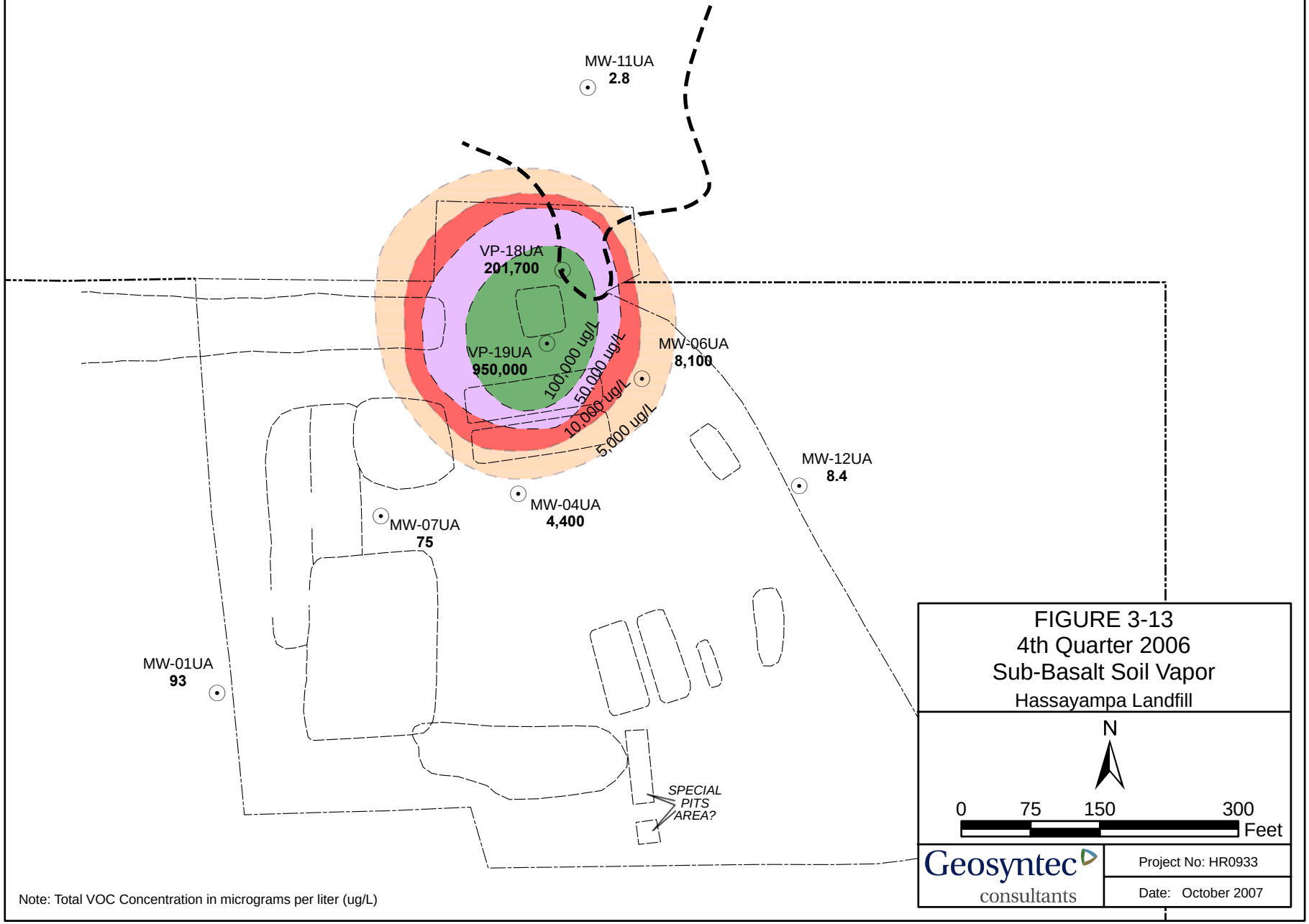

FIGURE 3-13
4th Quarter 2006
Sub-Basalt Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

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Figure 3-14
PID Measurements
Coarse-Grained Zone Vapor Monitoring Wells

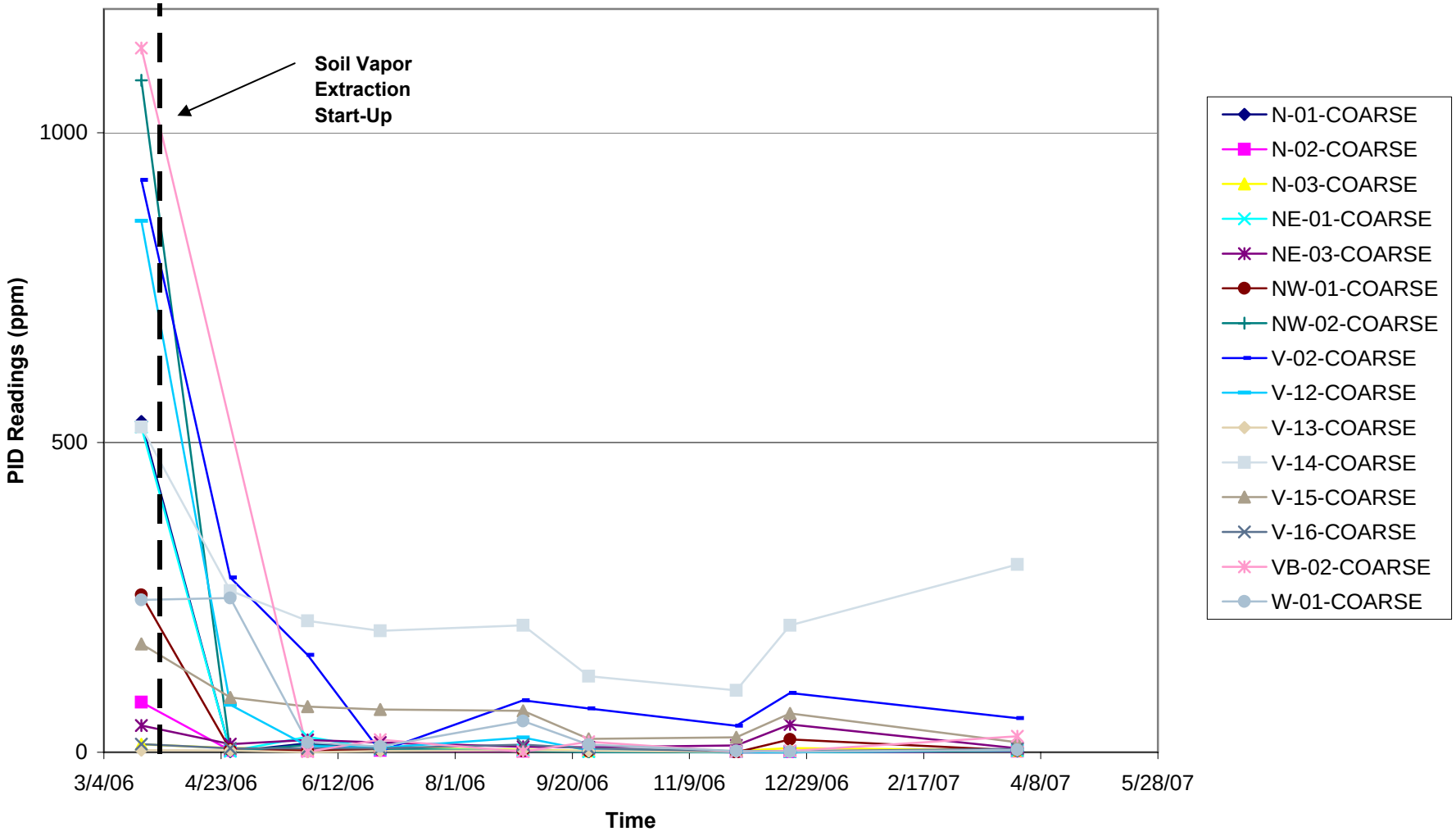


Figure 3-15
PID Measurements
Fine-Grained Zone Vapor Monitoring Wells

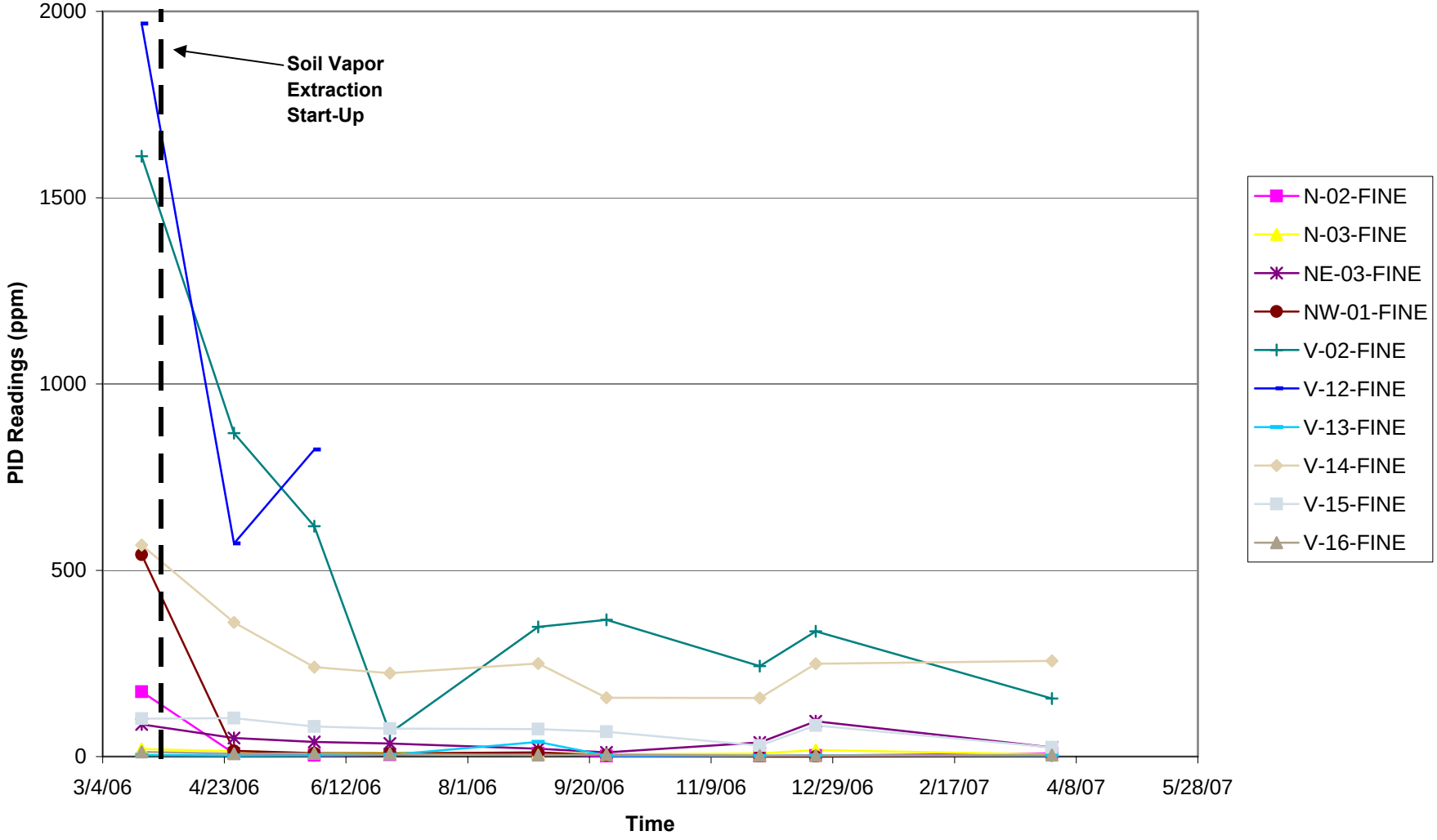
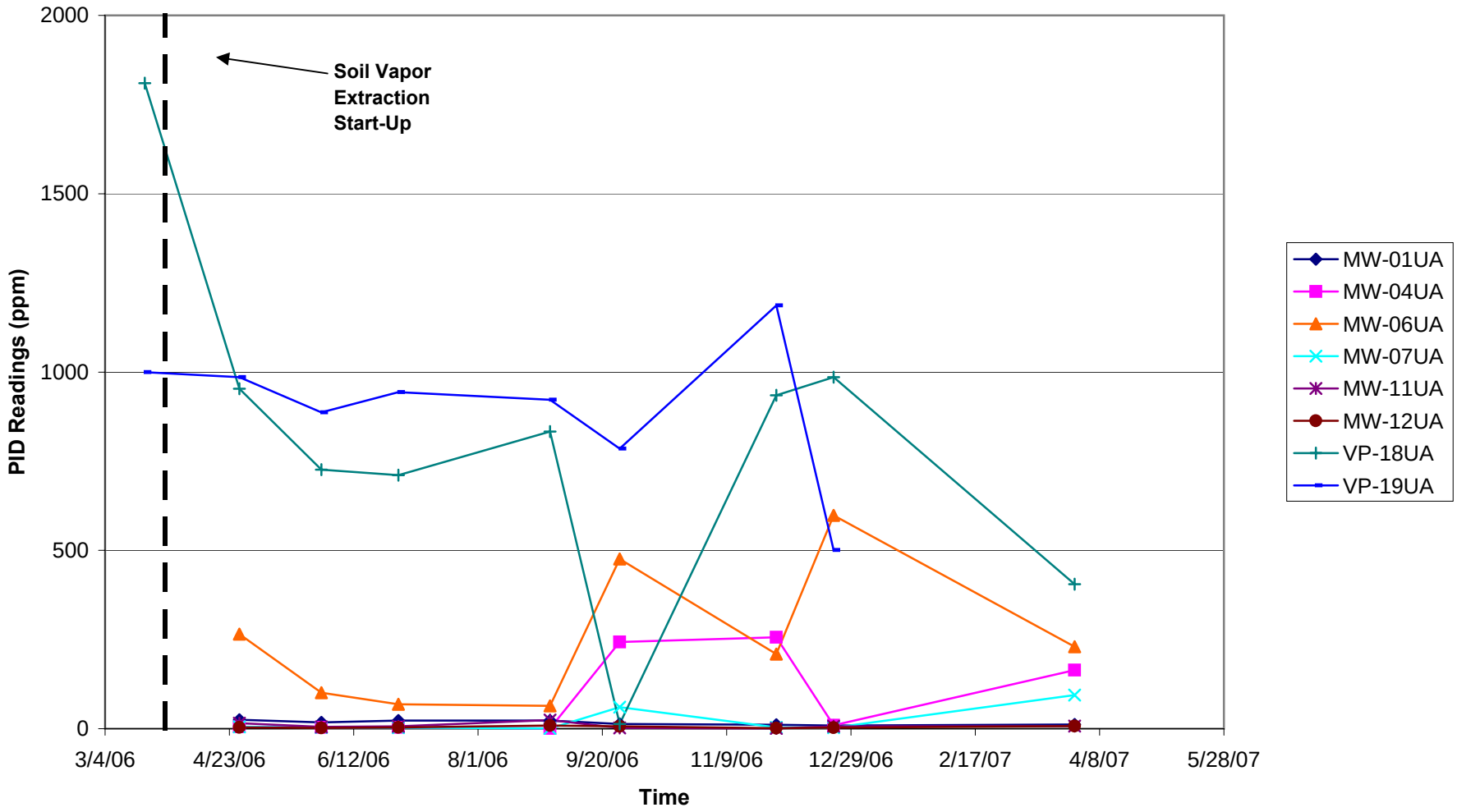
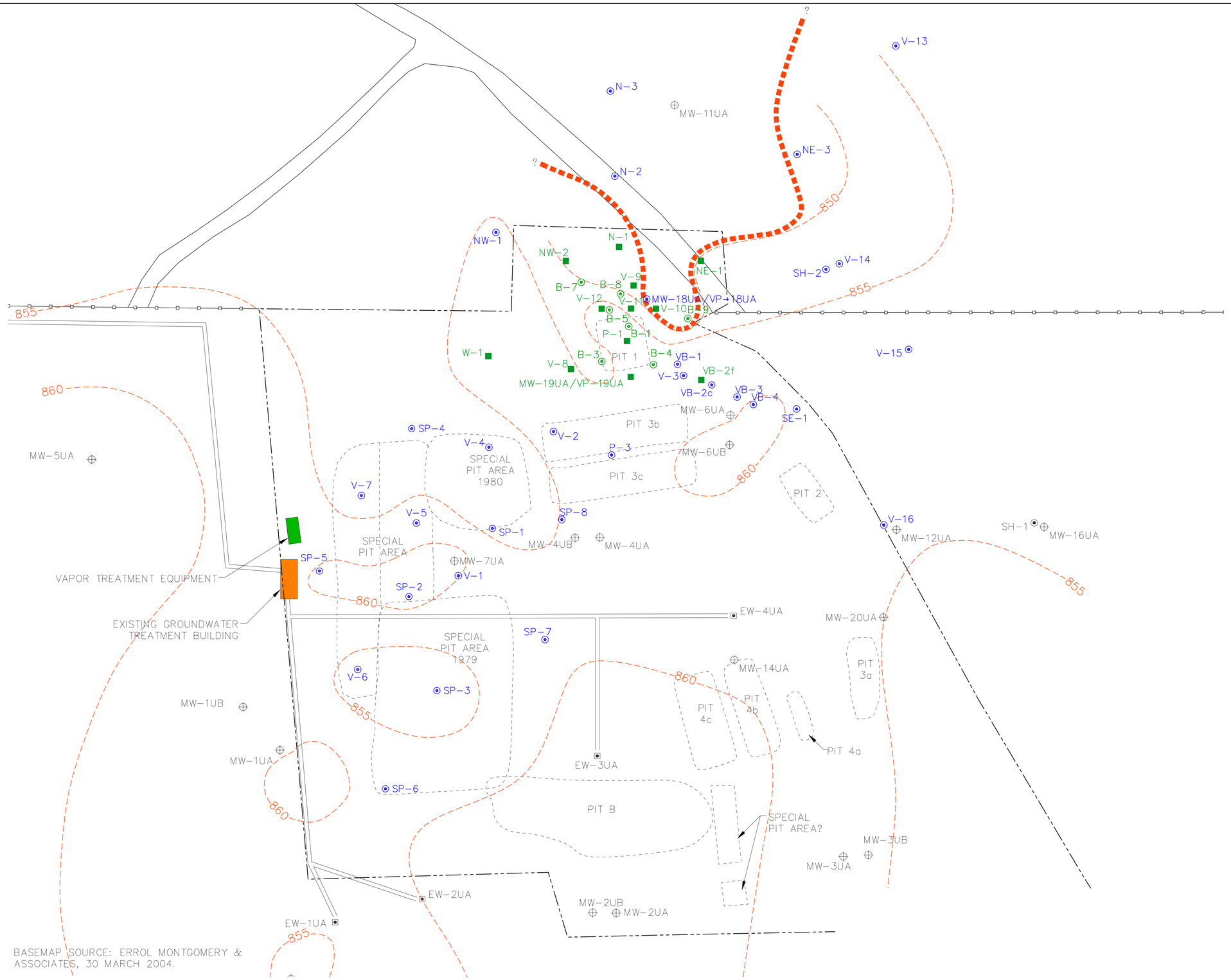


Figure 3-16
PID Measurments
Sub-Basalt Vapor Monitoring Wells





LEGEND

- FORMER HAZARDOUS WASTE DISPOSAL AREA
- FENCE
- TOP OF BASALT (ELEVATION, FEET MSL)
- LIMIT OF BASALT (INTERPRETED)
- MW-11UA — GROUNDWATER MONITORING WELL
- EW-3UA — GROUNDWATER EXTRACTION WELL
- SP-8 — SOIL VAPOR MONITORING PROBE
- SP-1 — SOIL VAPOR EXTRACTION WELL
- B-3 — PHASE I SOIL BORING
- EXISTING GROUNDWATER TREATMENT BUILDING
- VAPOR TREATMENT EQUIPMENT
- WATER CONVEYANCE LINE

NOTES

1. MW-18UA/VP-18UA WAS DRILLED AS A CONTINUATION OF BORING B-6.
2. MW-19UA/VP-19UA WAS DRILLED AS A CONTINUATION OF BORING B-2.

N

50 25 0 50 100
SCALE IN FEET

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ELEVATION OF BASALT
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4-1
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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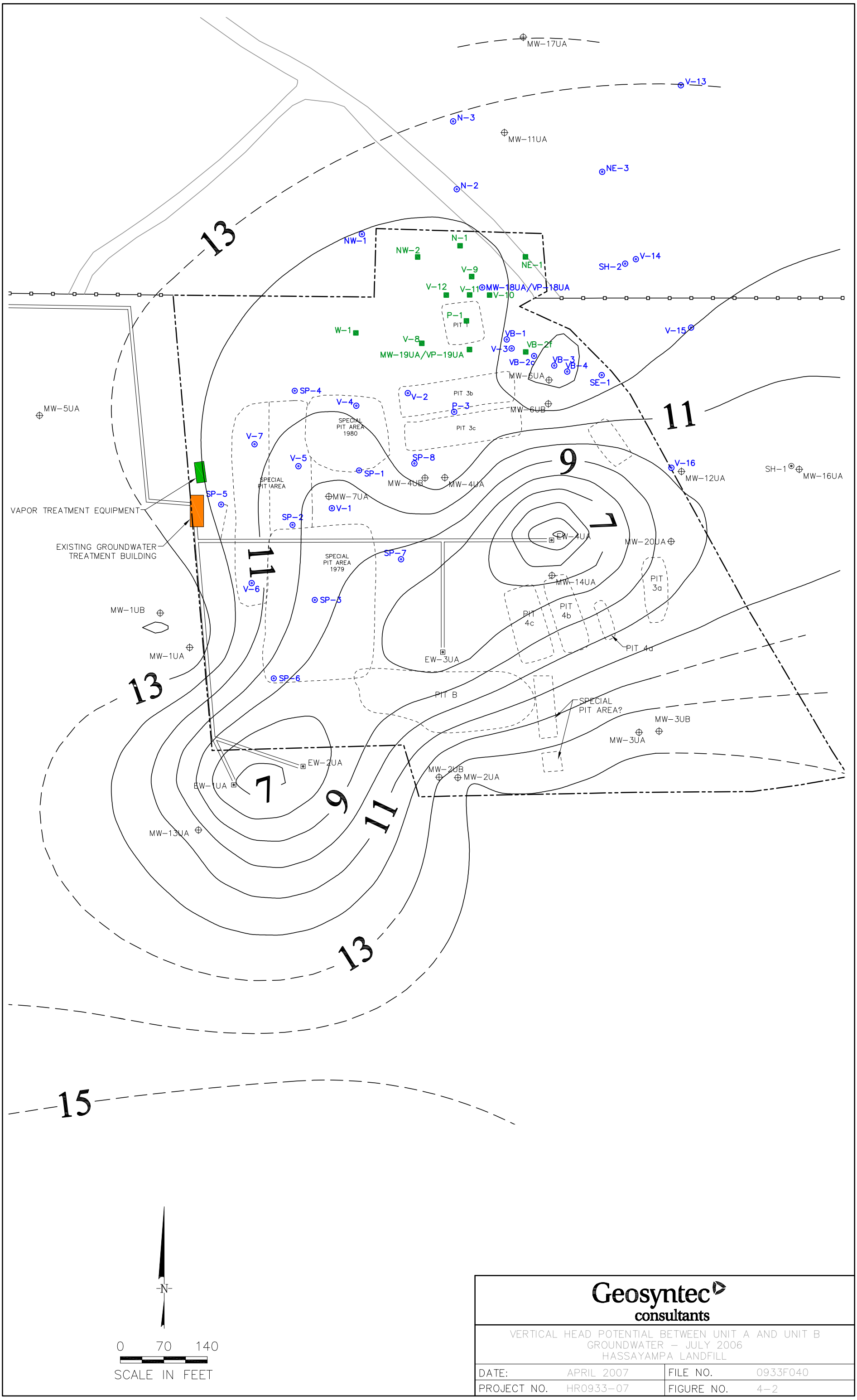

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VERTICAL HEAD POTENTIAL BETWEEN UNIT A AND UNIT B
GROUNDWATER – JULY 2006
HASSAYAMPA LANDFILL

DATE:	APRIL 2007	FILE NO.	0933F040
PROJECT NO.	HR0933-07	FIGURE NO.	4-2

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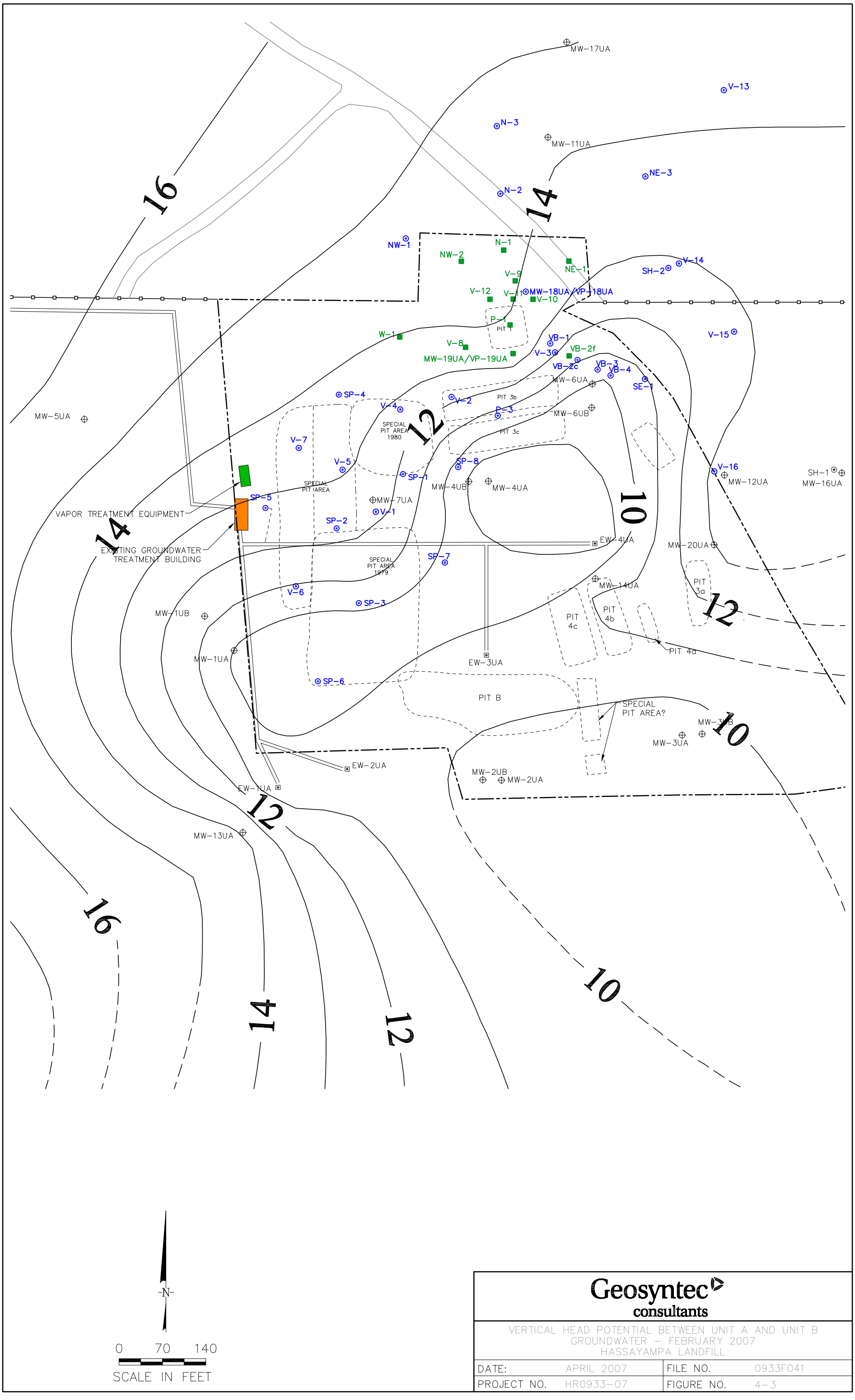

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VERTICAL HEAD POTENTIAL BETWEEN UNIT A AND UNIT B
GROUNDWATER – FEBRUARY 2007
HASSAYAMPA LANDFILL

DATE:	APRIL 2007	FILE NO.	0933F041
PROJECT NO.	HR0933-07	FIGURE NO.	4-3

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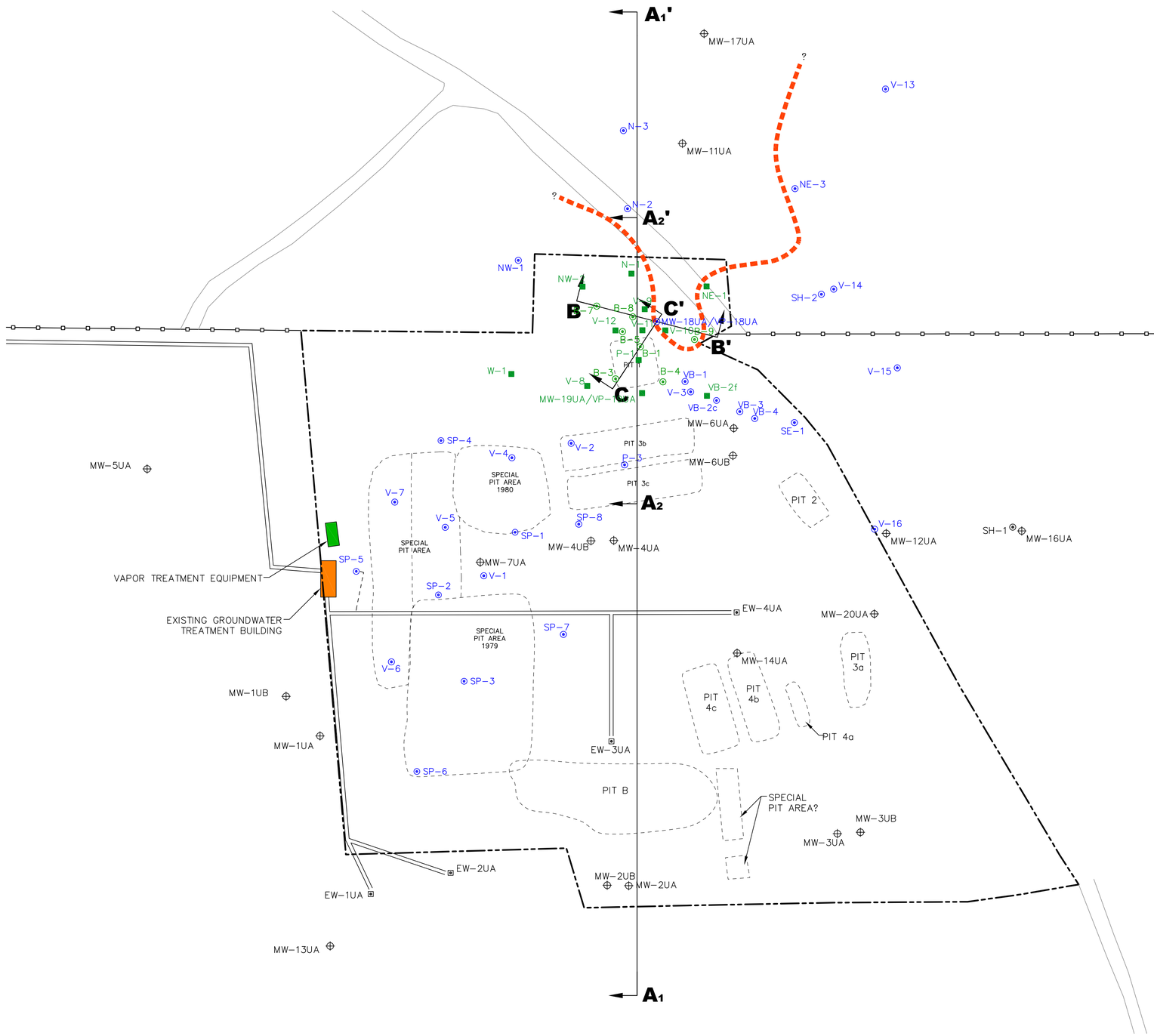

LEGEND

	FORMER HAZARDOUS WASTE DISPOSAL AREA
	FENCE
MW-16UA	GROUNDWATER MONITORING WELL
EW-3UA	GROUNDWATER EXTRACTION WELL
SP-8	SOIL VAPOR MONITORING PROBE
SP-1	SOIL VAPOR EXTRACTION WELL
B-3	PHASE I SOIL BORING
	LIMIT OF BASALT (INTERPRETED)
	EXISTING GROUNDWATER TREATMENT BUILDING
	VAPOR TREATMENT EQUIPMENT
	WATER CONVEYANCE LINE

SOURCE: ERROL MONTGOMERY & ASSOCIATES, 30 MARCH 2004.

Geosyntec consultants

PLAN VIEW AND CROSS SECTION LOCATIONS
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4-4
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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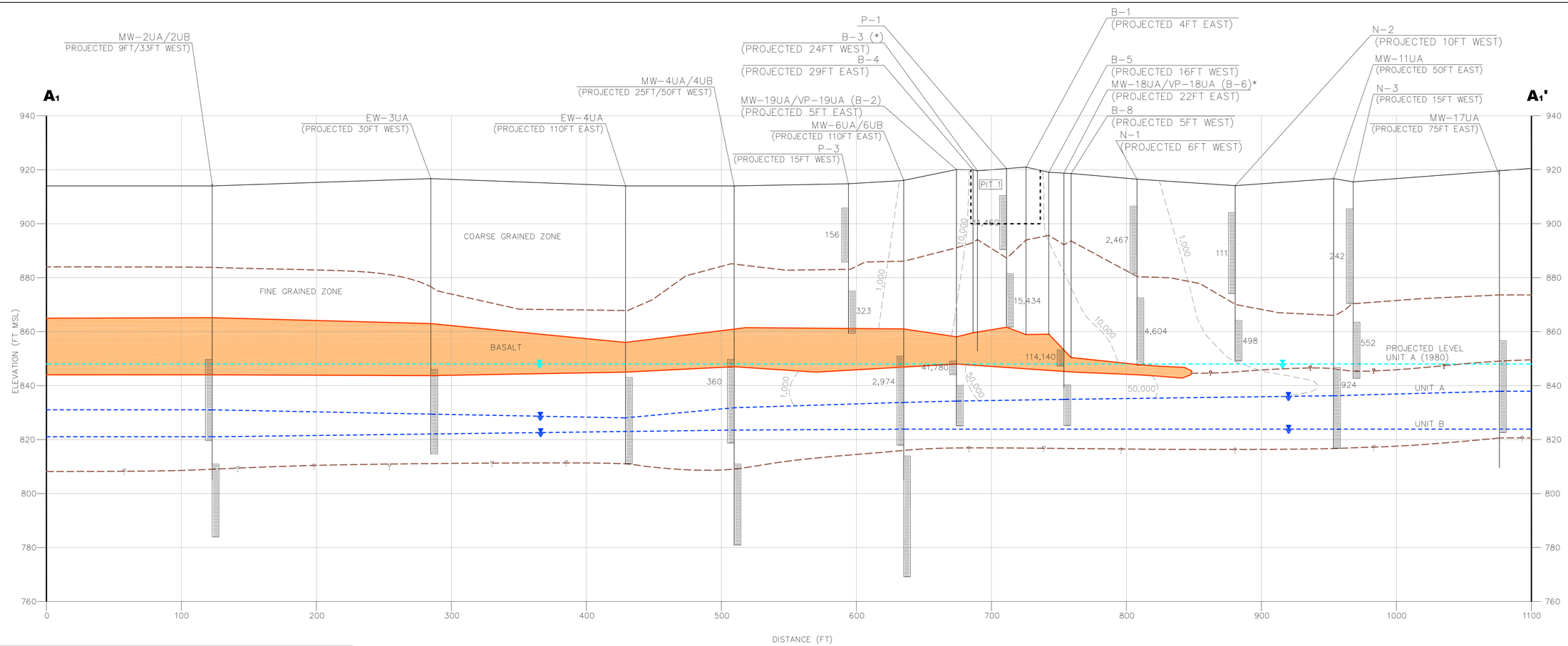
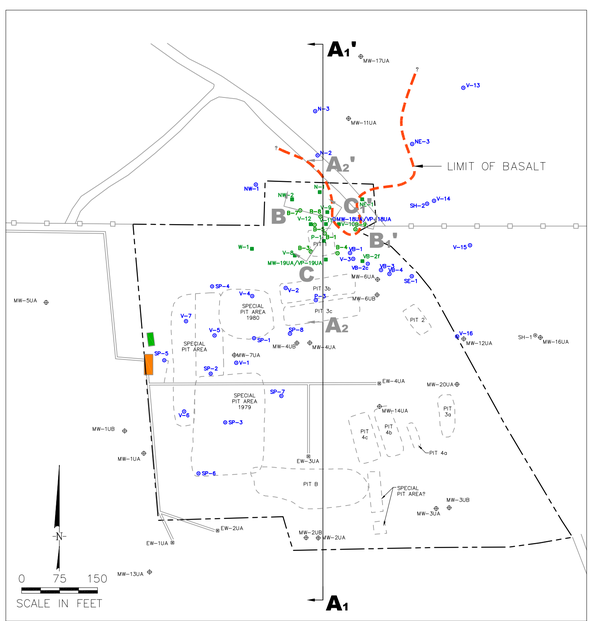




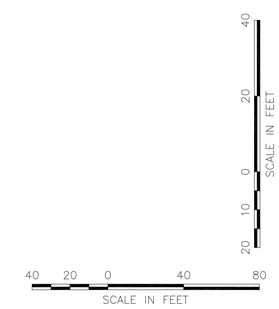
CROSS SECTION A–A' LOCATION AND SITE PLAN.

LEGEND

- LITHOLOGIC CONTACT
- PROJECTED POTENTIOMETRIC SURFACE (1980)
- POTENTIOMETRIC SURFACE (MARCH 2007)
- GROUND SURFACE
- BASALT BOUNDARY
- 1,000 — VOC SOIL VAPOR CONCENTRATION CONTOUR (ug/L)
- SCREEN INTERVAL
- 2,467 — TOTAL VOC CONCENTRATION IN SOIL VAPOR (ug/L), FEB 2007
- FT MSL — FEET ABOVE MEAN SEA LEVEL

NOTES:
BORINGS B-7 AND B-9 NOT SHOWN ON SECTION.

(*) BORINGS B-3 AND B-6 NOT USED TO INFER BASALT ELEVATION.



Geosyntec consultants	CROSS SECTION A1–A1' TOTAL VOC SOIL VAPOR CONCENTRATIONS (FEB 2007) HASSAYAMPA LANDFILL MARICOPA COUNTY, ARIZONA	FIGURE NO. 4–5 PROJECT NO. HR0933 DOCUMENT NO. DATE: OCTOBER 2007

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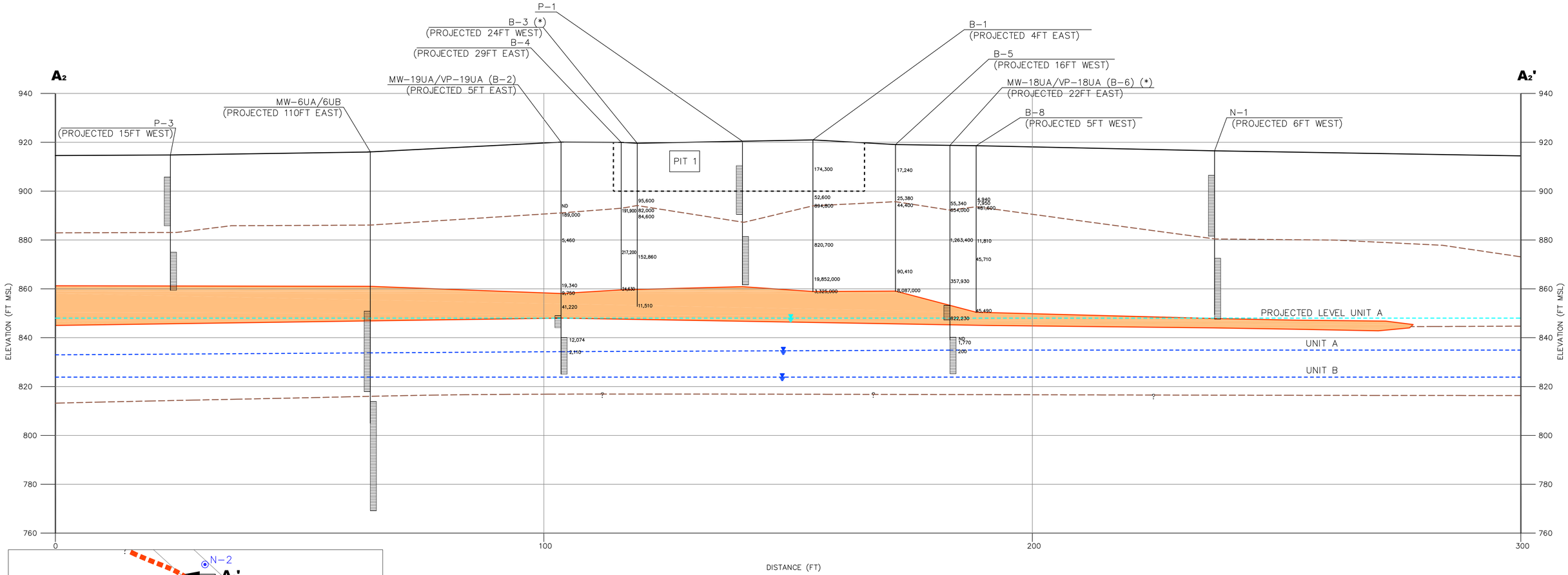

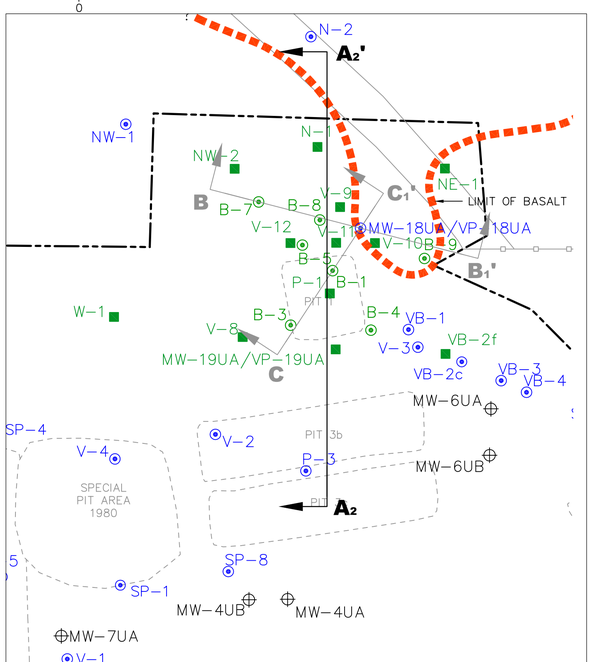

CROSS SECTION A2–A2' LOCATION AND SITE PLAN.

LEGEND

- LITHOLOGIC CONTACT
- PROJECTED POTENTIOMETRIC SURFACE (1980)
- POTENTIOMETRIC SURFACE (MARCH 2007)
- GROUND SURFACE
- BASALT BOUNDARY
- 5,460 — SCREEN INTERVAL; TOTAL VOC CONCENTRATION IN SOIL (ug/kg), JAN/FEB 2007
- FT MSL — FEET ABOVE MEAN SEA LEVEL

NOTES:
BORINGS B-7 AND B-9 NOT SHOWN ON SECTION

(*) BORINGS B-3 AND B-6 NOT USED TO INFER BASALT ELEVATION. BASALT NOT PRESENT AT B-6 LOCATION.

ND =NOT DETECTED ABOVE LABORATORY REPORTING LIMITS.

SCALE IN FEET: 10 5 0 10 20

SCALE IN FEET: 20 10 0 20 40

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CROSS SECTION A2–A2'
TOTAL VOC SOIL CONCENTRATIONS (JAN/FEB 2007)
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4-6
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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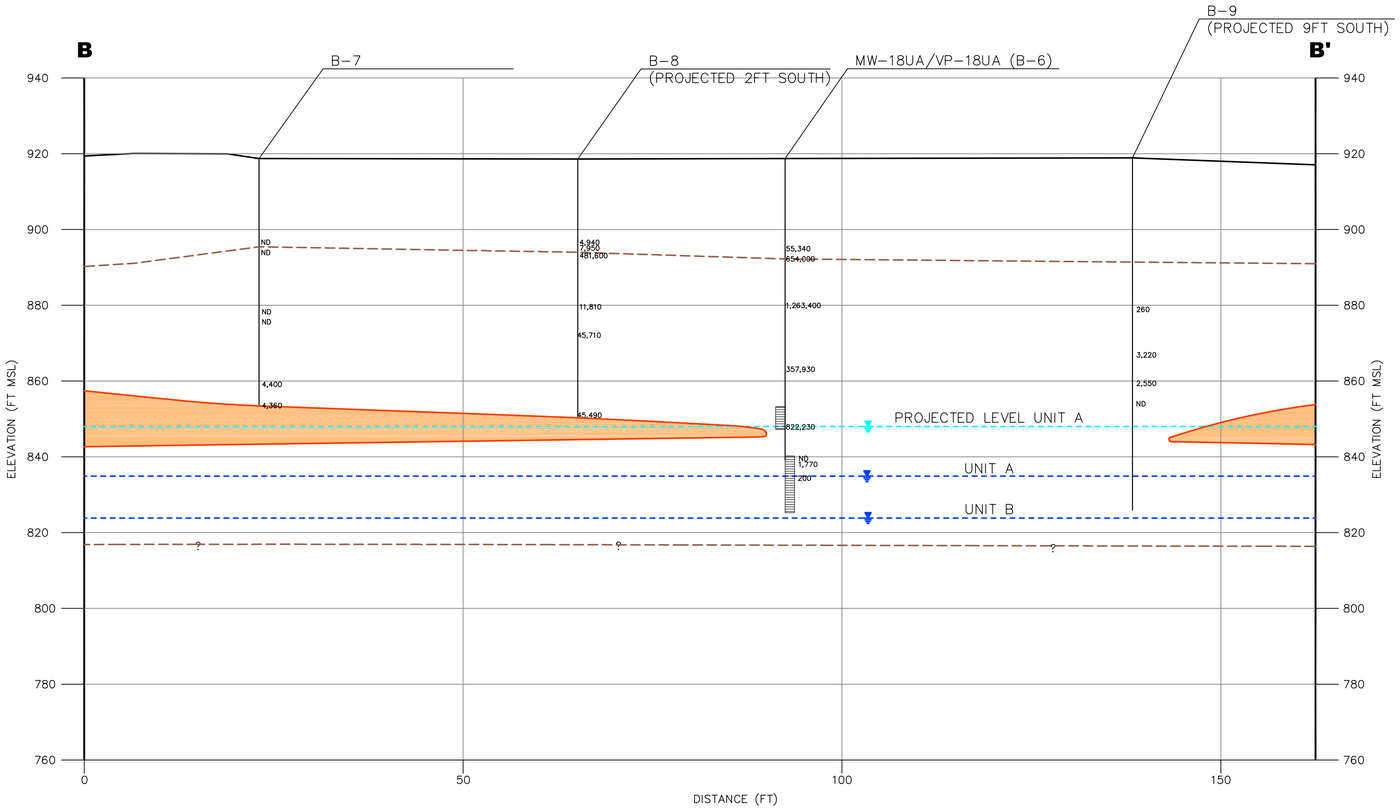
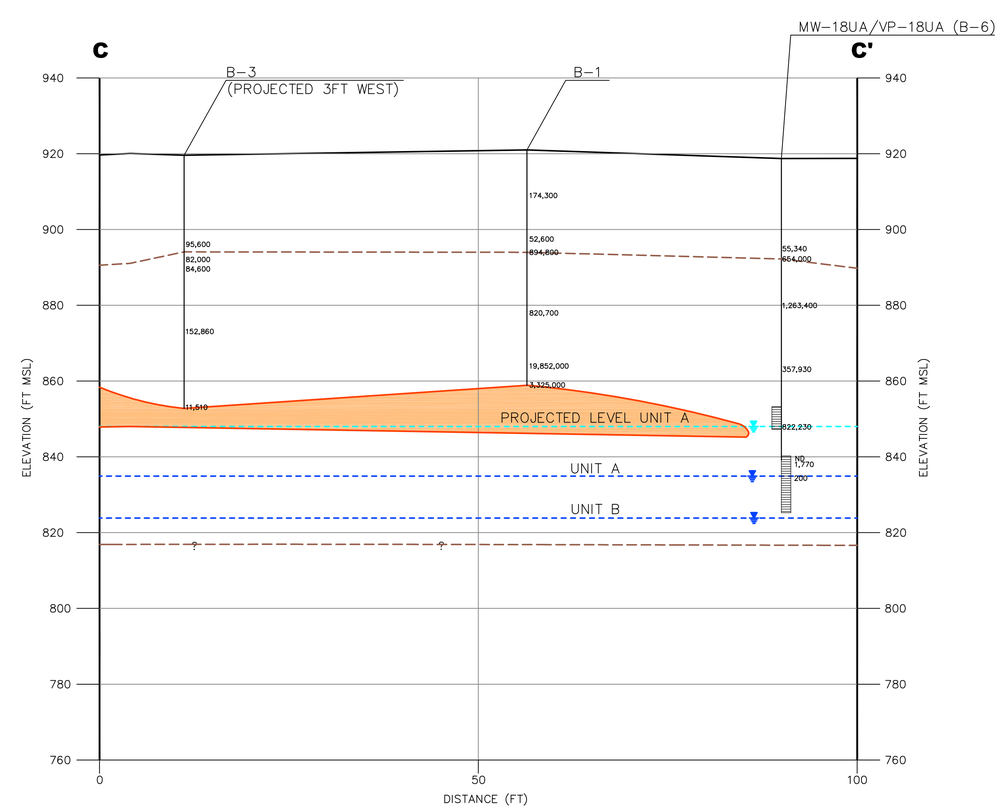
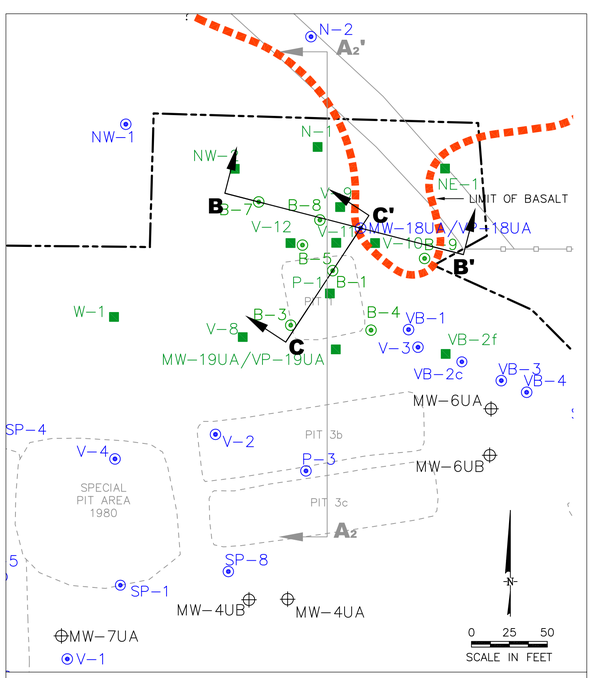




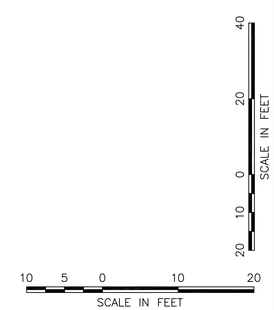


CROSS SECTIONS B–B' AND C–C' LOCATIONS AND SITE PLAN.

LEGEND

	LITHOLOGIC CONTACT
	PROJECTED POTENTIOMETRIC SURFACE (1980)
	POTENTIOMETRIC SURFACE (MARCH 2007)
	GROUND SURFACE
	BASALT BOUNDARY
4,400	SCREEN INTERVAL TOTAL VOC CONCENTRATION IN SOIL (ug/kg), JAN/FEB 2007
FT MSL	FEET ABOVE MEAN SEA LEVEL

NOTE:
ND =NOT DETECTED ABOVE LABORATORY REPORTING LIMITS.



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CROSS SECTION B–B' AND C–C'
TOTAL VOC SOIL CONCENTRATIONS (JAN/FEB 2007)
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4–7
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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Figure 4-8
Total VOC Concentrations in Soil Vapor and Groundwater - MW-01UA
Hassayampa Landfill

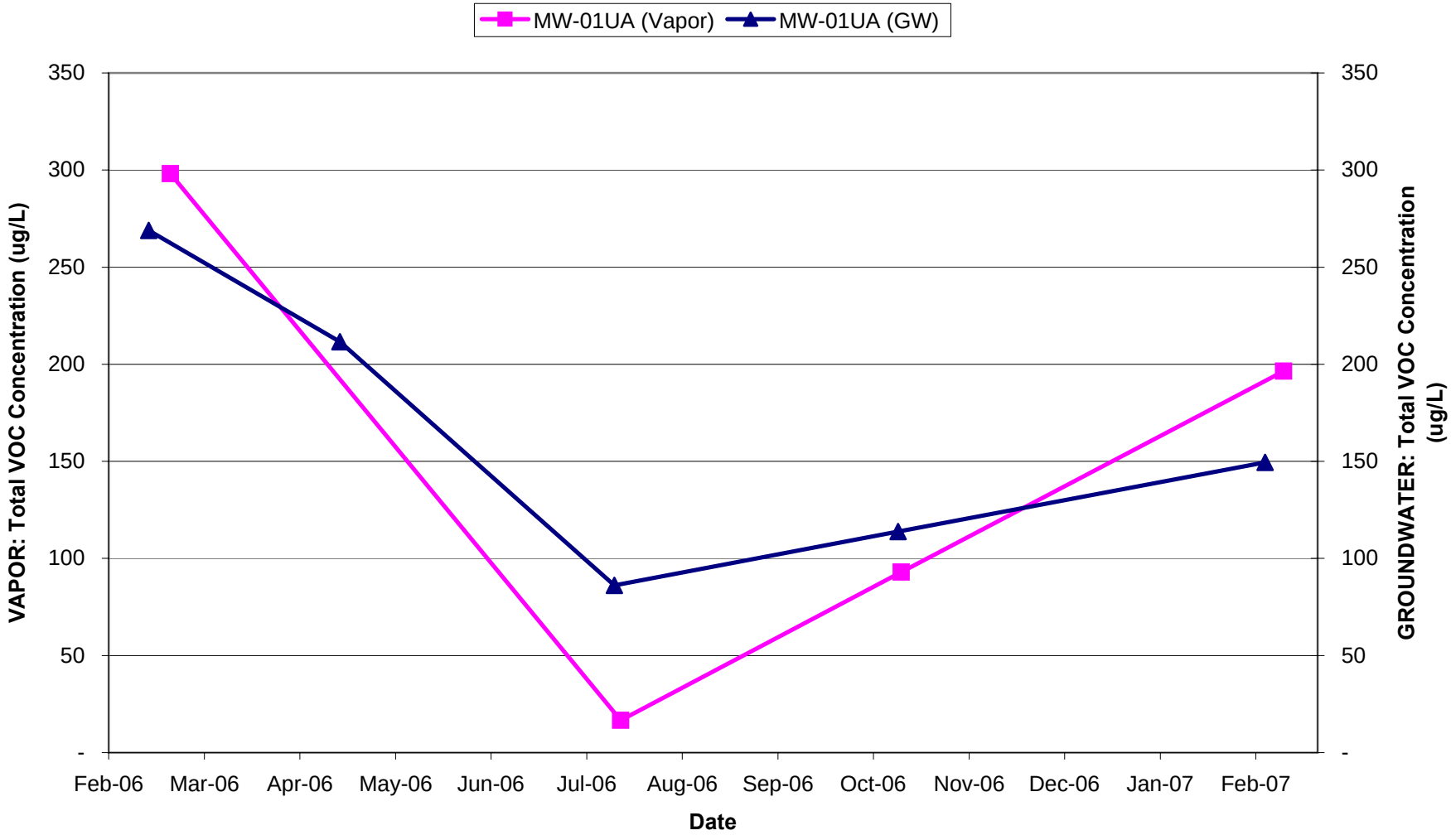


Figure 4-9
Total VOC Concentrations in Soil Vapor and Groundwater - MW-04UA
Hassayampa Landfill

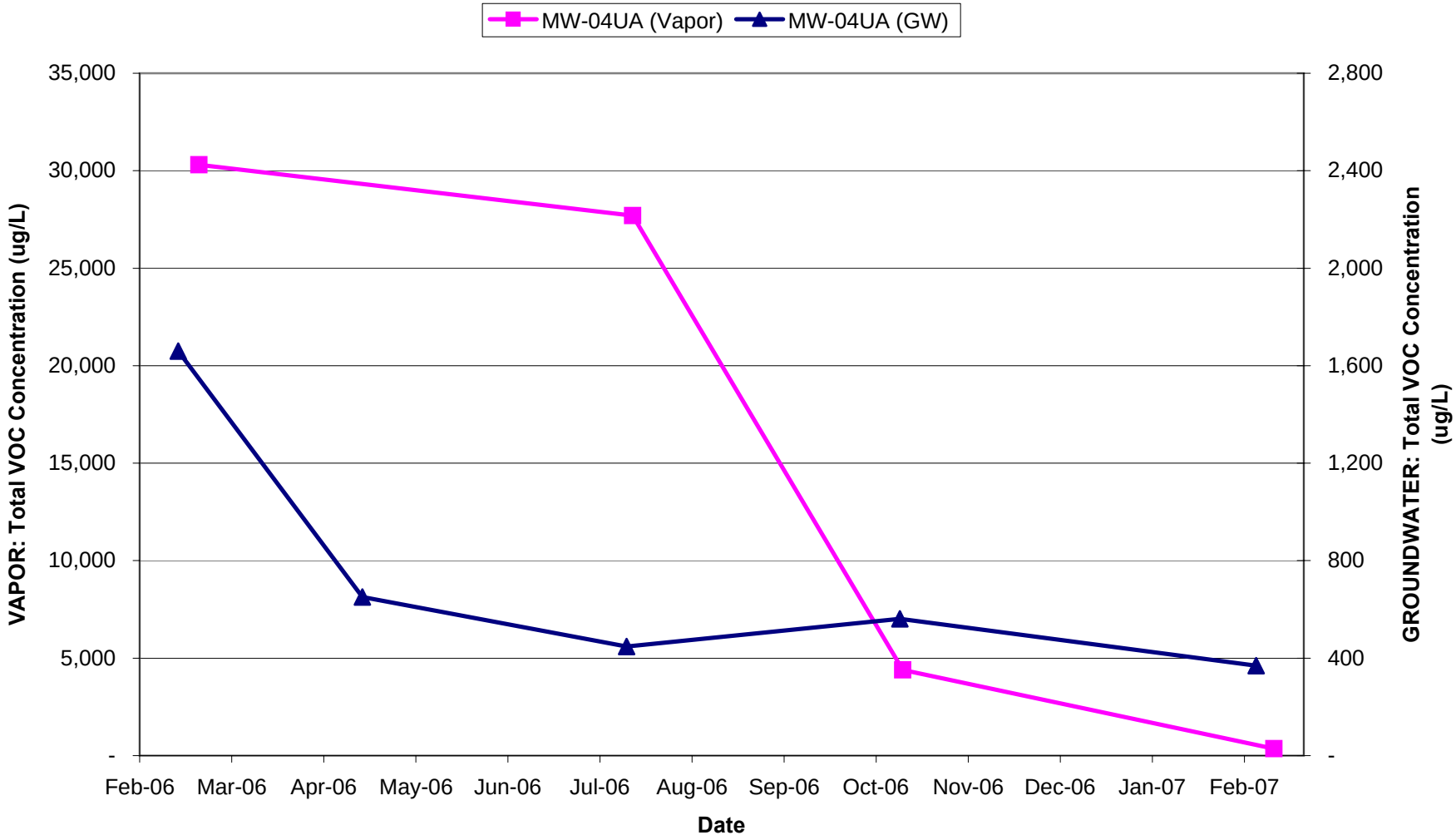


Figure 4-10
Total VOC Concentrations in Soil Vapor and Groundwater - MW-06UA
Hassayampa Landfill

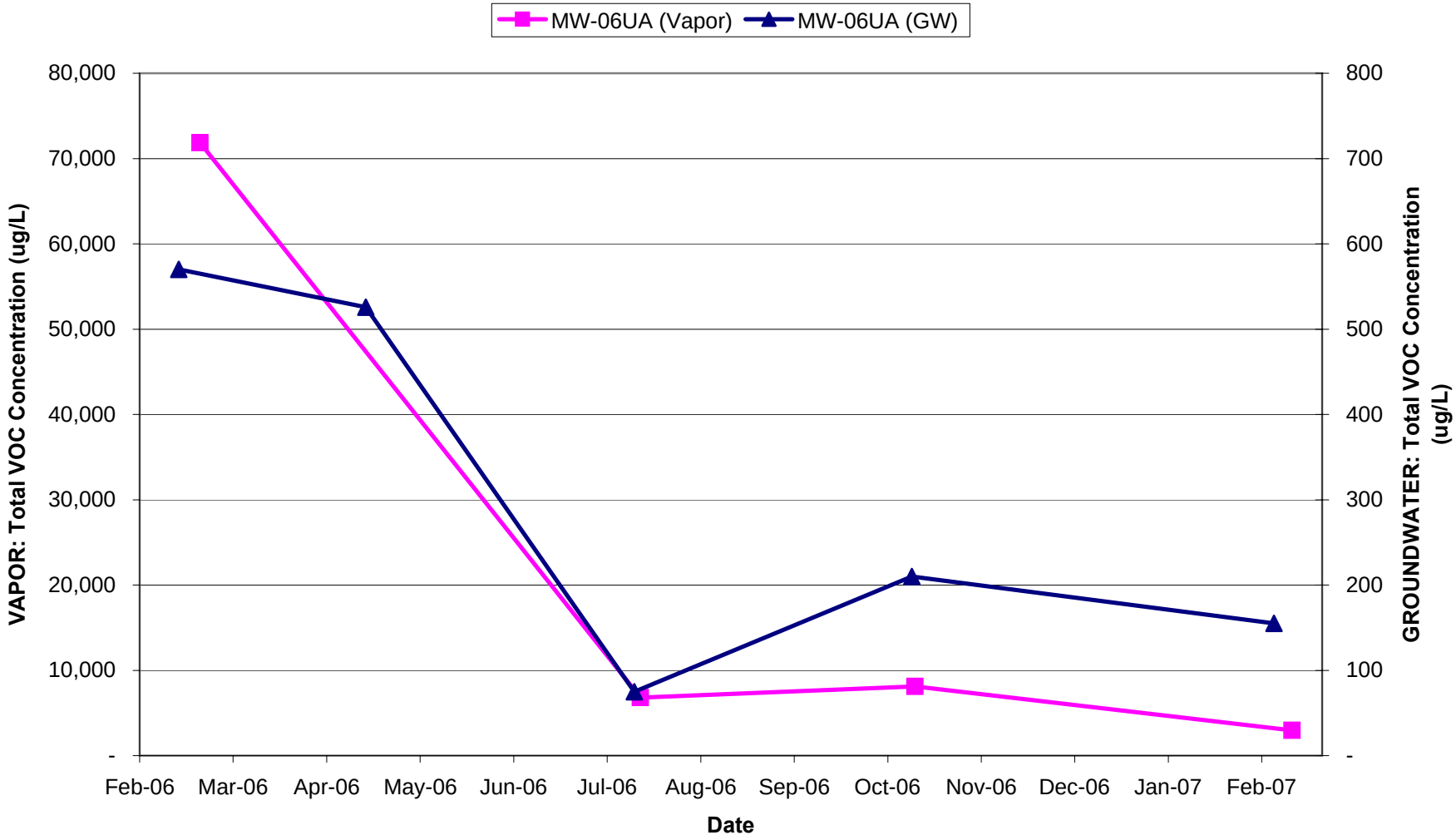


Figure 4-11
Total VOC Concentrations in Soil Vapor and Groundwater - MW-07UA
Hassayampa Landfill

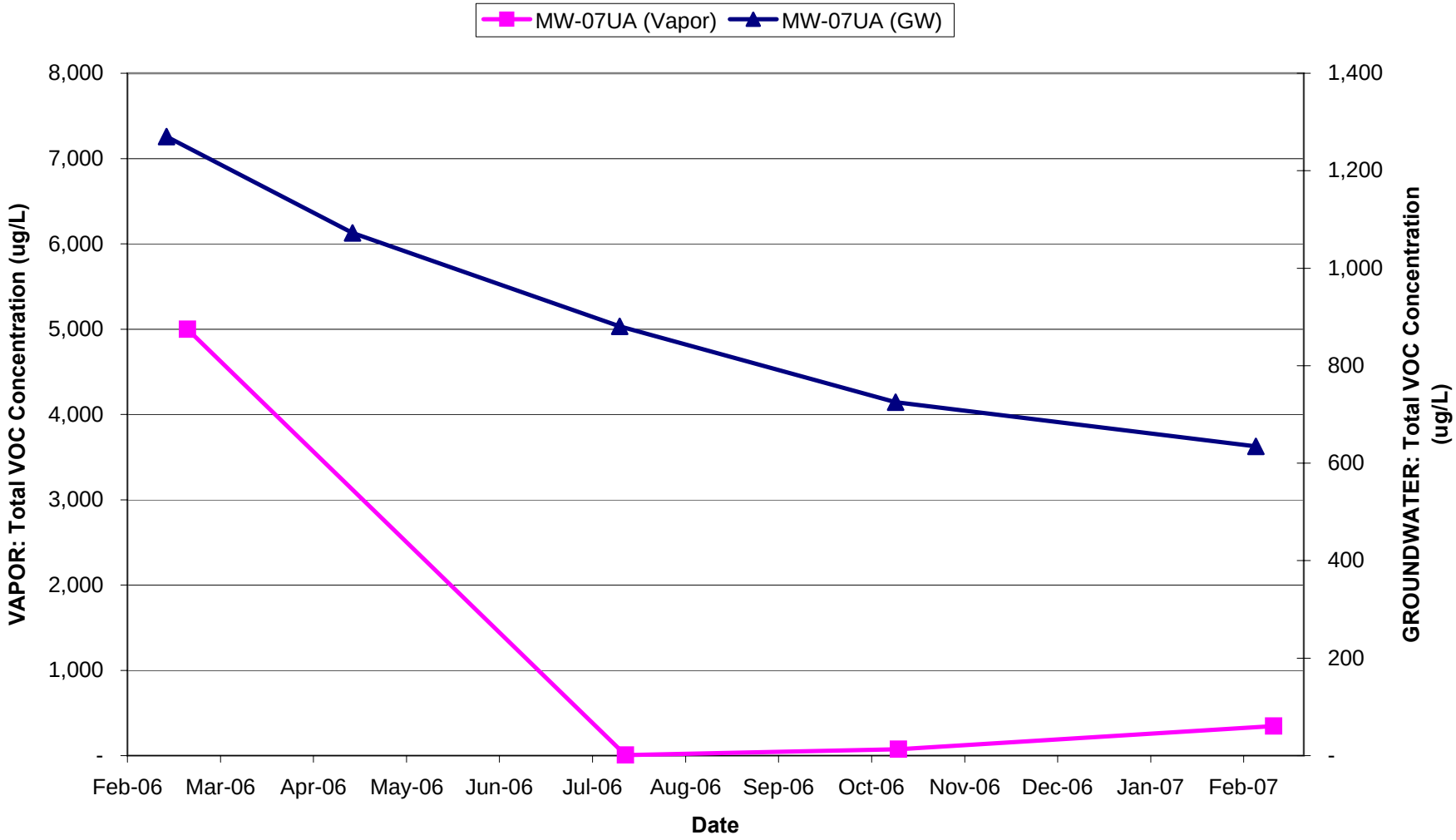


Figure 4-12
Total VOC Concentrations in Soil Vapor and Groundwater - MW-11UA
Hassayampa Landfill

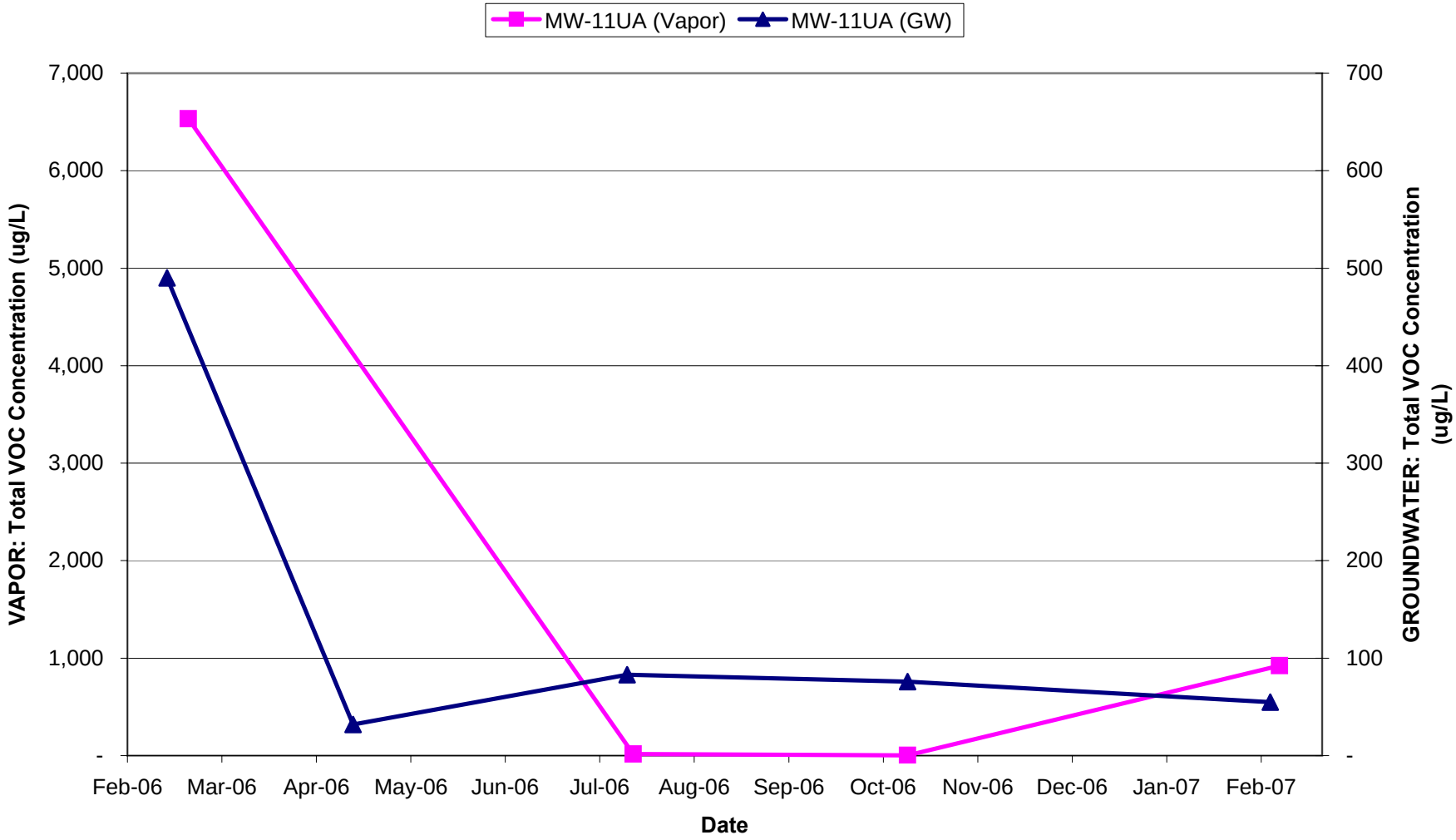


Figure 4-13
Total VOC Concentrations in Soil Vapor and Groundwater - MW-12UA
Hassayampa Landfill

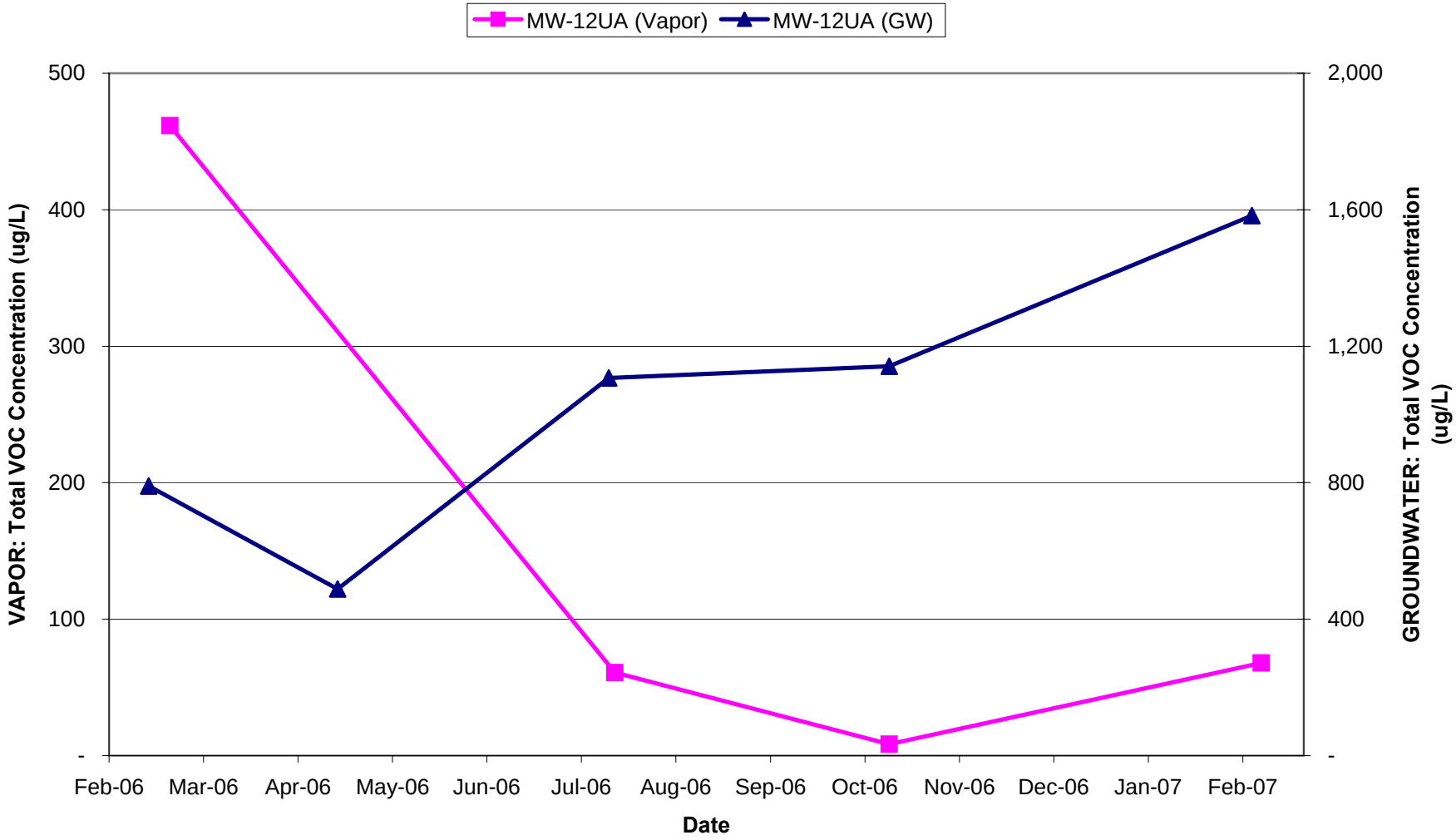


Figure 4-14
Total VOC Concentrations in Soil Vapor and Groundwater - VP-18UA / MW-18UA
Hassayampa Landfill

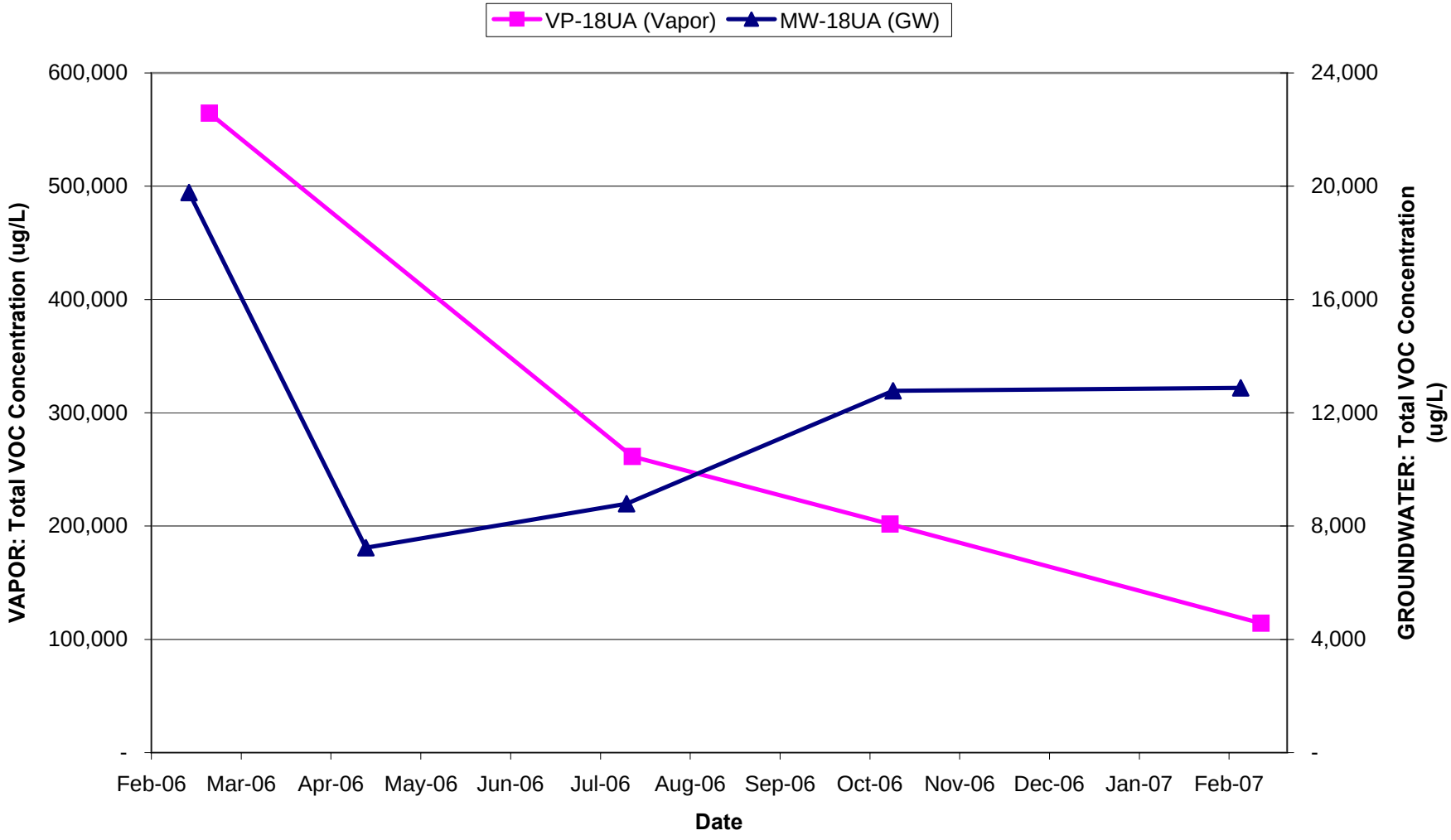
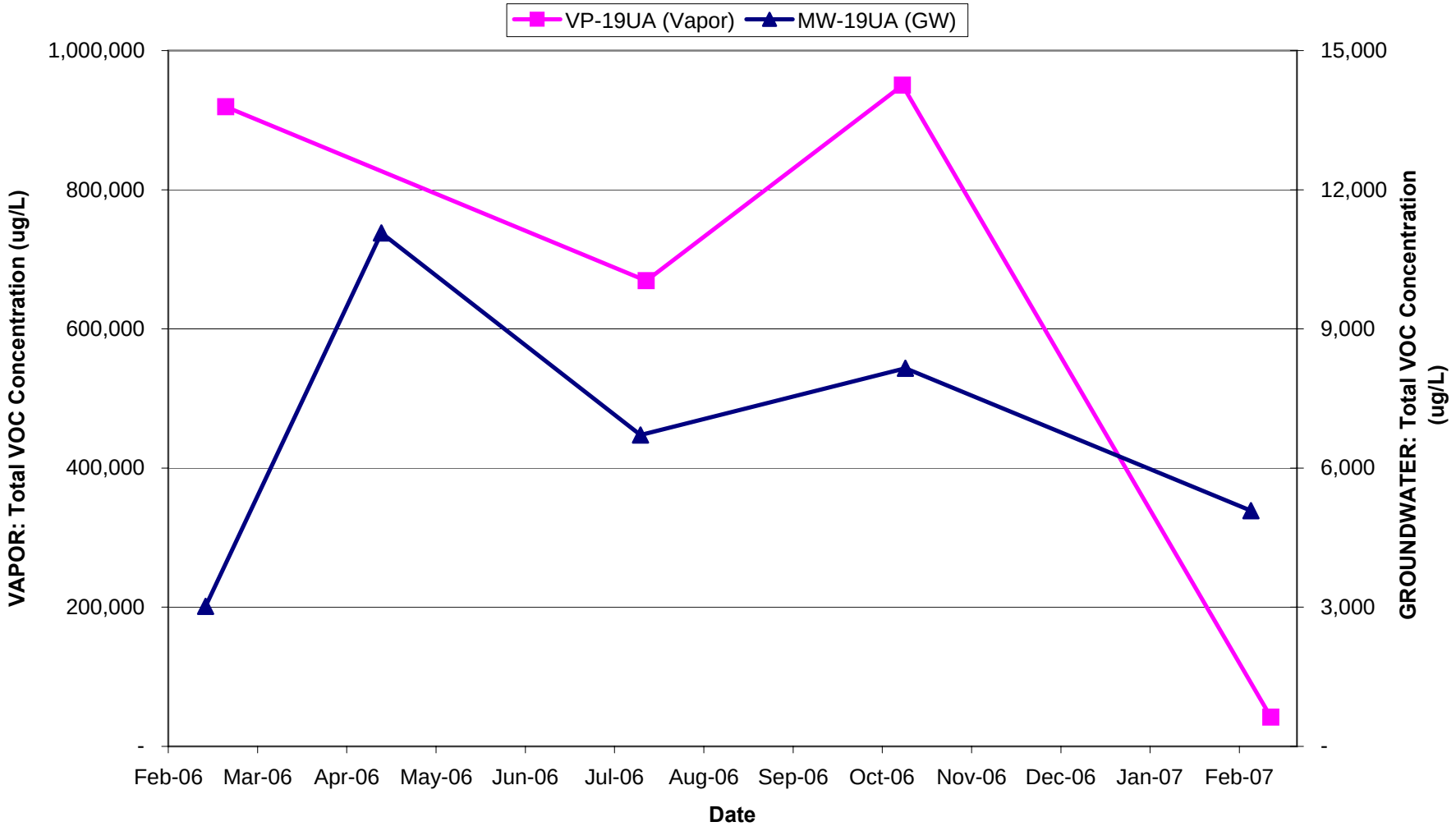
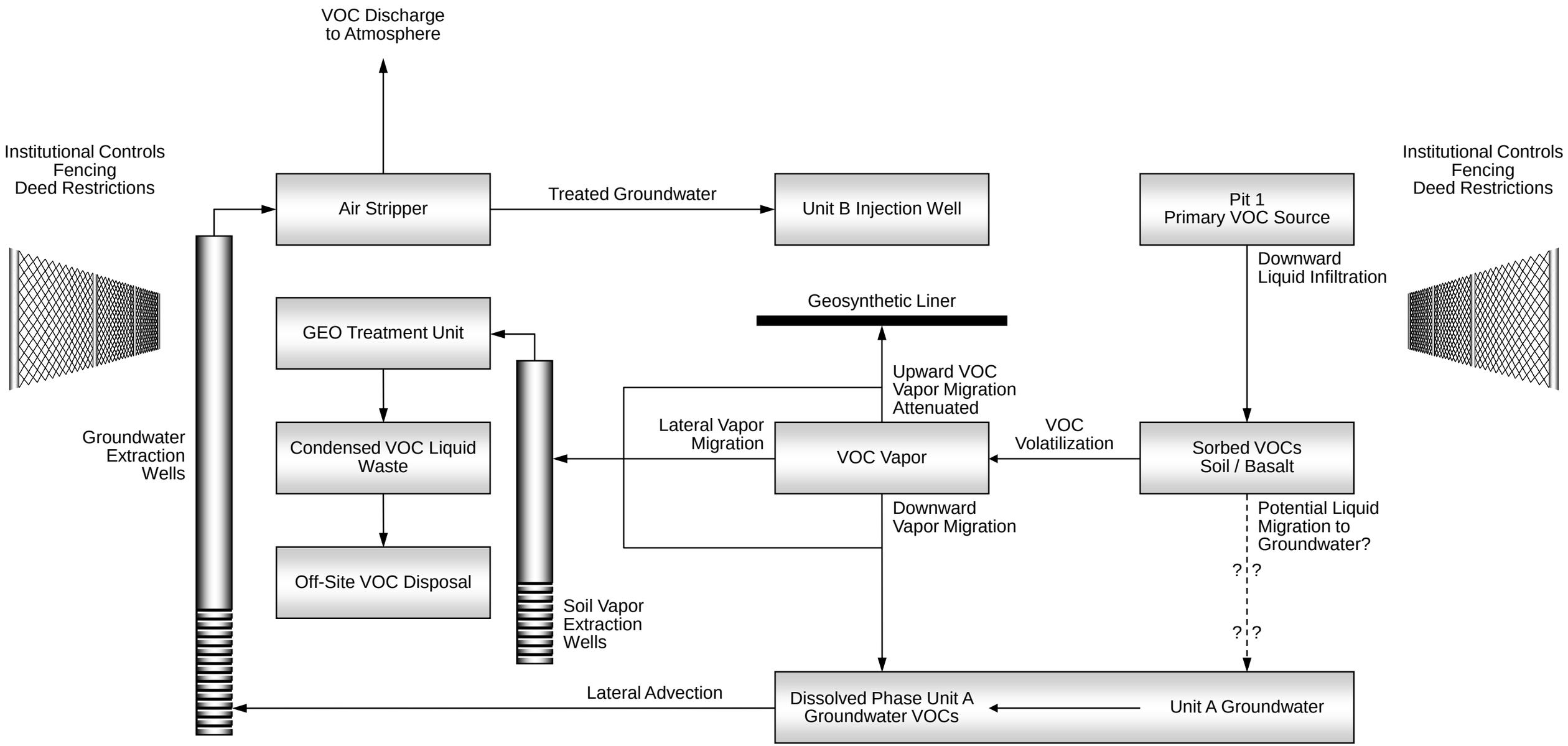


Figure 4-15
Total VOC Concentrations in Soil Vapor and Groundwater - VP-19UA / MW-19UA
Hassayampa Landfill





VOC Fate & Transport
Updated Site Conceptual Model
Hassayampa Superfund Site

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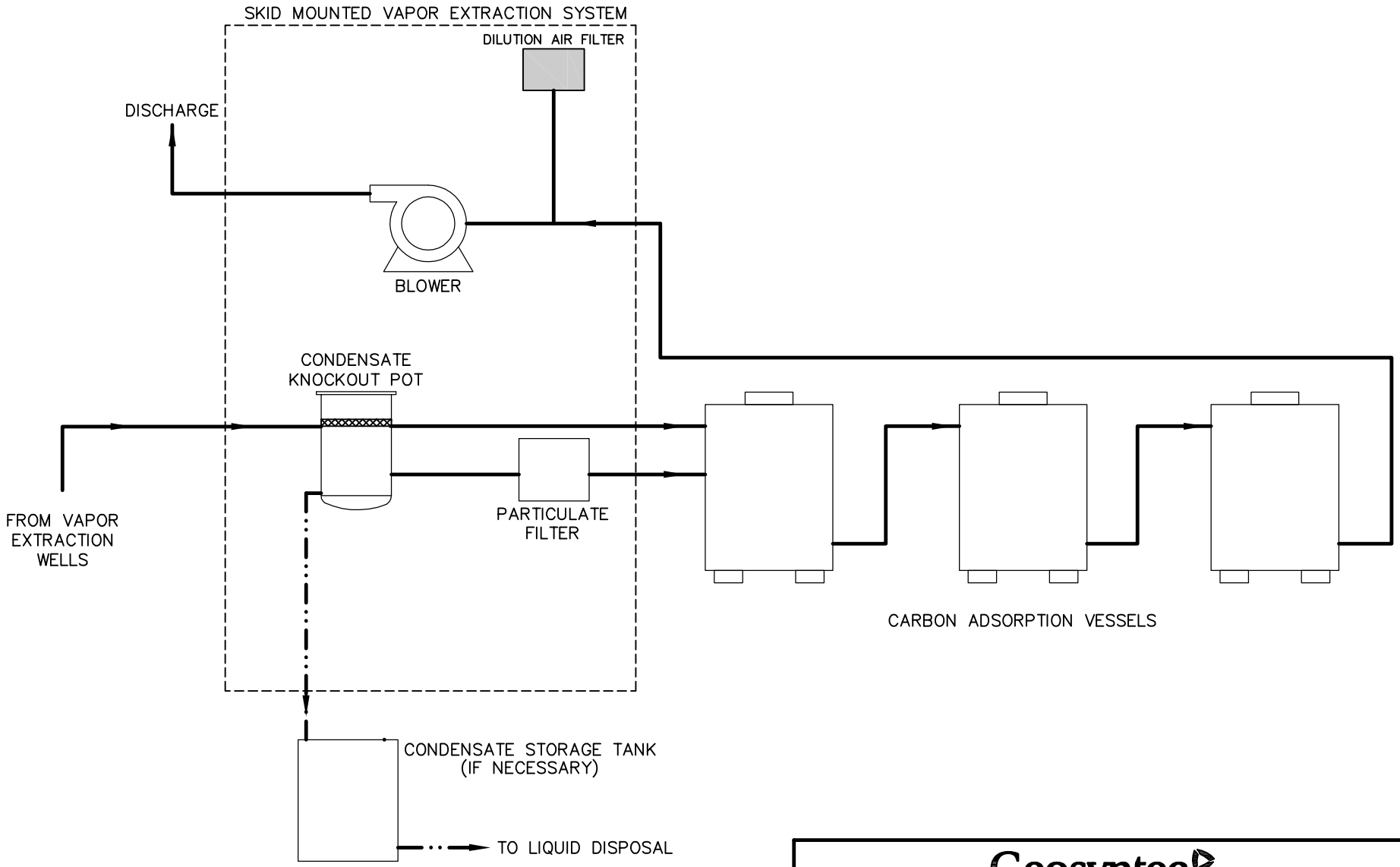
engineers | scientists | innovators

Figure 4-16

HR0933-01\HAS07-15.FIG.PPT



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GAC SYSTEM PROCESS FLOW DIAGRAM
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F037
PROJECT NO.	HR0933-07	FIGURE NO.	5-1

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Figures

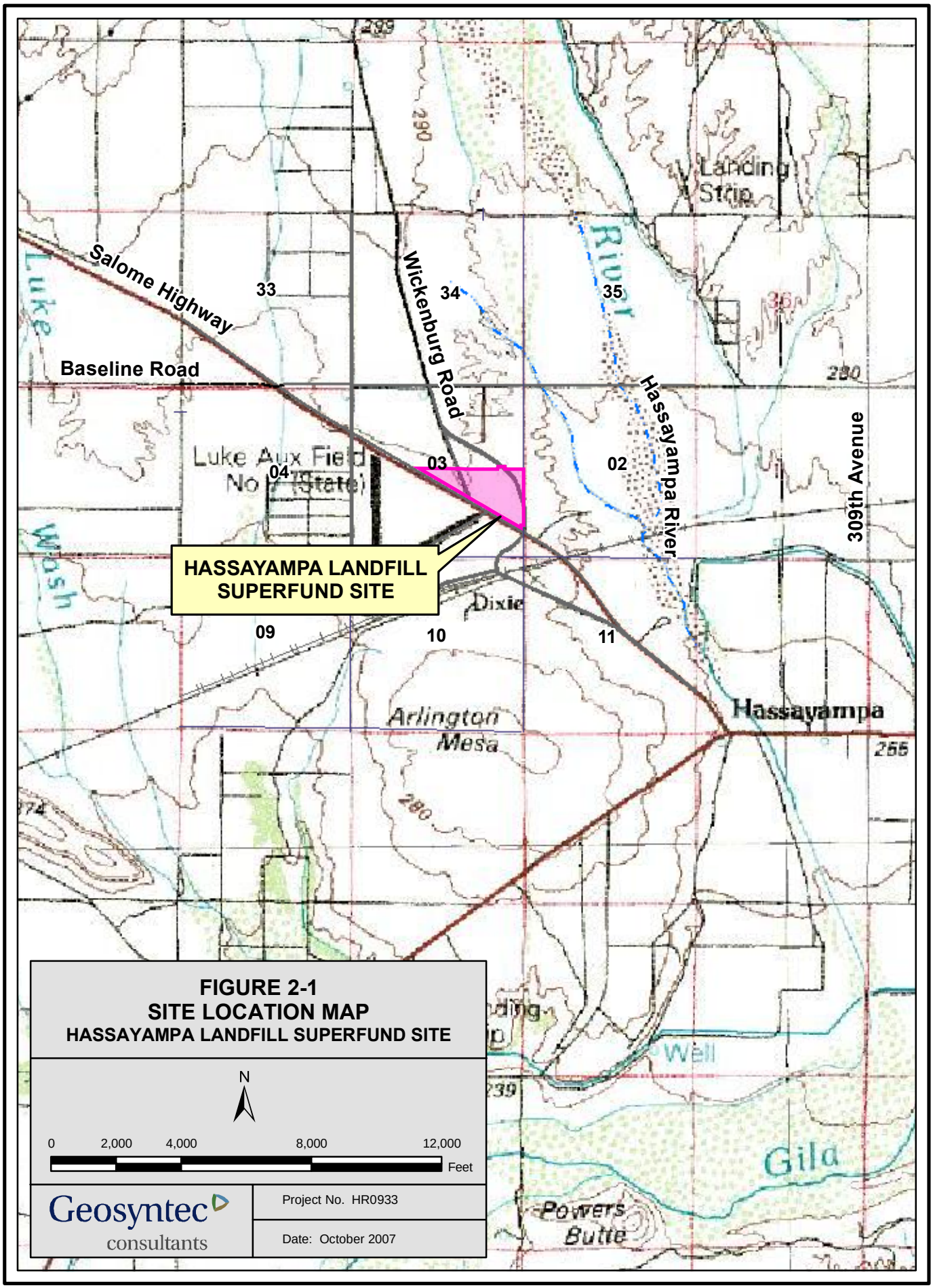

FIGURE 2-1
SITE LOCATION MAP
HASSAYAMPA LANDFILL SUPERFUND SITE

S:\GIS\HR0933\GIS\GIS files\Projects\Location_2007.mxd sn 20071030

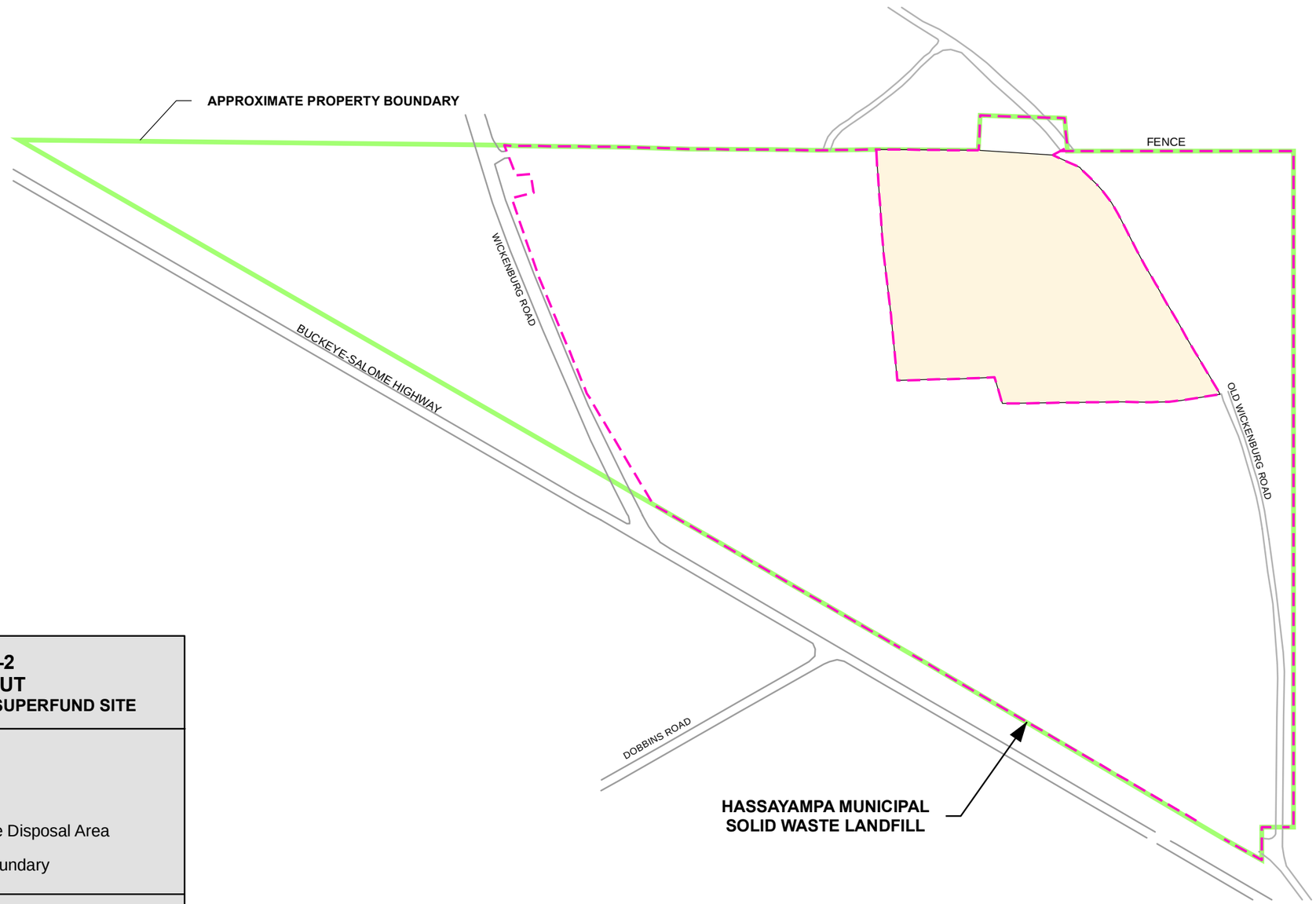

FIGURE 2-2
SITE LAYOUT
HASSAYAMPA LANDFILL SUPERFUND SITE

Explanation

- Fence
- Former Hazardous Waste Disposal Area
- Approximate Property Boundary

N

0 150 300 600 900 Feet

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Project No. HR0933

Date: October 2007

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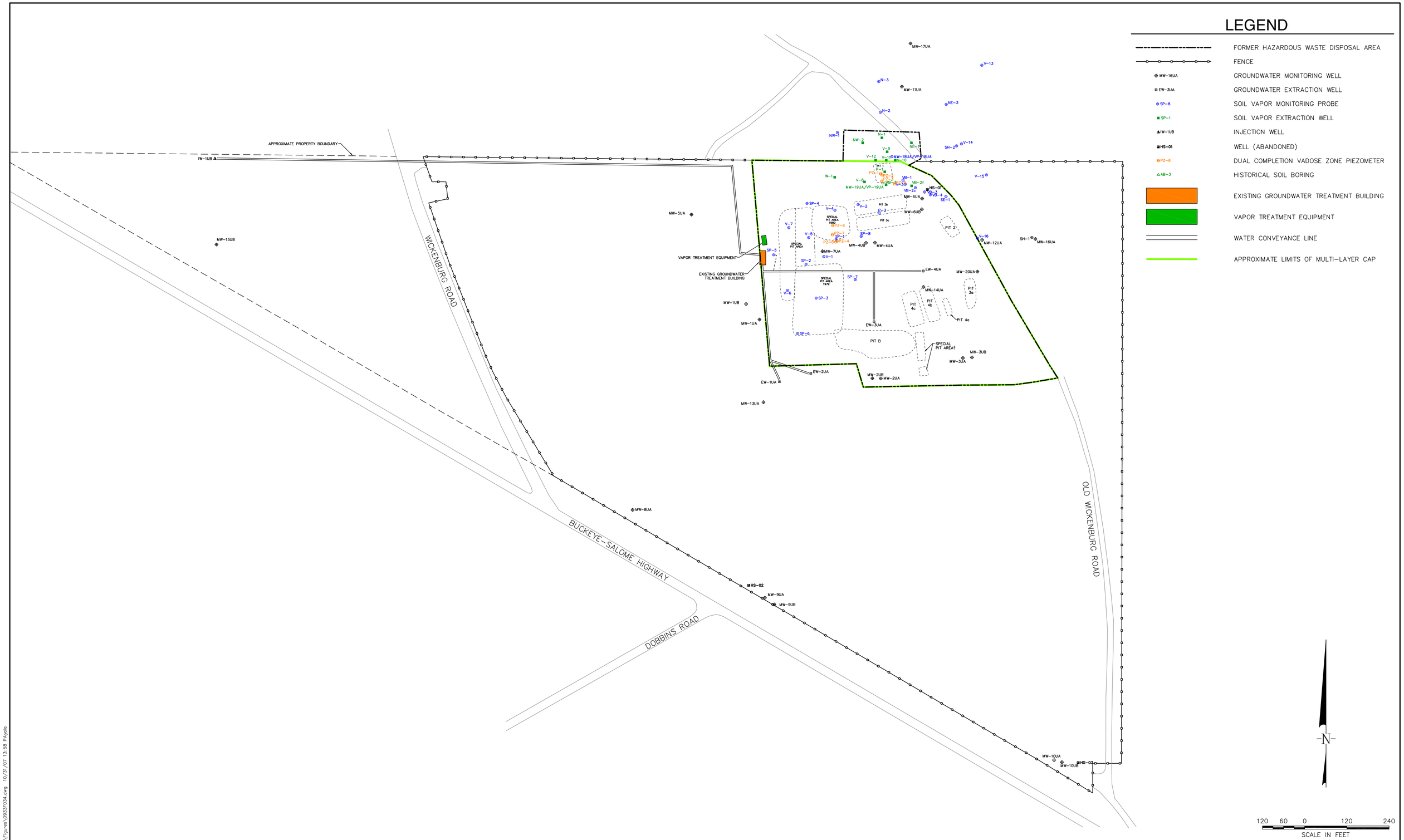

SOURCE: ERROL MONTGOMERY & ASSOCIATES, 30 MARCH 2004.

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DETAILED SITE LAYOUT
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	2-3
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

SOURCE: ERROL MONTGOMERY & ASSOCIATES, 30 MARCH 2004.

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PHASE I SOIL BORING LOCATIONS
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	3-1
PROJECT NO.	HR0933-07
DATE:	OCTOBER 2007

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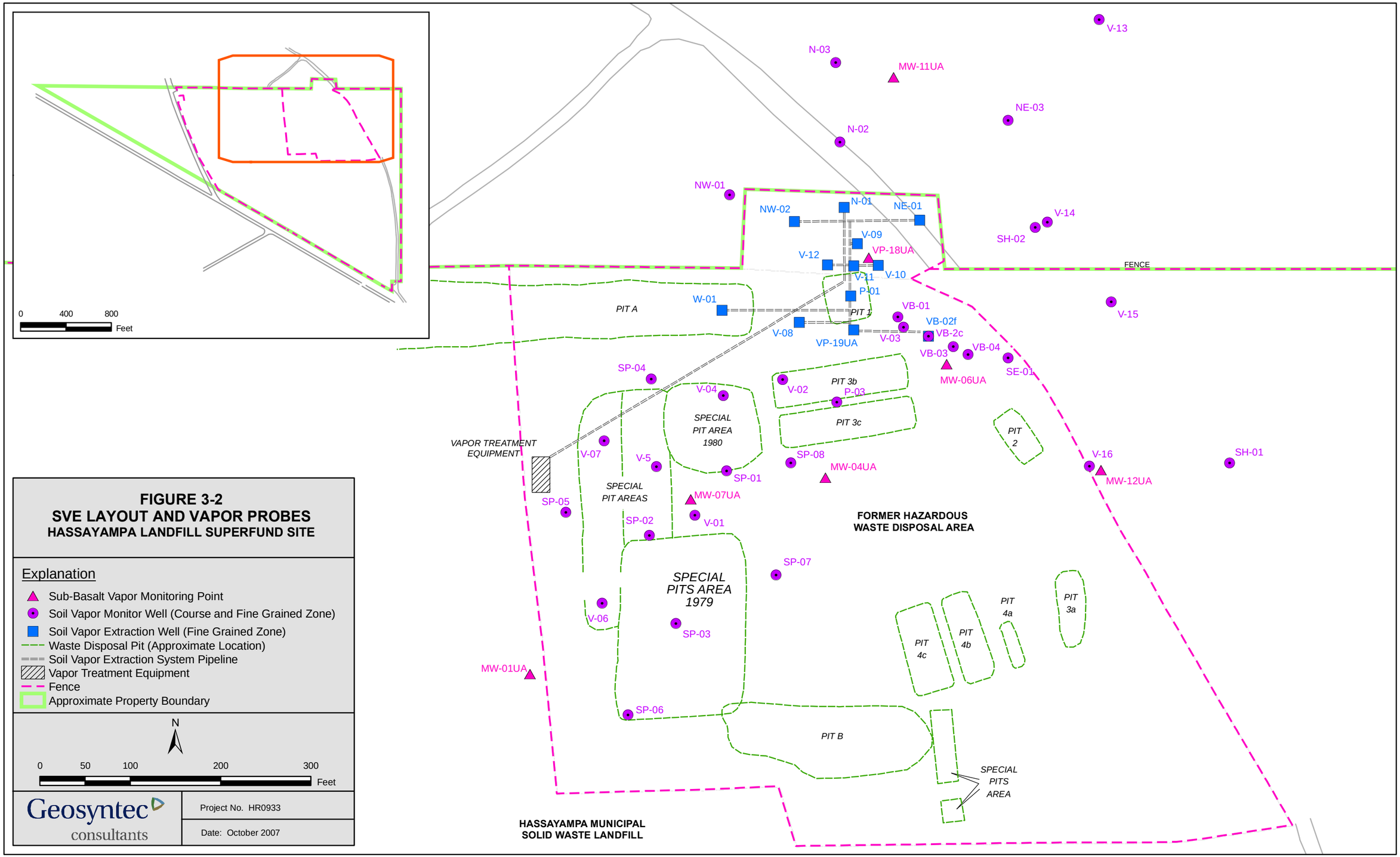

FIGURE 3-2
SVE LAYOUT AND VAPOR PROBES
HASSAYAMPA LANDFILL SUPERFUND SITE

Explanation

- Sub-Basalt Vapor Monitoring Point
- Soil Vapor Monitor Well (Course and Fine Grained Zone)
- Soil Vapor Extraction Well (Fine Grained Zone)
- Waste Disposal Pit (Approximate Location)
- Soil Vapor Extraction System Pipeline
- Vapor Treatment Equipment
- Fence
- Approximate Property Boundary

N

0 50 100 200 300 Feet

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Project No. HR0933

Date: October 2007

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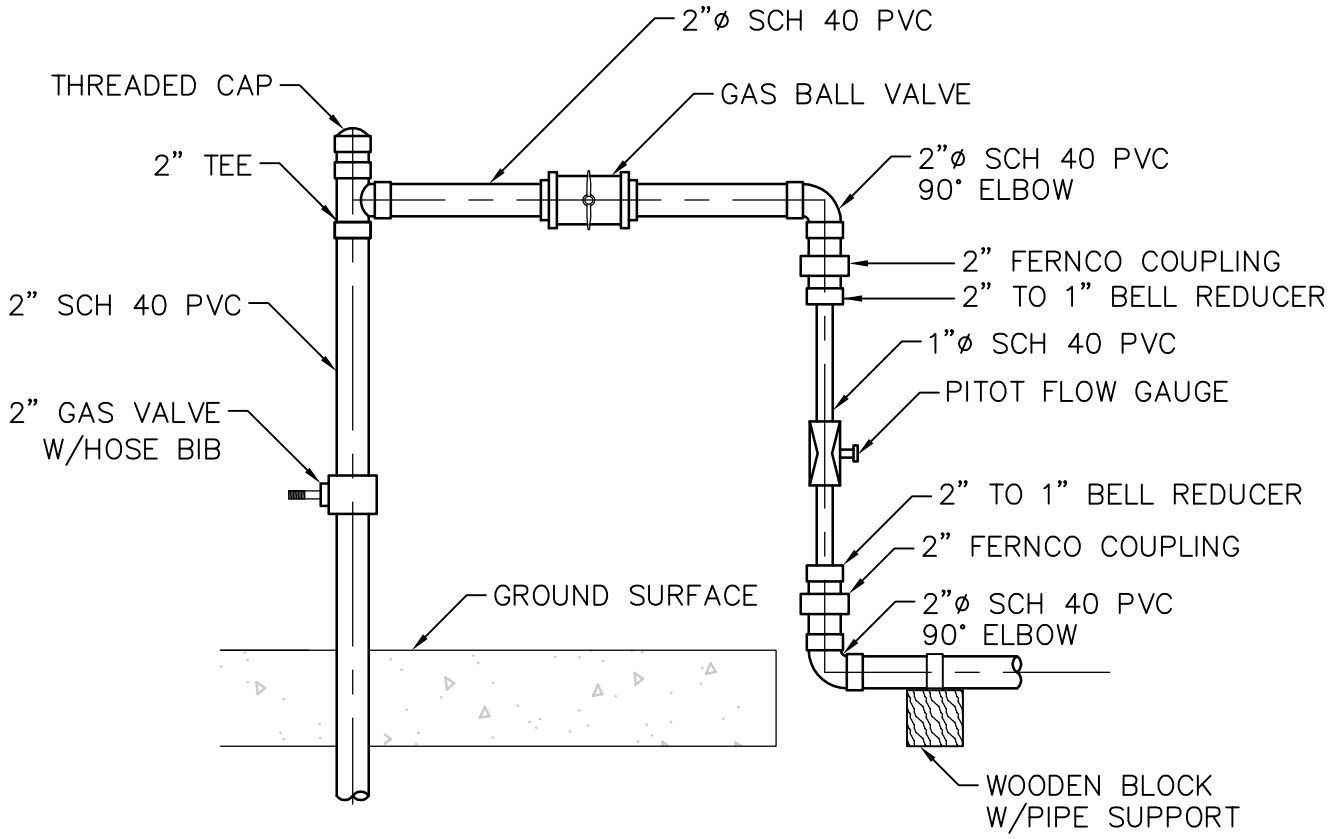

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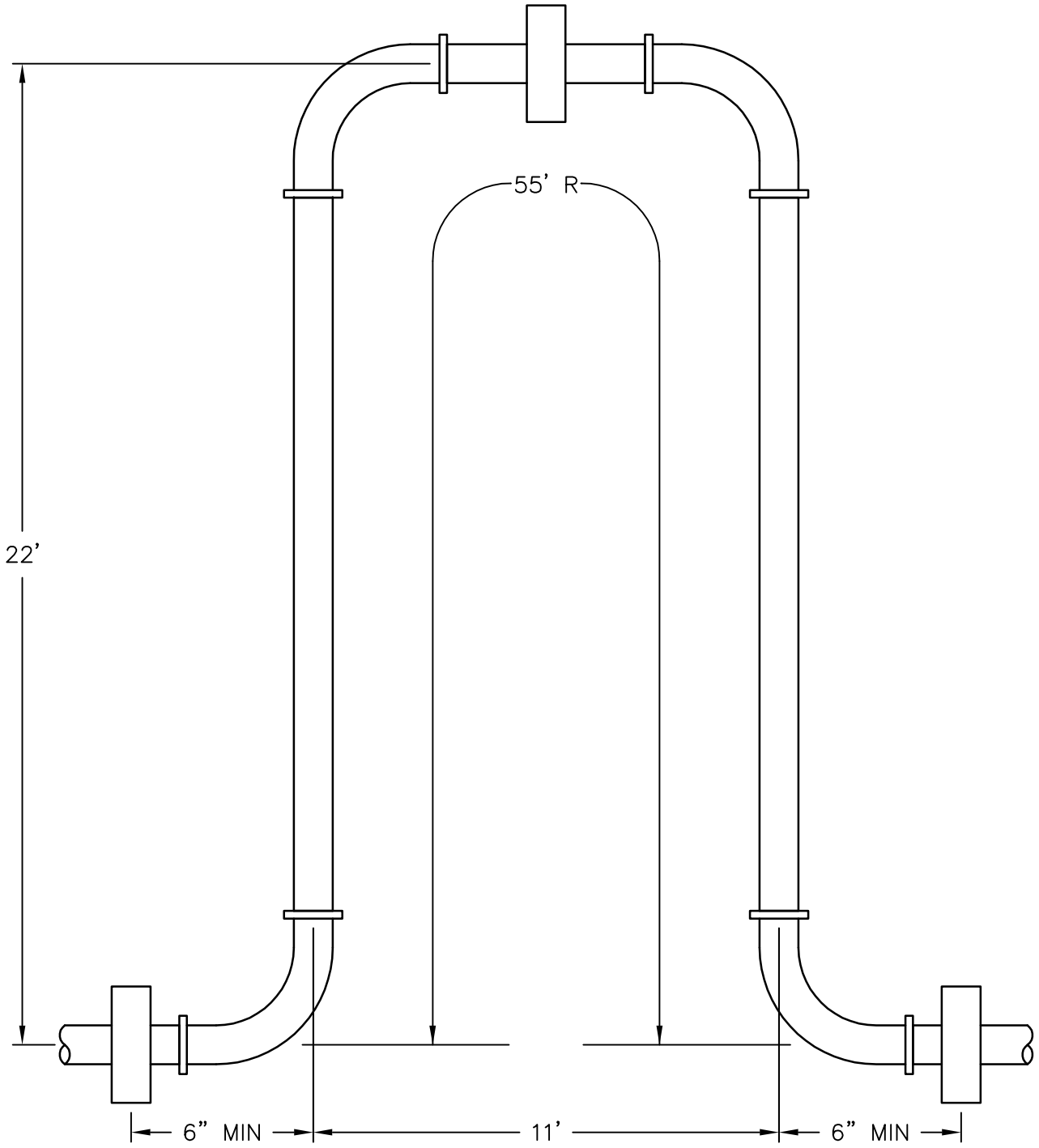
TYPICAL WELL HEAD CONSTRUCTION
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F036
PROJECT NO.	HR0933-07	FIGURE NO.	3-3



NOT TO SCALE

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TYPICAL TEMPERATURE EXPANSION LOOP
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F029
PROJECT NO.	HR0933-07	FIGURE NO.	3-4

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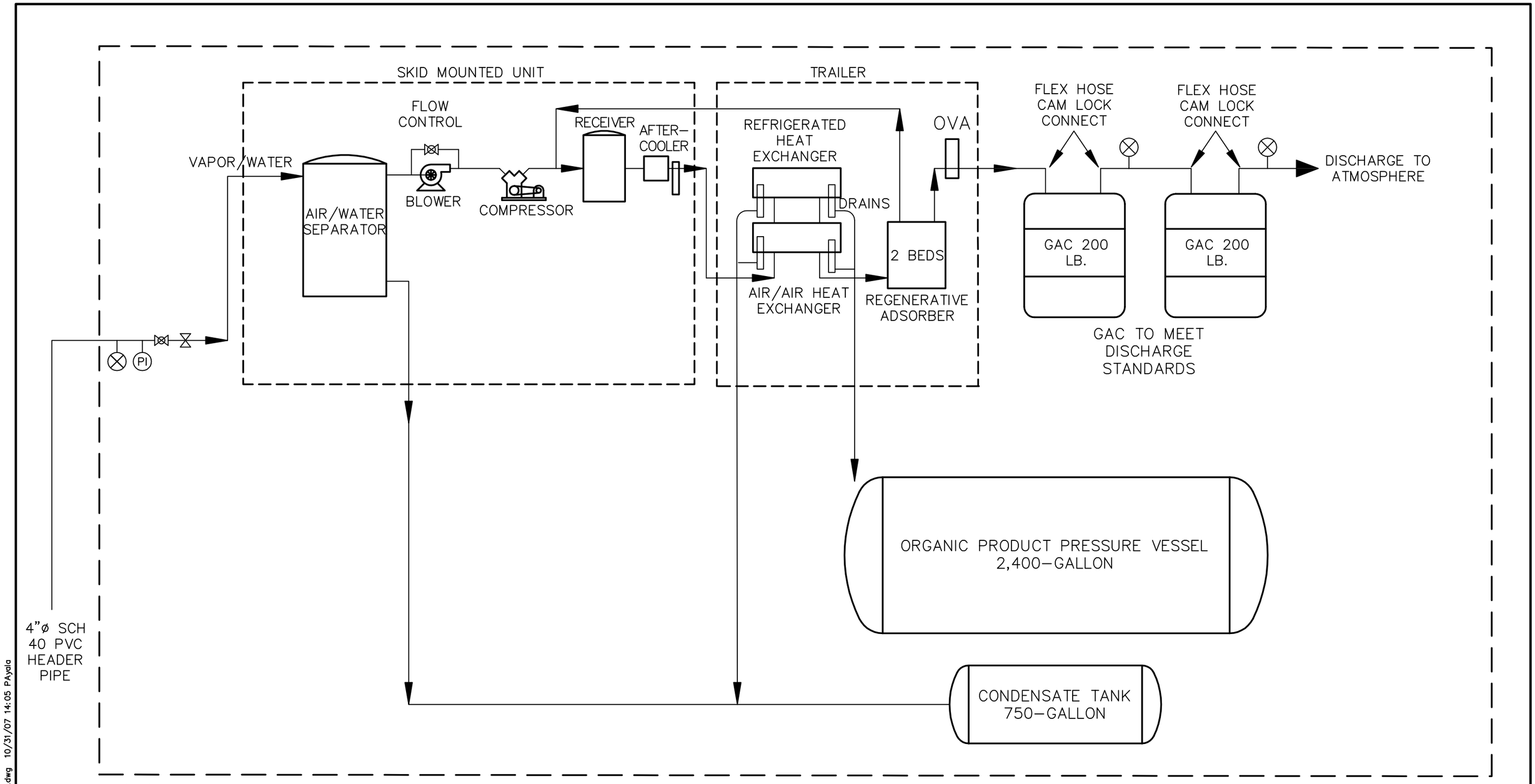

LEGEND

⊠	BALL VALVE	————	SYSTEM PIPING
⧖	CONTROL VALVE	- - - - -	PACKAGED SKID OUTLINE
⊗	SAMPLE PORT	— — —	ENCLOSURE PAD OUTLINE
(PI)	PRESSURE INDICATOR		

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GEO SYSTEM PROCESS FLOW DIAGRAM
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F035
PROJECT NO.	HR0933	FIGURE NO.	3-5

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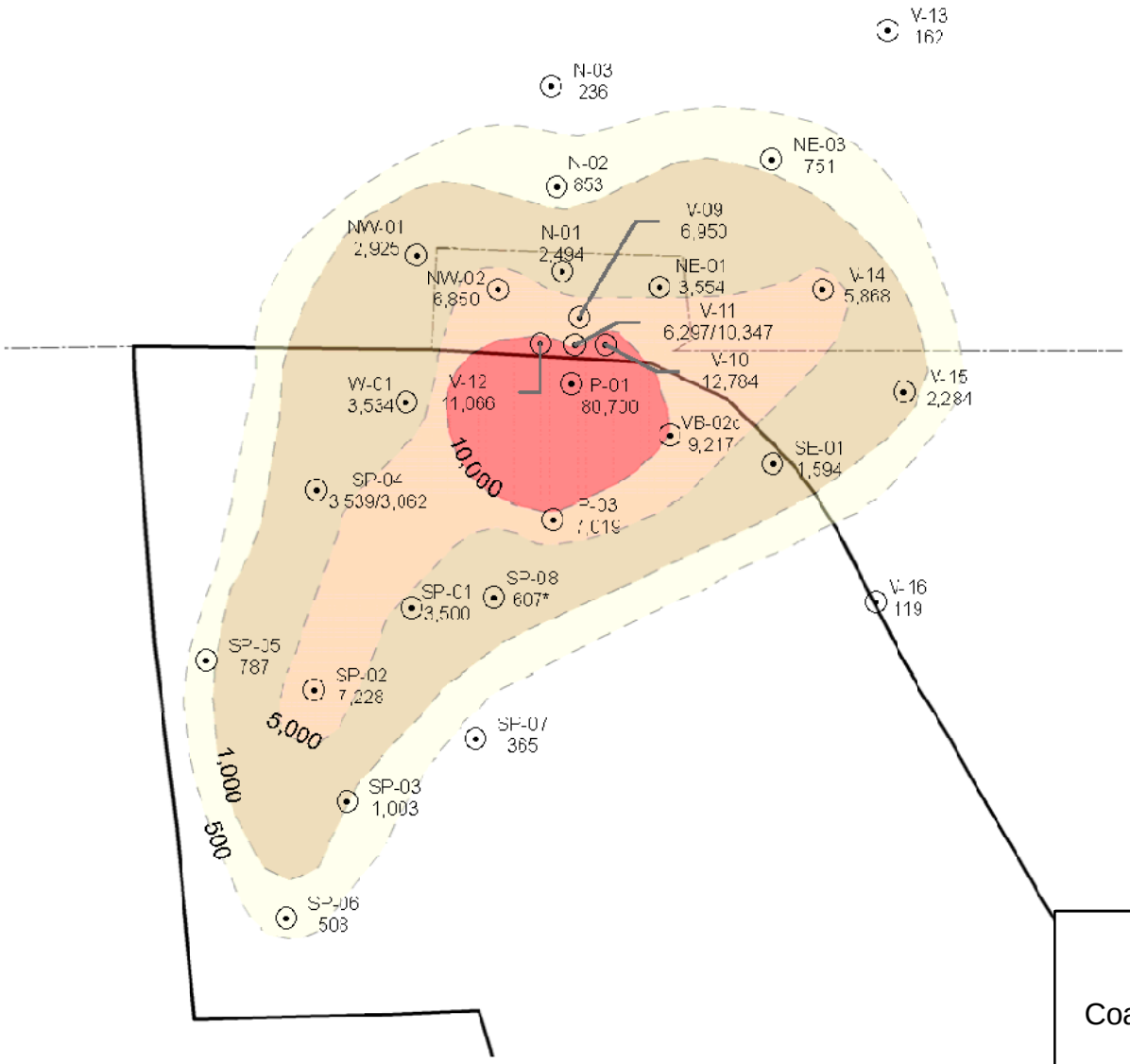


Note: Total VOC Concentration in Micrograms per Liter (ug/L)

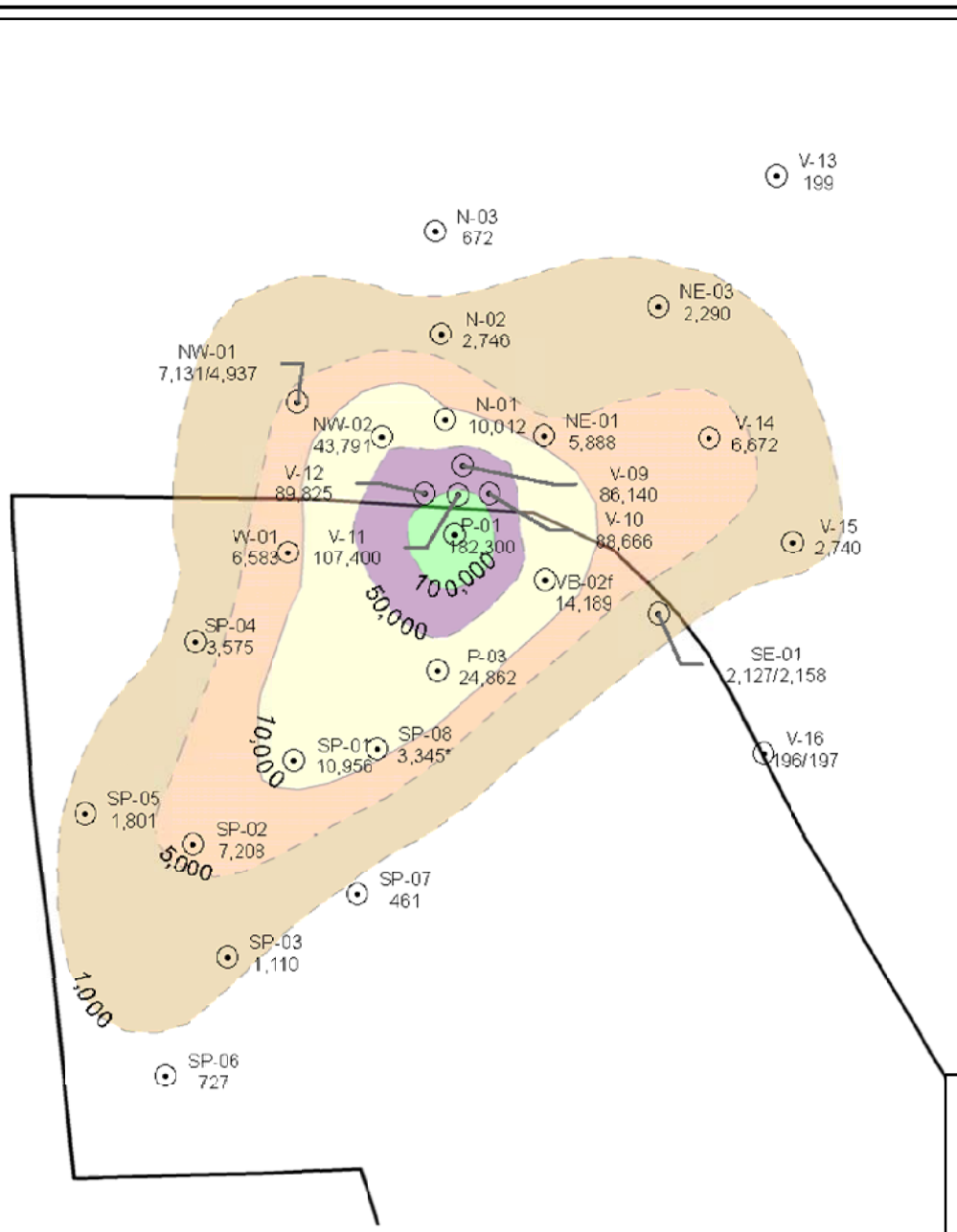
FIGURE 3-6
1st Quarter 2006
Coarse-Grained Zone Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

S:\GIS\HR0933\GIS\GIS files\Projects\1stQtr2006_CGZ.mxd sn 20071030



Note: Total VOC Concentration in Micrograms per Liter (ug/L)

FIGURE 3-7
1st Quarter 2006
Fine-Grained Zone Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

S:\GIS\HR0933\GIS\GIS files\Projects\1stQtr2006_FGZ.mxd sn 20071030

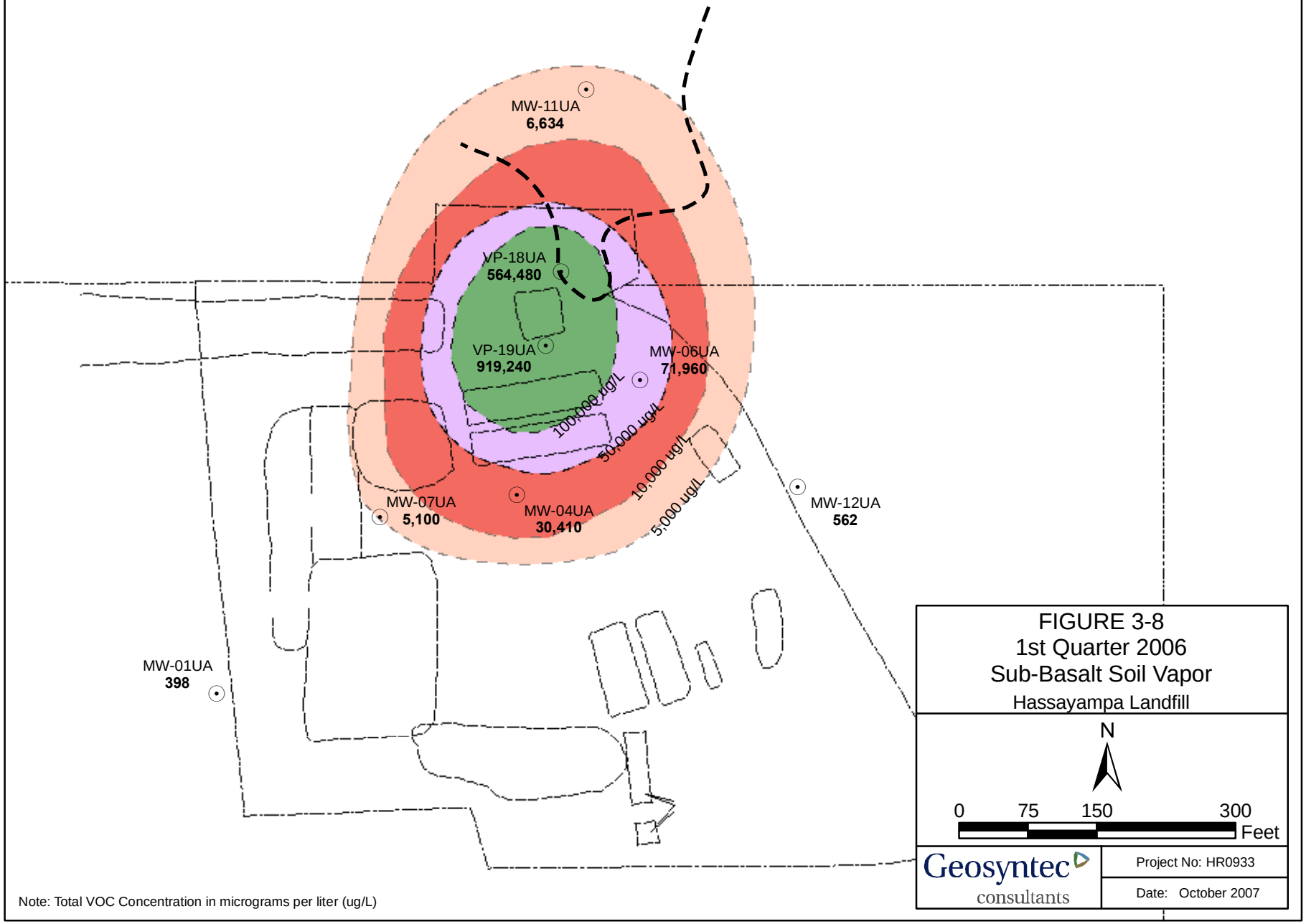


FIGURE 3-8
1st Quarter 2006
Sub-Basalt Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

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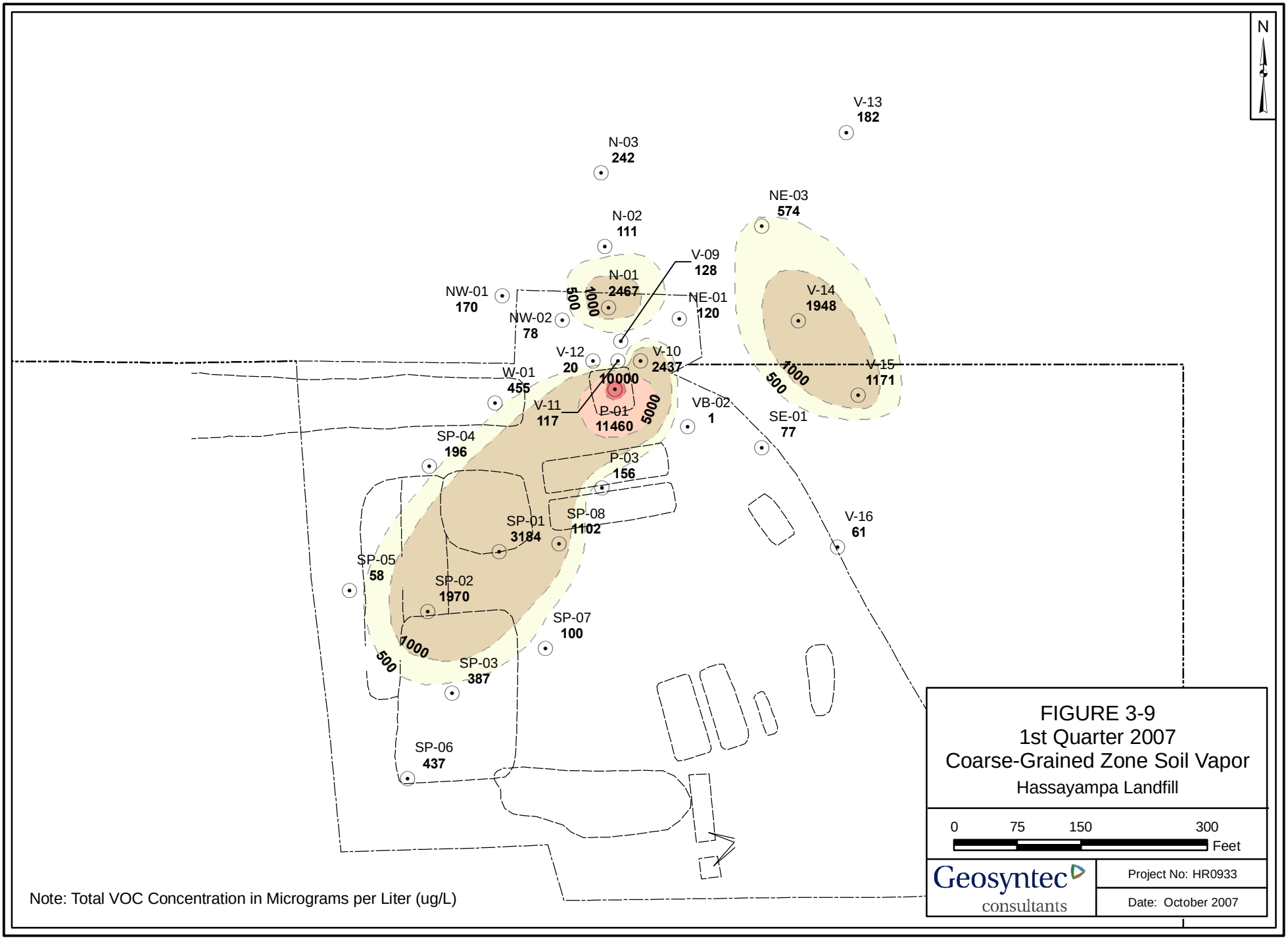

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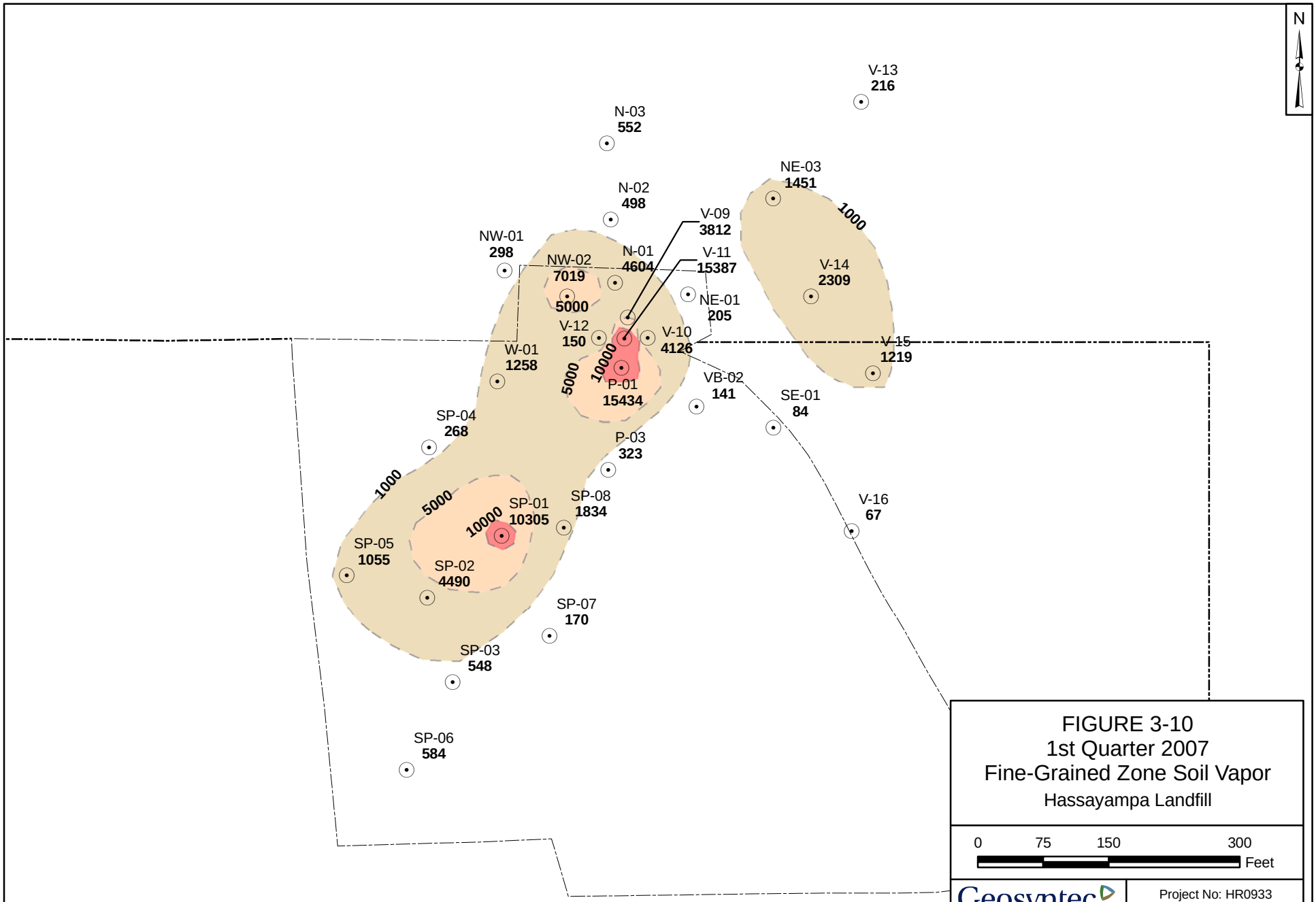

Note: Total VOC Concentration in Micrograms per Liter (ug/L)

FIGURE 3-10
1st Quarter 2007
Fine-Grained Zone Soil Vapor
Hassayampa Landfill

0 75 150 300 Feet

Geosyntec consultants

Project No: HR0933

Date: October 2007

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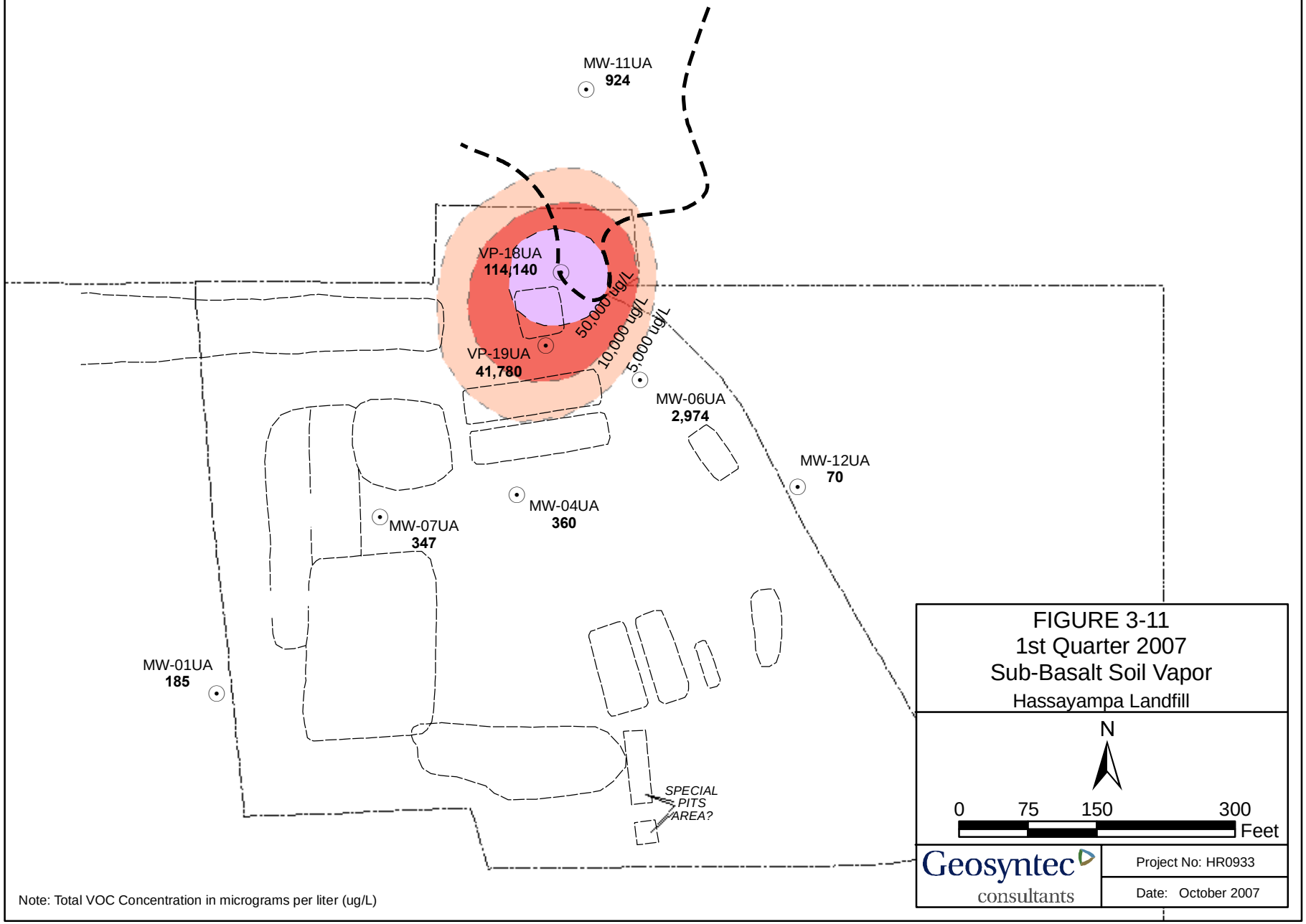

FIGURE 3-11
1st Quarter 2007
Sub-Basalt Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

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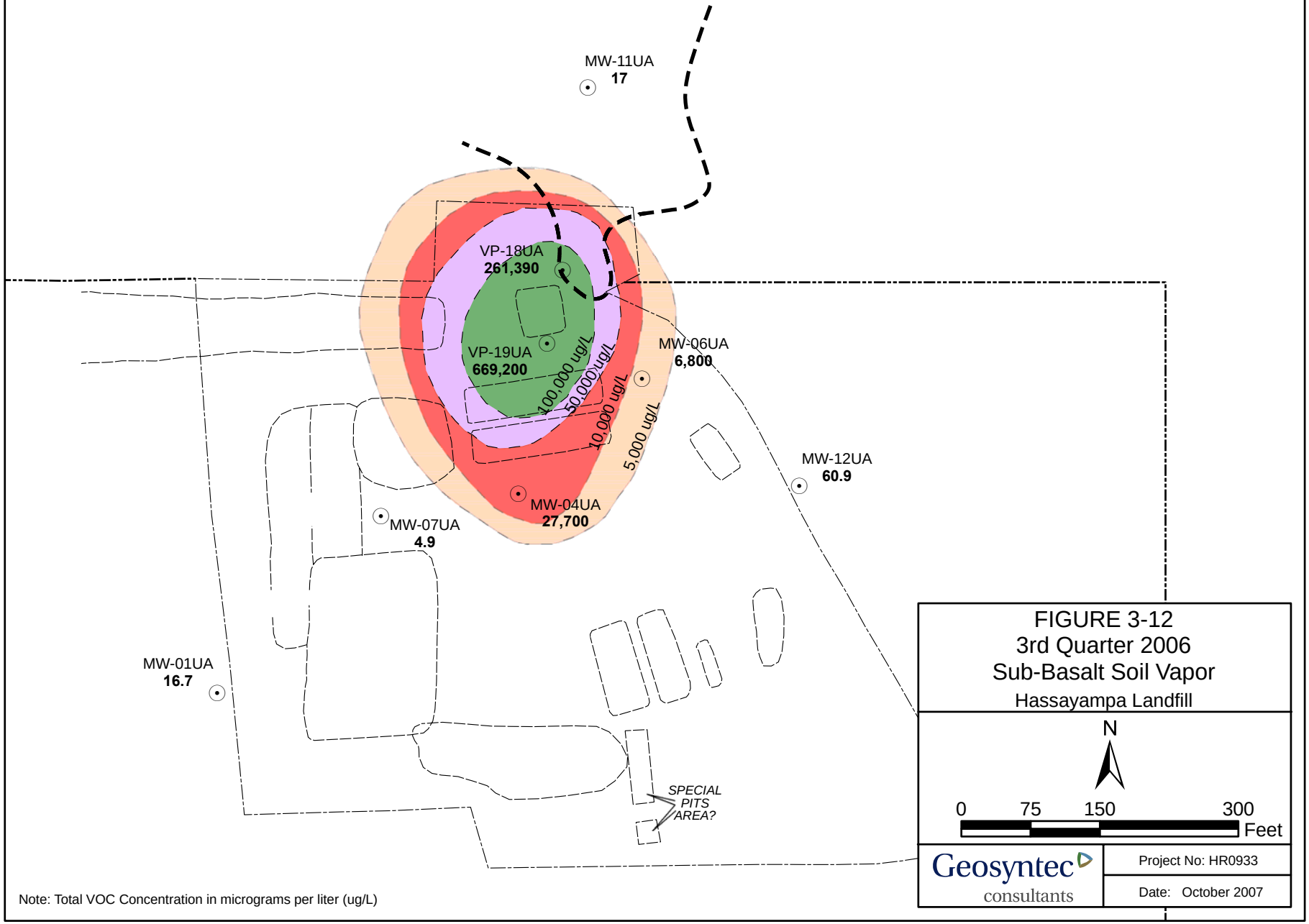

FIGURE 3-12
3rd Quarter 2006
Sub-Basalt Soil Vapor
Hassayampa Landfill

Geosyntec consultants

Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

S:\GIS\HR0933\GIS\GIS files\Projects\3rdqtr_2006TotalVOCs_20060817.mxd sn 200710330

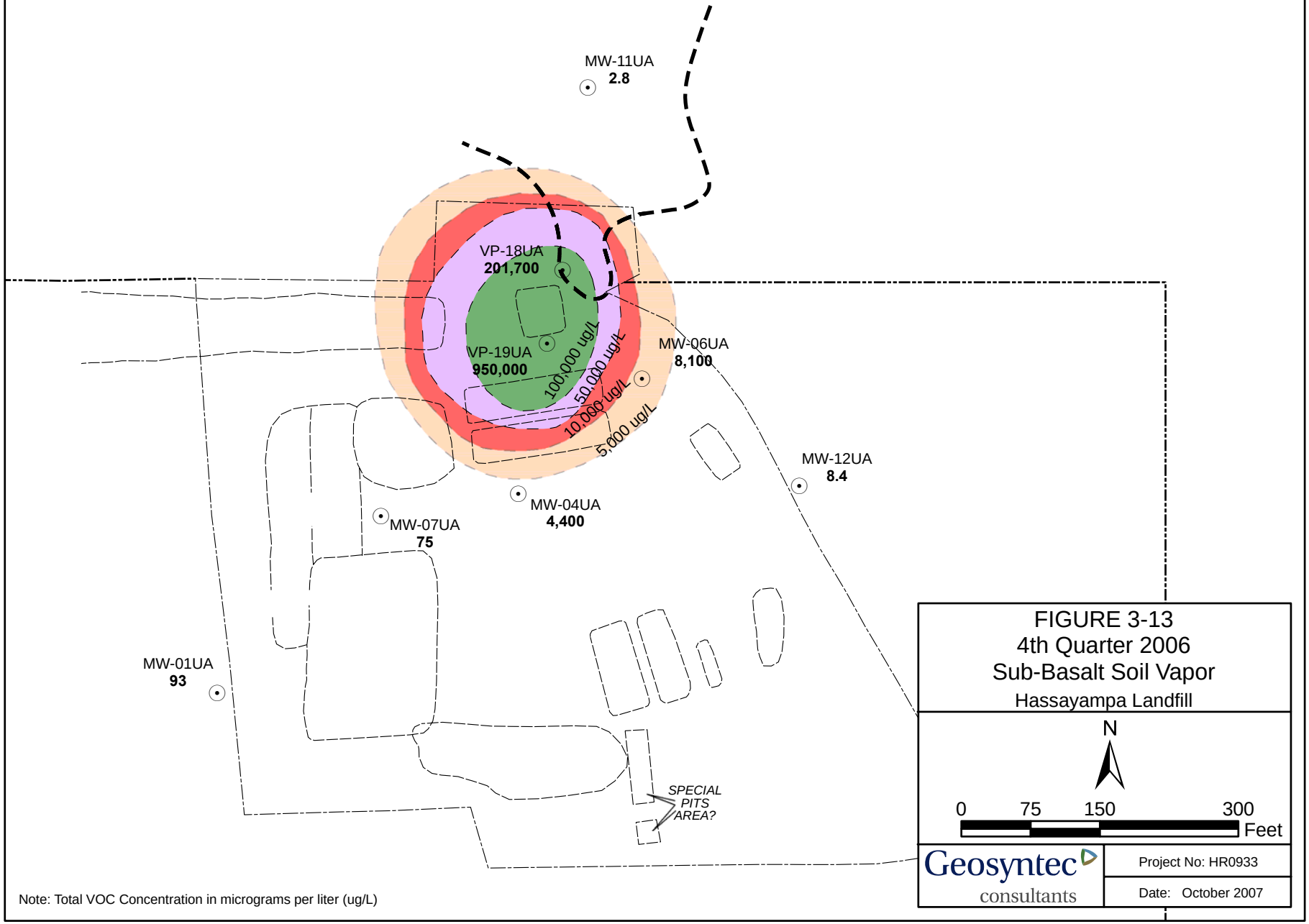

FIGURE 3-13
4th Quarter 2006
Sub-Basalt Soil Vapor
Hassayampa Landfill

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Project No: HR0933

Date: October 2007

Note: Total VOC Concentration in micrograms per liter (ug/L)

S:\GIS\HR0933\GIS\GIS files\Projects\4thQTR_2006TotalVOCs_20061215.mxd sn 20071030

Figure 3-14
PID Measurements
Coarse-Grained Zone Vapor Monitoring Wells

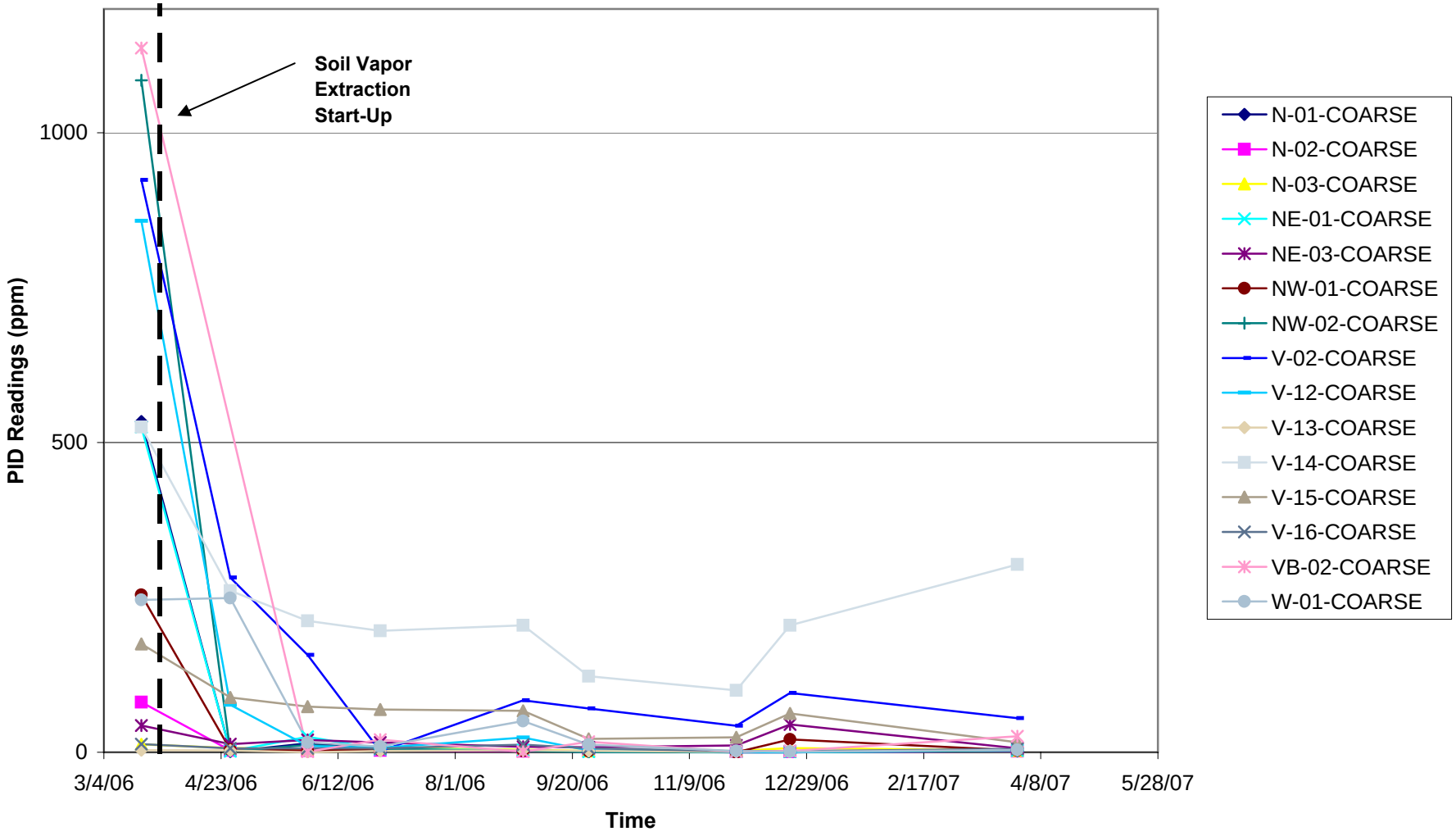


Figure 3-15
PID Measurements
Fine-Grained Zone Vapor Monitoring Wells

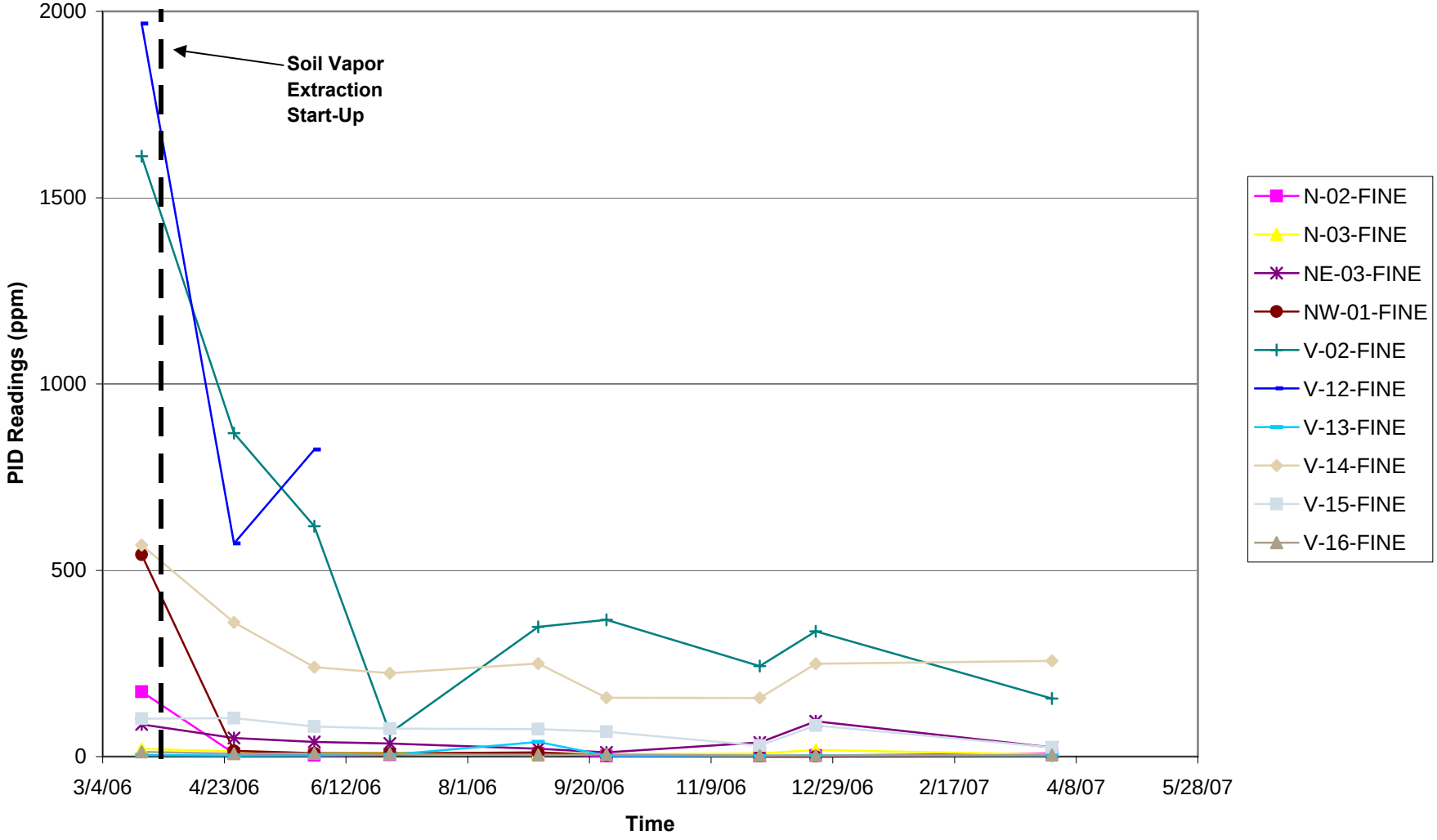
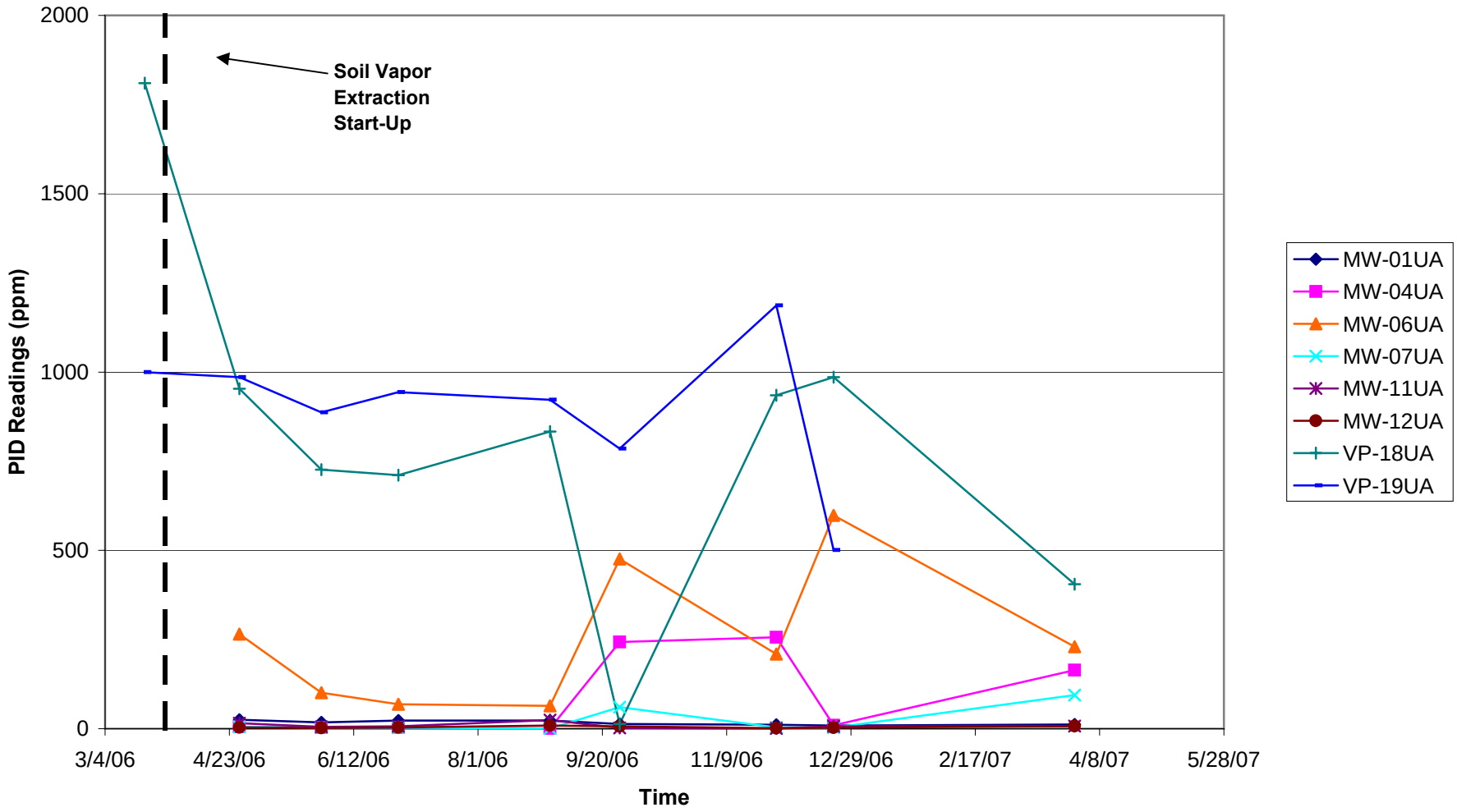
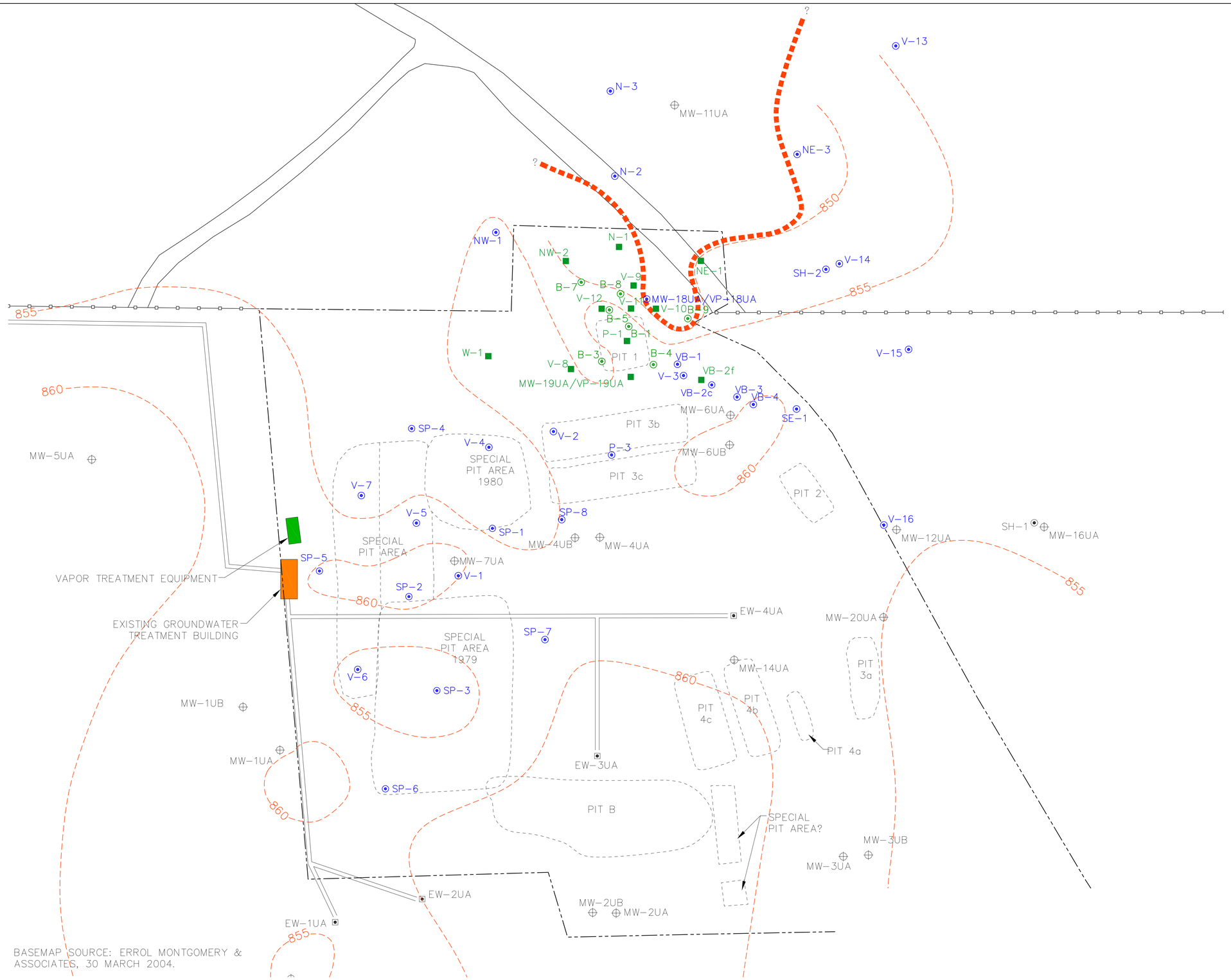


Figure 3-16
PID Measurments
Sub-Basalt Vapor Monitoring Wells





LEGEND

- FORMER HAZARDOUS WASTE DISPOSAL AREA
- FENCE
- TOP OF BASALT (ELEVATION, FEET MSL)
- LIMIT OF BASALT (INTERPRETED)
- MW-11UA — GROUNDWATER MONITORING WELL
- EW-3UA — GROUNDWATER EXTRACTION WELL
- SP-8 — SOIL VAPOR MONITORING PROBE
- SP-1 — SOIL VAPOR EXTRACTION WELL
- B-3 — PHASE I SOIL BORING
- EXISTING GROUNDWATER TREATMENT BUILDING
- VAPOR TREATMENT EQUIPMENT
- WATER CONVEYANCE LINE

NOTES

1. MW-18UA/VP-18UA WAS DRILLED AS A CONTINUATION OF BORING B-6.
2. MW-19UA/VP-19UA WAS DRILLED AS A CONTINUATION OF BORING B-2.

N

50 25 0 50 100
SCALE IN FEET

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ELEVATION OF BASALT
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4-1
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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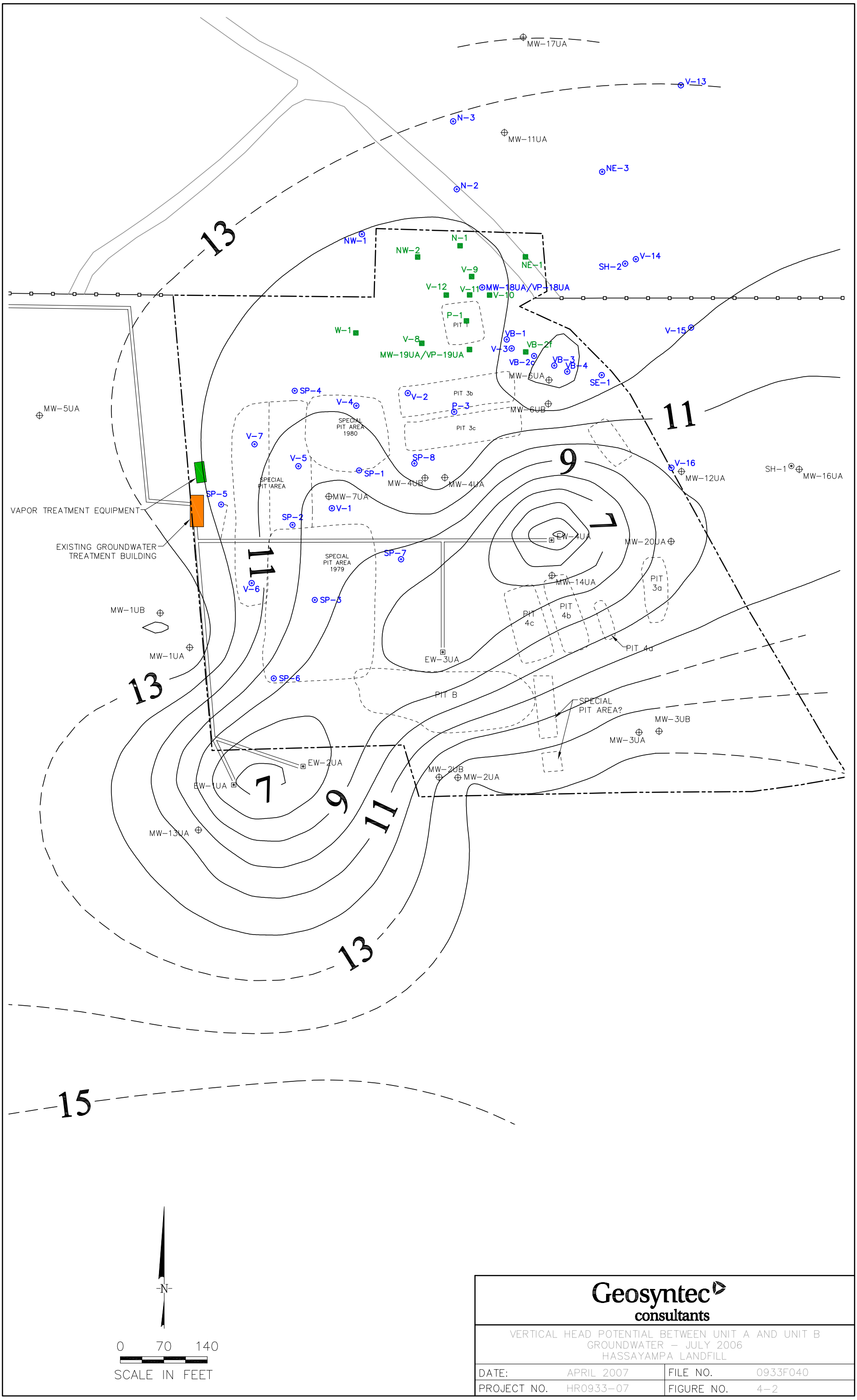

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VERTICAL HEAD POTENTIAL BETWEEN UNIT A AND UNIT B
GROUNDWATER – JULY 2006
HASSAYAMPA LANDFILL

DATE:	APRIL 2007	FILE NO.	0933F040
PROJECT NO.	HR0933-07	FIGURE NO.	4-2

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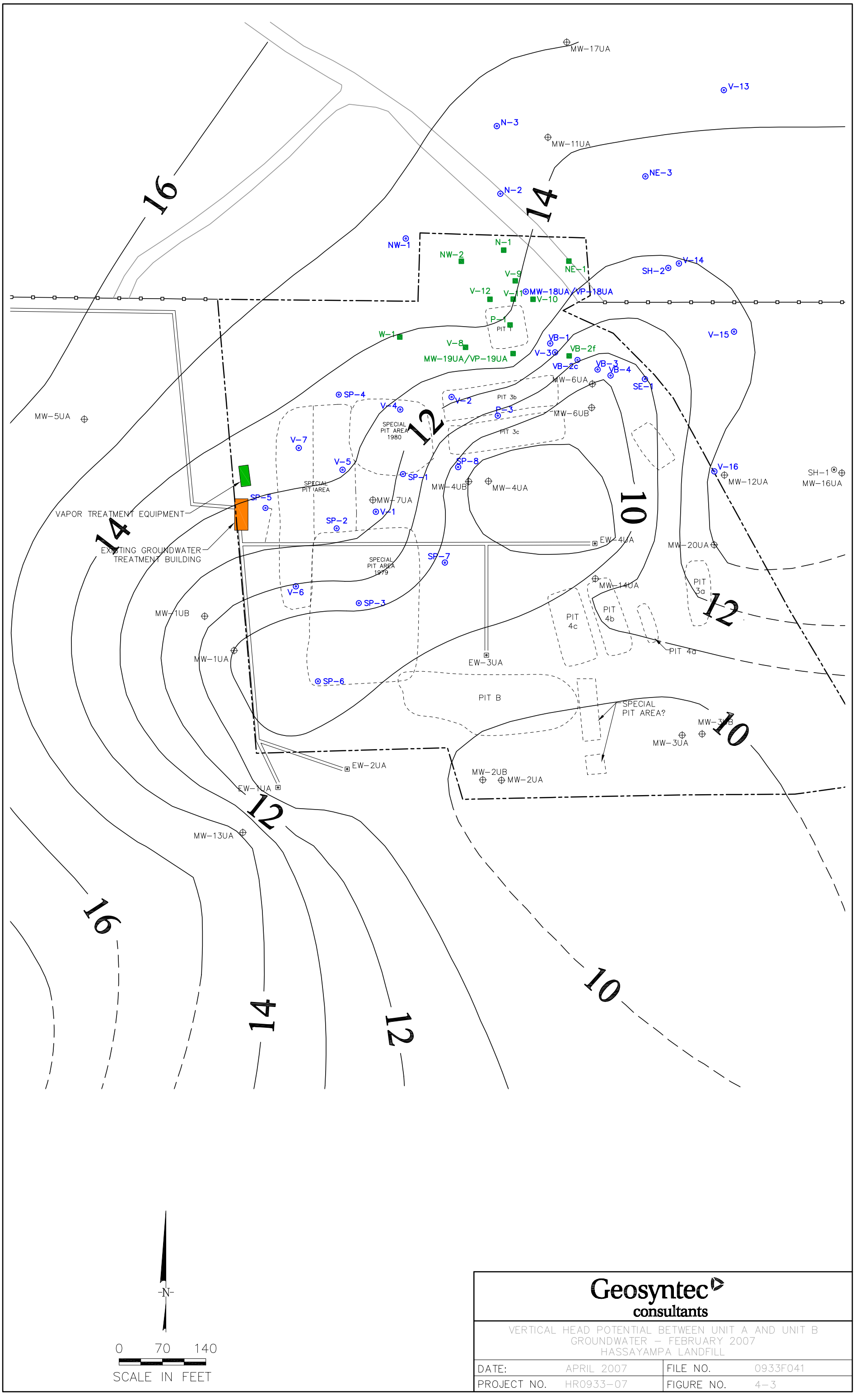

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VERTICAL HEAD POTENTIAL BETWEEN UNIT A AND UNIT B
GROUNDWATER – FEBRUARY 2007
HASSAYAMPA LANDFILL

DATE:	APRIL 2007	FILE NO.	0933F041
PROJECT NO.	HR0933-07	FIGURE NO.	4-3

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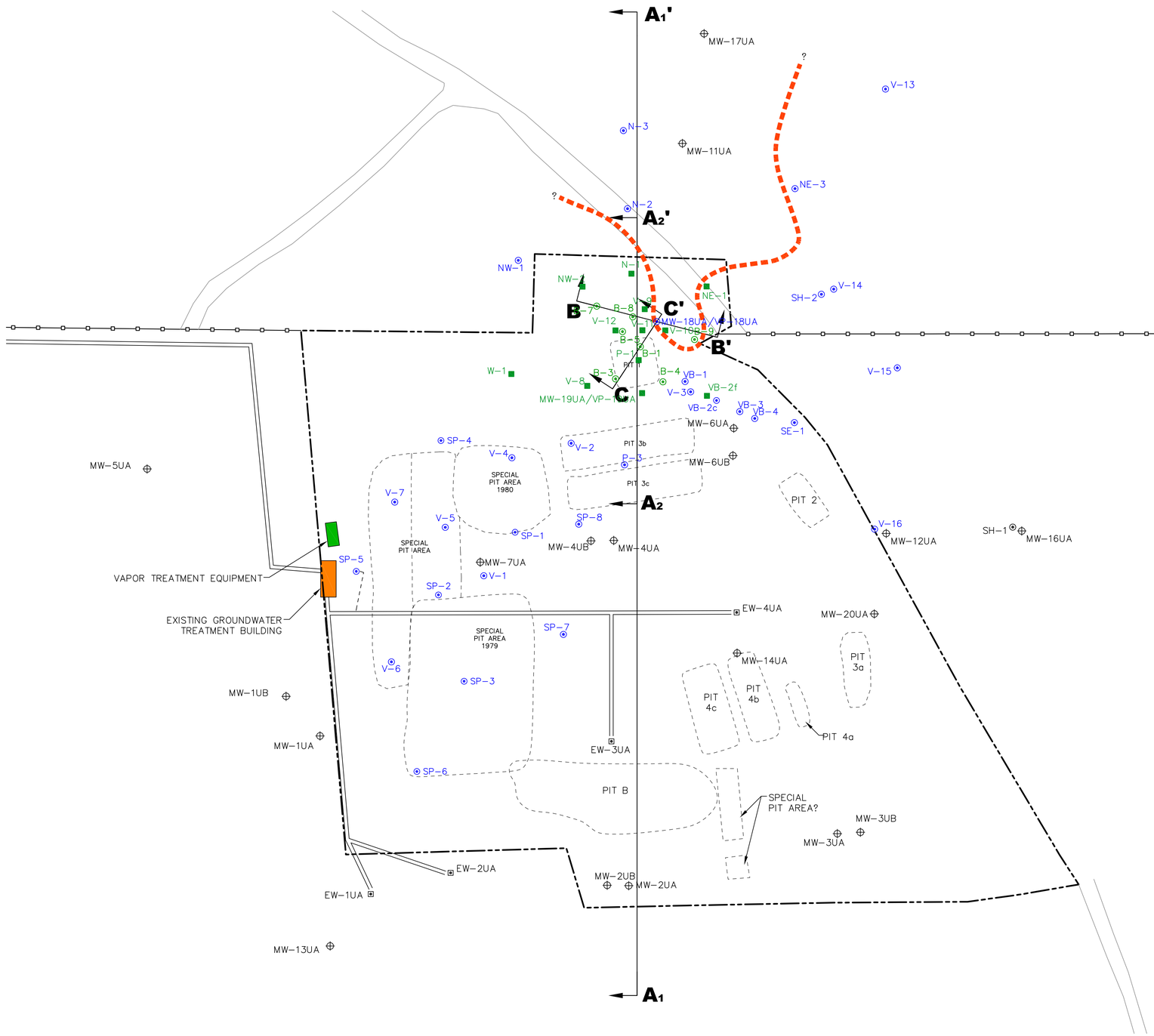

LEGEND

	FORMER HAZARDOUS WASTE DISPOSAL AREA
	FENCE
MW-16UA	GROUNDWATER MONITORING WELL
EW-3UA	GROUNDWATER EXTRACTION WELL
SP-8	SOIL VAPOR MONITORING PROBE
SP-1	SOIL VAPOR EXTRACTION WELL
B-3	PHASE I SOIL BORING
	LIMIT OF BASALT (INTERPRETED)
	EXISTING GROUNDWATER TREATMENT BUILDING
	VAPOR TREATMENT EQUIPMENT
	WATER CONVEYANCE LINE

SOURCE: ERROL MONTGOMERY & ASSOCIATES, 30 MARCH 2004.

Geosyntec consultants

PLAN VIEW AND CROSS SECTION LOCATIONS
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4-4
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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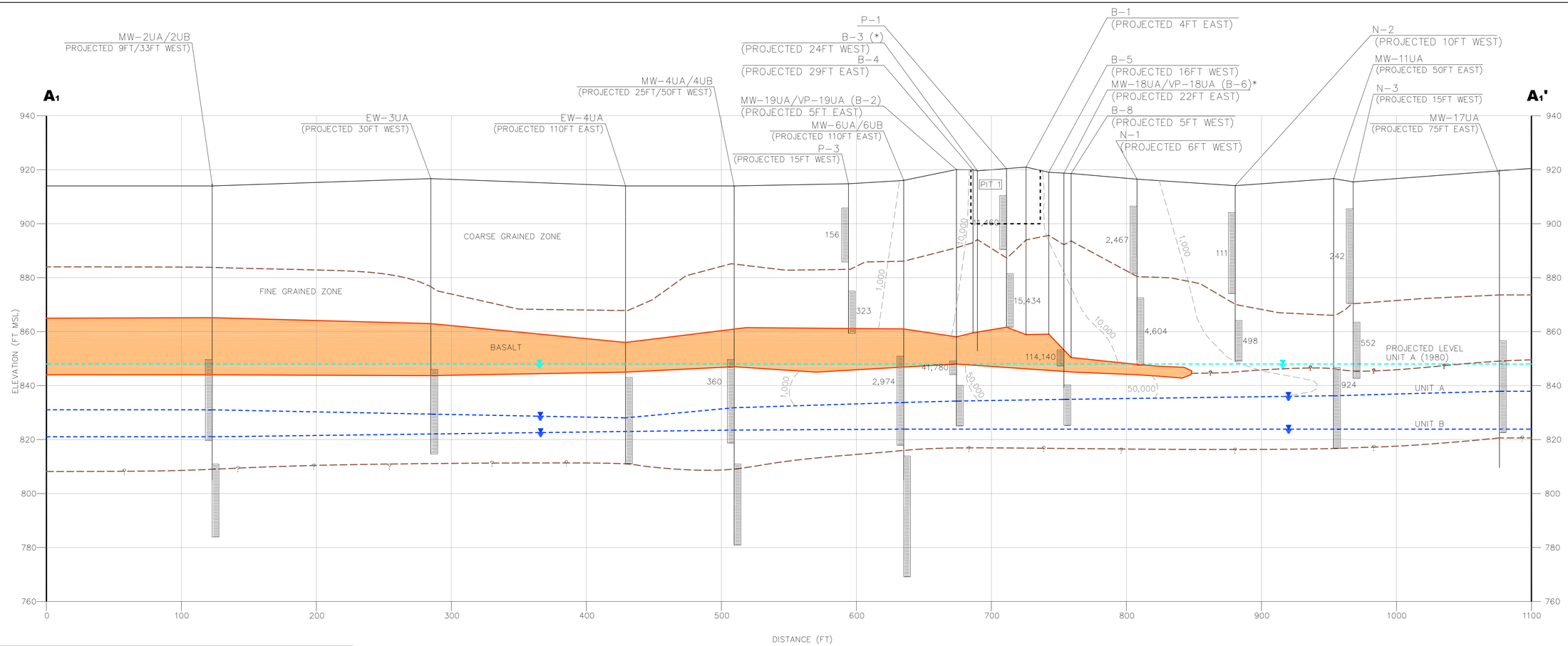
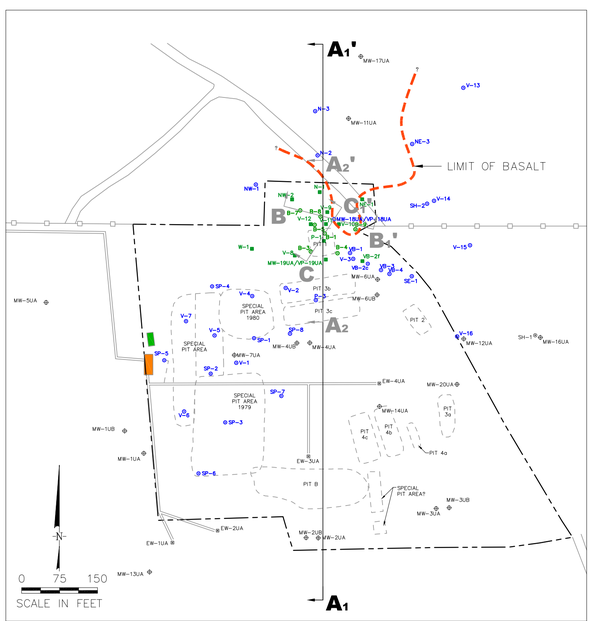




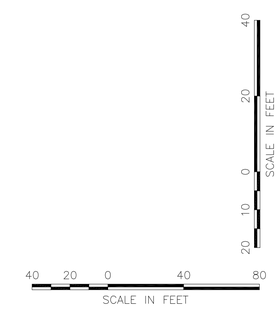
CROSS SECTION A–A' LOCATION AND SITE PLAN.

LEGEND

- LITHOLOGIC CONTACT
- PROJECTED POTENTIOMETRIC SURFACE (1980)
- POTENTIOMETRIC SURFACE (MARCH 2007)
- GROUND SURFACE
- BASALT BOUNDARY
- 1,000 — VOC SOIL VAPOR CONCENTRATION CONTOUR (ug/L)
- SCREEN INTERVAL
- 2,467 — TOTAL VOC CONCENTRATION IN SOIL VAPOR (ug/L), FEB 2007
- FT MSL — FEET ABOVE MEAN SEA LEVEL

NOTES:
BORINGS B-7 AND B-9 NOT SHOWN ON SECTION.

(*) BORINGS B-3 AND B-6 NOT USED TO INFER BASALT ELEVATION.



Geosyntec consultants	CROSS SECTION A1–A1' TOTAL VOC SOIL VAPOR CONCENTRATIONS (FEB 2007) HASSAYAMPA LANDFILL MARICOPA COUNTY, ARIZONA	FIGURE NO. 4–5 PROJECT NO. HR0933 DOCUMENT NO. DATE: OCTOBER 2007

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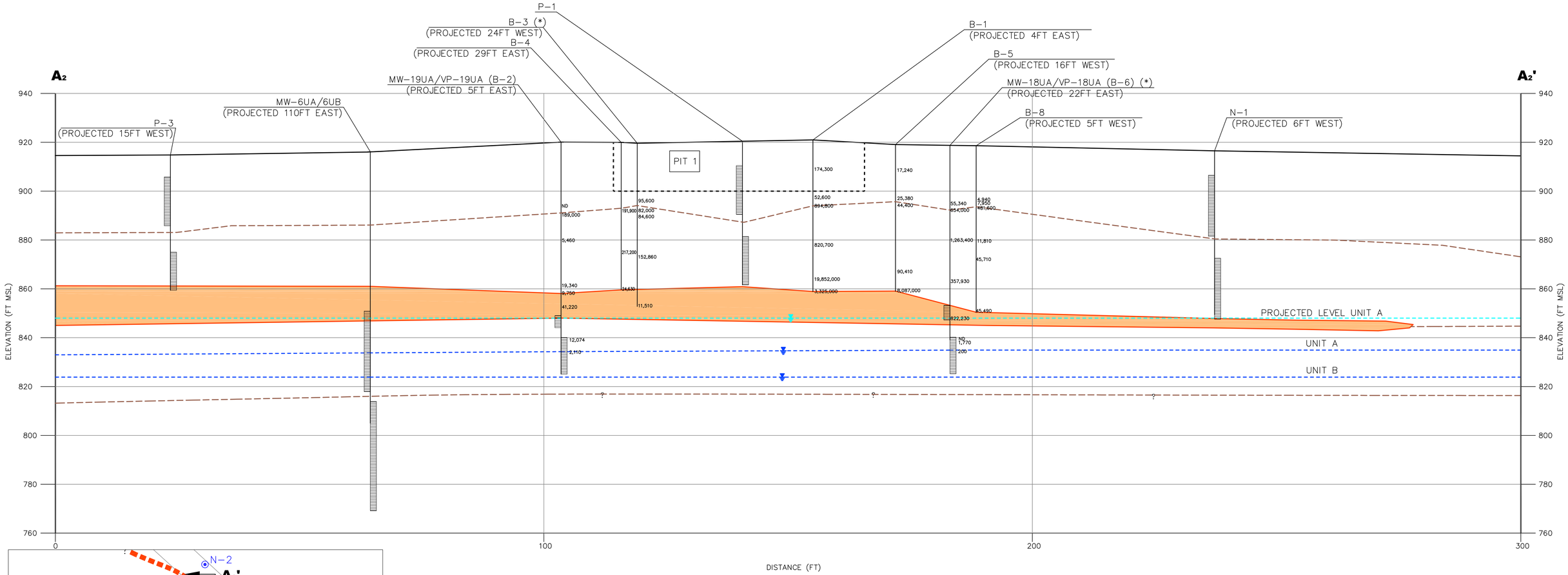

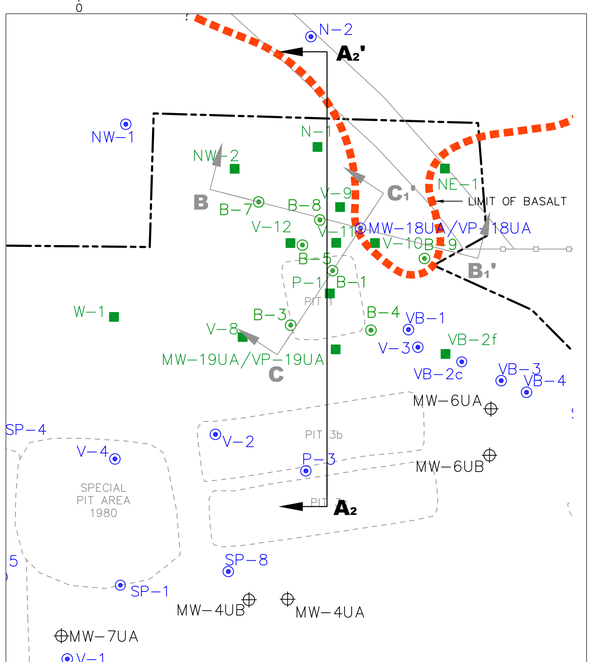

CROSS SECTION A2–A2' LOCATION AND SITE PLAN.

LEGEND

- LITHOLOGIC CONTACT
- PROJECTED POTENTIOMETRIC SURFACE (1980)
- POTENTIOMETRIC SURFACE (MARCH 2007)
- GROUND SURFACE
- BASALT BOUNDARY
- 5,460 — SCREEN INTERVAL; TOTAL VOC CONCENTRATION IN SOIL (ug/kg), JAN/FEB 2007
- FT MSL — FEET ABOVE MEAN SEA LEVEL

NOTES:
BORINGS B-7 AND B-9 NOT SHOWN ON SECTION

(*) BORINGS B-3 AND B-6 NOT USED TO INFER BASALT ELEVATION. BASALT NOT PRESENT AT B-6 LOCATION.

ND =NOT DETECTED ABOVE LABORATORY REPORTING LIMITS.

SCALE IN FEET: 10 5 0 10 20

SCALE IN FEET: 20 10 0 20 40

Geosyntec consultants

CROSS SECTION A2–A2'
TOTAL VOC SOIL CONCENTRATIONS (JAN/FEB 2007)
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4-6
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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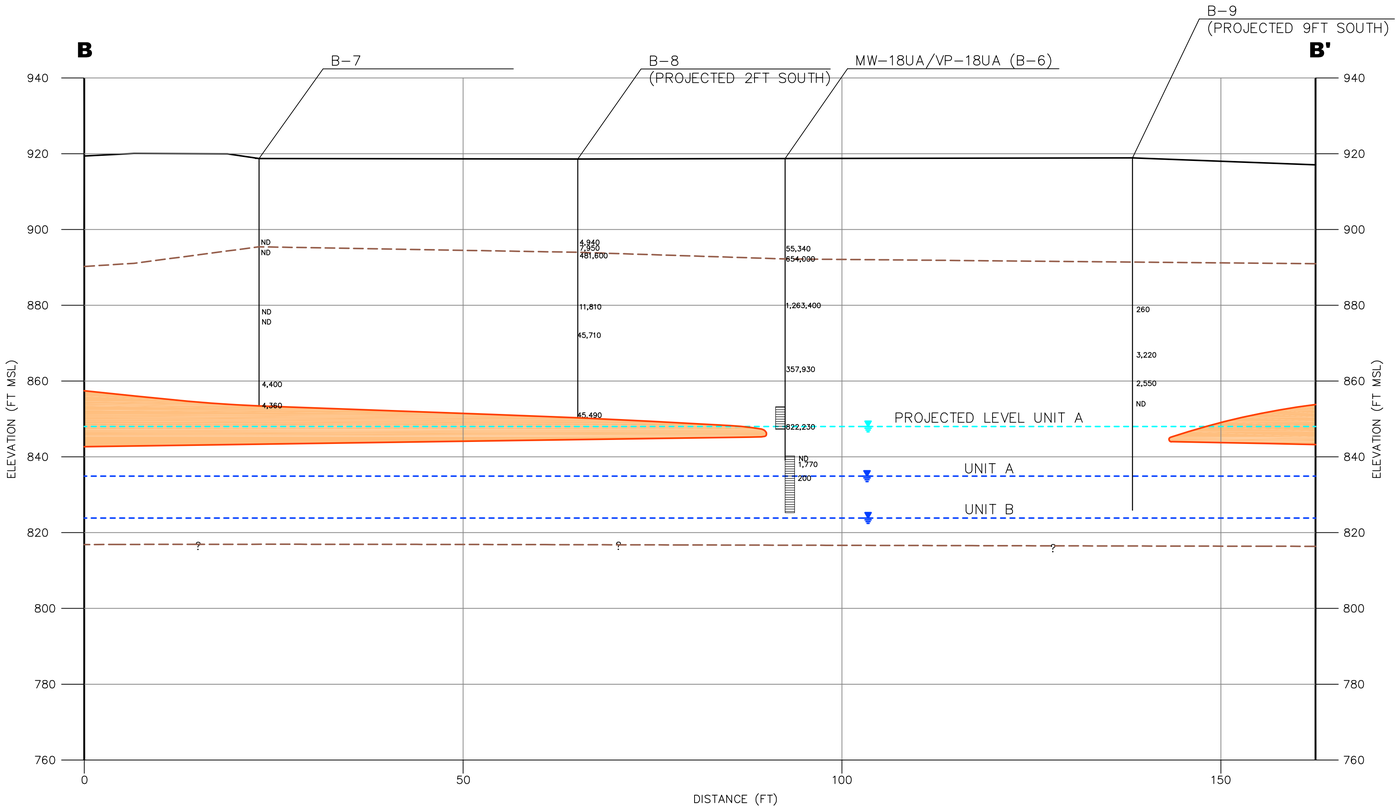
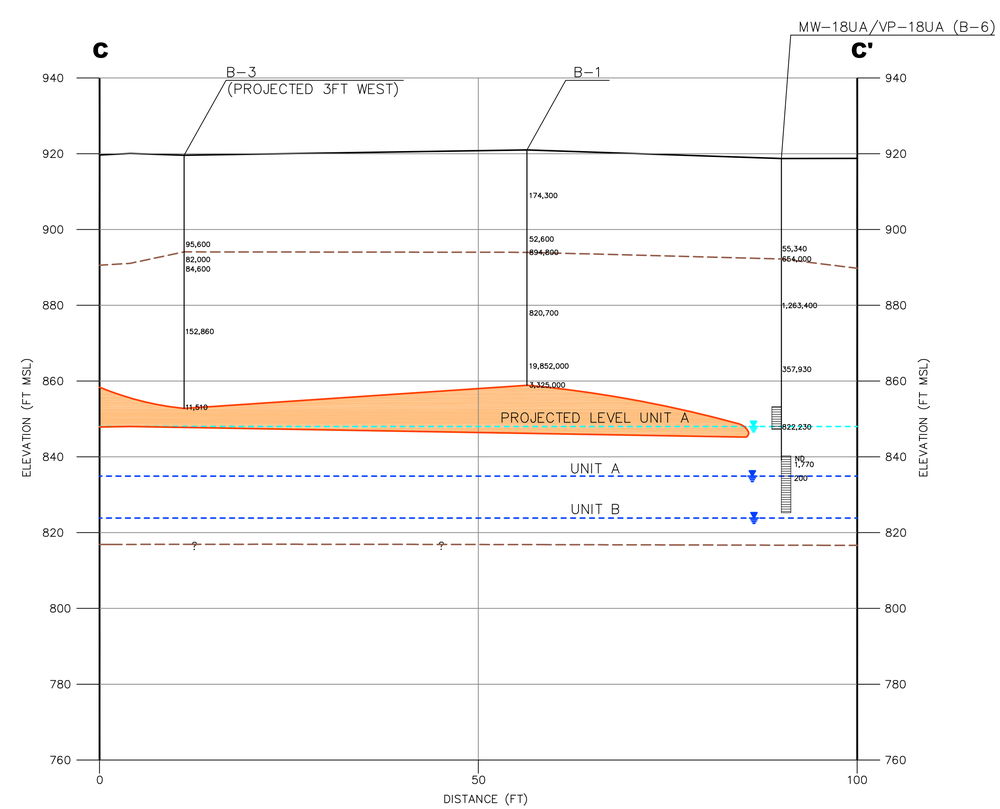
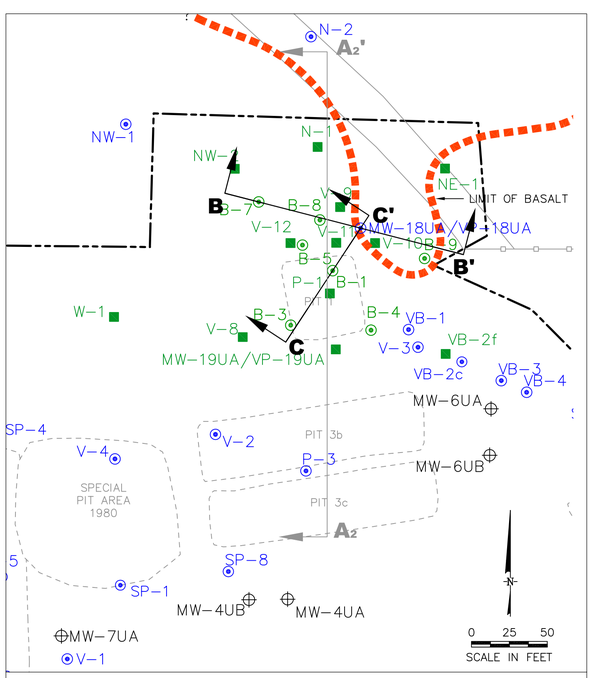




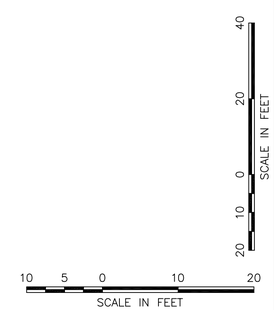


CROSS SECTIONS B–B' AND C–C' LOCATIONS AND SITE PLAN.

LEGEND

	LITHOLOGIC CONTACT
	PROJECTED POTENTIOMETRIC SURFACE (1980)
	POTENTIOMETRIC SURFACE (MARCH 2007)
	GROUND SURFACE
	BASALT BOUNDARY
4,400	SCREEN INTERVAL TOTAL VOC CONCENTRATION IN SOIL (ug/kg), JAN/FEB 2007
FT MSL	FEET ABOVE MEAN SEA LEVEL

NOTE:
ND =NOT DETECTED ABOVE LABORATORY REPORTING LIMITS.



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CROSS SECTION B–B' AND C–C'
TOTAL VOC SOIL CONCENTRATIONS (JAN/FEB 2007)
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

FIGURE NO.	4–7
PROJECT NO.	HR0933
DOCUMENT NO.	
DATE:	OCTOBER 2007

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Figure 4-8
Total VOC Concentrations in Soil Vapor and Groundwater - MW-01UA
Hassayampa Landfill

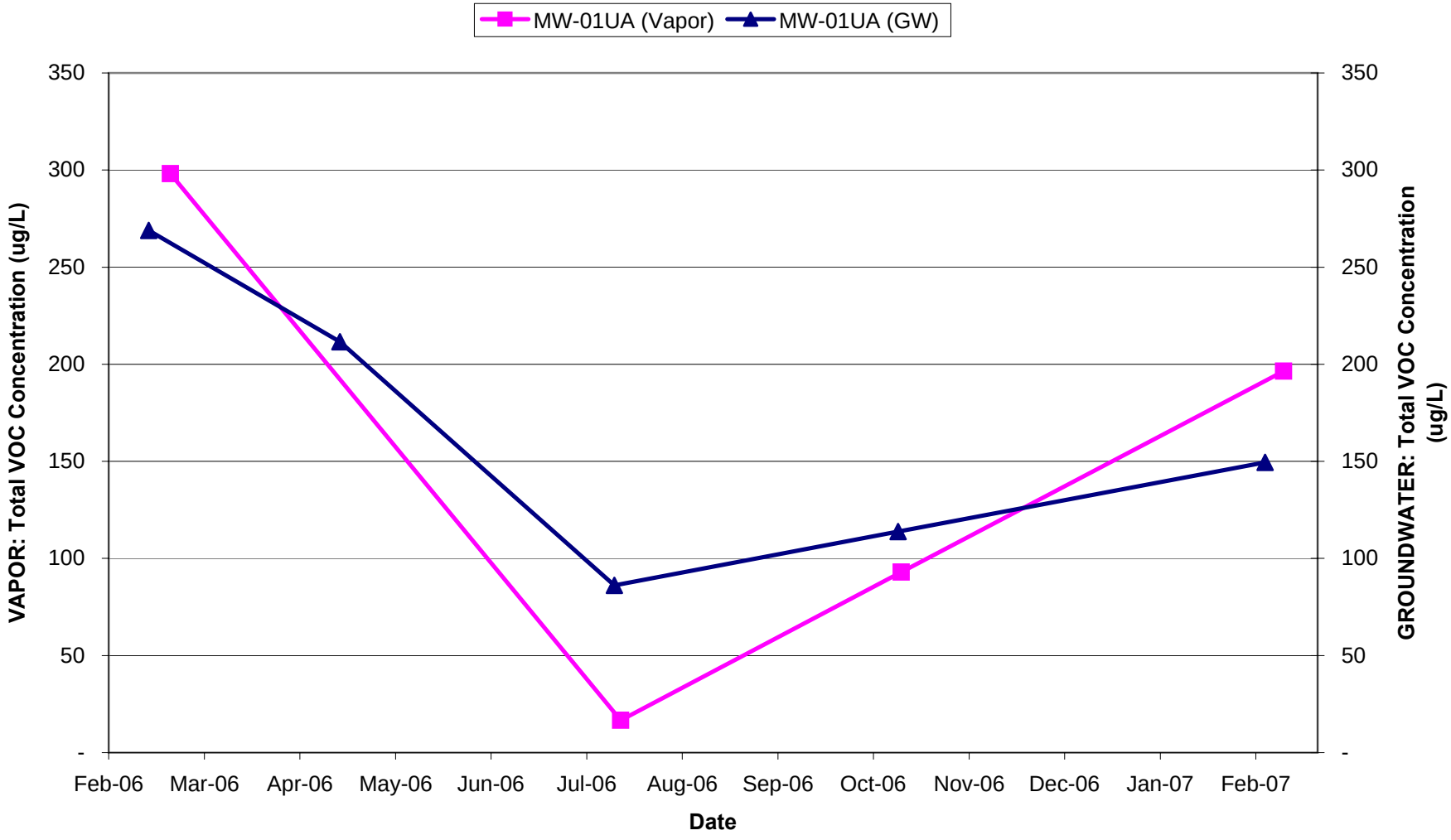


Figure 4-9
Total VOC Concentrations in Soil Vapor and Groundwater - MW-04UA
Hassayampa Landfill

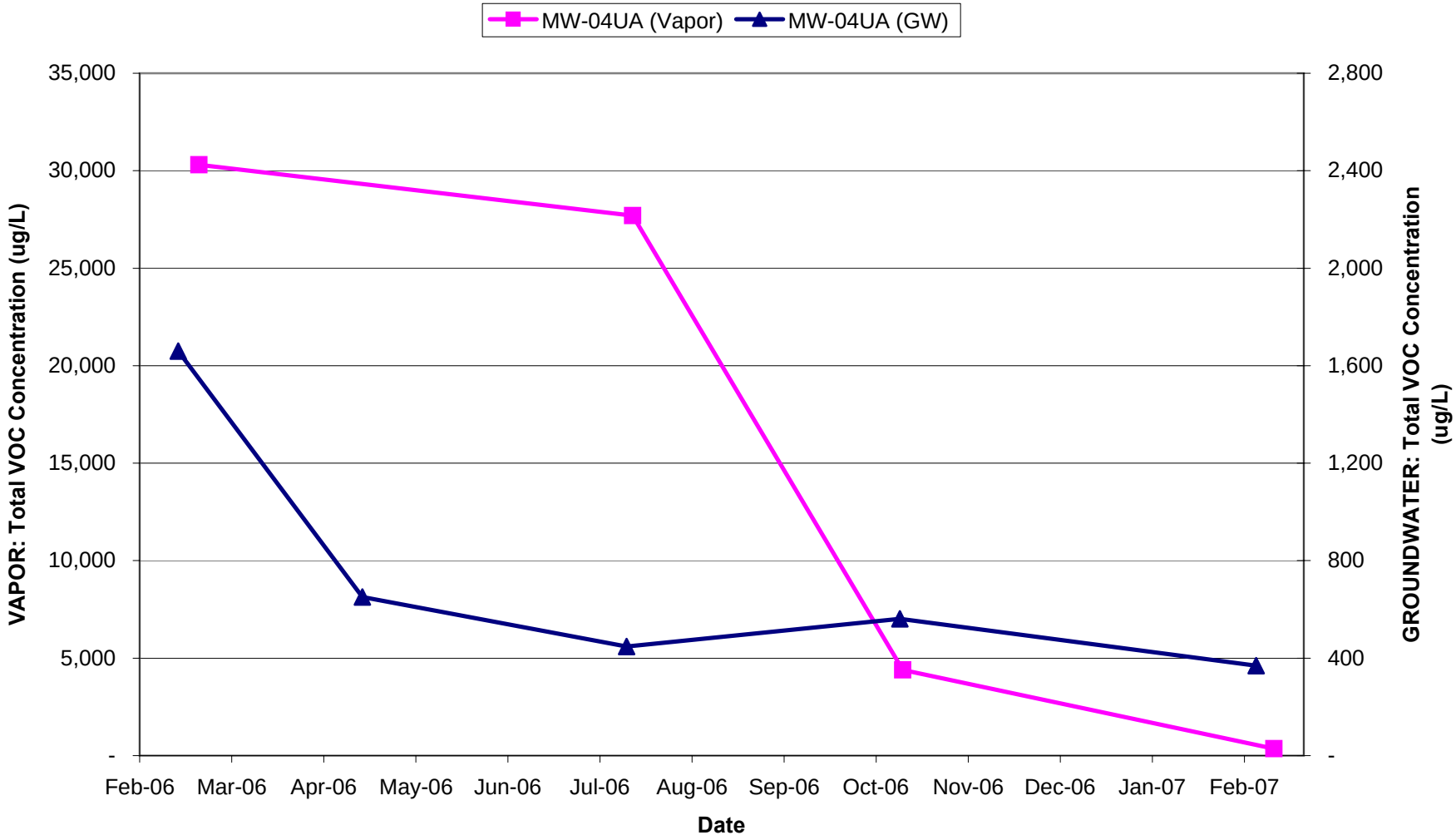


Figure 4-10
Total VOC Concentrations in Soil Vapor and Groundwater - MW-06UA
Hassayampa Landfill

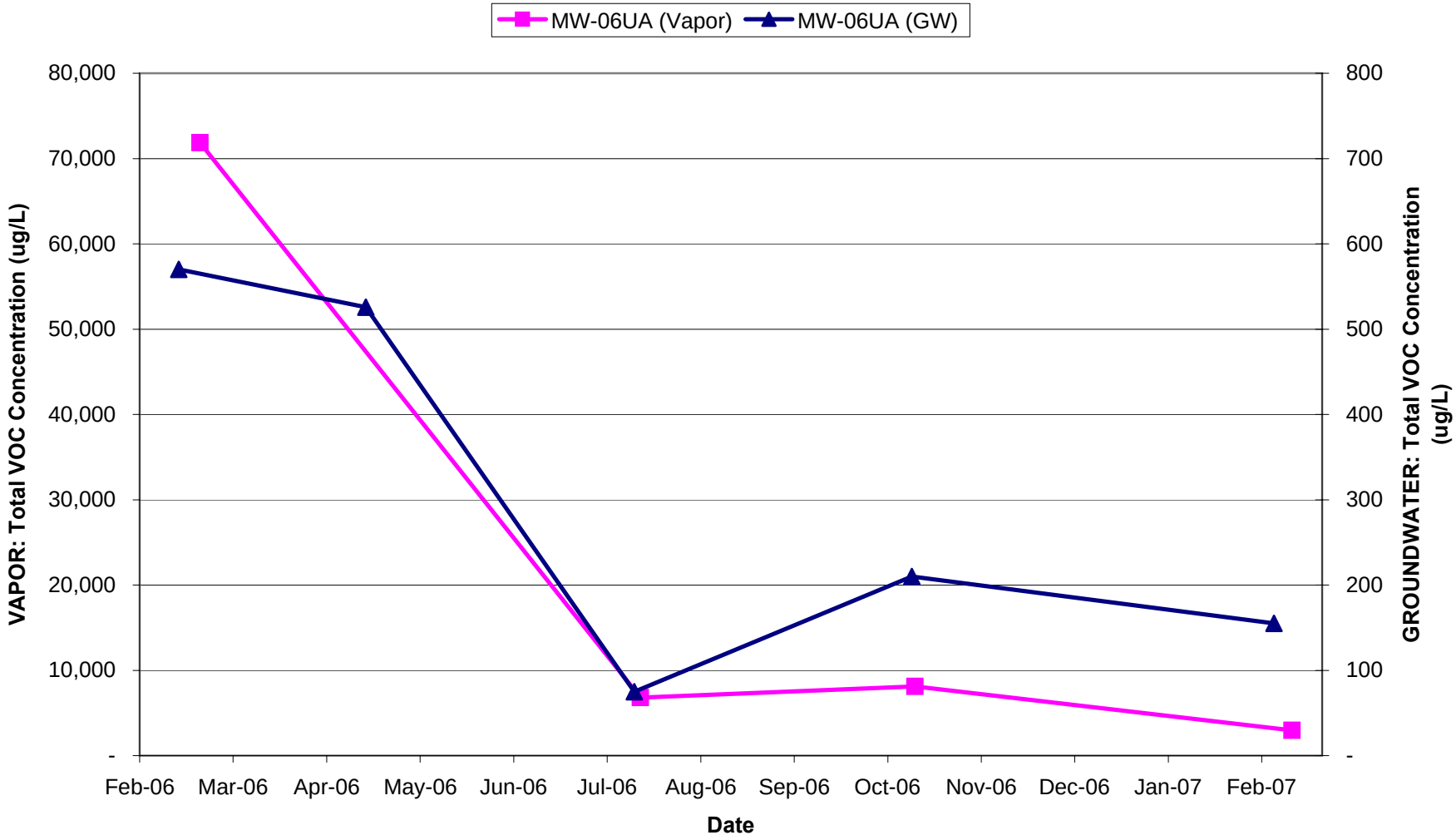


Figure 4-11
Total VOC Concentrations in Soil Vapor and Groundwater - MW-07UA
Hassayampa Landfill

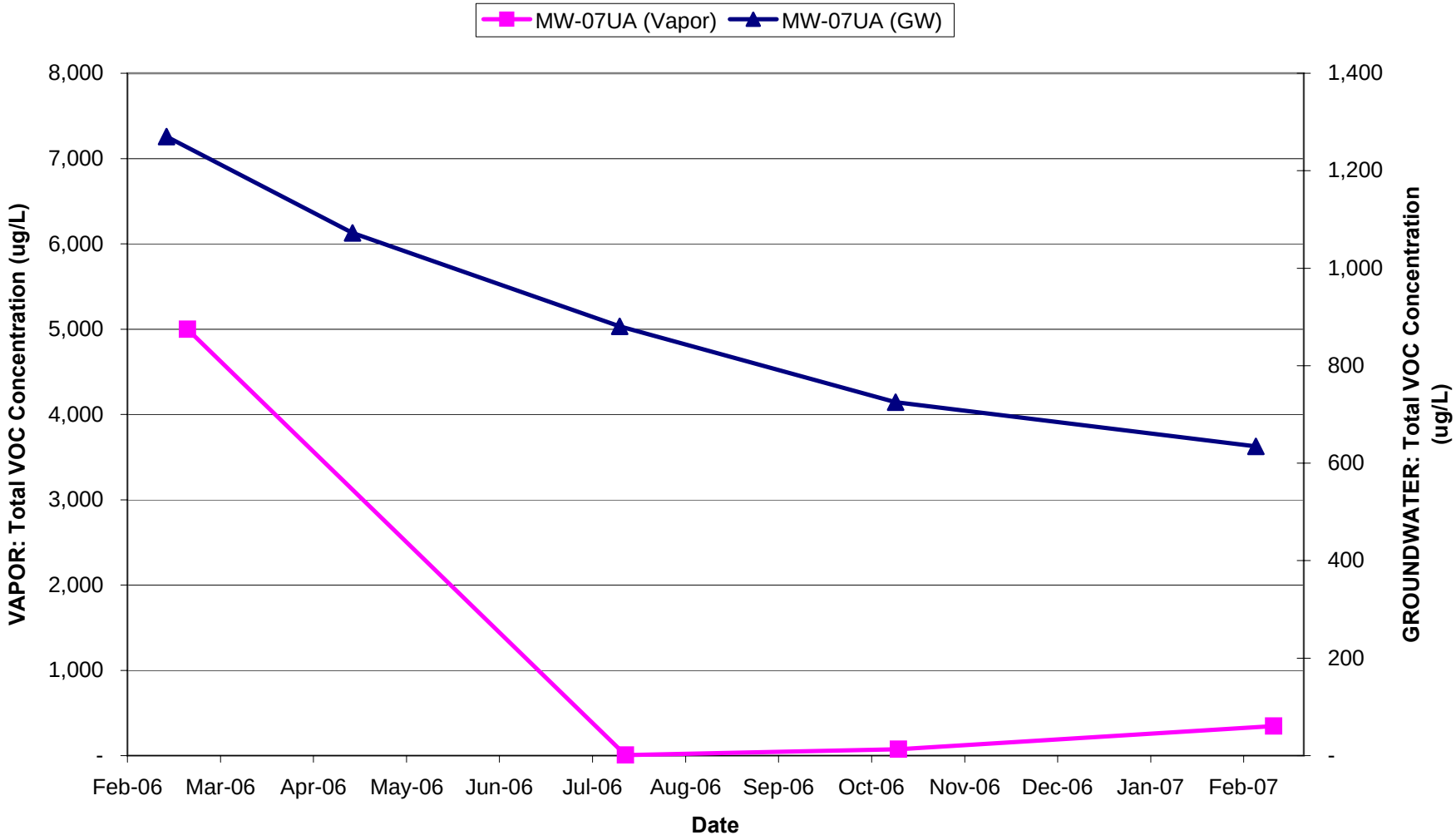


Figure 4-12
Total VOC Concentrations in Soil Vapor and Groundwater - MW-11UA
Hassayampa Landfill

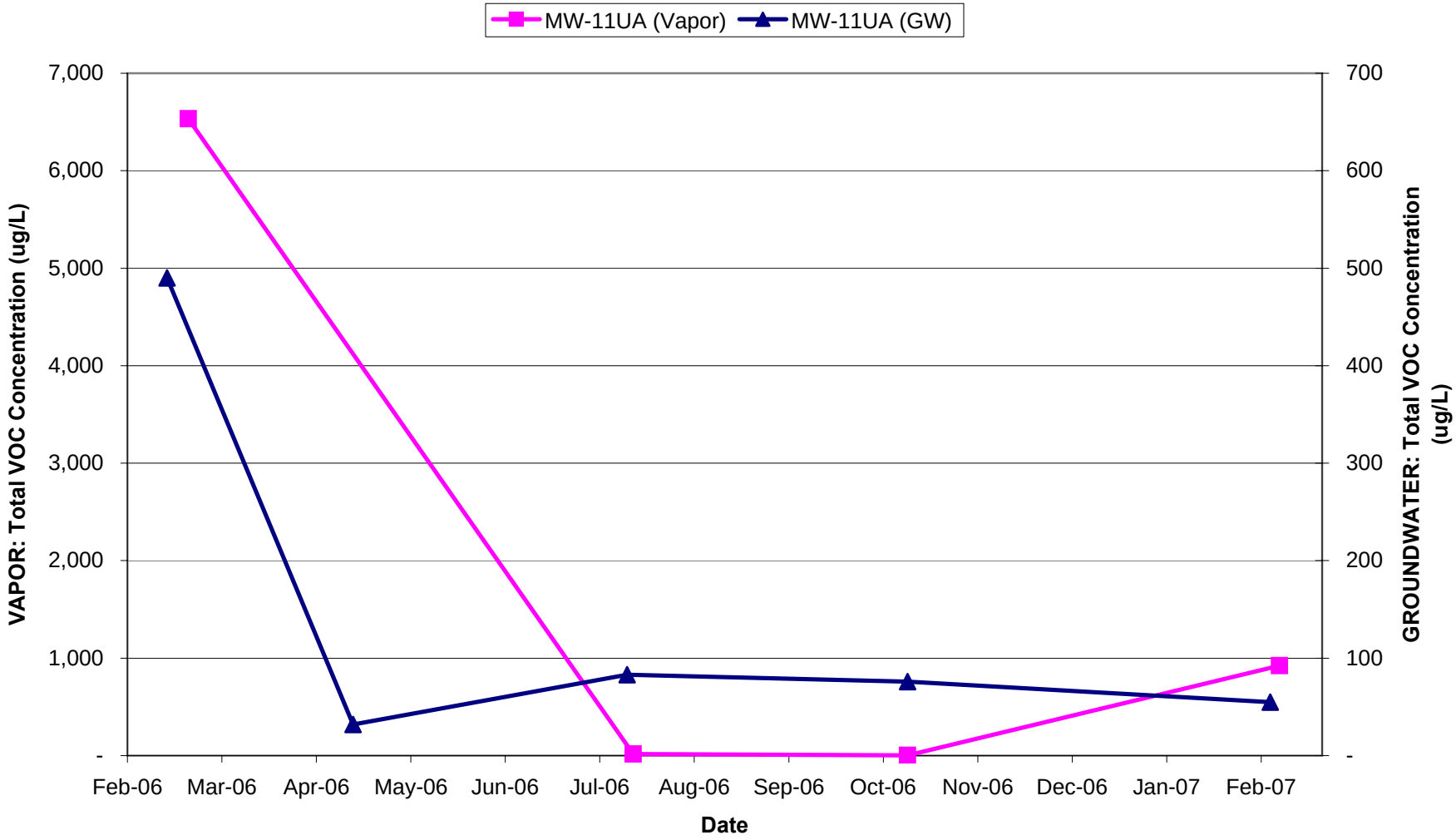


Figure 4-13
Total VOC Concentrations in Soil Vapor and Groundwater - MW-12UA
Hassayampa Landfill

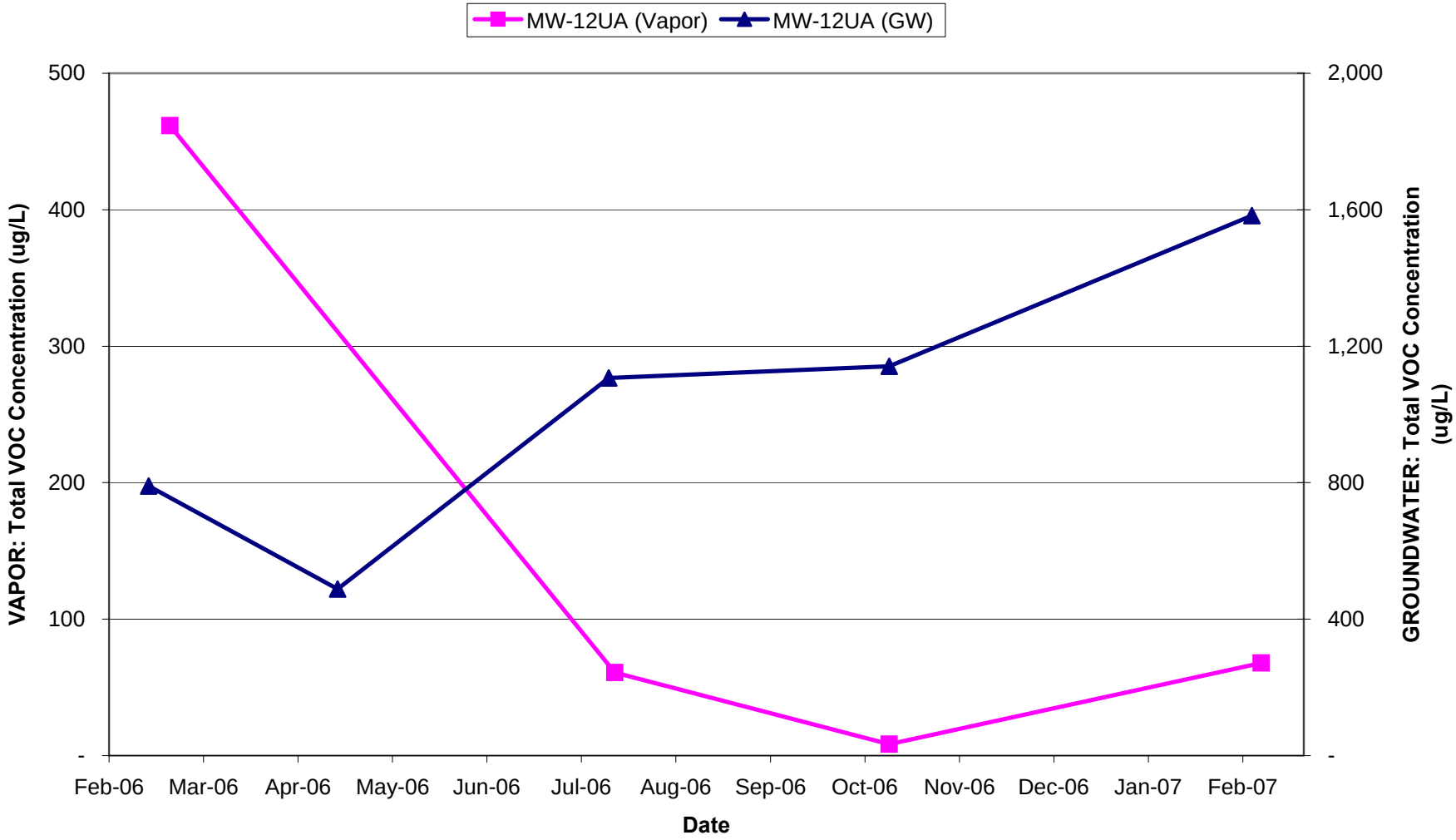


Figure 4-14
Total VOC Concentrations in Soil Vapor and Groundwater - VP-18UA / MW-18UA
Hassayampa Landfill

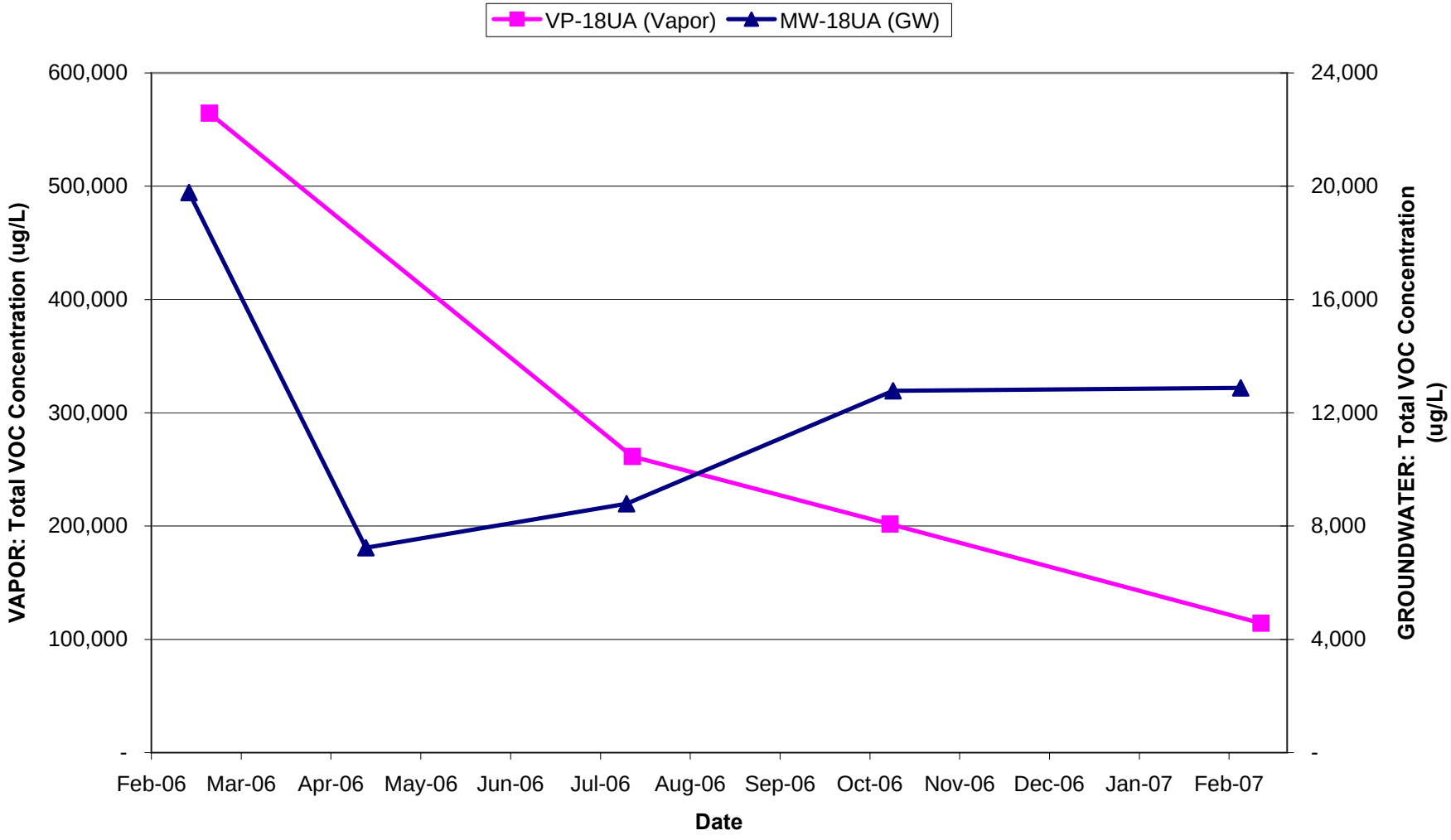
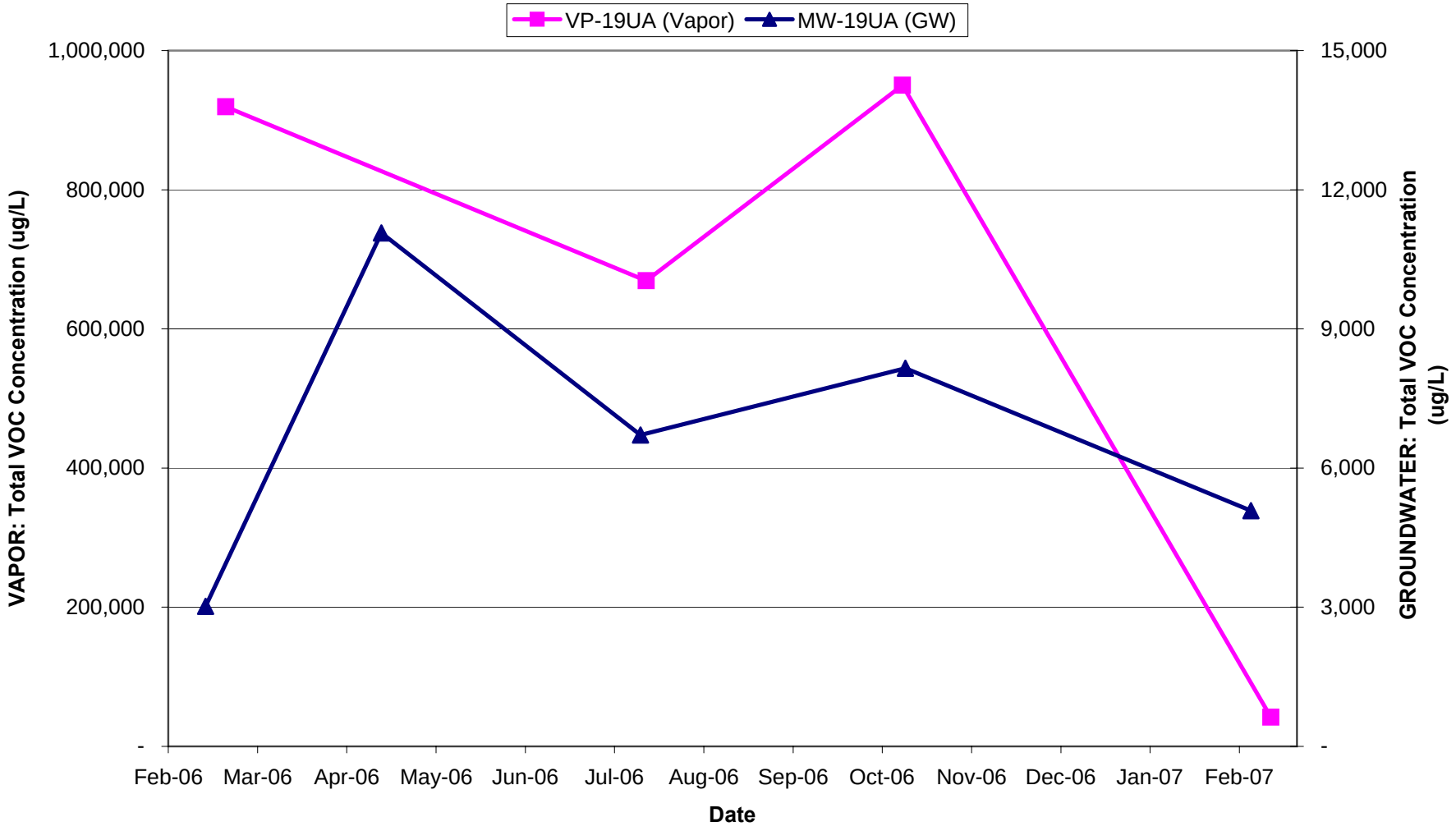
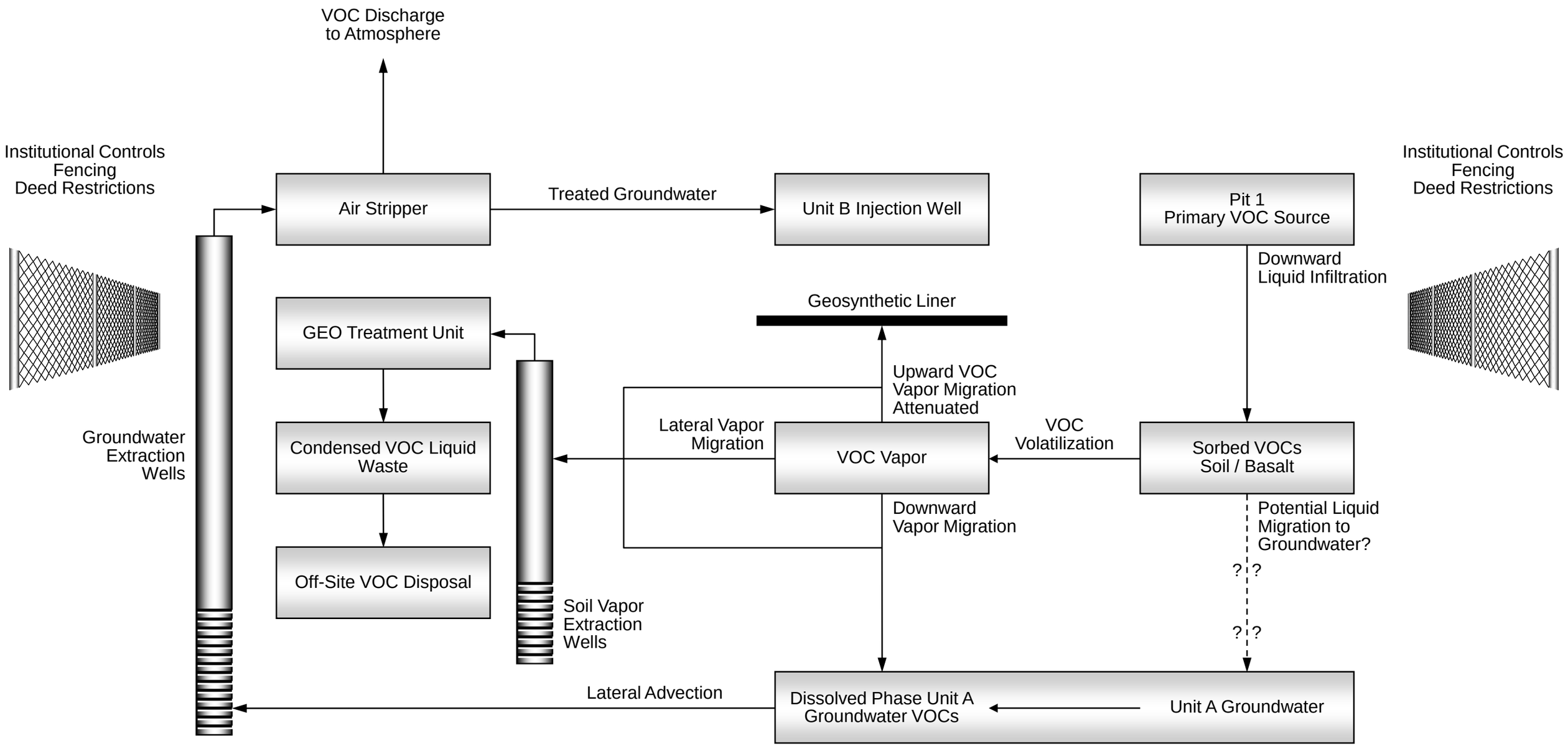


Figure 4-15
Total VOC Concentrations in Soil Vapor and Groundwater - VP-19UA / MW-19UA
Hassayampa Landfill



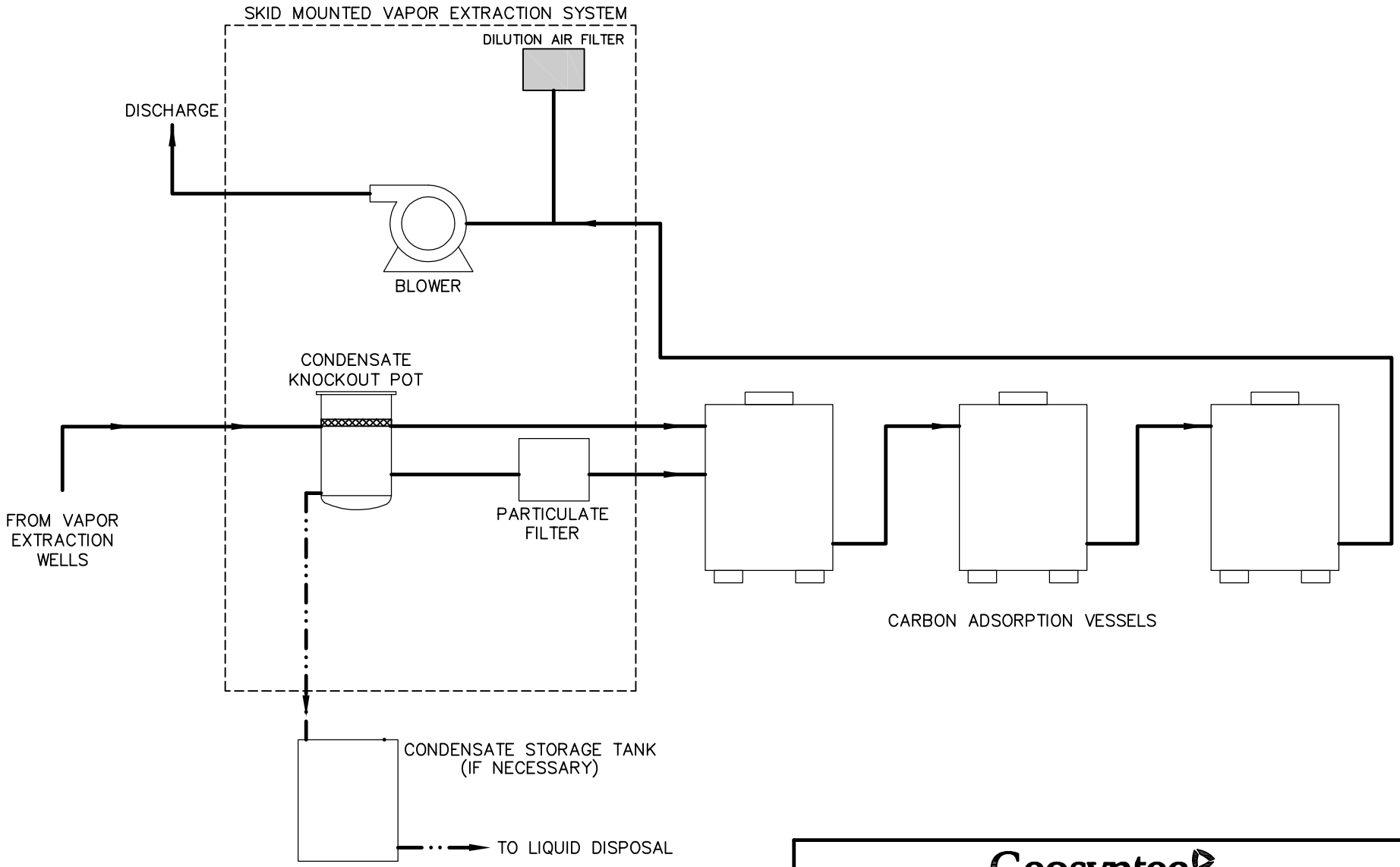


VOC Fate & Transport
Updated Site Conceptual Model
Hassayampa Superfund Site

Geosyntec consultants
engineers | scientists | innovators

Figure 4-16

HR0933-01\HAS07-15.FIG.PPT



Geosyntec consultants

GAC SYSTEM PROCESS FLOW DIAGRAM
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

DATE:	OCTOBER 2007	FILE NO.	0933F037
PROJECT NO.	HR0933-07	FIGURE NO.	5-1

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Geosyntec consultants

Appendix B: Phase I Borehole Logs / Well Construction Details

LITHOLOGIC LOG FOR SOIL BORING B-1

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0-1	ML-Fill	Sandy SILT, trace Gravel, 85% silt, 10% sand, 5% gravel, medium brown, loose, non-plastic; sand, coarse grained grading to fine-grained; slightly moist. Slight reaction to HCl. HDPE Liner at 1 foot.
1-10.5	SP	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained.
10.5-15		Non-native fill. Reddish sandy matrix.
15-27	SP	SAND with Silt, 90% sand, 10% silt, brownish-red, very dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl. At 25 -26 feet: CO_3 cemented.
27-62	SM	Silty SAND Silt, 55% sand, 45% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl. From 32.5- to 62 feet: lenses of CO_3 cemented silty sand and clayey-silt, hard.
62 -TD	Basalt	Basalt, black with white and brown, massive, vesicular, predominantly un-weathered, with some weathering near upper contact and some calcite filling in vesicles, reacts to HCL.

TOTAL DEPTH = 62.1 feet

LITHOLOGIC LOG FOR SOIL BORING B-2

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0 - 2	ML-Fill	Sandy SILT, 85% silt, 15% sand, medium brown, loose, non-plastic; sand, medium to fine-grained; slightly moist. Slight reaction to HCl. HDPE Liner at 2 feet.
2 - 13	SM	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. CO_3 cemented. Reacts strongly with HCl.
13 - 14	SW/SM	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. No reaction with HCl.
14 - 17	SM/GM	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Increase in gravel content with depth. CO_3 cemented. Reacts strongly with HCl.
17 - 23	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Localized zones of CO_3 cemented. Reacts strongly with HCl.
23 – 25.5	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
25.5 - 35	ML/SM	Sandy SILT, 55% silt, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Lenses of hard, clayey silt this interval. Reacts strongly with HCl.
35 - 44.5	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Local reaction to HCl. Caliche nodules at 40 feet.
44.5 - 47	ML	Sandy SILT, 80% silt, 20% sand, brownish red, dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl.
47 – 51.5	ML/CL	Sandy Clayey SILT, 70% silt, 20% sand 10% clay, brownish red, dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl.
51.5 - 62	ML	Sandy CLAYEY SILT, 80% clayey silt, 20% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.
62 - TD	Basalt	Basalt, black with white and brown, massive, vesicular, predominantly un-weathered, with some weathering near upper contact and some calcite filling in vesicles, reacts to HCL. TOTAL DEPTH= 62 feet

LITHOLOGIC LOG FOR SOIL BORING B-3

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0- 1	ML/Fill	Sandy SILT, 85% silt, 15% sand, medium brown, loose, non-plastic; sand, medium to fine-grained; slightly moist. Slight reaction to HCl. HDPE Liner at 1 foot.
1 - 15	SP/SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Gravel lense at 3 feet. At 11 to 12 feet: CO_3 cemented. Reacts strongly with HCl.
15 – 26	SP	SAND with Silt, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
26 - 49	SM	Silty SAND, 85% sand, 15% silt, medium brown, very dense; contains mineralized fractures. Reacts strongly with HCl. Lenses of CO_3 cemented clayey-silt and caliche, hard.
49 – 66.6	ML/CL	Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.
66.6 - TD	Basalt	Basalt, black with white and brown, massive, vesicular, predominantly un-weathered, with some weathering near upper contact and some calcite filling in vesicles.

TOTAL DEPTH= 66.8 feet

LITHOLOGIC LOG FOR SOIL BORING B-4

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0 - 1	ML/Fill	Sandy SILT, 85% silt, 15% sand, medium brown, loose, non-plastic; sand, medium to fine-grained; slightly moist. Slight reaction to HCl. HDPE Liner at 1 foot.
1 – 12	SM	Silty Sand, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Reacts strongly with HCl.
12 – 26.5	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from medium-grained to fine-grained. Gravel increase at 19 to 23 feet. Locally reacts strongly with HCl.
26.5 – 32	SP	Sand with Silt, 90% sand, 10% silt, reddish brown, dense to hard; sand, very fine-grained grading to silt. Reacts strongly with HCl.
32 – 49.5	SP/SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
49.5 – 60.2	SM	Silty SAND, 70% sand, 30% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
60 - TD	Basalt	Basalt, black with white and brown, massive, vesicular, predominantly un-weathered, with some weathering near upper contact and some calcite filling in vesicles, reacts to HCL.

TOTAL DEPTH = 60.2 feet

LITHOLOGIC LOG FOR SOIL BORING B-5

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0- 6.5	SP/SM	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Boulder at 4 feet.
6.5 – 23.5	SW	Sand with Silt, trace Gravel, 90% sand, 10% silt, loose; sand ranges from fine-grained to very fine-grained. Silty Sand lense at 15 feet.
23.5 - 49	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
49 - 60	ML	Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.
60 - TD	Basalt	Basalt, black with white and brown, massive, vesicular, predominantly un-weathered, with some weathering near upper contact and some calcite filling in vesicles, reacts to HCL.

TOTAL DEPTH = 60 feet

LITHOLOGIC LOG FOR SOIL BORING B-6

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0 - 9	SM	Silty Sand, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally reacts strongly with HCl.
9 - 14	SP	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally reacts strongly with HCl.
14 - 26	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl. Lenses of CO_3 cemented clayey-silt, hard.
26 – 30.5	SM/ML	Sandy SILT, 55% silt, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Lenses of hard, clayey silt this interval. Reacts strongly with HCl.
30.5 - 38	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
38 - 70	ML	Sandy CLAYEY SILT, 80% clayey silt, 20% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl. Lenses of Sandy, Silty Clay.
70 – TD	SM/ML	Sandy SILT, 60% silt, 40% sand, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt.

TOTAL DEPTH = 79.6 feet

LITHOLOGIC LOG FOR SOIL BORING B-7

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0 - 6	SM	Silty Sand, trace Gravel, 80% sand, 15% silt, 5% gravel, reddish brown, loose, non-plastic; concretions present, sand, coarse grained grading to fine-grained. Reacts strongly with HCl.
6 - 16	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally CO_3 cemented. Reacts strongly with HCl.
16 - 18	SP/SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
18 - 23	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally CO_3 cemented. Reacts strongly with HCl.
23 – 45.5	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl.
45.5 – 65.2	ML/CL	Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.
65.2 - TD	Basalt	Basalt, black with white and brown, massive, vesicular, weathered to orange , rust color at surface, calcite filling in vesicles, reacts to HCL.

TOTAL DEPTH = 65.3 feet

LITHOLOGIC LOG FOR SOIL BORING B-8

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0- 6	SM	Silty Sand, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Reacts strongly with HCl.
6 - 15	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Gravel increase at 19 to 23 feet. Locally reacts strongly with HCl.
15 – 20.5	SM	Silty Sand, trace Gravel, 85% sand, 10% silt, 5% gravel, moderately dense; sand ranges from fine-grained to very fine-grained. Caliche at @ 17 feet. Reacts strongly with HCl.
20.5 – 24.5	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose to moderately dense; sand ranges from fine-grained to very fine-grained. Increase in gravel content at approximately 24 to 25 feet and becomes dense to hard. Locally reacts strongly with HCl.
24.5 - 47	SM/ML	Sandy SILT, 55% silt, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Lenses of hard, clayey silt this interval. Reacts strongly with HCl.
47 - 66	CL	Sandy Silty CLAY, 50% clay, 30% silt, 20% sand, reddish brown, dense to very dense. Sandy Clay lense at 50.5 to 52 feet. Gypsum crystals at 62 feet. Very plastic at 65 feet. Reacts strongly with HCl.
66 – 68.2	SC	Clayey Sand, 55% clay, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Bands of caliche. Reacts strongly with HCl.
68.2 - TD	Basalt	Basalt, black with white and brown, massive, vesicular, predominantly un-weathered, with some weathering near upper contact and some calcite filling in vesicles, reacts to HCL.

TOTAL DEPTH = 68.3 feet

LITHOLOGIC LOG FOR SOIL BORING B-9

DEPTH INTERVAL (feet below land surface)		DESCRIPTION OF MATERIAL
0 – 7.5	SM	Silty Sand, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally reacts strongly with HCl.
7.5 - 14	SW/SP	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally reacts strongly with HCl.
14 – 15.5	SP/GP	Sand with Silt, trace Gravel, 80% sand, 10% silt, 10% gravel, loose; sand ranges from fine-grained to very fine-grained.
15.5 - 23	SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally reacts strongly with HCl.
23 – 26.5	SM	Silty Sand, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. Locally reacts strongly with HCl.
26.5 - 29	SM/ML	Sandy SILT, 55% silt, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Lenses of hard, clayey silt this interval. Reacts strongly with HCl.
29 – 30.5	ML	Sandy SILT, 80% silt, 20% sand, light reddish brown with lighter colored areas, very dense; sand, very fine-grained grading to silt. Reacts strongly with HCl.
30.5 - 43	SM	Silty SAND, 85% sand, 15% silt, reddish brown, very dense. Sandy Silt and caliche lenses. Reacts strongly with HCl. Top of fine grained zone at 39.5 feet.
43 - 47	ML	Sandy SILT, 80% silt, 20% sand, light reddish brown with lighter colored areas, very dense; sand, very fine-grained grading to silt. Reacts strongly with HCl.
47 - 50	ML/CL	Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.
50 – 51.5	SC	Clayey Sand, 55% clay, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Reacts strongly with HCl.
51.5 - 65	ML/CL	Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.

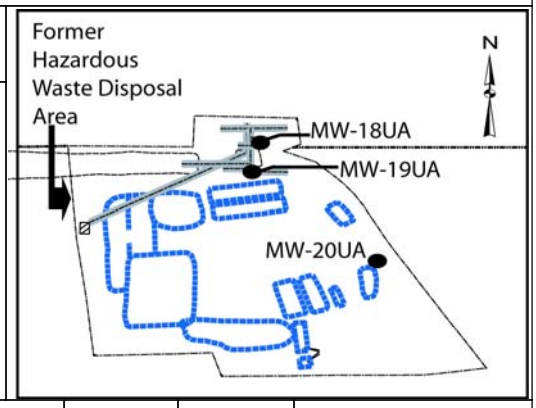
TOTAL DEPTH = 65 feet

Hassayampa Land Fill Superfund Site

Lithologic and well construction log: MW-18UA

Northing 863265.82
Easting 446040.75
LS Elev. (ft) 918.73
Ref. Pnt. Top of case
Ref. Pnt. Elev. (ft) 920.48
Total Depth (ft) 94
Depth to Water (ft) N/A
Date 2/16/2006 - 2/20/2006

Drill Method Rotosonic
Sampling Method
Diameter of Casing 1" and 2"
Type of Casing Steel
Slot Size 0.020"
Filter #10-20 Sand Pack



Depth (Feet Below Land Surface)	Lithologic Log	USCS	Lithologic Description	Soil Vapor Well Construction	GW Well Construction	Comments
0						Monument Vault
5						9" diameter borehole (0 - 65 feet bls)
						Cement Bentonite Grout (0 - 62 feet bls)
10			0 - 80 feet bls was not logged			
15						1" ID diameter PVC pipe (0 - 66.5 feet bls)

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HYDROGEOLOGY · ENGINEERING

Logged By JCY
Checked By MFW

Lithologic and well construction log: MW-18UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Shallow well Construction	Deep well Construction	Comments
20							
25							2" ID diameter Steel casing (0 - 78.5 feet bls)
30				0 - 80 feet bls was not logged			
35							
40							
45							

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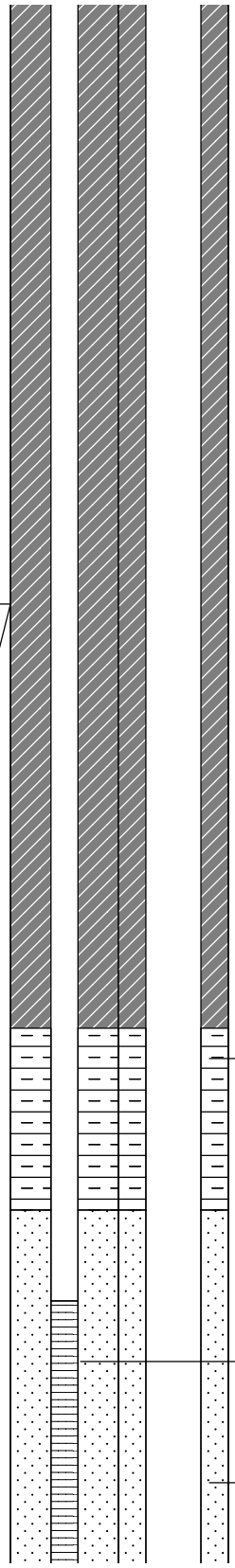
Logged By JCY
Checked By MFW

Lithologic and well construction log: MW-18UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Shallow well Construction	Deep well Construction	Comments
45							
50							
55				0 - 80 feet bls was not logged			
60							
65							
70							



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Logged By JCY
Checked By MFW

Lithologic and well construction log: MW-18UA

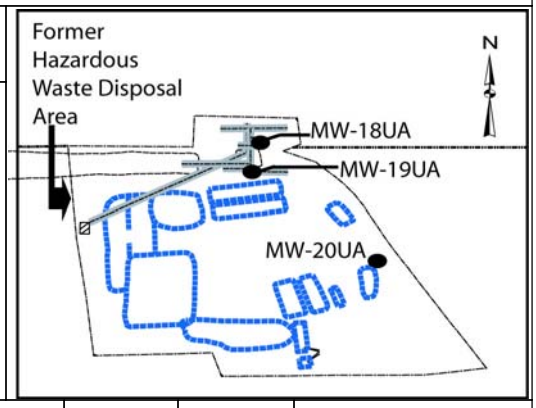
Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Shallow well Construction	Deep well Construction	Comments
75							Bentonite Seal (71.5 - 74.5 feet bls)
80		ML		CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, reddish brown, moderately dense to dense, plasticity, low- to none; sand, very fine-grained grading to silt.			
		ML		Sandy SILT, 60% silt, 40% sand, reddish brown, moderately dense to dense, moist; sand, very fine-grained grading to silt.			
		ML		Sandy SILT, 80% silt, 20% sand, reddish brown, hard, moist, cemented fragments; sand, very fine-grained grading to silt.			
85		SM		CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, moderately dense to dense, low plasticity, weak reaction to HCl.			2" ID diameter Schedule 40 0.020" Screen (78.5 - 93.5 feet bls)
		ML		Silty SAND, 60% sand, 40% silt, reddish brown, loose to moderately dense, mica present, cemented fragments, reacts with HCl; sand, very fine-grained grading to silt.			
		SM		CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, brownish red, dense, low- to medium plasticity.			
				Silty SAND, 60% sand, 40% silt, reddish brown, loose to moderately dense, mica present, cemented fragments, reacts with HCl; sand, very fine-grained grading to silt.			Sand Filter Pack (74.5 - 94 feet bls)
90		SM-SP		Silty SAND grading to SAND with Silt, coarser with depth this interval; At 90 feet: Silty SAND, 60% sand, 40% silt, sand, fine-grained grading to silt; at 91.5 feet: Sand with Silt, 90% sand, 10% silt, olive, loose; sand, medium-grained grading to fine-grained.			
		ML		CLAYEY SILT, reddish brown, dense, low- to medium-plasticity, strong reaction to HCl.			Total Depth = 94 feet bls

Hassayampa Land Fill Superfund Site

Lithologic and well construction log: MW-19UA

Northing 863186.20
Easting 446023.98
LS Elev. (ft) 920.08
Ref. Pnt. Top of case
Ref. Pnt. Elev. (ft) 922.08
Total Depth (ft) 95
Depth to Water (ft) N/A
Date 2/14/2006 - 2/15/2006

Drill Method Rotosonic
Sampling Method
Diameter of Casing 1" and 2"
Type of Casing Steel
Slot Size 0.020"
Filter #10-20 Sand Pack



Depth (Feet Below Land Surface)	Lithologic Log	USCS	Lithologic Description	Soil Vapor Well Construction	GW Well Construction	Comments
0						Monument Vault
5						9" diameter borehole (0 - 61 feet bls)
						Cement Bentonite Grout (0 - 65 feet bls)
10			0-60 feet was not logged			
15						1" ID diameter PVC pipe (0 - 71 feet bls)

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Lithologic and well construction log: MW-19UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Shallow well Construction	Deep well Construction	Comments
20							2" ID diameter Steel casing (0 - 80 feet bls)
25							
30				0-60 feet was not logged			
35							
40							
45							

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Lithologic and well construction log: MW-19UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Shallow well Construction	Deep well Construction	Comments
45							
50							
55							
60		BASALT		Vesicular Basalt			8" diameter borehole (61 - 95 feet bls)
		SM-ML		Sandy SILT/Silty SAND, 50% sand, 50% silt, reddish brown, dense to very dense, slightly moist; sand, very fine-grained grading to silt. Reacts strongly with HCl.			
		BASALT		Vesicular basalt, vesicles are filled with cemented clayey silt.			
65		BASALT		Basalt, massive. At 64- and 67 feet: Fractures filled with cemented clayey silt.			Bentonite Seal (65 - 70 feet bls)
70							

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Lithologic and well construction log: MW-19UA

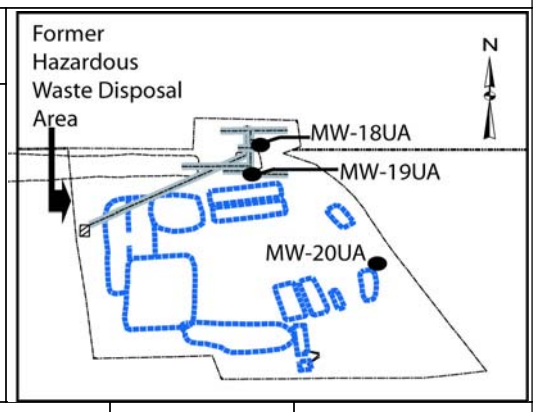
Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Shallow well Construction	Deep well Construction	Comments
							Sand Filter Pack (70 - 76 feet bls)
			SM	Silty SAND, 55% sand, 45% silt, reddish brown, very dense, VOC odor; sand, very fine-grained grading to silt.			
			ML	Sandy SILT, 60% silt, 40% sand, reddish brown, dense; sand, very fine-grained grading to silt.			
75							1" ID diameter Schedule 40 Screen (71 - 76 feet bls)
			ML	Sandy SILT, 70% silt, 30% sand, olive, loose to moderately dense, abundant mica; sand, very fine-grained grading to silt.			
							Bentonite Seal (76 - 79 feet bls)
80			ML	CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, reddish brown, dense, moderate plasticity, mica present.			
			ML	Sandy SILT, 70% silt, 30% sand, olive, dense, slightly moist; abundant mica, weak reaction to HCl; sand, very fine-grained grading to silt.			
85			ML	CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, reddish brown, slightly moist, no reaction to HCL; sand, very fine-grained grading to silt.			Sand Filter Pack (79 - 95 feet bls)
				No recovery.			
			ML	Sandy SILT, 70% sand, 30% silt, sand, fine-grained grading to silt. Formation coarser with depth this interval.			
90							2" ID diameter Schedule 40 0.020" Screen (80 - 95 feet bls)
			SW	SAND, trace Silt, 95% sand, 5% silt, olive, loose to moderately dense, abundant mica, strong reaction to HCl. Formation coarser with depth this interval. At 92 feet: caliche, whitish-gray, hard, appears dry.			
			ML	CLAYEY SILT, trace sand, 95% clayey silt, 5% sand, reddish brown, dense, low- to medium plasticity, sand, very fine-grained grading to silt; contains lenses of caliche, strong reaction to HCl.			Total Depth = 95 feet bls
95							

Hassayampa Land Fill Superfund site

Lithologic and well construction log: MW-20UA

Northing 862938.91
Easting 446283.99
LS Elev. (ft) 916.66
Ref. Pnt. Top of case
Ref. Pnt. Elev. (ft) 919.79
Total Depth (ft) 100
Depth to Water (ft) N/A
Date 02/10/2006 - 02/13/2006

Drill Method Rotosonic
Sampling Method
Diameter of Casing 2"
Type of Casing Steel
Slot Size 0.020"
Filter 10-20 Sand Pack



Depth (Feet Below Land Surface)	Lithologic Log	USCS	Lithologic Description	Well Construction	Comments
0		ML	Sandy SILT, trace Gravel, 85% silt, 10% sand, 5% gravel, reddish brown, loose, non-plastic; concretions present, sand, coarse grained grading to fine-grained. Reacts strongly with HCl.		Monument Vault
5, 10, 15, 20, 25		SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. At 25.5-26 feet: CO3 cemented. Reacts strongly with HCl.		8" diameter borehole (0 - 55 feet bls) Cement bentonite grout (0 - 63.5 feet bls)
		ML	Sandy SILT, 80% silt, 20% sand, reddish brown, moderately dense to dense; sand, very fine-grained grading to silt. Sand stringers within this interval. Reacts strongly with HCl.		

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Lithologic and well construction log: MW-20UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Well Construction	Comments
				At 30- to 35 feet: Silty Sand, grayish-green, appears to be derived from basalt.		
30		SW-SM		Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl. From 32.5- to 36 feet: lenses of CO3 cemented clayey-silt, hard.		2" ID Steel casing (0 - 71 feet bls)
35		ML		Sandy SILT, 80% silt, 20% sand, light reddish brown with lighter colored areas, very dense; sand, very fine-grained grading to silt. Reacts strongly with HCl.		
40		ML		Sandy SILT, 55% silt, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Lenses of hard, clayey silt this interval. Reacts strongly with HCl.		
45		ML		Sandy CLAYEY SILT, 80% clayey silt, 20% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.		
50		ML		Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.		
55		BASALT		Basalt		6.5" diameter borehole (55 - 94 feet bls)
60						
65						Bentonite seal (63.5 - 68 feet bls)

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Lithologic and well construction log: MW-20UA

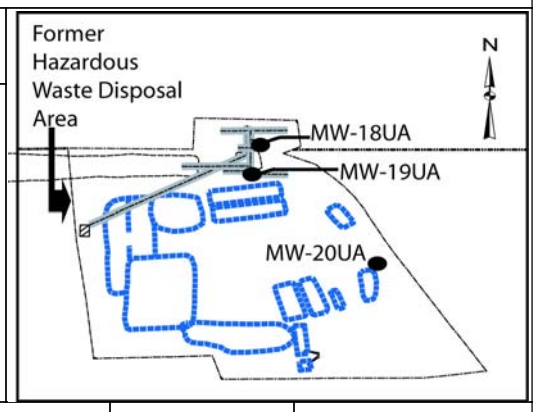
Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Well Construction	Comments
70		SP		SAND with Silt, 90% sand, 10% silt, brownish-red, very dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl.		
		ML		Sandy SILT, 80% silt, 20% sand, brownish red, dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl. From 75.5-76.5: Sandy CLAYEY SILT.		
75		SW		SAND, trace Silt, 95% sand, 5% silt, loose to moderately dense, loose to moderately dense, abundant mica; sand, fine-grained grading to silt.		2" ID Schedule 40 0.020" screen (71 - 96 feet bls)
		ML		Sandy SILT, 60% silt, 40% sand, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt.		
80		SM		Silty SAND, 60% sand, 40% silt, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt.		
85		ML		Sandy SILT, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt. At 85.5- 86 feet: well cemented sand, hard, dry, reacts strongly with HCl.		Sand filter pack (68 - 96 feet bls)
		SW-SM		Silty SAND, 60% sand, 40% silt, moderately dense to dense; coarser with depth this interval; at 89- to 90 feet: sand with silt, medium-grained grading to silt.		
90		ML		CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, moderately dense to dense, plasticity ranges from low to medium. Reacts strongly with HCl.		5.5" diameter borehole (94 -100 feet bls)
95						Bentonite hole plug (96 - 100 feet bls)
100						Total Depth = 100 feet bls

Hassayampa Land Fill Superfund site

Lithologic and well construction log: MW-20UA

Northing 862938.91
Easting 446283.99
LS Elev. (ft) 916.66
Ref. Pnt. Top of case
Ref. Pnt. Elev. (ft) 919.79
Total Depth (ft) 100
Depth to Water (ft) N/A
Date 02/10/2006 - 02/13/2006

Drill Method Rotosonic
Sampling Method
Diameter of Casing 2"
Type of Casing Steel
Slot Size 0.020"
Filter 10-20 Sand Pack



Depth (Feet Below Land Surface)	Lithologic Log	USCS	Lithologic Description	Well Construction	Comments
0		ML	Sandy SILT, trace Gravel, 85% silt, 10% sand, 5% gravel, reddish brown, loose, non-plastic; concretions present, sand, coarse grained grading to fine-grained. Reacts strongly with HCl.		Monument Vault
5, 10, 15, 20, 25		SW	Sand with Silt, trace Gravel, 85% sand, 10% silt, 5% gravel, loose; sand ranges from fine-grained to very fine-grained. At 25.5-26 feet: CO3 cemented. Reacts strongly with HCl.		8" ID diameter borehole (0- 55 feet bls) Cement Bentonite Grout (0 - 63.5 feet bls)
		ML	Sandy SILT, 80% silt, 20% sand, reddish brown, moderately dense to dense; sand, very fine-grained grading to silt. Sand stringers within this interval. Reacts strongly with HCl.		

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Lithologic and well construction log: MW-20UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Well Construction	Comments
				At 30- to 35 feet: Silty Sand, grayish-green, appears to be derived from basalt.		
30		SW-SM		Silty SAND, 85% sand, 15% silt, reddish brown, very dense; contains mineralized fractures. Reacts strongly with HCl. From 32.5- to 36 feet: lenses of CO3 cemented clayey-silt, hard.		2" ID Steel casing (0 - 71 feet bls)
35		ML		Sandy SILT, 80% silt, 20% sand, light reddish brown with lighter colored areas, very dense; sand, very fine-grained grading to silt. Reacts strongly with HCl.		
40		ML		Sandy SILT, 55% silt, 45% sand, reddish brown, dense; sand, very fine-grained grading to silt. Lenses of hard, clayey silt this interval. Reacts strongly with HCl.		
45		ML		Sandy CLAYEY SILT, 80% clayey silt, 20% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.		
50		ML		Sandy CLAYEY SILT, 70% clayey silt, 30% sand, reddish brown, dense to very dense, contains mineralized fractures. Reacts strongly with HCl.		
55		BASALT		Basalt		6.5" ID diameter borehole (55-94 feet bls)
60						
65						Hydrated Bentonite Seal feet (63.5 - 68 bls)

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Lithologic and well construction log: MW-20UA

Depth (Feet Below Land Surface)	PID/FID (ppm)	Log Lithologic	USCS	Lithologic Description	Well Construction	Comments
70			SP	SAND with Silt, 90% sand, 10% silt, brownish-red, very dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl.		
			ML	Sandy SILT, 80% silt, 20% sand, brownish red, dense, slightly moist; sand, predominantly very fine-grained. Reacts strongly with HCl. From 75.5-76.5: Sandy CLAYEY SILT.		
75			SW	SAND, trace Silt, 95% sand, 5% silt, loose to moderately dense, loose to moderately dense, abundant mica; sand, fine-grained grading to silt.		2" ID Schedule 40 0.020" Screen (71 - 96 feet bls)
			ML	Sandy SILT, 60% silt, 40% sand, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt.		
80			SM	Silty SAND, 60% sand, 40% silt, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt.		
85			ML	Sandy SILT, loose to moderately dense, brownish olive; sand, very fine-grained grading to silt.		Sand Filter Pack (68 - 96 feet bls)
			SW-SM	At 85.5- 86 feet: well cemented sand, hard, dry, reacts strongly with HCl. Silty SAND, 60% sand, 40% silt, moderately dense to dense; coarser with depth this interval; at 89- to 90 feet: sand with silt, medium-grained grading to silt.		
90			ML	CLAYEY SILT, trace Sand, 95% clayey silt, 5% sand, moderately dense to dense, plasticity ranges from low to medium. Reacts strongly with HCl.		
95						5.5" ID diameter borehole (94-100 feet bls)
100						Bentonite hole plug (96 - 100 feet bls)

Geosyntec consultants

Appendix C: Aquifer Test

Monitor Wells MW-UA18 and MW-UA19 Aquifer Test Results
Hassayampa Landfill, Maricopa County, Arizona

Introduction

This appendix summarizes the results of the analysis of data collected during aquifer testing at the Hassayampa Landfill near Buckeye in Maricopa County, Arizona (site). The aquifer testing program consisted of two 12-hour constant rate aquifer tests conducted in June 2006. The aquifer tests were conducted on two newly installed monitor wells at the site, MW-18UA and MW-19UA; monitor well MW-06UA was used as an observation well for each test. Monitor well MW-19UA was also used as an observation well during the testing of MW-18UA and MW-18UA was used as an observation well while testing monitor well MW-19UA. Monitor wells MW-18UA and 19UA are two-inch diameter wells screened solely within the upper most fine-grained water bearing zone in the regional aquifer beneath the site that has been designated as Unit A.

Objectives

The objective of the aquifer testing program was to estimate aquifer properties in Unit A at the locations of the newly installed monitor wells. The test wells, monitor wells MW-18UA and MW-19UA, are additions to the monitor well network for an existing groundwater extraction and treatment system.

Aquifer Test Procedures

The tested wells are constructed of two-inch diameter steel casing and PVC screen. The aquifer tests were preceded by some minor well pumping due to the scaling of rust in the steel well casing installed above the water table during test pump installation. The two-inch well diameter required the use of a pump which was 1.875 inches in diameter and scraping the sides of the steel casing was unavoidable during pump installation and removal. Each well was pumped several times, which involved removing the pump and cleaning the intake screen of rust and reinstalling the pump. This

was repeated until no more rust was in the well, which stopped the pump clogging. Water levels were allowed to recover to static conditions prior to commencing the aquifer tests.

Transducers connected to a data logger were installed in all three wells involved in the testing. The data logger recorded the water level drawdown in all three wells being tested. Well discharge rates were measured and keeping the discharge constant was a primary goal within the constraints of the small well diameter and the use of a small, low-flow pump. As would be expected, variations in pumping rates were recorded, and the sustainable pumping rate in each well declined approximately 15 percent throughout the tests..

Upon cessation of the pumping portion of the test, water level recovery data were recorded by the data logger. Tests were analyzed for both dynamic and recovery conditions using several methods typically used in Arizona alluvial sediments and also in wide use in the public domain.

The extraction well system associated with the groundwater recovery system was not shut down during the testing period in order to continue to provide capture of affected groundwater. However, extraction well EW-04UA was not operating during the aquifer test on MW-18UA but came back on line shortly after the pumping portion of the test of MW-19UA began.

Analysis of AquiferTest Data

The pumping portion of the MW-18UA aquifer test was conducted for 12 hours. The pump was started at 06:00 on June 13, 2006 and turned off at 18:00 on June 13, 2006. Generally, there was an overall decline in the pumping rate from 1.50 gallons per minute (gpm) to 1.28 gpm at the end of the pumping portion of the test. The average pumping rate was 1.32 gpm.

Monitor well MW-19UA is located 82 feet from pumped well MW-18UA and monitor well MW-06UA is located 147 feet away. Recovery data were collected for at least 12 hours after the pumping portion of the test.

The pumping portion of the MW-19UA aquifer test was conducted for 12 hours. The pump was started at 06:00 on June 15, 2006 and turned off at 18:00 on June 15, 2006. Generally, there was an overall decline in the pumping rate from 1.81 gallons per minute (gpm) to 1.53 gpm at the end of the pumping portion of the test. The average pumping rate was 1.64 gpm.

Monitor well MW-18UA is located 82 feet from pumped well MW-19UA and monitor well MW-06UA is located 111 feet away.

Data were analyzed under the same assumptions for monitor wells MW-18UA and MW-19UA. The assumptions were that the aquifer system was unconfined and the wells have generally similar construction:

- two-inch well casing in pumped wells; 4-inch at well MW-06UA;
- ~8-inch boring;
- 15 foot screened interval in pumped wells, and
- Screen top at depth of ~78 feet below land surface.

Water level drawdown data were transferred to Excel and plotted against time. The data were examined for any irregularities. A fluctuation in drawdown was noted approximately one hour into the pumping portion of the test for MW-19UA and this fluctuation was more evident on the aquifer test curves. It was also noted that the monitor wells used for the MW-19UA test did not fully recover at the end of the test period. These observations may be related to the fact the extraction well EW-04UA came back on line approximately at the same time. The pumpage from EW-04UA could have affected the drawdown curve in MW-19UA and the drawdown caused by continued operation of EW-04UA would have affected the water level recovery at the monitor wells.

Data were imported into the aquifer analysis program Aquifer Win32 and compared to classic drawdown curves developed by Theis, 1935. It was noted that late time data deviated from curve due to a flattening of the curve. This would typically indicate that another source of water is dampening the drawdown. However, since the system is unconfined, the curve flattening could also be attributed to delayed drainage (pore dewatering) and/or an effect due to declining pumping rates. Transmissivity values were not calculated from the Theis curves.

The data were then compared to unconfined aquifer curves developed by Neuman, 1972 and matched fairly well with minor deviations. Late-time data deviated from the curve with the same flattening observed in the Theis analysis and the same reasons were considered as explaining the flattening: pore dewatering combined with a minor effect from a decreasing pumping rate. The short-

term nature of the test did not allow time to observed whether drawdown would have increased in later time.

An average transmissivity estimate of 250 gal/d/ft (30 ft^2/d) was derived from the analysis using the Neuman unconfined curves. Due to the observed flattening of the drawdown curves in late time, the data were analyzed by using curves which accommodate leakage into the aquifer.

The aquifer test data were then analyzed using methods developed by Hantush and the Jacob method developed in 1955 which accommodate the assumption that water is leaking into the aquifer from other sources. This accommodates the observed flattening of the curves in late time if the flattening was attributable to pore water drainage. The curve matches were judged to be good. The average transmissivity estimate was 250 gal/d/ft (30 ft^2/d) using this method.

Finally, the data were analyzed using the Theis straight-line method developed in 1946. The curves matched reasonably well and a transmissivity estimate of 400 gal/d/ft (55 ft^2/d) was determined from this method.

Because the aquifer tests were of short duration, results from transmissivity calculations are approximate. The data derived from the aquifer tests of the two newly installed two-inch monitor wells indicate a transmissivity (and corresponding hydraulic conductivity) lower than values obtained from testing larger diameter wells (four inch) during previous investigations.

Pumping rates during previous aquifer testing were higher. Discharges during the two tests averaged 1.32 and 1.64 gpm. Previous tests had well discharges ranging from 2.5 to 11.1 gpm with an overall average from eight tests of 6.1 gpm.

Transmissivity values from early tests conducted on Unit A wells as part of the RI ranged from 800 gpd/ft (107 ft^2/day) to 5,000 gpd/ft (668 ft^2/day) with a geometric mean of 2,400 gpd/ft (321 ft^2/day). The operative transmissivity for Unit A was estimated at 2,000 gpd/ft (276 ft^2/day) in the RI.

Transmissivity values from the tests on MW-18UA and MW-19UA averaged 250 gpd/ft (30 ft^2/day) from the drawdown data and 400 gpd/ft (55 ft^2/day) from the recovery data for an overall average of 300 gpd/ft (40 ft^2/day). Recovery data are considered the most representative of conditions in the vicinity of the tested wells.

Several factors, or combinations of factors, could contribute to an explanation of the relatively low transmissivity values for these tests, when compared to earlier tests.

- The small diameter of the wells and the limitations on pumping equipment.
- The effects of the sloping water table caused by the pumpage from the extraction wells.
- Borehole wall "smear" caused by the use of Rotosonic drilling equipment in clays and silts, creating a localized zone of lower permeability along the borehole wall.
- Partial penetration of the wells which did not allow testing of the complete saturated thickness of the materials within Unit A.
- Regional water level declines reducing the saturated thickness in Unit A between the time of aquifer testing during the RI to present.
- The possibility that the values are low because the geologic materials in the vicinity of the tested wells have lower permeability than surrounding previously tested areas.
- The fundamental assumptions on which aquifer test analysis is based were not met by conditions at the site during these tests.

The lower estimated aquifer parameters may be due to the inability to significantly stress the aquifer given the constraints of well diameter and available pumps for small diameter wells. That is, it may have been possible to pump more water with similar drawdowns (or marginally increased drawdowns) from a larger diameter well.

The artificial slope in the water table caused by operation of the extraction well field down gradient of the tested wells would tend to cause the tested wells to withdraw water from the aquifer asymmetrically. Because the water table is assumed to be flat for the analysis, bias would be introduced by the tendency of the well to withdraw more water from upgradient than from areas of much lower head down gradient. Thus, instead of 360 degrees of aquifer contribution, the water most easily available to the well may have come from a reduced circumference.

The potential for borehole wall "smear" would be exacerbated by the use of Rotosonic drilling equipment in the fine-grained sediments of Unit A. Rotosonic equipment would not be the first choice if the wells were, as an example, designed as production wells in this geologic environment. Previously installed monitor wells (which were aquifer tested) and the extraction wells at the site were installed with drilling methods other than Rotosonic, primarily air and mud rotary equipment. The borehole wall "smear" effect would artificially limit the permeability in the immediate vicinity of the borehole, reducing the amount of water that could be moved into the borehole due to stresses caused by pumping and therefore resulting in lower aquifer parameter values.

At the request of ADEQ, the tested wells were constructed to only partially penetrate the Unit A water-bearing zone. The four Unit A extraction wells range from 101 to 114 feet deep. The tested wells are 94 and 96 feet deep and are not able to directly test the lower most water bearing portions of Unit A.

Regional water levels have been observed to be declining at a rate of 0.3 feet per year from 1984 to the present. Early aquifer tests on Unit A wells were conducted in 1988. In the intervening 18 years the saturated thickness of Unit A would have declined approximately 5.4 feet. The reduction in saturated thickness would reduce estimated transmissivities.

It is possible that geologic materials in the vicinity of the tested wells have hydraulic properties that are different than other tested areas of the site. Available geologic information obtained from lithologic logging is not judged sufficient to determine subtle differences in hydraulic properties which may affect aquifer test results.

The primary assumptions for obtaining valid data from the equations used in aquifer test analysis are:

- The aquifer is homogeneous, isotropic, confined and of infinite areal extent.
- The aquifer has uniform thickness.
- The extraction wells are fully penetrating.
- The water table gradient is uniform and stable.

- Steady state flow conditions prevail in the aquifer.
- There is a negligible vertical gradient.

From a practical standpoint, none of these assumptions are completely met by hydrologic conditions prevailing at the site in Unit A.

In summary, the data derived from the testing of the small-diameter monitor wells MW-18UA and 19UA does not compare well with data previously collected from seven larger diameter monitor wells stressed at higher pumpage rates. The data are considered semi-quantitive in nature and may, if valid, apply only locally near the wells, and to the portion of the aquifer penetrated by the wells. Based on previously collected data from seven Unit A wells, the newly derived data are not representative of conditions across the site.

HARGIS + ASSOCIATES, INC.

TABLE 1

ESTIMATED AQUIFER PARAMETERS
HASSAYAMPA LANDFILL AQUIFER TEST

Pumping Well	Observation Well	Analysis Method	Transmissivity (gal/d/ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity[a] (ft/d)
MW-18	MW-06	Theis	--	--	--
		Neuman	250	35	2.0
		Hantush	250	35	2.0
		Theis (recovery)	500	70	3.5
	MW-19	Theis	--	--	--
		Neuman	200	25	1.5
		Hantush	200	25	1.5
		Theis (recovery)	300	40	2.0
MW-19	MW-06	Theis	--	--	--
		Neuman	250	30	2.0
		Hantush	250	35	2.0
		Theis (recovery)	550	75	4.0
	MW-18	Theis	--	--	--
		Neuman	250	30	2.0
		Hantush	250	30	2.0
		Theis (recovery)	350	50	2.5
Average Drawdown:			250	30	1.5
Average Recovery:			400	55	3.0
Overall Average:			300	40	2.0

FOOTNOTES

[a]Hydraulic Conductivity estimates based on a 20-foot saturated thickness

gal = gallons
d = day
ft = feet

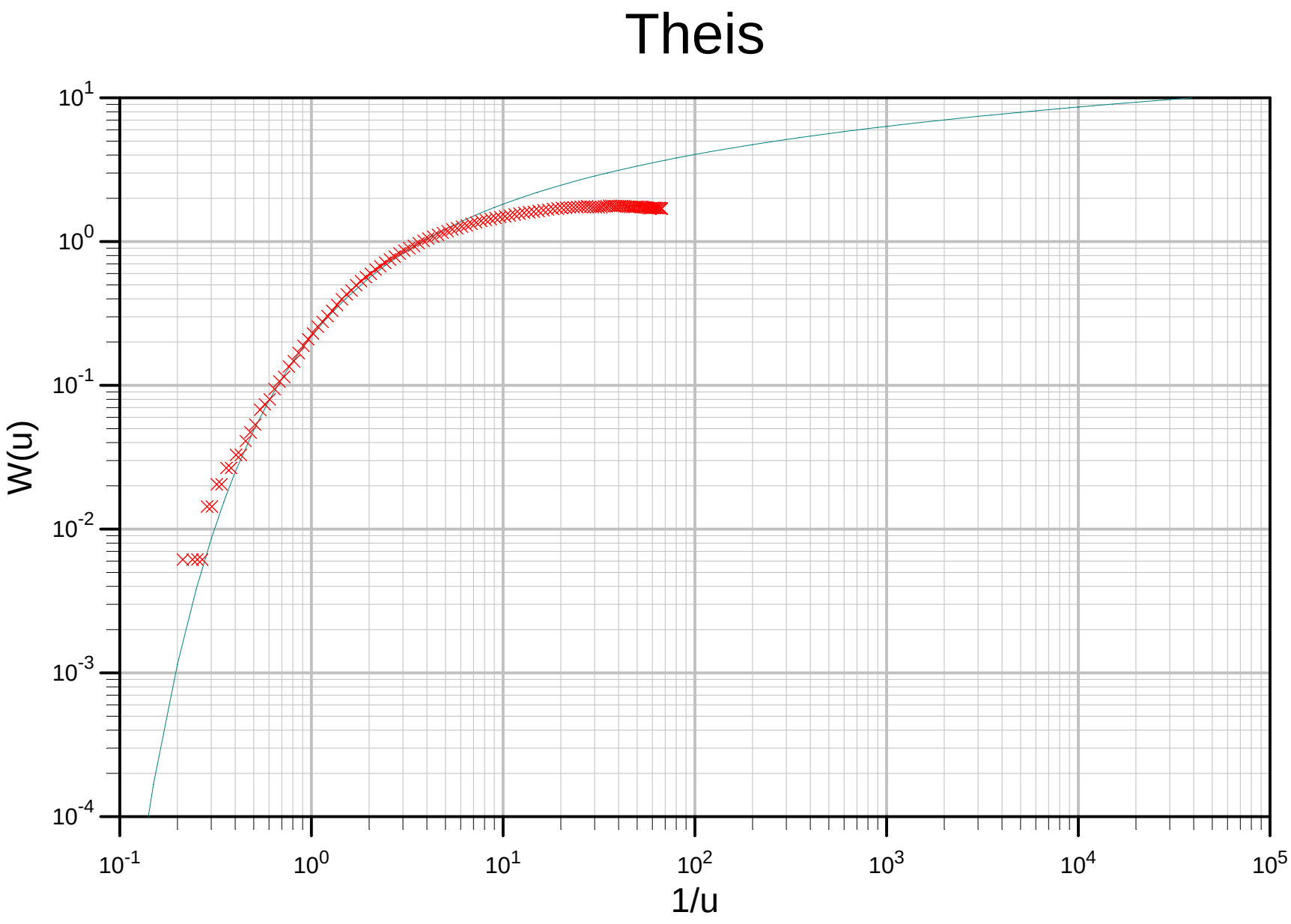


FIGURE 1. THEIS CURVE FIT FOR DRAWDOWN AT MW-06 FROM PUMPING AT MW-18

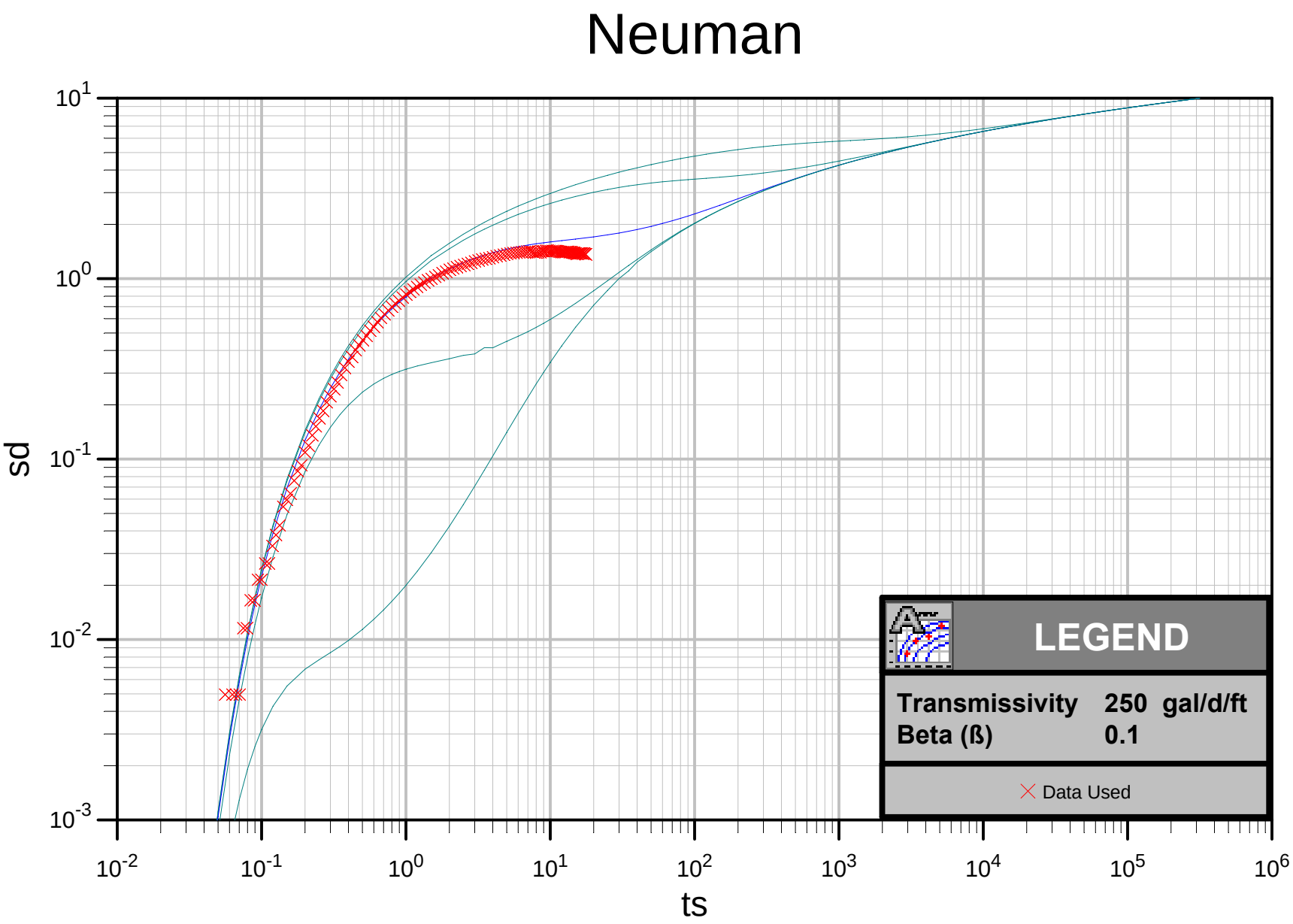


FIGURE 2. NEUMAN CURVE FIT FOR DRAWDOWN AT MW-06 FROM PUMPING AT MW-18

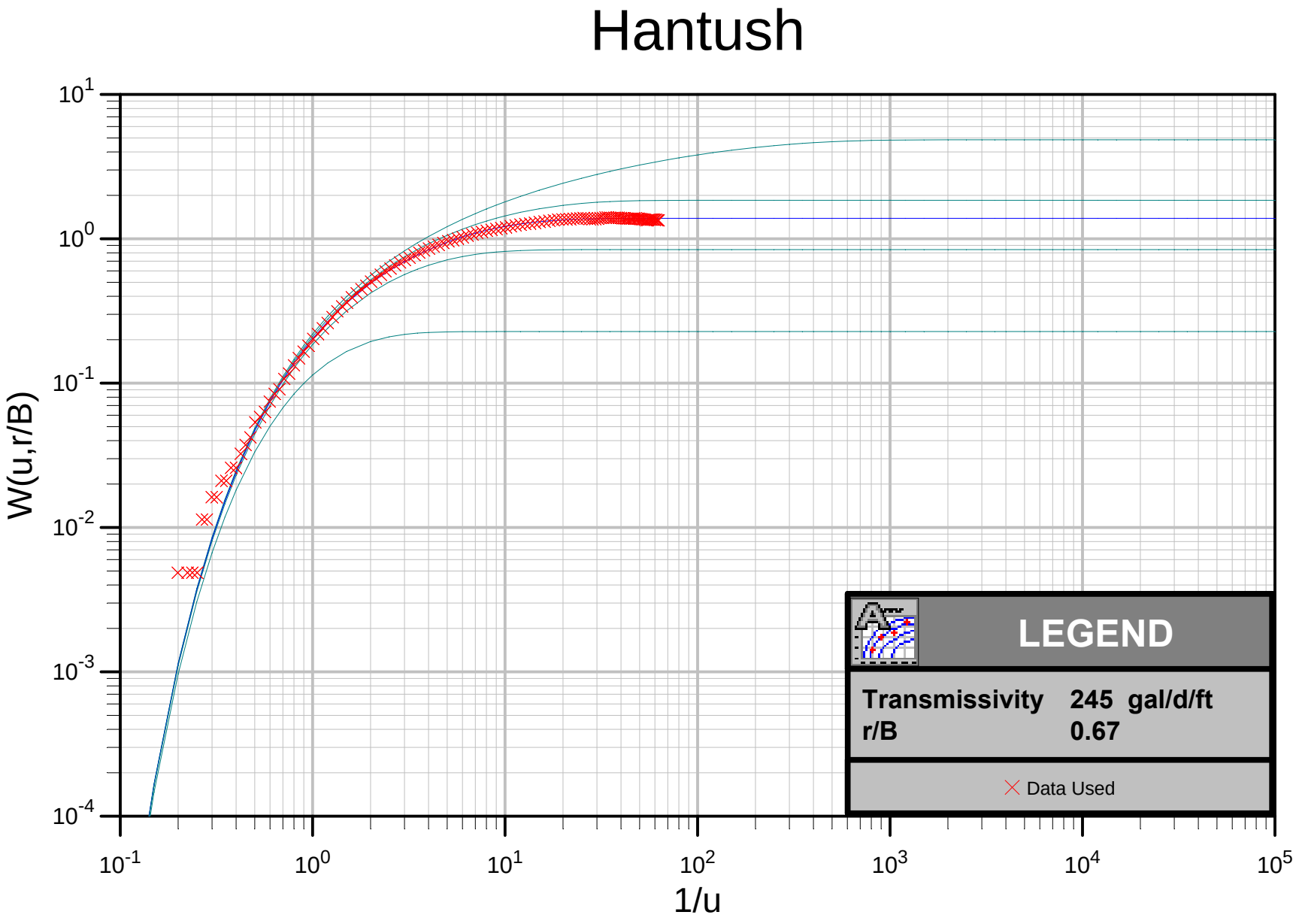


FIGURE 3. HANTUSH CURVE FIT FOR DRAWDOWN AT MW-06 FROM PUMPING AT MW-18

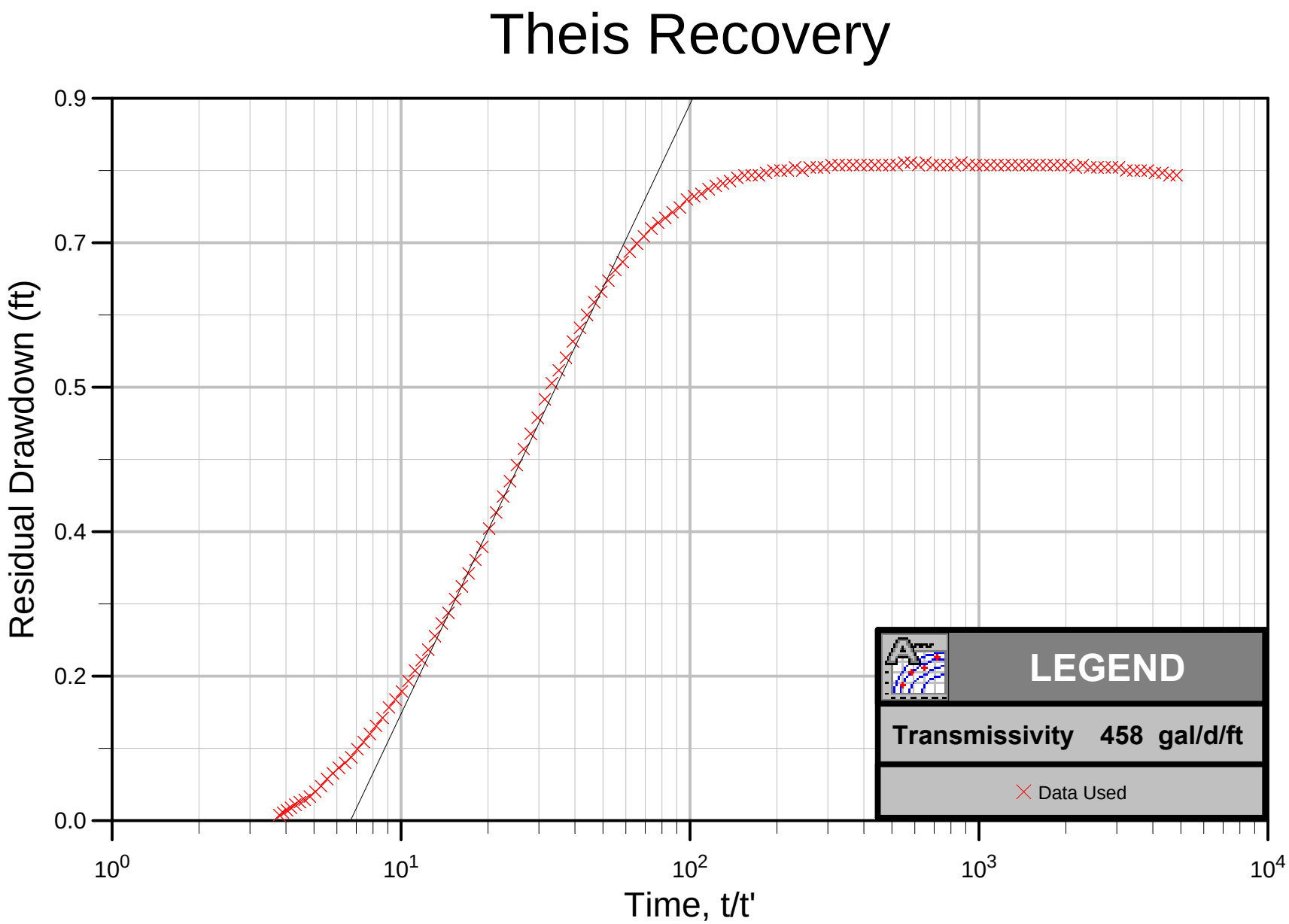


FIGURE 4. THEIS CURVE FIT FOR RECOVERY AT MW-06 FROM PUMPING AT MW-18

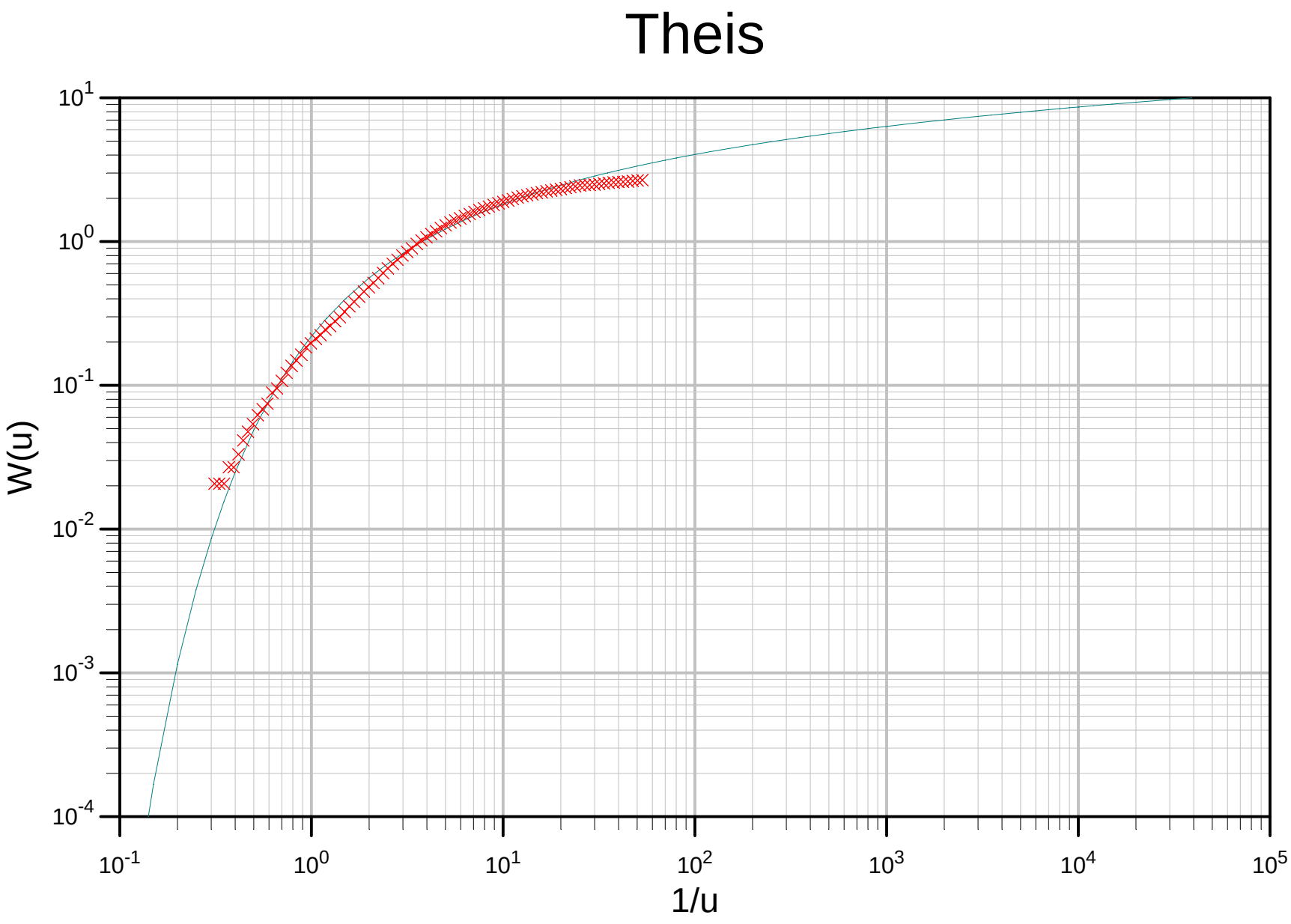


FIGURE 5. THEIS CURVE FIT FOR DRAWDOWN AT MW-19 FROM PUMPING AT MW-18

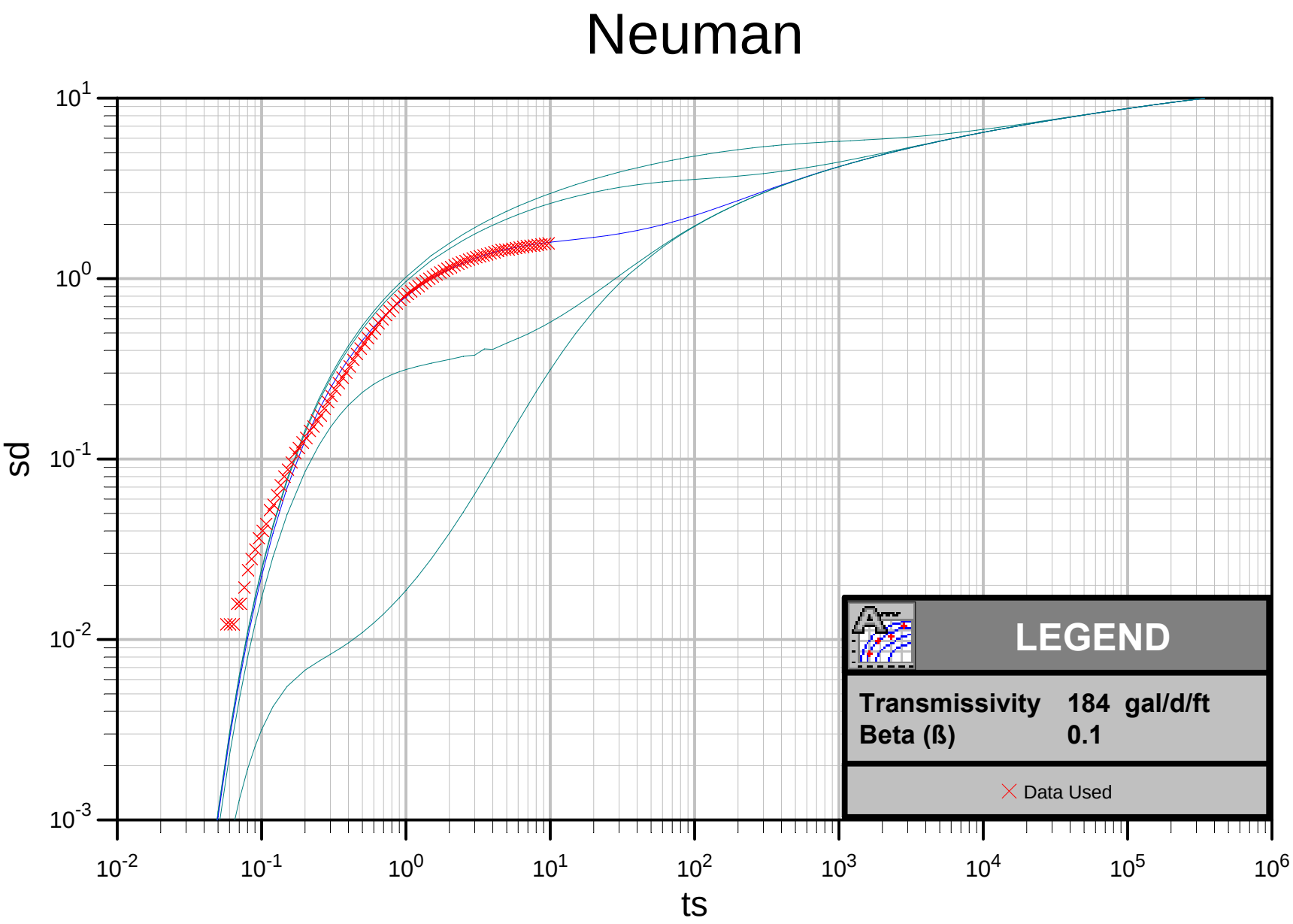


FIGURE 6. NEUMAN CURVE FIT FOR DRAWDOWN AT MW-19 FROM PUMPING AT MW-18

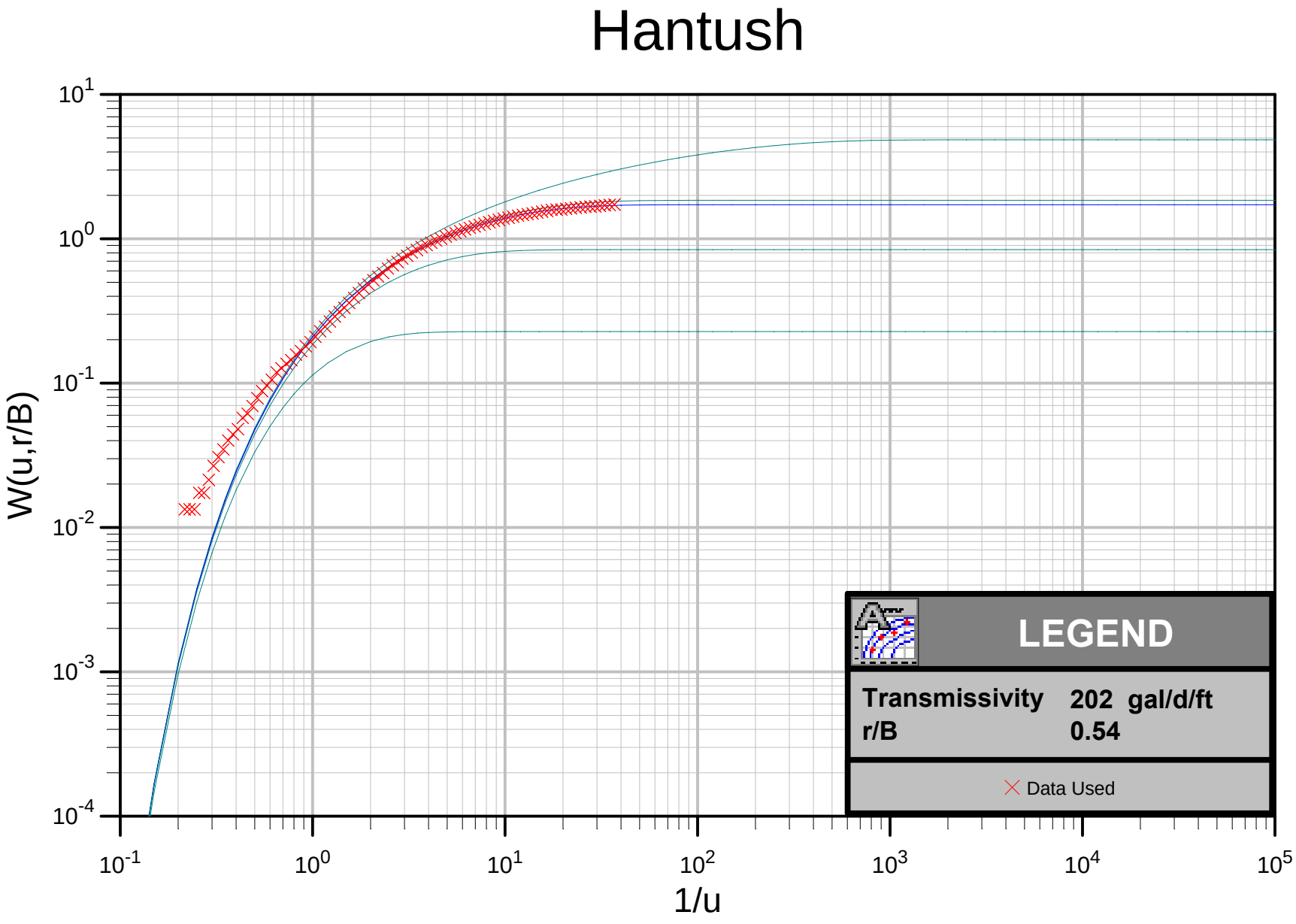


FIGURE 7. HANTUSH CURVE FIT FOR DRAWDOWN AT MW-19 FROM PUMPING AT MW-18

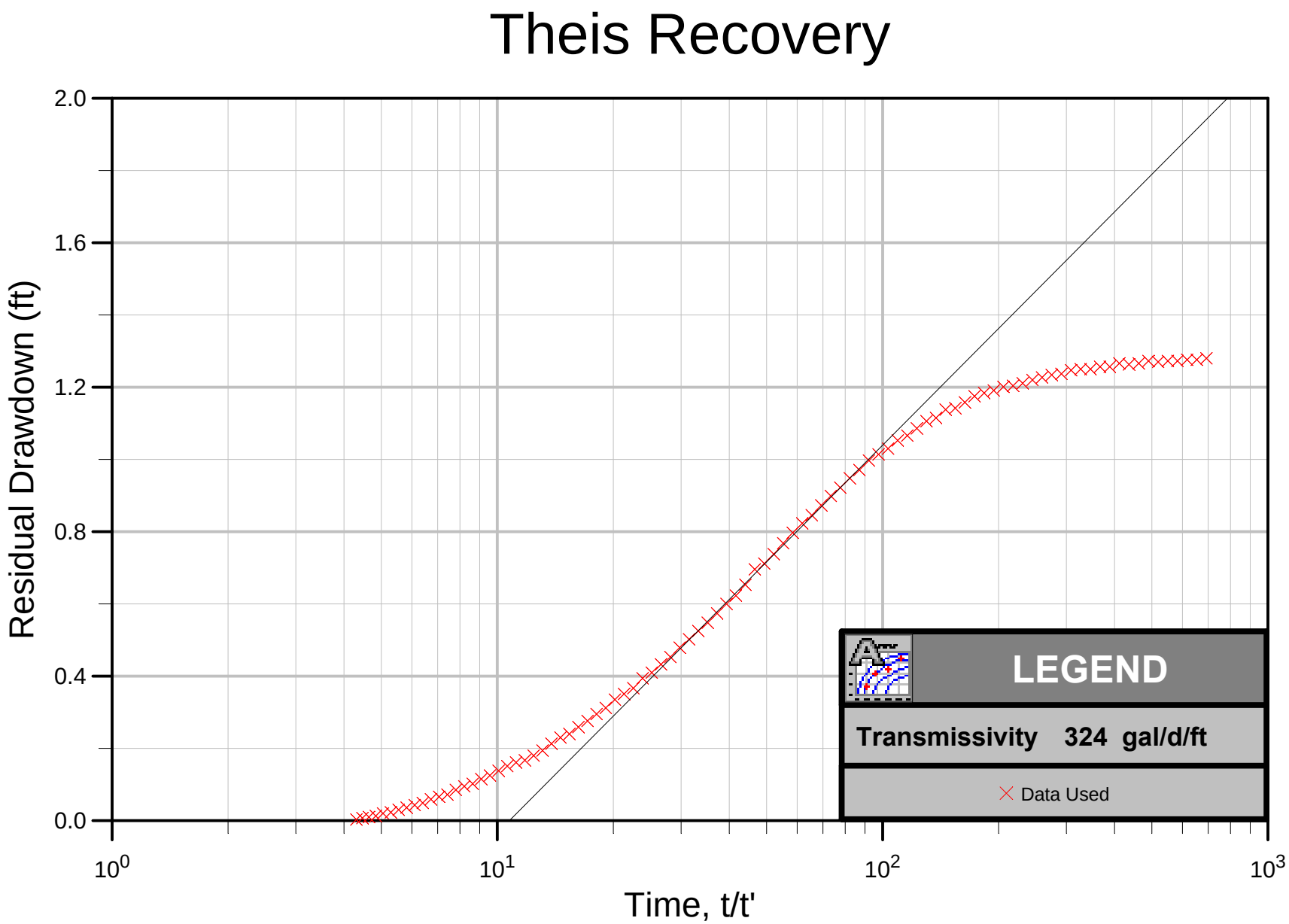


FIGURE 8. THEIS CURVE FIT FOR RECOVERY AT MW-19 FROM PUMPING AT MW-18

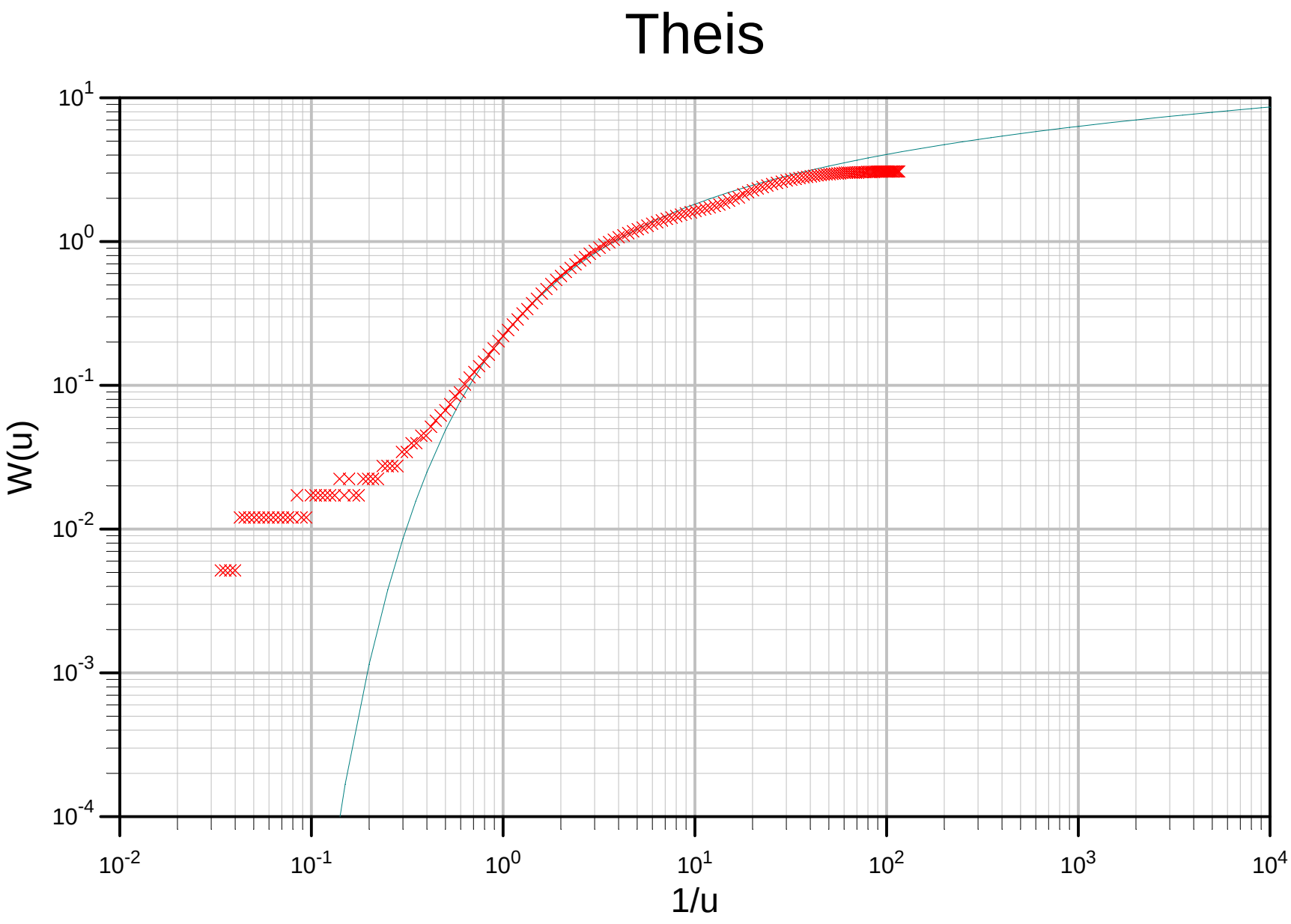


FIGURE 9. THEIS CURVE FIT FOR DRAWDOWN AT MW-06 FROM PUMPING AT MW-19

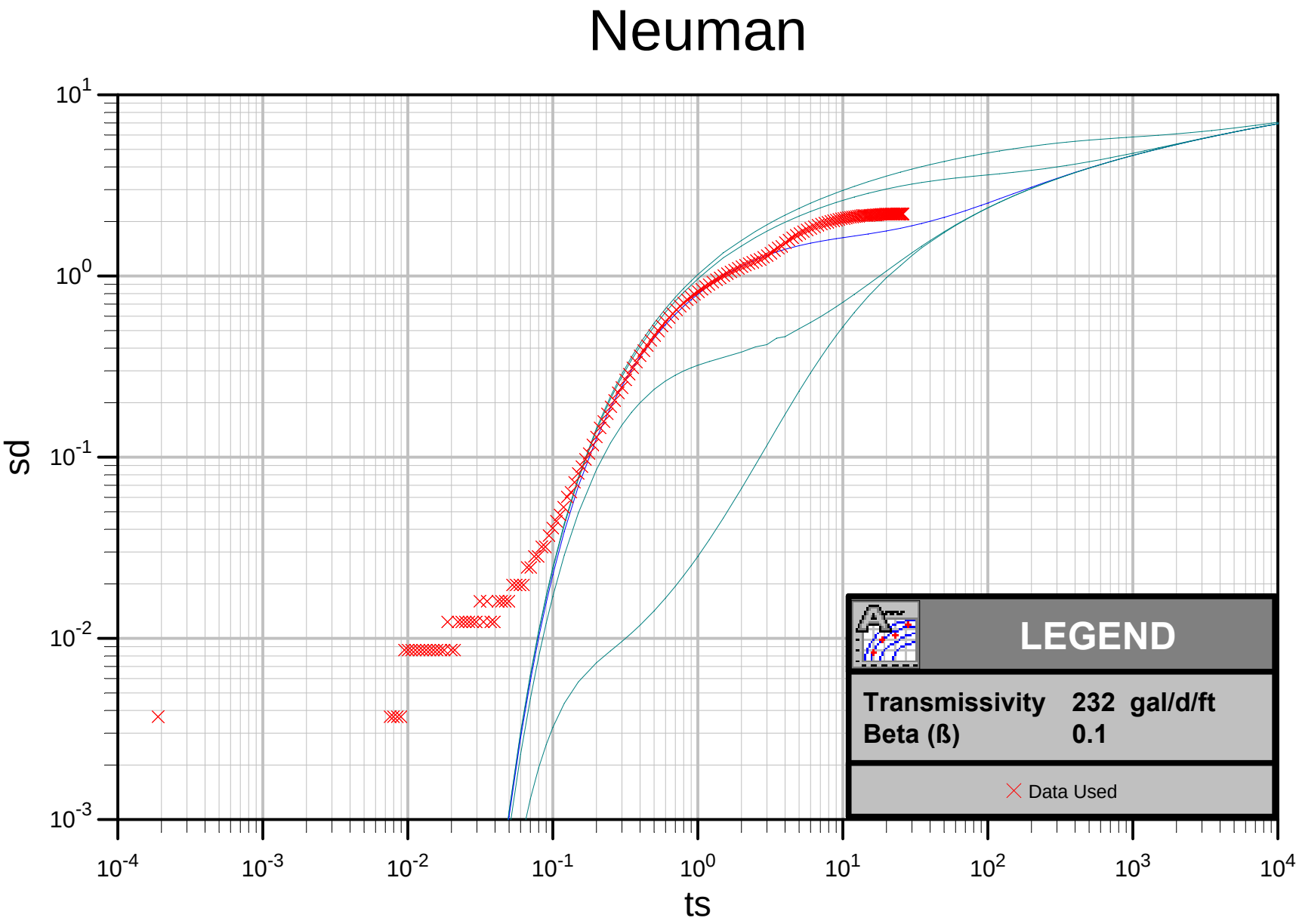


FIGURE 10. NEUMAN CURVE FIT FOR DRAWDOWN AT MW-06 FROM PUMPING AT MW-19

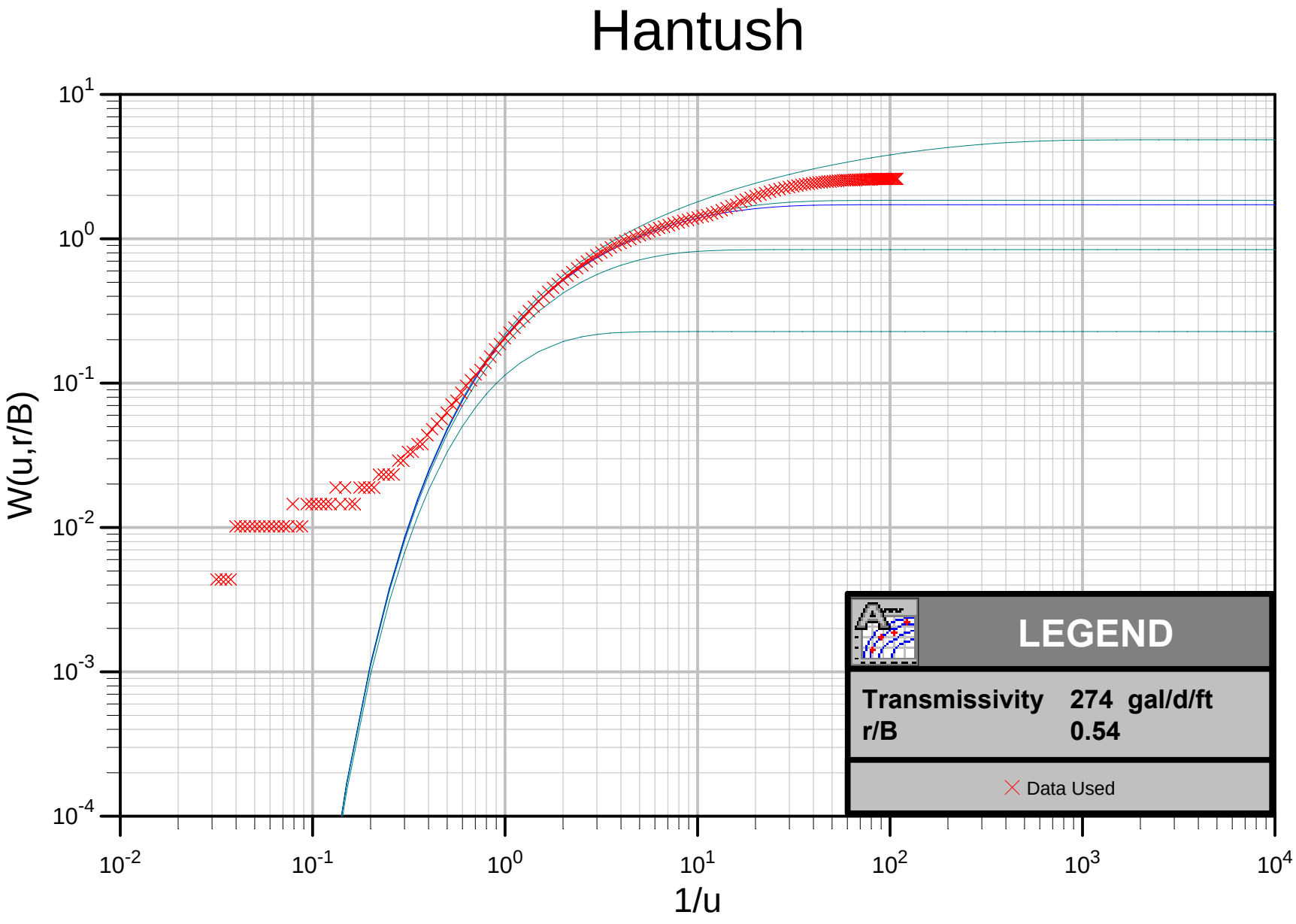


FIGURE 11. HANTUSH CURVE FIT FOR DRAWDOWN AT MW-06 FROM PUMPING AT MW-19

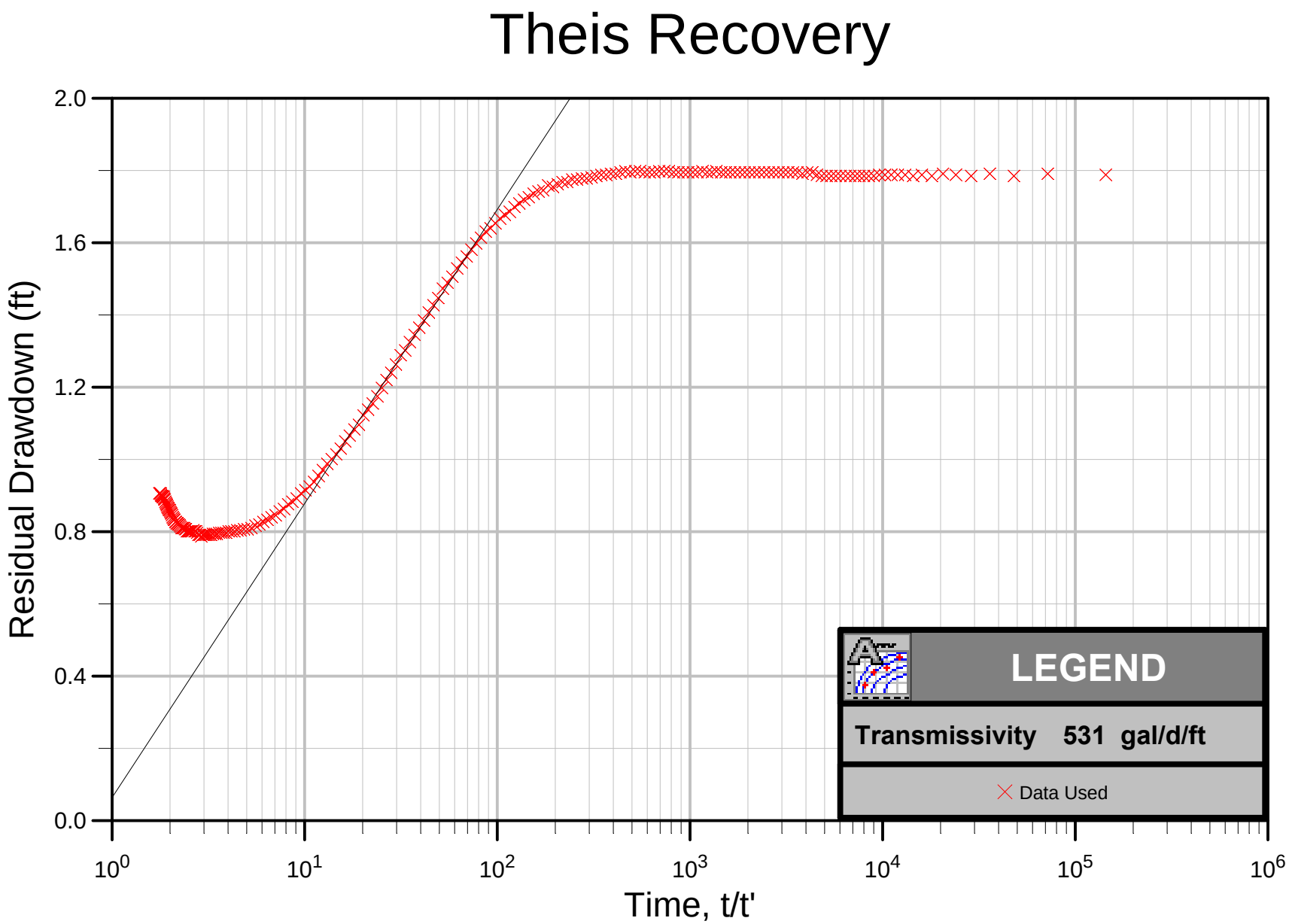


FIGURE 12. THEIS CURVE FIT FOR RECOVERY AT MW-06 FROM PUMPING AT MW-19

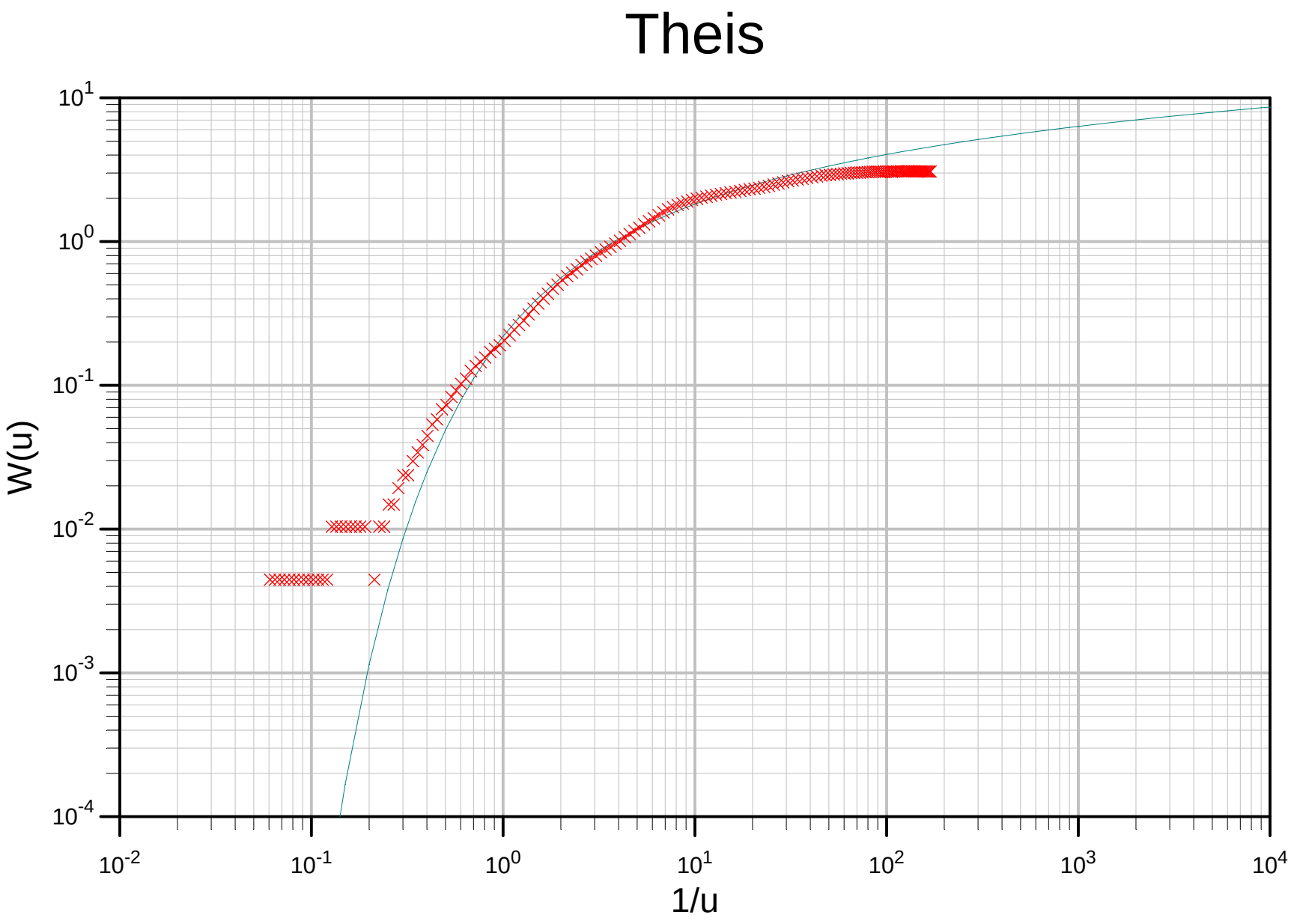


FIGURE 13. THEIS CURVE FIT FOR DRAWDOWN AT MW-18 FROM PUMPING AT MW-19

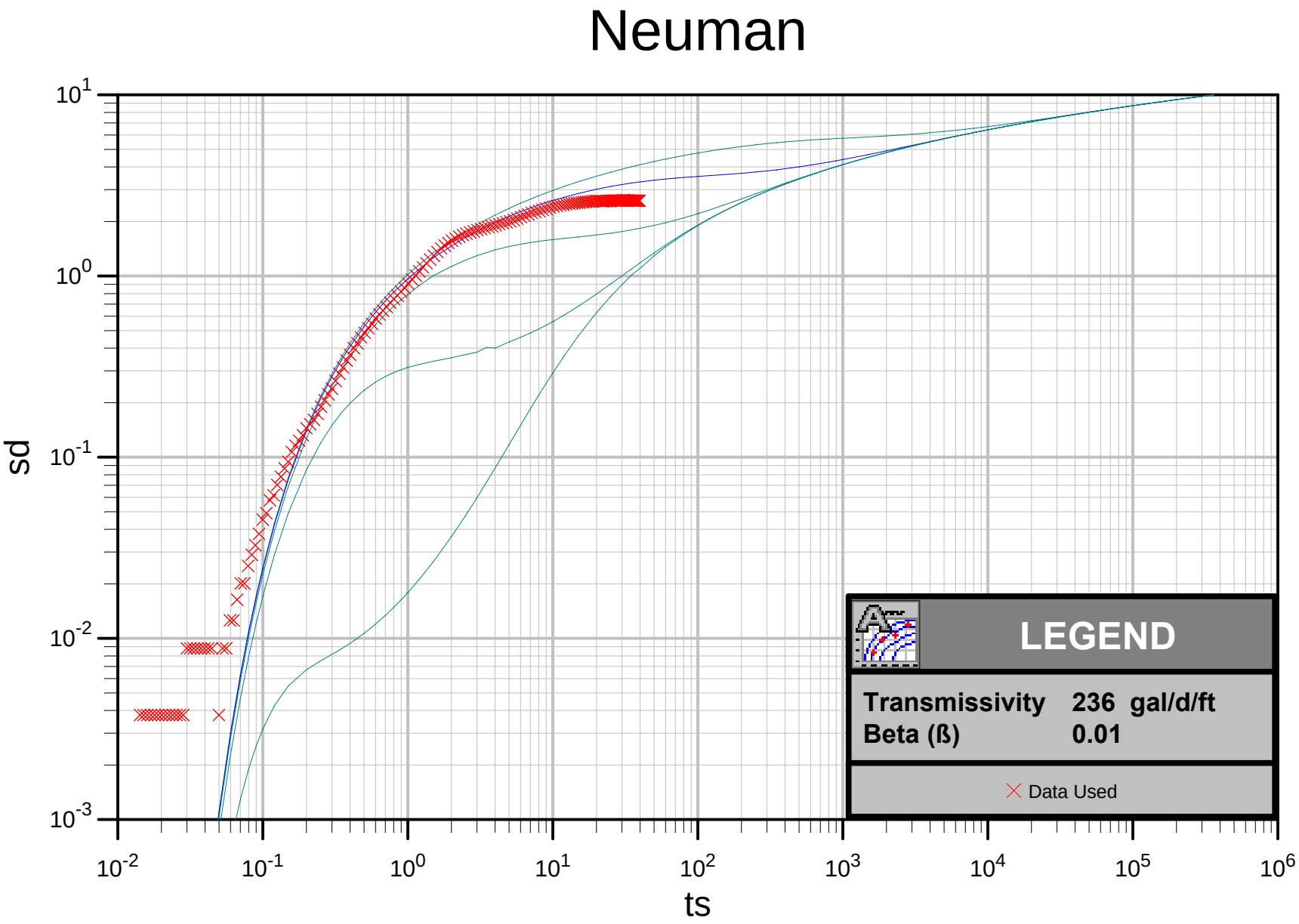


FIGURE 14. NEUMAN CURVE FIT FOR DRAWDOWN AT MW-18 FROM PUMPING AT MW-19

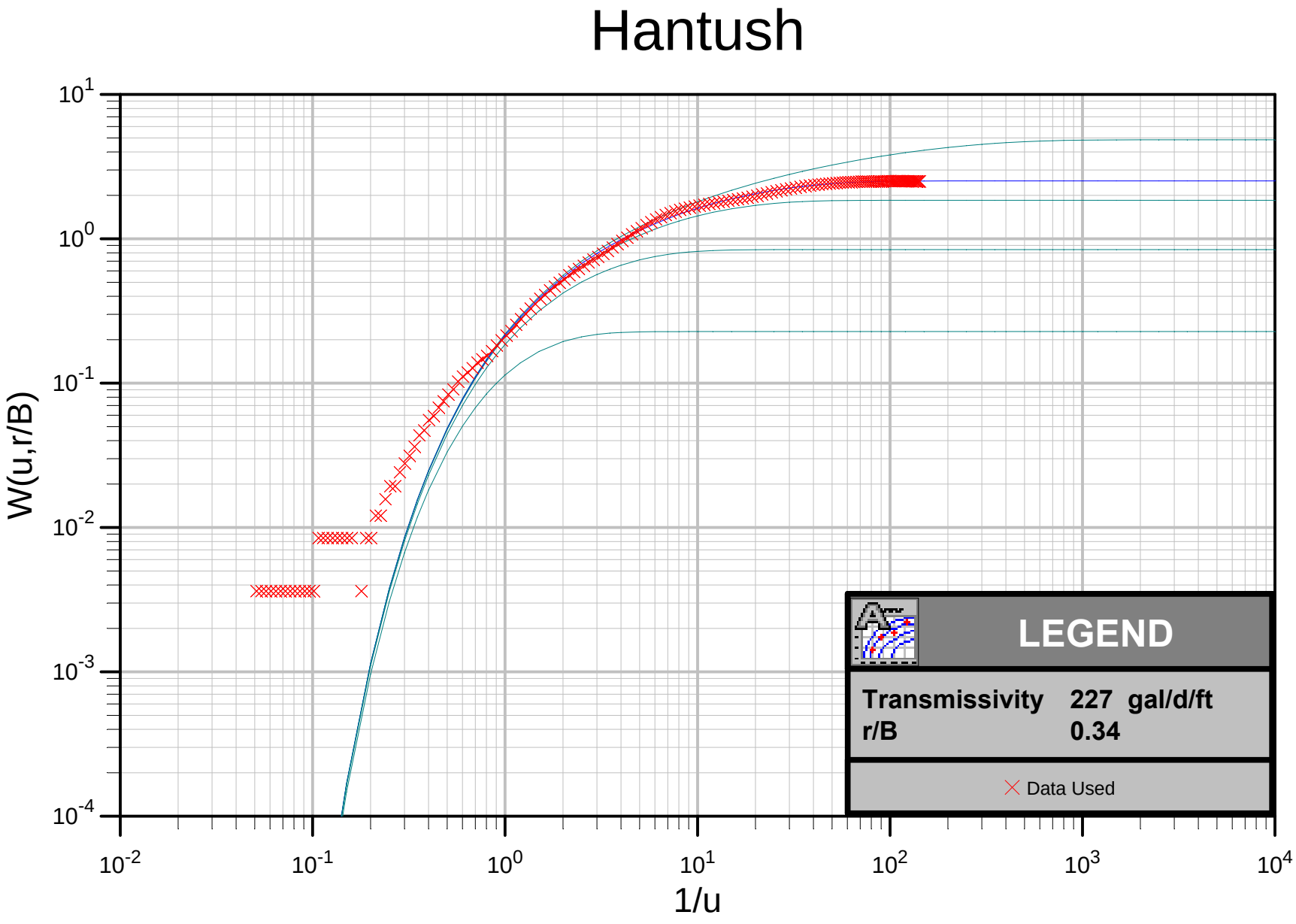


FIGURE 15. HANTUSH CURVE FIT FOR DRAWDOWN AT MW-18 FROM PUMPING AT MW-19

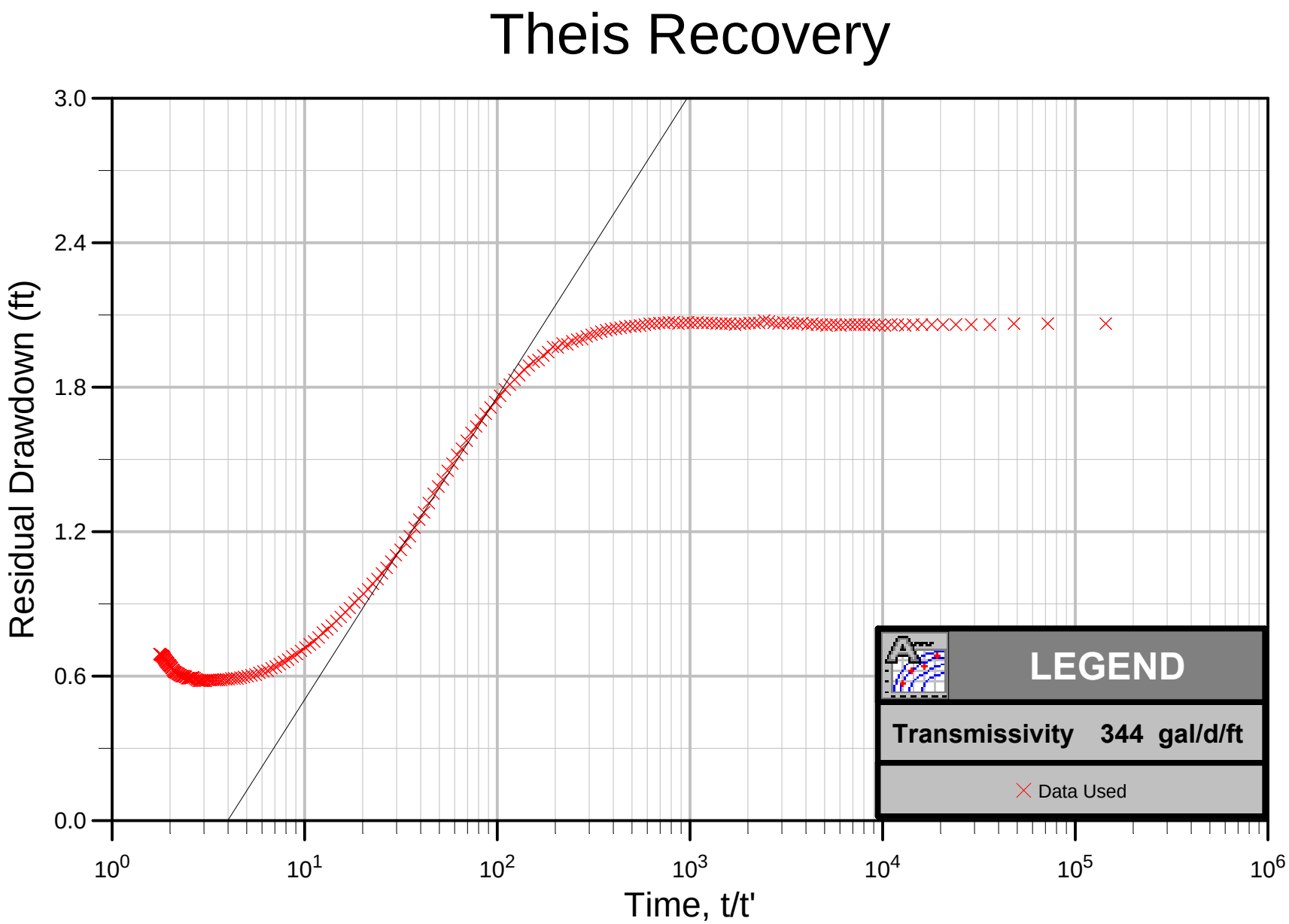


FIGURE 16. THEIS CURVE FIT FOR RECOVERY AT MW-18 FROM PUMPING AT MW-19

Geosyntec consultants

Appendix D: Soil Vapor Extraction Data

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

Date	Run Time (hours)	System Midpoint (psi)	System Out (psi)	System In (psi)	Vacuum at K/O (in W.C.)
3/21/2006	16	145	138	175	72
3/22/2006	24	145	138	175	70
3/23/2006	24	145	138	175	70
3/24/2006	24	145	138	175	68
3/25/2006	24	145	156	175	68
3/26/2006	24	149	156	175	68
3/27/2006	24	149	159	177	68
3/28/2006	24	149	160	177	65
3/29/2006	24	147	160	177	65
3/30/2006	24	147	160	177	59
3/31/2006	24	148	166	178	57
4/1/2006	24	148	166	178	57
4/2/2006	24	147	166	178	56
4/3/2006	17	147	165	176	53
4/4/2006	16	145	163	174	48
4/5/2006	24	149	167	178	51
4/6/2006	24	150	167	178	53
4/7/2006	23	147	166	177	53
4/8/2006	16	137	155	158	54
4/9/2006	23	147	159	169	54
4/10/2006	0	-	-	-	-
4/12/2006	0	-	-	-	-
4/13/2006	15	139	158	163	5
4/14/2006	22	140	160	167	19
4/15/2006	24	139	159	165	41
4/16/2006	24	126	146	154	39
4/17/2006	24	106	129	141	39
4/18/2006	23	109	130	142	37
4/19/2006	23	110	130	142	51
4/20/2006	0	-	-	-	-
4/21/2006	0	-	-	-	-
4/22/2006	12	129	149	146	29
4/23/2006	24	129	149	145	27
4/24/2006	24	128	148	143	25
4/25/2006	24	126	147	139	23
4/26/2006	24	122	143	133	19
4/27/2006	24	120	141	131	17
4/28/2006	24	123	144	132	16
4/29/2006	24	121	143	128	18
4/30/2006	24	115	137	122	16
5/1/2006	0	-	-	-	-
5/2/2006	0	-	-	-	-
5/3/2006	23	145	163	163	20
5/4/2006	19	146	164	166	26
5/7/2006	25	152	159	159	9
5/8/2006	23	147	153	154	13
5/9/2006	24	132	151	146	47

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
5/10/2006	0	-	-	-	-
5/11/2006	20	110	131	132	33
5/12/2006	24	111	132	134	36
5/13/2006	24	123	144	144	31
5/14/2006	24	132	153	151	34
5/15/2006	24	129	149	144	31
5/17/2006	25	103	128	106	14
5/18/2006	24	104	128	107	14
5/19/2006	24	112	135	120	19
5/20/2006	24	127	148	142	31
5/21/2006	0	-	-	-	-
5/22/2006	25	126	146	141	25
5/23/2006	23	126	147	143	30
5/24/2006	24	116	137	125	23
5/25/2006	24	103	126	105	14
5/26/2006	24	103	126	105	13
5/27/2006	24	104	126	105	13
5/28/2006	24	103	126	104	13
5/29/2006	24	112	134	117	19
5/30/2006	24	119	139	130	30
5/31/2006	24	123	144	133	28
6/1/2006	24	122	145	134	30
6/2/2006	24	124	144	128	32
6/3/2006	0	-	-	-	-
6/4/2006	0	-	-	-	-
6/5/2006	13	120	142	129	24
6/6/2006	23	120	140	128	36
6/7/2006	24	132	153	145	60
6/8/2006	24	116	140	124	60
6/9/2006	24	115	139	122	60
6/10/2006	7	104	129	107	61
6/11/2006	9	106	134	122	61
6/12/2006	0	-	-	-	-
6/13/2006	8	107	122	134	60
6/14/2006	10	104	128	105	60
6/15/2006	24	105	129	108	61
6/16/2006	24	104	130	108	61
6/17/2006	24	105	132	111	48
6/18/2006	20	105	129	108	48
6/19/2006	24	104	129	107	48
6/20/2006	24	105	130	108	48
6/21/2006	0	101	129	105	48
6/22/2006	0	-	-	-	-
6/23/2006	13	103	126	104	36
6/24/2006	23	113	136	120	28
6/25/2006	24	105	130	108	38
6/26/2006	23	114	137	120	47
6/27/2006	16	105	128	108	47

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
6/28/2006	20	118	112	99	28
6/29/2006	15	119	138	112	28
6/30/2006	24	127	146	138	42
7/1/2006	24	90	115	88	42
7/2/2006	24	90	116	88	42
7/3/2006	24	89	115	88	43
7/4/2006	24	92	116	91	41
7/5/2006	21	77	121	96	45
7/6/2006	24	124	144	134	47
7/7/2006	24	132	151	144	45
7/8/2006	24	130	149	142	36
7/9/2006	24	122	143	130	45
7/10/2006	24	102	127	103	45
7/11/2006	24	102	127	103	48
7/12/2006	24	102	126	102	48
7/13/2006	24	102	126	102	45
7/14/2006	24	116	138	122	45
7/15/2006	24	130	150	143	45
7/16/2006	24	129	149	142	45
7/17/2006	24	124	145	134	45
7/18/2006	24	107	131	109	45
7/19/2006	24	108	131	109	45
7/20/2006	24	108	131	109	45
7/21/2006	24	107	130	108	45
7/22/2006	24	107	130	108	48
7/23/2006	24	106	130	107	45
7/24/2006	23	110	133	113	47
7/25/2006	24	117	139	124	45
7/26/2006	23	125	145	135	40
7/27/2006	24	122	143	131	40
7/28/2006	24	128	149	141	40
7/29/2006	24	122	144	132	40
7/30/2006	24	122	143	131	40
7/31/2006	24	122	144	131	40
8/1/2006	24	122	143	130	45
8/2/2006	24	120	142	128	45
8/3/2006	23	109	132	111	45
8/4/2006	25	109	133	112	45
8/5/2006	24	112	134	115	45
8/6/2006	24	112	134	116	45
8/7/2006	24	110	133	113	45
8/8/2006	24	110	133	113	45
8/9/2006	24	111	134	114	45
8/10/2006	20	-	-	-	-
8/11/2006	21	118	134	121	45
8/12/2006	25	113	135	117	45
8/13/2006	24	114	135	118	45
8/14/2006	24	119	134	123	46

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
8/15/2006	24	114	134	118	46
8/16/2006	24	111	134	114	46
8/17/2006	24	114	137	118	46
8/18/2006	24	111	131	112	46
8/19/2006	24	105	129	107	46
8/20/2006	23	106	127	107	46
8/21/2006	25	102	126	102	46
8/22/2006	24	115	133	119	46
8/23/2006	24	117	137	121	46
8/24/2006	24	105	118	105	46
8/25/2006	23	90	104	93	46
8/26/2006	23	130	137	143	46
8/27/2006	26	130	131	133	46
8/28/2006	24	131	132	134	46
8/29/2006	24	127	129	129	46
8/30/2006	11	134	142	132	46
8/31/2006	22	143	145	133	46
9/1/2006	24	137	146	135	46
9/2/2006	22	135	148	136	46
9/3/2006	24	135	147	137	46
9/4/2006	23	135	149	138	46
9/5/2006	14	143	147	139	46
9/6/2006	22	129	130	130	46
9/7/2006	15	145	143	152	56
9/8/2006	24	151	148	162	56
9/9/2006	24	140	140	150	56
9/10/2006	24	137	135	144	56
9/11/2006	24	134	134	142	56
9/12/2006	24	146	145	160	56
9/13/2006	24	141	140	153	56
9/14/2006	24	139	139	150	56
9/15/2006	24	138	137	148	56
9/16/2006	24	137	137	148	56
9/17/2006	24	137	137	147	56
9/18/2006	24	142	142	156	56
9/19/2006	24	146	146	163	46
9/20/2006	24	144	144	162	56
9/21/2006	24	144	145	161	56
9/22/2006	24	144	145	162	56
9/23/2006	24	146	146	164	46
9/24/2006	24	146	145	163	56
9/25/2006	24	146	145	163	56
9/26/2006	24	148	147	161	56
9/27/2006	15	134	134	151	56
9/28/2006	14	132	136	158	56
9/29/2006	8	134	135	151	56
9/30/2006	0	-	-	-	-
10/1/2006	14	148	143	160	58

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
10/2/2006	24	146	132	149	56
10/3/2006	24	144	129	150	57
10/4/2006	24	138	142	145	57
10/5/2006	24	145	145	145	57
10/6/2006	24	145	146	145	57
10/7/2006	24	146	148	145	57
10/8/2006	24	143	147	145	57
10/9/2006	24	141	149	145	57
10/10/2006	24	141	147	145	57
10/11/2006	24	139	130	145	57
10/12/2006	24	138	143	145	57
10/13/2006	24	145	148	145	57
10/14/2006	12	129	140	145	57
10/15/2006	24	138	135	145	57
10/16/2006	24	146	134	143	57
10/17/2006	24	134	145	143	57
10/18/2006	24	146	140	143	57
10/19/2006	24	145	139	143	57
10/20/2006	24	145	137	143	57
10/21/2006	24	145	137	143	57
10/22/2006	0	146	137	143	57
10/23/2006	23	142	142	143	57
10/24/2006	24	142	146	143	57
10/25/2006	23	142	144	143	57
10/26/2006	24	134	145	143	57
10/27/2006	24	150	145	143	57
10/28/2006	24	147	146	143	57
10/29/2006	24	147	134	143	57
10/30/2006	24	138	135	143	57
10/31/2006	0	-	-	-	-
11/1/2006	24	150	144	143	48
11/2/2006	24	149	134	143	48
11/3/2006	24	150	137	143	48
11/4/2006	24	148	137	143	48
11/5/2006	24	146	138	143	48
11/6/2006	24	154	135	143	48
11/7/2006	24	148	140	150	48
11/8/2006	24	144	143	145	48
11/9/2006	24	145	127	147	55
11/10/2006	24	145	127	145	55
11/11/2006	24	146	126	149	55
11/12/2006	24	156	126	139	55
11/13/2006	24	143	138	146	55
11/14/2006	0	152	150	149	55
11/15/2006	24	155	149	149	55
11/16/2006	24	154	145	149	55
11/17/2006	24	153	131	149	55
11/19/2006	24	154	129	149	55

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
11/20/2006	24	154	130	149	58
11/21/2006	24	155	133	149	58
11/22/2006	24	156	134	149	58
11/23/2006	24	147	134	149	58
11/24/2006	24	147	140	149	58
11/25/2006	24	148	138	149	58
11/26/2006	24	150	134	155	58
11/27/2006	24	149	136	138	58
11/28/2006	24	148	137	135	58
11/29/2006	24	148	138	135	58
11/30/2006	24	150	140	135	58
12/1/2006	23	153	134	144	58
12/2/2006	24	158	140	148	58
12/3/2006	24	138	124	129	58
12/4/2006	24	158	140	148	58
12/5/2006	24	141	128	134	58
12/6/2006	24	143	123	134	75
12/7/2006	24	162	143	150	75
12/8/2006	24	151	136	143	78
12/9/2006	22	145	119	130	75
12/10/2006	24	142	127	130	78
12/11/2006	24	138	124	128	76
12/12/2006	24	134	121	125	75
12/13/2006	24	140	124	129	70
12/14/2006	24	169	129	142	68
12/15/2006	24	145	124	130	70
12/16/2006	24	139	123	127	72
12/17/2006	24	137	124	126	78
12/18/2006	24	140	124	127	74
12/19/2006	23	152	137	143	70
12/20/2006	24	156	141	147	70
12/21/2006	24	154	139	145	70
12/22/2006	24	151	136	143	74
12/23/2006	24	151	136	143	74
12/24/2006	24	151	137	143	74
12/25/2006	24	136	121	129	74
12/26/2006	24	144	128	134	74
12/27/2006	24	145	123	137	74
12/28/2006	24	145	125	143	74
12/29/2006	24	144	124	140	76
12/30/2006	24	148	124	140	77
12/31/2006	24	147	132	140	78
1/1/2007	24	154	138	144	78
1/2/2007	23	149	140	138	78
1/3/2007	24	151	151	142	78
1/4/2007	24	150	150	142	78
1/5/2007	24	149	151	140	78
1/6/2007	24	148	146	138	78

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
1/7/2007	24	148	147	139	78
1/8/2007	24	153	153	143	78
1/9/2007	24	150	150	141	78
1/10/2007	24	152	152	142	78
1/11/2007	24	151	152	142	78
1/12/2007	24	152	152	142	78
1/13/2007	24	151	151	142	78
1/14/2007	24	146	147	136	78
1/15/2007	24	149	150	137	78
1/16/2007	24	144	145	131	78
1/17/2007	24	143	144	129	78
1/18/2007	22	147	148	138	78
1/19/2007	24	159	159	153	78
1/20/2007	24	156	157	150	78
1/21/2007	24	144	144	142	78
1/22/2007	24	155	155	145	78
1/23/2007	24	154	154	143	78
1/24/2007	24	151	152	139	78
1/25/2007	24	155	156	145	78
1/26/2007	24	155	156	146	78
1/27/2007	24	155	155	145	75
1/28/2007	24	154	155	144	75
1/29/2007	24	145	156	135	75
1/30/2007	24	135	148	134	75
1/31/2007	24	132	133	128	75
2/1/2007	24	132	132	128	75
2/2/2007	24	131	130	127	75
2/3/2007	24	122	124	116	75
2/4/2007	24	120	120	116	75
2/6/2007	24	134	145	136	75
2/7/2007	11	144	147	132	75
2/8/2007	24	148	150	137	75
2/9/2007	24	152	153	140	75
2/10/2007	24	151	152	139	75
2/11/2007	24	150	151	138	75
2/12/2007	24	156	142	147	75
2/13/2007	24	-	-	-	-
2/14/2007	24	150	151	138	76
2/15/2007	9	145	146	132	78
2/16/2007	0	-	-	-	-
2/17/2007	0	-	-	-	-
2/18/2007	0	-	-	-	-
2/19/2007	0	-	-	-	-
2/20/2007	0	-	-	-	-
2/21/2007	0	-	-	-	-
2/22/2007	1	143	146	131	
2/23/2007	0	-	-	-	-
2/24/2007	0	-	-	-	-

GEO SYSTEM MONITORING DATA
HASSAYAMPA LANDFILL SUPERFUND SITE
MARICOPA COUNTY, ARIZONA

	Run Time	System Midpoint	System Out	System In	Vacuum at K/O
2/25/2007	0	-	-	-	-
2/26/2007	0	-	-	-	-
2/27/2007	0	-	-	-	-
2/28/2007	10	141	142	126	80
3/1/2007	24	-	-	-	-
3/2/2007	24	-	-	-	-
3/3/2007	24	-	-	-	-
3/4/2007	24	-	-	-	-
3/5/2007	12	158	159	148	81
3/6/2007	24	157	158	148	81
3/7/2007	24	158	159	149	81
3/8/2007	24	158	159	148	81
3/9/2007	24	155	156	145	81
3/10/2007	24	148	149	135	81
3/11/2007	24	150	150	136	81
3/12/2007	24	151	152	139	81
3/13/2007	24	153	154	142	81
3/14/2007	24	152	152	140	81
3/15/2007	24	155	156	145	81
3/16/2007	24	154	155	144	81
3/17/2007	24	151	152	140	81
3/18/2007	23	144	145	129	81
3/19/2007	20	141	142	124	81
3/20/2007	17	142	145	131	81
3/21/2007	16	141	143	129	81
3/22/2007	22	139	139	131	81
3/23/2007	24	137	132	131	81
3/24/2007	24	137	133	132	81
3/25/2007	24	138	133	133	81
3/26/2007	24	138	133	133	81
3/27/2007	24	138	133	133	81
3/28/2007	24	138	134	135	81
3/29/2007	24	-	-	-	-
3/30/2007	19	138	134	134	81
3/31/2007	16	139	135	138	77

SVE System Monitoring Data - Extraction Well N-1
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	16	127	108.5	75	30.00	-	40.6
3/27/2006	6.5	73.9	64.5	75	30.00	-	28.2
3/27/2006	1.79	36.2	33.9	75	30.00	-	15.6
3/29/2006	3.43	49.6	45.8	69	30.00	-	21.4
4/5/2006	4	-	27	82	29.86	-	-
4/7/2006	1.34	-	28	62	30	-	-
4/11/2006	2.5	-	29	79	30.01	78	-
4/18/2006	1.58	29.9	29.9	-	30	-	-
4/22/2006	1.34	15.4	-	-	30	-	-
4/24/2006	1.6	27	25	62	30	32	15.1
4/28/2006	1.25	21	23	69	29.99	-	13.4
5/5/2006	2.4	-	33	85	30	312	18.3
5/8/2006	2.08	31	31	100	30	-	16.6
5/17/2006	0.53	13.1	14	105	30	43	8.5
5/23/2006	1.86	27.5	35.1	98	30	-	15.8
5/29/2006	1.25	27.5	35	95	30	36	13.0
5/31/2006	0.77	28.1	35	75	30	-	10.4
6/15/2006	0.98	14.8	15.3	65	29.6	623	11.9
6/17/2006	0.27	14.1	20	90	30	-	6.2
6/26/2006	0.58	34	-	108	29.9	-	8.6
6/30/2006	0.98	36.3	45	98	29.8	26	11.3
7/7/2006	0.67	38.3	50	74	29.8	-	9.5
7/14/2006	0.5	32.6	-	116	29.7	-	8.0
7/17/2006	0.55	28.2	44	107	29.7	19.2	8.5
7/25/2006	0.57	25.5	50	98	29.7	22	8.7
8/8/2006	0.91	33.3	-	92	29.9	24.9	11.0
8/22/2006	0.57	40.7	46	98	29.9	39	8.6
9/6/2006	0.24	18.3	26	101	29.9	606	5.7
9/8/2006	0.09	68.7	69.8	98	29.9	-	3.3
9/18/2006	0.14	42.5	46	88	29.9	4.8	4.3
9/25/2006	0.18	60.6	65	92	29.9	-	4.7
10/6/2006	0.13	67.1	75	84	29.9	22	4.0
10/14/2006	0.14	60.4	65	82	29.9	16.8	4.2
10/30/2006	0.11	63	68	85	29.9	27	3.7
11/20/2006	0.12	42	50	82	29.9	270	4.0
12/5/2006	0.11	54	65	75	29.9	57	3.8
12/19/2006	0.18	37	100	38	29.9	43	5.1
12/29/2006	0.25	47	80	62	29.9	29	5.8
1/4/2007	0.14	44	80	-	29.9	-	-
1/1607	0.01	23	40	58	29.9	-	1.2
1/30/2007	0.02	31	60	57	29.9	392	1.7
2/7/2007	0.03	19.2	28	74	29.9	36	2.1
3/7/2007	0.63	34	64	68	29.9	27	9.3
3/22/2007	0.01	24	40	68	29.9	204	1.2

SVE System Monitoring Data - Extraction Well NE-1
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	ppmv	(scfm)
3/27/2006	37.5	133.3	91.7	80	30.00	-	61.2
3/27/2006	15.5	77.5	59.3	80	30.00	-	43.1
3/27/2006	3	32.7	28.8	80	30.00	-	20.2
3/29/2006	8	48.8	39.9	72	30.00	-	32.6
4/5/2006	8.1	-	24.7	82	29.86	-	-
4/7/2006	3.67	-	-	68	30	-	-
4/11/2006	5.4	13	33.3	76	30.01	200	27.9
4/18/2006	1.73	28	28	74	30	-	15.5
4/22/2006	4.18	29.2	-	-	30	-	-
4/24/2006	3.8	23	22	62	30	46	23.5
4/28/2006	2.57	20	23	69	29.99	-	19.2
5/5/2006	2.5	13	33	85	30	306	18.9
5/8/2006	5.14	30	31	100	30	-	26.1
5/17/2006	1.3	13.1	14	105	30	85	13.4
5/23/2006	4.52	27.8	35.1	98	30	-	24.6
5/29/2006	1.3	13.1	14	105	30	47	13.4
5/31/2006	1.86	18.2	35	75	30	-	16.3
6/15/2006	1.65	14.9	15.3	65	29.6	593	15.5
6/17/2006	1.32	13	20	90	30	-	13.6
6/26/2006	3.29	33.6	-	108	-	-	-
6/30/2006	2.44	35.3	45	98	29.8	65	17.8
7/7/2006	2.29	38.4	50	74	-	-	-
7/14/2006	1.89	34	-	116	39.7	-	18.0
7/17/2006	1.6	28.8	44	107	29.8	749	14.4
7/25/2006	0.38	27.3	50	98	29.7	52	7.1
8/8/2006	0.55	33.2	50	92	29.9	49.4	8.5
8/22/2006	0.54	40.7	46	98	29.9	81	8.3
9/6/2006	0.22	18.3	26	101	29.9	56	5.5
9/8/2006	0.04	68.7	69.8	98	29.9	-	2.2
9/18/2006	0.03	44.1	46	88	29.9	6.6	2.0
9/25/2006	0.07	60.4	65	92	29.9	-	2.9
10/6/2006	0.1	67.4	75	84	29.9	52	3.5
10/14/2006	0.14	60.4	65	82	29.9	31	4.2
10/23/2006	0.12	70	94	82	29.9	68	3.8
10/30/2006	0.11	63	68	85	29.9	15.4	3.7
11/20/2006	0.12	35	50	82	29.9	450	4.0
12/5/2006	0.12	50.7	65	75	29.9	30	4.0
12/19/2006	0.12	37	100	38	29.9	29	4.2
12/29/2006	0.23	47	80	62	29.9	31	5.6
1/4/2007	0.16	45	80	-	29.9	-	-
1/16/2007	0.11	21	40	58	29.9	48	4.0
1/30/2007	0.12	31	60	57	29.9	48	4.1
2/7/2007	0	19	28	74	29.9	61	0.0
3/7/2007	0.23	27	64	68	29.9	37	5.7
3/22/2007	0.11	24	40	68	29.9	25.9	4.0

SVE System Monitoring Data - Extraction Well NW-2
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	2.25	139.6	135.5	80	30.00	-	14.8
3/27/2006	0.9	75.6	74.7	80	30.00	-	10.4
3/27/2006	0.33	34.2	34.3	80	30.00	-	6.7
3/29/2006	0.5	48	48	72	30.00	-	8.1
4/5/2006	1.1	-	42	82	29.86	-	-
4/7/2006	0.2	-	-	62	-	-	-
4/11/2006	1.3	25	20	74	30.01	74	13.5
4/18/2006	0.89	29	29	74	-	-	-
4/22/2006	0.4	14.2	-	-	-	-	-
4/24/2006	1.23	28	25	85	29.9	87	12.9
4/28/2006	1.02	21	23	69	29.99	-	12.1
5/5/2006	1.03	25	33	85	29.9	1280	11.9
5/8/2006	2.07	30	31	100	-	-	-
5/17/2006	0.66	13.1	14	105	29.8	308	9.5
5/23/2006	2.03	27.3	35.1	98	-	-	-
5/29/2006	0.66	25	30	90	29.8	106	9.5
5/31/2006	2.1	28.1	35	75	-	-	-
6/15/2006	0.98	15	15.3	65	29.6	423	11.9
6/17/2006	0.89	13.9	20	90	-	-	-
6/26/2006	2.74	34	-	108	-	-	-
6/30/2006	3.45	34.4	45	98	29.8	85	21.2
7/7/2006	1.34	37.9	50	74	-	-	-
7/14/2006	1.89	35.5	-	116	29.7	-	15.4
7/17/2006	1.74	28.6	44	107	29.8	33	15.1
7/25/2006	0.78	24.4	50	98	29.7	51	10.2
8/8/2006	1.02	33.7	40	92	29.9	25	11.6
8/22/2006	0.33	40.8	46	98	29.9	51	6.5
9/6/2006	0.14	18.4	26	101	29.9	377	4.4
9/8/2006	0.17	68.8	69.8	98	29.9	-	4.5
9/18/2006	0.24	44.4	46	88	29.9	40	5.6
9/25/2006	0.25	60.5	65	92	29.9	-	5.5
10/6/2006	0.12	67.1	75	84	29.9	26	3.8
10/14/2006	0.14	60.4	65	82	29.9	25.6	4.2
10/23/2006	0.15	71	94	82	29.9	57	4.3
10/30/2006	0.12	61	68	85	29.9	24	3.9
11/20/2006	0.14	45	50	82	29.9	450	4.3
12/5/2006	0.36	50.8	65	75	29.9	51	6.9
12/19/2006	0.12	37	100	38	29.9	45	4.2
12/29/2006	0.16	48	80	62	29.9	42	4.6
1/4/2007	0.16	45	80	-	29.9	-	-
1/16/2007	0.03	23	40	58	29.9	48	2.1
1/30/2007	0.1	32	60	57	29.9	39	3.8
2/7/2007	0.04	19	28	74	29.9	142	2.4
3/7/2007	0.6	35	64	68	29.9	22	9.1
3/22/2007	0.03	22	40	68	29.9	50	2.1

SVE System Monitoring Data - Extraction Well P-1
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	3.1	132	123	80	30.00	-	17.6
3/27/2006	0.85	70.5	68.2	80	30.00	-	10.2
3/27/2006	0.22	38.4	37.6	80	30.00	-	5.4
3/29/2006	0.4	47.7	47.7	74	30.00	-	7.3
4/5/2006	0.5	-	47	82	29.86	-	-
4/7/2006	0.13	-	-	72	-	-	-
4/11/2006	0.1	25	35	76	30.01	932	3.7
4/18/2006	0.17	29.4	29	86	-	-	-
4/22/2006	0.06	14	-	-	-	-	-
4/24/2006	0.2	28	25	58	29.9	1390	5.4
4/28/2006	0.14	22	23	69	29.99	-	4.5
5/5/2006	0.07	25	33	85	29.8	3800	3.1
5/8/2006	0.17	30	31	100	-	-	-
5/17/2006	0	12.6	14	105	29.7	467	0.0
5/23/2006	0.2	28	35.1	98	-	-	-
5/29/2006	0.05	35	35	95	29.9	812	2.6
6/15/2006	0.06	15	15.3	65	29.6	799	2.9
6/17/2006	0.13	13.8	20	90	-	-	-
6/26/2006	0.15	33.7	-	108	-	-	-
6/30/2006	0.15	35.3	45	98	29.8	1080	4.4
7/7/2006	0.78	37.2	50	74	-	-	-
7/14/2006	0.26	35.3	-	116	29.7	-	5.7
7/17/2006	0.44	28.9	44	107	29.7	980	7.6
7/25/2006	0.15	27.5	50	98	29.7	1307	4.5
8/8/2006	0.16	32	50	92	29.9	893	4.6
8/22/2006	0.25	40.8	46	98	29.9	948	5.7
9/6/2006	0.03	18.3	26	101	29.9	670	2.0
9/8/2006	0.6	69.1	69.8	98	29.9	-	8.4
9/18/2006	0.3	43.1	46	88	29.9	10000	6.2
9/25/2006	0.54	60.7	65	92	29.9	-	8.1
10/6/2006	0.6	67.9	75	84	29.9	1143	8.6
10/14/2006	0.53	60.5	65	82	29.9	635	8.1
10/23/2006	1.5	69	94	82	29.9	3,000	13.5
10/30/2006	0.57	63	68	85	29.9	1256	8.4
11/20/2006	0.37	50	50	82	29.9	9999	6.9
12/5/2006	0.13	52	65	75	29.9	1010	4.1
12/19/2006	0.2	37.7	100	38	29.9	1902	5.4
12/29/2006	0.32	47	80	62	29.9	1322	6.6
1/4/2007	0.3	44	80	-	29.9	-	-
1/16/2007	0.05	24	40	58	29.9	1146	2.7
1/30/2007	0.16	32	60	57	29.9	1348	4.8
2/7/2007	0.06	19.8	28	74	29.9	1181	2.9
3/7/2007	0.29	39	64	68	29.9	1646	6.3
3/22/2007	0.05	24	40	68	29.9	1133	2.7

SVE System Monitoring Data - Extraction Well V-10
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	2.8	196	189.5	80	30.00	-	14.7
3/27/2006	0.25	70.4	67.3	80	30.00	-	5.5
3/27/2006	0.11	29.7	28.5	80	30.00	-	3.9
3/29/2006	0.16	48.3	49.2	75	30.00	-	4.6
4/5/2006	0.01	-	46.8	82	29.86	-	-
4/7/2006	0.05	-	-	76	-	-	-
4/11/2006	0.1	29	35.5	74	30.01	1159	3.7
4/18/2006	0	29.2	29	88	-	-	-
4/22/2006	0.01	28	-	-	-	-	-
4/24/2006	0.2	29	26	60	29.9	1550	5.3
4/28/2006	0.09	21	23	69	29.99	-	3.6
5/5/2006	0	29	33	85	29.8	9999	0.0
5/8/2006	0.1	30	31	100	-	-	-
5/17/2006	1	13.1	14	105	29.7	1032	11.7
5/23/2006	0	27.4	35.1	98	-	-	-
5/29/2006	0.16	28.1	35	75	29.9	1484	4.7
5/31/2006	0.16	28.1	35	75	-	-	-
6/15/2006	2.1	15	15.3	65	29.6	1344	17.4
6/17/2006	0.03	12.8	20	90	-	-	-
6/26/2006	0.01	33.7	-	108	-	-	-
6/30/2006	0.04	35.3	45	98	29.8	1572	2.3
7/7/2006	0.14	38.2	50	74	-	-	-
7/14/2006	0.2	35.3	-	116	29.7	-	5.0
7/17/2006	0.44	28.9	44	107	29.9	1538	7.6
7/25/2006	0.02	27.4	50	98	29.7	1475	1.6
8/8/2006	0.13	33.3	50	92	29.9	531	4.2
8/22/2006	0.12	37.5	46	98	29.9	1096	3.9
9/6/2006	0.03	18.3	26	101	29.9	1198	2.0
9/8/2006	0.1	68.7	69.8	98	29.9	-	3.4
9/18/2006	0.15	39.3	46	88	29.9	67	4.4
9/25/2006	0.26	60.5	65	92	29.9	-	5.7
10/6/2006	0.2	67.2	75	82	29.9	1229	5.0
10/14/2006	0.23	60.5	65	82	29.9	1302	5.4
10/23/2006	0.29	70	94	82	29.9	3000	5.9
10/30/2006	0.31	63	68	85	29.9	972	6.2
11/20/2006	0.28	31	50	82	29.9	1325	6.2
12/5/2006	0.15	50.2	65	75	29.9	1055	4.4
12/19/2006	0.29	37	100	38	29.9	1368	6.5
12/29/2006	-	-	-	-	29.9	511	-
1/4/2007	0.55	41	80	-	29.9	-	-
1/16/2007	0.19	20	40	58	29.9	409	5.3
1/30/2007	0.21	33	60	57	29.9	264	5.5
2/7/2007	0.57	18.1	28	74	29.9	165	9.0
3/7/2007	2.2	40	64	68	29.9	203	17.3
3/22/2007	0.18	21	40	68	29.9	487	5.1

SVE System Monitoring Data - Extraction Well V-11
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	3.84	139.9	131	78	30.00	-	19.4
3/27/2006	1.15	68	66.1	85	30.00	-	11.9
3/27/2006	0.23	34.6	34.9	85	30.00	-	5.6
8/8/2006	0.33	32.4	-	92	29.9	494	6.6
8/22/2006	0.33	40.8	46	98	29.9	855	6.5
9/6/2006	0.08	18.4	26	101	29.9	981	3.3
9/8/2006	0.7	68.5	69.8	98	29.9	-	9.1
9/18/2006	0.31	42	46	88	29.9	1213	6.4
9/25/2006	0.66	60.5	65	92	29.9	-	9.0
10/6/2006	0.59	67.4	75	84	29.9	1479	8.5
10/14/2006	0.75	60.6	65	82	29.9	1454	9.7
10/23/2006	0.92	70	94	82	29.9	3000	10.6
10/30/2006	0.6	63	68	85	29.9	1683	8.6
11/20/2006	0.83	49	50	82	29.9	6500	10.4
12/5/2006	0.57	51.2	65	75	29.9	1288	8.6
12/19/2006	0.24	37.5	100	38	29.9	2224	5.9
12/29/2006	0.31	48	80	62	29.9	1449	6.5
1/4/2007	0.54	43	80	-	29.9	-	-
1/16/2007	0.2	24.1	40	58	29.9	1527	5.4
1/30/2007	0.31	33	60	57	29.9	1087	6.6
2/7/2007	0.2	19.8	28	74	29.9	1710	5.3
3/7/2007	0.4	40	64	68	29.9	1926	7.4
3/22/2007	0.2	24.1	40	68	29.9	1188	5.3

SVE System Monitoring Data - Extraction Well V-12
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(°F)	(in Hg)	(ppmv)	(scfm)
3/29/2006	0.07	48.2	48.2	74	30.00	-	3.0
4/5/2006	0.08	-	27	82	29.86	-	-
4/7/2006	0	-	-	78	-	-	-
4/11/2006	0	15	35.5	77	30.01	876	0.0
4/18/2006	0.02	28	28	88	-	-	-
4/22/2006	0	28	-		-	-	-
4/24/2006	0.05	28	26	75	29.9	1006	2.6
4/28/2006	0	22	23	69	29.99	-	0.0
5/5/2006	0	15	33	85	29.8	1433	0.0
5/8/2006	0	30	31	100	-	-	-
5/17/2006	1.3	13.1	14	105	29.7	578	13.3
5/23/2006	0.03	27.5	35.1	98	-	-	-
5/29/2006	0.02	28.1	35	75	29.9	821	1.7
5/31/2006	0.02	28.1	35	75	-	-	-
6/15/2006	0	15.3	15.3	65	29.6	1180	0.0
6/17/2006	0.06	13.8	20	90	-	-	-
6/26/2006	0.01	33.7	-	108	-	-	-
6/30/2006	0	38.5	45	98	29.8	1040	0.0
7/7/2006	1.02	37	50	74	-	-	-
7/14/2006	0.03	35.3	-	116	29.7	-	1.9
7/17/2006	0.24	28.3	44	107	29.9	812	5.6
7/25/2006	0.06	27.4	50	98	29.7	1195	2.8
8/8/2006	0.14	34.4	50	92	29.9	529	4.3
8/22/2006	0.06	40.8	46	98	29.9	650	2.8
9/6/2006	0.01	18.4	26	101	29.9	981	1.2
9/8/2006	0.02	69.1	69.8	98	29.9	-	1.5
9/18/2006	0.06	43.4	46	88	29.9	1213	2.8
9/25/2006	0.08	60.5	65	92	29.9	-	3.1
10/6/2006	0.05	67.5	75	84	29.9	1479	2.5
10/14/2006	0.03	60.6	65	82	29.9	1400	1.9
10/23/2006	0.09	70	94	82	29.9	3000	3.3
10/30/2006	0.05	63	68	85	29.9	-	2.5
12/5/2006	0.05	52	65	75	29.9	-	2.6
12/29/2006	0.01	47	80	62	29.9	-	1.2
1/4/2007	0.03	42	80	-	29.9	-	-
1/16/2007	0.03	24.5	40	58	29.9	-	2.1
1/30/2007	0.02	33	60	57	29.9	-	1.7
2/7/2007	0	19.8	28	74	29.9	-	0.0
3/7/2007	0.18	38	64	68	29.9	-	5.0
3/22/2007	0.04	24.7	40	68	29.9	-	2.4

SVE System Monitoring Data - Extraction Well V-8
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	11.6	112.9	99.4	76	30.00	-	35.4
3/27/2006	4.5	73	66.2	76	30.00	-	23.5
3/27/2006	1.2	30.6	29.2	76	30.00	-	12.9
3/29/2006	2.7	47.6	44.5	72	30.00	-	18.9
4/5/2006	4.27	-	25.5	82	29.86	-	-
4/7/2006	3.28	12.4	-	68	-	-	-
4/11/2006	1.11	-	33.9	77	30.01	443	-
4/18/2006	2.2	30.6	28	72	-	-	-
4/22/2006	1.92	25.2	-	-	-	-	-
4/24/2006	2.7	28	24	64	29.9	479	19.6
4/28/2006	1.54	23	23	69	29.99	-	14.8
5/5/2006	2.61	-	33	85	29.8	8600	-
5/8/2006	2.83	30	31	100	-	-	-
5/17/2006	0.05	13	14	105	29.7	612	2.6
5/23/2006	2.48	27	35.1	98	-	-	-
5/29/2006	2.58	25.9	35	75	29.9	584	19.0
5/31/2006	2.58	25.9	35	75	-	-	-
6/15/2006	1.06	15	15.3	65	29.6	646	12.4
6/17/2006	0.77	13.1	20	90	-	-	-
6/26/2006	2.81	33.7	-	108	-	-	-
6/30/2006	3.11	35.2	45	98	29.8	526	20.1
7/7/2006	3.73	38.2	50	74	-	-	-
7/14/2006	3.09	35.3	-	116	29.7	-	19.7
7/17/2006	2.28	28.8	44	107	29.9	445	17.3
7/25/2006	1.99	27.8	50	98	29.7	196	16.2
8/8/2006	2.23	33.1	50	92	29.9	336	17.2
8/22/2006	2.38	36.6	46	98	29.9	398	17.6
9/6/2006	0.79	18.3	26	101	29.9	342	10.4
9/8/2006	4.66	64.3	69.8	98	29.9	-	23.7
9/18/2006	2.53	42.6	46	88	29.9	886	18.2
9/25/2006	4.36	58.9	65	92	29.9	-	23.2
10/6/2006	4.52	67.4	75	84	29.9	332	23.5
10/14/2006	3.55	58.8	65	82	29.9	302	21.1
10/23/2006	4.8	66	94	82	29.9	821	24.3
10/30/2006	4.26	61	68	85	29.9	302	23.0
11/20/2006	3.08	44	50	82	29.9	923	20.1
12/5/2006	3.69	53	65	75	29.9	336	21.9
12/19/2006	3.4	42.8	100	38	29.9	217	22.1
12/29/2006	4.23	47	80	62	29.9	152	23.9
1/4/2007	3.3	40	80	-	29.9	-	-
1/16/2007	1.48	24	40	58	29.9	109	14.6
1/30/2007	4.1	32	60	57	29.9	178	24.1
2/7/2007	1.8	19.8	28	74	29.9	160	16.0
3/7/2007	3.08	36	64	68	29.9	177	20.6
3/22/2007	2.82	26.7	40	68	29.9	152	20.0

SVE System Monitoring Data - Extraction Well V-9
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	1.5	140	132.4	82	30.00	-	12.1
3/27/2006	0.52	78	72.7	82	30.00	-	7.9
3/27/2006	0.16	28.7	28.1	82	30.00	-	4.7
3/29/2006	0.05	28.7	49.4	70	30.00	-	2.6
4/5/2006	0	-	30	82	29.86	-	-
4/7/2006	1.9	-	-	62	-	-	-
4/11/2006	0.1	-	35.9	77	30.01	698	-
4/18/2006	0	28	28	88	-	-	-
4/22/2006	0	14.8	-	-	-	-	-
4/24/2006	0	28	26	56	29.9	1250	0.0
4/28/2006	0.07	22	23	69	29.99	-	3.2
5/5/2006	0	-	33	85	29.8	1500	-
5/8/2006	0.1	3	31	100	-	-	-
5/17/2006	0	12	14	105	29.7	663	0.0
5/23/2006	0.1	27.5	35.1	98	-	-	-
5/29/2006	0.1	28.1	35	75	29.9	1400	3.7
5/31/2006	0.1	28.1	35	75	-	-	-
6/15/2006	0.9	14.9	15.3	65	29.6	792	11.4
6/17/2006	0.01	14.1	20	90	-	-	-
6/26/2006	0.05	33.6	-	108	-	-	-
6/30/2006	0.09	38.5	45	98	29.8	1258	3.4
7/7/2006	0.93	37.1	50	74	-	-	-
7/14/2006	0.15	35.2	-	116	29.7	-	4.3
7/17/2006	0.31	28.3	44	107	29.9	1226	6.4
7/25/2006	0.13	27.1	50	98	29.7	894	4.2
8/8/2006	0.21	34.1	-	92	29.9	796	5.3
8/22/2006	0.12	40.8	46	98	29.9	681	3.9
9/6/2006	0.02	18.8	26	101	29.9	726	1.6
9/8/2006	0.24	69.2	69.8	98	29.9	-	5.3
9/18/2006	0.11	46.5	46	88	29.9	54	3.8
9/25/2006	0.33	60.9	65	92	29.9	-	6.4
10/6/2006	-	-	-	-	29.9	728	-
10/14/2006	0.33	60.8	65	82	29.9	902	6.4
10/23/2006	0.4	70	94	82	29.9	3000	7.0
10/30/2006	0.28	63	68	85	29.9	729	5.9
11/20/2006	0.21	50	50	82	29.9	680	5.2
12/5/2006	0.36	50.8	65	75	29.9	545	6.9
12/19/2006	0.07	42	100	38	29.9	765	3.2
12/29/2006	0.35	49	80	62	29.9	321	6.9
1/4/2007	0.18	44	80	-	29.9	-	-
1/16/2007	0.13	24.2	40	58	29.9	540	4.3
1/30/2007	0.14	32	60	57	29.9	355	4.5
2/7/2007	0.04	19.8	28	74	29.9	587	2.4
3/7/2007	0.16	39	64	68	29.9	613	4.7
3/22/2007	0.12	25	40	68	29.9	620	4.1

SVE System Monitoring Data - Extraction Well VB-2
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

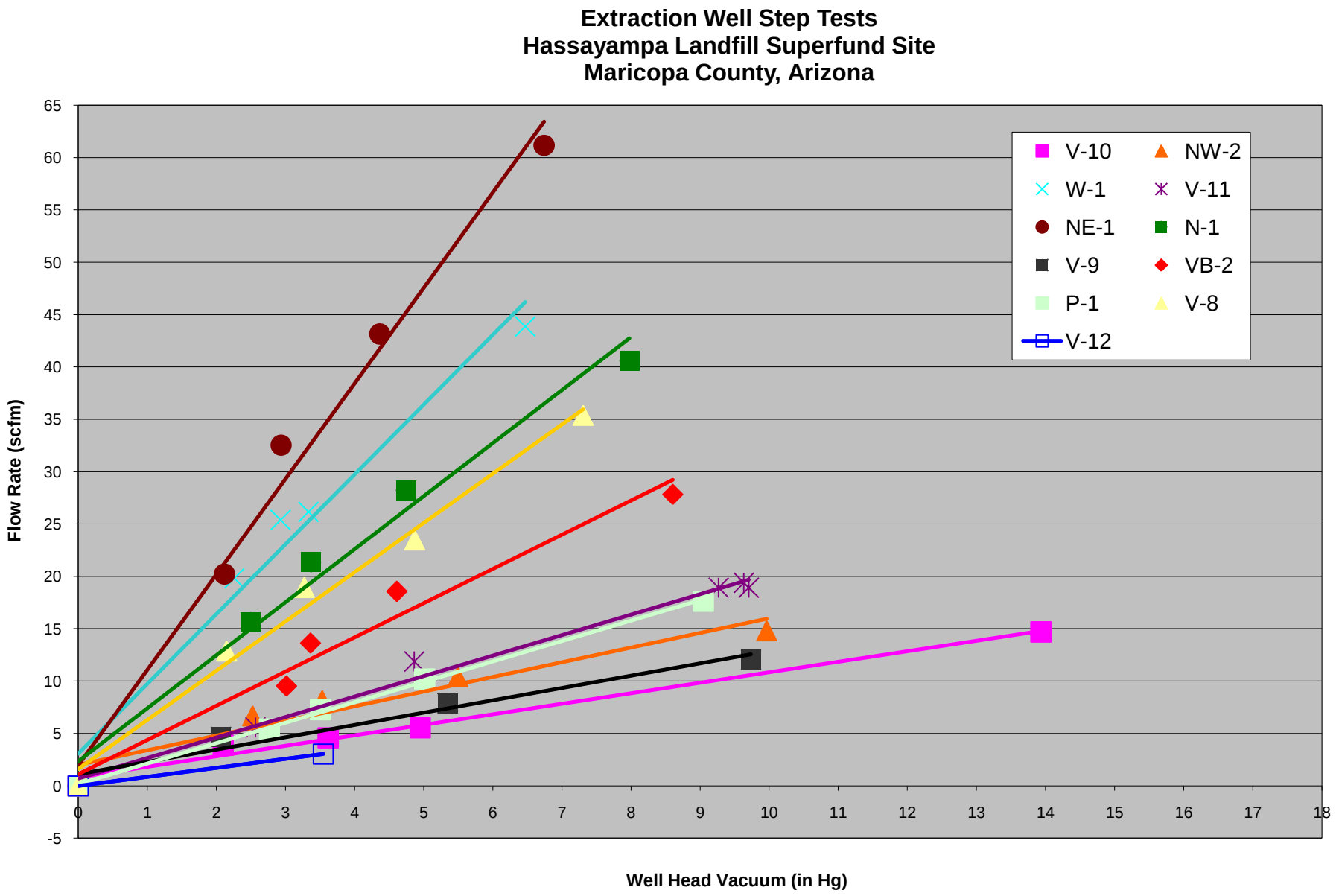
Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)	(scfm)
3/27/2006	7.8	134.6	117	80	30.00	-	27.8
3/27/2006	2.78	67.1	62.7	80	30.00	-	18.6
3/27/2006	0.67	35.2	41	80	30.00	-	9.5
3/29/2006	1.4	47.4	45.7	73	30.00	-	13.6
4/5/2006	1.8	-	28.6	82	29.86	-	-
4/7/2006	0.5	-	-	70	-	-	-
4/11/2006	1.02	-	33.8	74	30.01	326	-
4/18/2006	0.24	28	28	85	-	-	-
4/22/2006	0.13	15.1	-	-	-	-	-
4/24/2006	0.3	14	25	64	29.9	296	6.6
4/28/2006	0.3	21	23	69	29.99	-	6.6
5/5/2006	0.2	-	33	85	29.8	9999	-
5/8/2006	0.74	30	31	100	-	-	-
5/17/2006	5.1	13.1	14	105	29.7	560	26.3
5/23/2006	0.59	27.5	35.1	98	-	-	-
5/29/2006	0.7	26.4	35	75	29.9	285	9.9
5/31/2006	0.7	26.4	35	75	-	-	-
6/15/2006	0.22	14.3	15.3	65	29.6	241	5.7
6/17/2006	0.16	13.2	20	90	-	-	-
6/26/2006	0.84	33.3	-	108	-	-	-
6/30/2006	0.85	35.5	45	98	29.8	208	10.5
7/7/2006	1.17	38.2	50	74	-	-	-
7/14/2006	1.05	35.3	-	116	29.7	-	11.5
7/17/2006	1.01	28.4	44	107	29.9	159	11.5
7/25/2006	0.13	27.1	50	98	29.7	160	4.2
8/8/2006	0.96	32.5	-	92	29.9	107	11.3
8/22/2006	1.23	36.9	46	98	29.9	109	12.6
9/6/2006	0.29	18.3	26	101	29.9	704	6.3
9/8/2006	2.31	64.6	69.8	98	29.9	-	16.7
9/18/2006	1.36	42.1	46	88	29.9	2502	13.3
9/25/2006	2.84	59.8	65	92	29.9	-	18.7
10/6/2006	3.18	67.3	75	84	29.9	71.9	19.7
10/14/2006	3.12	58.8	65	82	29.9	80	19.8
10/23/2006	3.8	66.3	94	82	29.9	175	21.6
10/30/2006	3.28	58	68	85	29.9	57	20.3
11/20/2006	1.03	30	50	82	29.9	1353	11.9
12/5/2006	2.8	50	65	75	29.9	537	19.1
12/19/2006	1.32	37.5	100	38	29.9	70	13.9
12/29/2006	0.8	46	80	62	29.9	40	10.4
1/4/2007	1.62	40	80	-	29.9	-	-
1/16/2007	0.42	20	40	58	29.9	43	7.8
1/30/2007	0.12	32	60	57	29.9	51	4.1
2/7/2007	0.36	19.8	28	74	29.9	59	7.2
3/7/2007	1.05	35	64	68	29.9	47	12.0
3/22/2007	0.41	23	40	68	29.9	1138	7.6

SVE System Monitoring Data - Extraction Well W-1
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

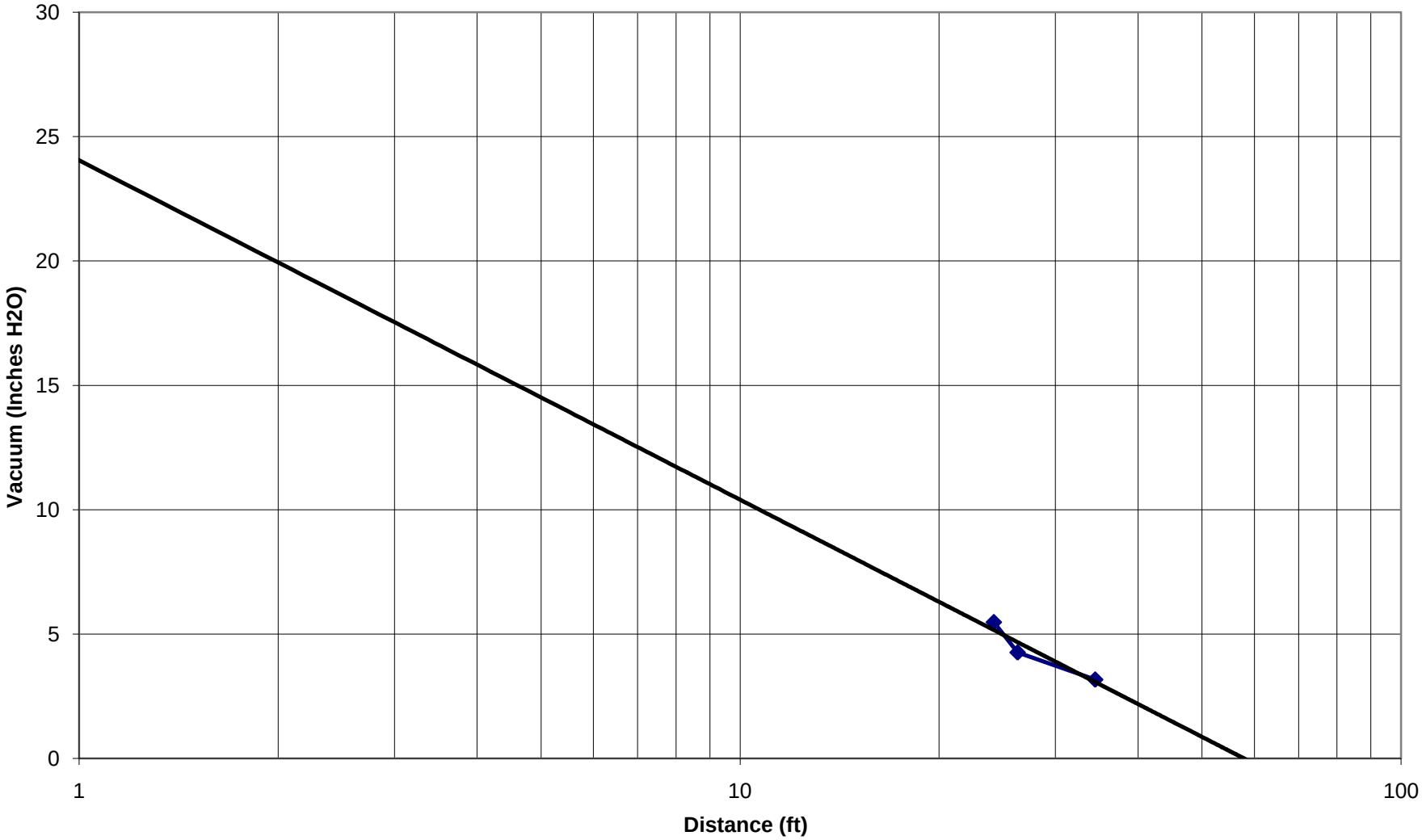
Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID
	(in. H20)	(in. H20)	(in. H20)	(^oF)	(in Hg)	(ppmv)
3/27/2006	17.6	109	88	76	30.00	-
3/27/2006	5.5	67.8	45.3	76	30.00	-
3/27/2006	2.87	34.3	30.7	76	30.00	-
3/29/2006	4.84	45.4	39.8	74	30.00	-
4/5/2006	2.79	-	37	82	29.86	-
4/7/2006	2.87	-	-	62	-	-
4/11/2006	4.47	-	19.4	74	30.01	307
4/18/2006	4.5	28	29	72	-	-
4/22/2006	1.26	12.9	-	-	-	-
4/24/2006	3.4	26	21	64	29.9	153
4/28/2006	3.29	23	23	69	29.99	-
5/5/2006	4.46	-	33	85	29.8	9999
5/8/2006	4.93	30.5	31	100	-	-
5/17/2006	1.5	12.8	14	105	29.7	598
5/23/2006	4.06	26.8	35.1	98	-	-
5/29/2006	4.12	27	35	75	29.9	344
5/31/2006	4.12	27	35	75	-	-
6/15/2006	1.78	14.5	15.3	65	29.6	652
6/17/2006	1.67	13.8	20	90	-	-
6/26/2006	5.38	33.3	-	108	-	-
6/30/2006	5.53	34.5	45	98	29.8	261
7/7/2006	5.08	36.7	50	74	-	-
7/14/2006	5.31	33.6	-	116	29.7	-
7/17/2006	4.23	27.6	44	107	29.9	566
7/25/2006	3.13	23.5	50	98	29.7	188
8/8/2006	4.16	31.1	-	92	29.9	181
8/22/2006	5.53	35.5	46	98	29.9	77.3
9/6/2006	1.79	18.2	26	101	29.9	700
9/8/2006	10.7	65.8	69.8	98	29.9	-
9/18/2006	5.45	36.2	46	88	29.9	5300
9/25/2006	10.21	58.4	65	92	29.9	-
10/6/2006	10.56	64.9	75	84	29.9	152
10/14/2006	8.56	59.8	65	82	29.9	231
10/23/2006	12.09	67	94	82	29.9	768
10/30/2006	10.4	61	68	85	29.9	257
11/20/2006	8.69	49	50	82	29.9	1246
12/5/2006	8.65	49	65	75	29.9	293
12/19/2006	6.5	39	100	38	29.9	321
12/29/2006	9.05	46	80	62	29.9	190
1/4/2007	7.69	39	80	-	29.9	-
1/16/2007	3.8	22	40	58	29.9	234
1/30/2007	6.48	33	60	57	29.9	252
2/7/2007	2.51	18.6	28	74	29.9	251
3/7/2007	6.2	32.8	64	68	29.9	249
3/22/2007	3.59	26	40	68	29.9	191

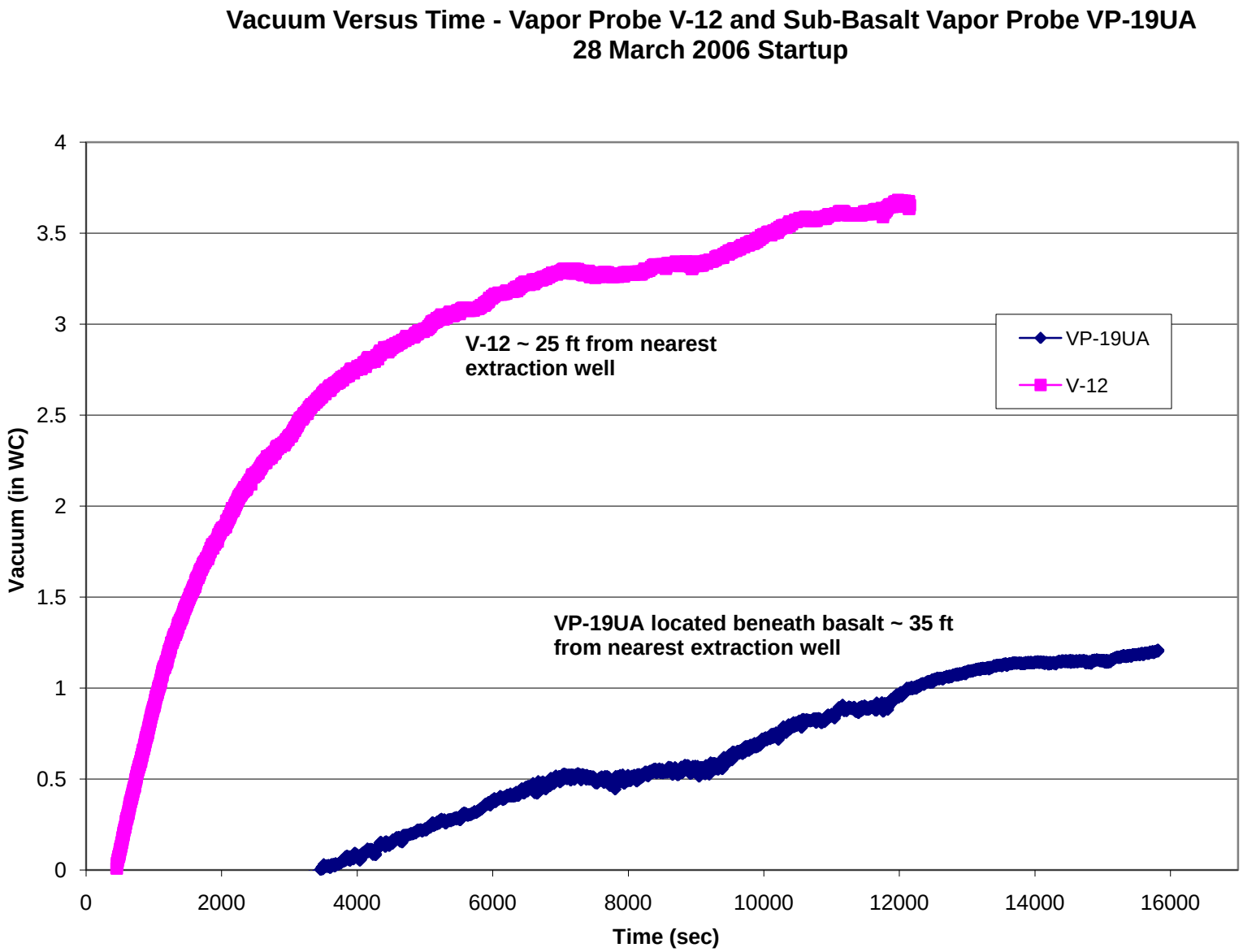
SVE System Monitoring Data - Extraction Well VP-19UA
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Date	Pitot Differential Pressure	Static Vacuum	Applied Wellhead Vacuum	Temp	Barometric Pressure	PID	Flowrate
	(in H_2O)	(in. H20)	(in H_2O)	(^oF)	(in Hg)	ppmv	SCFM
12/5/2006	-	-	-	-	29.90	1295	-
12/5/2006	0	50	56	78	29.90	783	0.0
12/5/2006	-	-	-	-	29.90	500	-
12/5/2006	0.26	160	60+	78	29.90	-	4.8
12/5/2006	0.04	95	60+	78	29.90	-	2.1
12/5/2006	0.03	54.2	56	78	29.90	367	2.0
12/6/2006	-	-	-	-	29.90	150	-
12/19/2006	0.02	41.2	100	38	29.90	805	1.7
12/29/2006	0.02	47	80	62	29.9	854	1.6
1/4/2007	0.02	44	80	-	29.9	-	-
1/16/2007	0.04	24	40	58	29.9	1092	2.4
1/30/2007	0.04	29	60	57	29.9	480	2.4
2/7/2007	0	19.8	28	74	29.9	938	0.0
3/7/2007	0.32	40	64	68	29.9	834	6.6
3/22/2007	0	28	40	68	29.9	186	0.0


Extraction Well Step Tests
Hassayampa Landfill Superfund Site
Maricopa County, Arizona
Flow Rate (scfm)
Well Head Vacuum (in Hg)
V-10
NW-2
W-1
V-11
NE-1
N-1
V-9
VB-2
P-1
V-8
V-12
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Pressure Versus Distance Test - Extraction Well V-11
@ 131 Inches (H2O) Vaccum
Hassayampa Landfill Superfund Site
Maricopa County, Arizona




Vacuum Versus Time - Vapor Probe V-12 and Sub-Basalt Vapor Probe VP-19UA
28 March 2006 Startup
Vacuum (in WC)
Time (sec)
0
0.5
1
1.5
2
2.5
3
3.5
4
0
2000
4000
6000
8000
10000
12000
14000
16000
V-12 ~ 25 ft from nearest extraction well
VP-19UA located beneath basalt ~ 35 ft from nearest extraction well
VP-19UA
V-12

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
NW-2F	13:50	17.5
	13:59	48.6
	14:08	48.3
	14:16	16.4
	14:26	48.1
	14:35	47.5
	14:44	29.6
	14:54	24.0
	15:58	15.0
	17:21	25.4
NW-2C	13:50	0.5
	13:59	1.4
	14:08	1.6
	14:16	1.2
	14:26	1.6
	14:35	1.6
	14:44	1.5
	14:54	1.5
	15:58	1.4
	17:21	1.5
N-1F	13:51	41.9
	14:00	30.4
	14:09	40.8
	14:11	45.6
	14:27	28.8
	14:36	14.2
	14:45	45.9
	14:55	45.1
	15:59	46.1
	17:23	26.1
N-1C	13:51	5.6
	14:00	5.6
	14:09	6.8
	14:17	6.4
	14:27	5.2
	14:36	4.5
	14:45	6.7
	14:55	6.6
	15:59	6.5
	17:23	5.4
NE-1F	13:52	26.3
	14:01	41.6
	14:10	18.8
	14:14	35.1
	14:30	41.5
	14:37	40.4
	14:47	20.3
	14:56	19.8
	16:00	27.6
	17:25	23.2

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
NE-1C	13:52	4.2
	14:01	6.4
	14:10	4.2
	14:19	5.5
	14:30	5.9
	14:37	5.9
	14:47	4.5
	14:56	4.5
	16:00	5.0
	17:25	4.2
V-9F	13:53	44.2
	14:02	29.1
	14:11	46.9
	14:20	47.9
	14:31	30.3
	14:38	14.6
	14:48	48.3
	14:57	47.5
	16:01	48.0
	17:26	44.6
V-9C	13:53	0.1
	13:53	0.9
	14:11	0.3
	14:20	0.4
	14:31	0.5
	14:38	0.6
	14:48	0.8
	14:57	0.7
	16:01	0.4
	17:26	0.6
V-10F	13:55	47.4
	14:03	47.6
	14:12	48.0
	14:20	29.4
	14:32	48.5
	14:40	48.6
	14:49	43.0
	14:59	29.2
	16:03	42.3
	17:28	43.9
V-10C	13:55	0.4
	14:03	1.0
	14:12	0.2
	14:20	0.2
	14:32	0.4
	14:40	0.6
	14:49	0.7
	14:59	0.7
	16:03	0.3
	17:28	0.6

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
VP-18UA	13:56	0.4
	14:04	1.1
	14:12	0.7
	14:21	1.0
	14:31	1.3
	14:39	1.6
	14:48	1.9
	14:58	2.0
	16:02	2.3
	17:27	3.0
V-11F	13:57	28.6
	14:05	28.3
	14:13	43.6
	14:22	18.1
	14:33	30.5
	14:41	48.0
	14:50	48.8
	14:59	47.6
	16:04	48.0
	17:30	16.7
V-11C	13:57	0.5
	14:05	0.8
	14:13	0.2
	14:22	0.2
	14:33	0.4
	14:41	0.6
	14:50	0.7
	14:59	0.6
	16:04	0.4
	17:30	0.6
V-12C	13:57	0.5
	14:06	0.8
	14:14	0.2
	14:22	0.2
	14:34	0.2
	14:42	0.6
	14:52	0.6
	15:01	0.5
	16:06	0.2
	17:32	0.5
P-1F	13:58	31.3
	14:07	36.1
	14:15	39.5
	14:24	30.1
	14:34	14.7
	14:43	47.2
	14:51	26.6
	15:00	48.5
	16:05	29.2
	17:31	29.0

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
P-1C	13:58	0.6
	14:07	1.0
	14:15	0.3
	14:24	0.4
	14:34	0.6
	14:43	0.8
	14:51	0.9
	15:00	0.8
	16:05	0.5
	17:31	0.9
MW-12UA	13:50	0.28
	14:07	0.17
	14:24	0.31
	14:41	0.41
	15:57	0.52
	17:08	1.02
V-16C	13:51	0.21
	14:07	0.12
	14:24	0.13
	14:42	0.13
	15:59	0.15
	17:10	0.11
V-16F	13:52	0.24
	14:08	0.17
	14:25	0.16
	14:42	0.22
	15:59	0.25
	17:10	0.14
V-15C	13:53	0.27
	14:09	0.14
	14:26	0.20
	14:43	0.16
	16:00	0.22
	17:12	0.13
V-15F	13:53	0.30
	14:09	0.17
	14:26	0.20
	14:44	0.20
	16:01	0.26
	17:12	0.18
V-14C	13:54	0.29
	14:10	0.10
	14:48	0.07
	14:45	0.09
	15:02	0.06
	17:14	0.06

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
V-14F	13:55	0.27
	14:10	0.03
	14:48	0.16
	14:45	0.03
	15:02	0.18
	17:14	0.03
V-13C	13:56	0.17
	14:12	0.07
	14:30	0.09
	14:49	0.07
	15:04	0.07
	17:16	0.06
V-13F	13:56	0.18
	14:12	0.05
	14:30	0.11
	14:49	0.10
	16:04	0.04
	17:16	0.07
NE-3C	13:58	0.07
	14:14	0.07
	14:32	0.10
	14:52	0.07
	16:06	0.03
	17:19	0.07
NE-3F	13:50	0.04
	14:14	0.04
	14:32	0.11
	14:50	0.07
	16:06	0.03
	17:19	0.07
MW-11UA	13:59	0.01
	14:16	0.09
	14:33	0.06
	14:53	0.10
	16:08	0.13
	17:20	0.35
N-3C	14:00	0.14
	14:17	0.16
	14:34	0.17
	14:54	0.12
	16:09	0.10
	17:23	0.09
N-3F	14:00	0.13
	14:17	0.13
	14:34	0.14
	14:54	0.12
	16:09	0.07
	17:23	0.09

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
N-2C	14:02	0.05
	14:19	0.03
	14:36	0.06
	14:56	0.00
	16:10	0.05
	17:25	0.01
N-2F	14:02	0.10
	14:19	0.05
	14:36	0.09
	14:56	0.01
	16:11	0.04
	17:25	0.02
NW-1C	14:04	0.00
	14:20	0.01
	14:37	0.04
	14:57	0.01
	16:12	0.05
	17:27	0.01
NW-1F	14:04	0.08
	14:20	0.09
	14:37	0.12
	14:57	0.05
	16:12	0.01
	17:27	0.01
V-2F	13:50	0.1
	14:01	0.0
	14:12	0.0
	14:22	0.0
	14:33	0.0
	14:42	0.0
	14:50	0.0
	15:00	0.0
	15:50	0.0
	16:49	0.2
V-2C	13:50	0.1
	14:01	0.1
	14:12	0.0
	14:22	0.0
	14:33	0.0
	14:42	0.0
	14:50	-0.1
	15:00	0.1
	15:50	0.3
	16:49	0.5

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
MW-6UA	13:52	0.0
	14:03	0.0
	14:13	0.0
	14:24	0.0
	14:35	0.0
	14:43	0.1
	14:52	0.0
	15:52	0.1
	16:50	0.2
MW-4UA	14:00	0.0
	14:08	0.0
	14:20	0.0
	14:28	0.3
	14:37	0.5
	14:46	0.5
	14:56	0.7
	15:54	1.0
	16:53	1.3
MW-7UA	13:59	0.0
	14:09	0.0
	14:18	0.0
	14:29	0.5
	14:39	0.5
	14:47	0.6
	14:57	0.7
	15:56	1.0
	16:54	1.4
VB-2F	13:54	26.6
	14:05	44.8
	14:15	46.8
	14:25	28.9
	14:36	29.5
	14:44	43.4
	14:53	22.4
	15:53	46.3
	16:51	46.4
VB-2C	13:53	0.0
	14:04	0.2
	14:14	0.4
	14:25	0.4
	14:36	0.4
	14:44	0.5
	14:53	0.5
	15:53	0.5
	16:51	0.6

Manual Vacuum Gauge Measurements at System Start-up
Hassayampa Landfill Superfund Site
Maricopa County, Arizona

Well	Time	Vacuum (in H20)
W-1F	13:57	41.8
	14:11	40.4
	14:21	41.8
	14:30	41.0
	14:40	38.3
	14:48	38.7
	14:58	39.3
	15:59	41.3
	16:56	42.5
W-1C	13:57	4.0
	14:11	4.3
	14:21	4.6
	14:30	4.3
	14:40	4.3
	14:48	4.4
	14:58	4.4
	15:59	4.6
	16:56	3.5
V-8F	13:55	45.8
	14:06	27.4
	14:17	44.5
	14:32	29.4
	15:57	45.7
	16:58	45.4
V-8C	13:55	2.4
	14:06	3.1
	14:17	3.9
	14:32	3.5
	15:57	4.2
	16:58	4.4

Geosyntec consultants

Appendix E: Capture Zone Analysis

HARGIS + ASSOCIATES, INC.

CAPTURE ZONE ANALYSIS

GROUNDWATER RECOVERY SYSTEM

HASSAYAMPA LANDFILL

MARICOPA COUNTY, ARIZONA

TABLE OF CONTENTS

Section Page

ACRONYMS AND ABBREVIATIONS ii

1.0 INTRODUCTION 1

2.0 PURPOSE AND SCOPE 2

3.0 SITE DATA, CONCEPTUAL MODEL AND REMEDY OBJECTIVES 4
3.1 SITE DATA 4

4.0 TARGET CAPTURE ZONE 7

5.0 WATER LEVEL DATA 8

6.0 FLOW BUDGET AND EXTRACTION WELL CAPTURE ZONES 11
6.1 FLOW BUDGET 11
6.2 INDIVIDUAL EXTRACTION WELL CAPTURE ZONES 13
6.3 VERTICAL CAPTURE ANALYSIS 14

7.0 VOC CONCENTRATION TRENDS DOWNGRADIENT OF THE TCZ 20

8.0 SUMMARY OF CONVERGING LINES OF EVIDENCE 22
8.1 TARGET CAPTURE ZONE 22
8.2 WATER LEVEL DATA 23
8.3 FLOW BUDGET AND WELL CAPTURE ZONE ANALYSIS 23
8.4 EXTRACTION WELL CAPTURE ZONE ANALYSIS 23
8.5 VOC CONCENTRATION TREND ANALYSIS 24
8.6 RECOMMENDATIONS 25

9.0 REFERENCES 26

ACRONYMS AND ABBREVIATIONS

µg/l	micrograms per liter
bls	below land surface
EPA	U.S. Environmental Protection Agency
FS	Feasibility Study
gpd/ft	gallons per day per foot
GRS	groundwater recovery system
K	hydraulic conductivity
RI	Remedial Investigation
SVE	soil vapor extraction
TCZ	target capture zone
VOCs	volatile organic chemicals

CAPTURE ZONE ANALYSIS
GROUNDWATER RECOVERY SYSTEM
HASSAYAMPA LANDFILL
MARICOPA COUNTY, ARIZONA

1.0 INTRODUCTION

This appendix presents the results of a capture zone analysis for the currently operating groundwater recovery system (GRS) at the Hassayampa Landfill near Buckeye, Maricopa County, Arizona. The capture zone analysis is based on information presented at a U.S. Environmental Protection Agency (EPA) sponsored short course (May 2005) and a draft guidance document entitled *A Systematic Approach for Evaluation of Capture Zone at Pump and Treat Systems (8/17/04).*

2.0 PURPOSE AND SCOPE

The purpose of the capture zone analysis is to evaluate the currently operating GRS at the Hassayampa Landfill using techniques suggested in the short course and the draft guidance document. The capture zone is defined as *"…the three-dimensional region that contributes the ground water extracted by one or more wells…".* The guidance uses a systematic *"converging lines of evidence"* approach to evaluate the extent of groundwater capture produced by extractions wells(s) associated with a groundwater pump and treat system, such as the GRS. The scope of the capture zone analysis closely conforms to the format suggested in the guidance.

Section 3.0 discusses available site data used in the analysis, presents a brief overview of the hydrogeology portion of the site conceptual model and outlines the objectives of the capture zone analysis.

Section 4.0 defines the target capture zone (TCZ), the rationale for selecting the original TCZ, and the rationale for selecting the TCZ used in this analysis.

Section 5.0 discusses the current monitoring program and the resulting water level data generated as a result of monitoring. This section discusses the local hydrogeologic conditions and how the upper portion of the local system (Unit A) is related to the lower portion of the local aquifer system (Unit B). As noted in the EPA draft guidance, interpretation of the water level data is the first line of evidence in the capture zone analysis.

Section 6.0 provides the results of the flow budget calculations (groundwater flux through the area affected by volatile organic chemicals (VOCs)) and compares the results to the average pumpage rates for the GRS. This section also provides the results of the individual extraction well capture zone analysis, including a section on vertical capture. When combined, the individual capture zones form the composite capture zone for the entire extraction well field. When combined, the flow budget and the individual extraction well capture zones form the second line of evidence in the capture zone analysis, as outlined in EPA draft guidance.

Section 7.0 analyzes the VOC concentration trends in monitor wells located downgradient of the TCZ. Downgradient monitor wells are divided into two groups: downgradient performance monitoring wells and sentinel wells. The analysis of concentration trends is the third line of evidence in the capture zone analysis.

Section 8.0 summarizes and combines the different lines of evidence by comparing the interpreted capture zone(s) to the TCZ, assessing uncertainties in the analysis, discussing potential data gaps, and evaluating the need to adjust extraction rates and/or extraction locations. Based on the analysis of the converging lines of evidence, recommendations regarding the GRS are made.

Section 9.0 is the reference section, and lists the documents used in the capture zone analysis.

3.0 SITE DATA, CONCEPTUAL MODEL AND REMEDY OBJECTIVES

This section outlines the available site data on which the capture zone analysis is based, briefly outlines the hydrogeologic portion of the site conceptual model and summarizes the remedy objectives for the site.

3.1 SITE DATA

The following summary is derived primarily from the Remedial Investigation Report (Montgomery/CRA, 1991).

The Hassayampa Landfill site has been investigated since the mid-1980s. An administrative order on consent was issued on February 19, 1988. In accordance with the order a Remedial Investigation (RI)/Feasibility Study (FS) process was implemented. The initial RI report was issued on February 7, 1991 and described the first significant phase of targeted investigation of the site.

Hazardous waste was disposed at the site for an 18 month period from April 1979 to October 1980. The residual effects of the disposal of approximately 3.44 million gallons of liquid wastes (primarily VOCs) form the basis of the situation currently being addressed by the soil vapor extraction system and the GRS. The solvent disposal created a soil vapor plume which is in contact with Unit A groundwater. The current site conceptual model hypothesizes that the dispersed soil vapor plume is primarily responsible for the presence of VOCs in groundwater. The observed VOC concentrations in groundwater are not present in a pattern which suggests a classic plume developed from a point source.

The RI/FS process led to the primary remedy components of an engineered cap over the primary hazardous waste disposal areas, the installation and subsequent operation of a groundwater extraction and treatment system and the installation and operation of a soil vapor extraction (SVE) system in the vadose zone beneath the site. All of the remedy components are still in place today, and the active systems are operating.

The site conceptual model was developed as a result of the RI process, and has been refined as each new set of data was integrated into the conceptual model. A soil vapor plume of VOCs in the vadose zone appears to be the primary mechanism for distributing VOCs in the groundwater system. The groundwater system beneath the site consists of a subset of the uppermost portions of a regional alluvial aquifer system in the lower Hassayampa River basin. The site hydrostratigraphy includes the A and B hydrogeologic units, with the A unit overlying the B unit. These two hydrostratigraphic units are divided primarily on the basis of vertical head differences between the units and the geology beneath the site.

During the conduct of the RI, the site was found to consist of the vadose zone, the Unit A hydrostratigraphic unit and the Unit B hydrostratigraphic unit. The vadose zone, under the majority of the site, has an intermediate layer of basalt above the first encountered water table in Unit A. Unit A is bounded on the top by the basalt, where present, and on the bottom by the top of Unit B (Montgomery/CRA, 1991). Where the basalt is not present, the top of Unit A is generally defined as in the vicinity of where Unit A groundwater was first encountered during the RI. Unit A is the uppermost water bearing strata of the regional alluvial aquifer. Unit A consists of interbedded clayey silt and silty clay, with a thin layer of interbedded sandy silt and siltstone. Depth to the top of Unit A ranges from 67-84 feet below land surface (bls); the average depth to the top of Unit A is approximately 73 feet. The thickness of Unit A ranges from 32-44 feet with an average thickness of 35 feet.

Unit B is bounded on the top by Unit A and on the bottom by the Middle Alluvial unit (Montgomery/CRA, 1991). The uppermost portions of Unit B are the uppermost coarse-grained water bearing strata of the regional aquifer. Unit B consists of interbedded coarse-grained and fine-grained units with the fine-grained units being similar to those in Unit A. The coarse-grained strata in Unit B consist primarily of sand and gravel. Depth to the top of Unit B ranges from 101 to 116 feet bls and the average depth to the top of Unit B is approximately 107 feet. Data from one deeper exploratory boring indicate Unit B is approximately 152 feet thick in the Site area. The Middle Alluvial Unit lies beneath Unit B and in the vicinity of the landfill consists of the Palo Verde Clay.

As a result of the RI/FS process, and follow up activities, substantial and detailed investigations have been performed resulting in a significant amount of site data. This capture zone analysis is based on water level and chemical quality data from 19 monitor wells and four extraction

wells completed in Unit A (Figure 1). Water level and chemical quality data from six Unit B wells were also utilized in the analysis.

Prior to initiating pumping for remedial activities in Unit A, the regional groundwater gradient was approximately 0.0035 and groundwater flow was generally to the south (Montgomery/CRA, 1995). Water levels in Unit A were observed to be declining approximately 0.3 feet per year prior to the initiation of pumpage from the GRS. The saturated thickness in Unit A currently averages approximately 25 feet. The transmissivity of Unit A, derived from several aquifer tests conducted as part of the RI, is approximately 2000 gallons per day per foot (gpd/ft) (267 ft^2/day) (Montgomery/CRA, 1992). The long term specific yield of Unit A was estimated to be approximately 0.10 (Montgomery/CRA, 1991).

Data from several laboratory tests on cores from the site to obtain vertical hydraulic conductivity values were used to estimate an average vertical hydraulic conductivity value for Unit A near and below the water table (Montgomery/CRA, 1991, Appendix K). Analysis of these data sets yields an average vertical hydraulic conductivity ranging from 1.25E-04 ft/day to 4.76E-03 ft/day. When compared to estimated horizontal hydraulic conductivities in Unit A of 8.0 to 13.4 ft/day, the anisotropy ratios range from three to five orders of magnitude difference (Montgomery/CRA, 1995). That is, the data indicate that the horizontal hydraulic conductivities are 1000 to 100,000 times greater than the average vertical hydraulic conductivities at the site.

Remedy objectives are to capture and control groundwater containing VOCs up gradient from the extraction wells and prevent migration off site.

Potential downgradient receptors are wells completed in Unit B. Because Unit B is not impacted by VOCs and Unit A groundwater is contained on site, little if any threat exists to potential downgradient receptors.

4.0 TARGET CAPTURE ZONE

The original TCZ was developed in the preliminary design stages of the Unit A hydraulic containment system. Originally called the target zone, the original TCZ was outlined based on data available through early 1992. The original TCZ was defined as *"…the part of Unit A currently targeted for hydraulic control and capture by…extraction wells…"* (Montgomery/CRA,1992). The original TCZ was approximately 750 feet wide, primarily due to the inclusion of monitor well MW-05UA, which, at the time, had detections of trace amounts of VOCs early in the RI process. Since that time, groundwater samples from MW-05UA have not documented the presence of VOCs.

The current TCZ used in the capture analysis was based on the same premise as the original TCZ. All Unit A wells known to contain VOCs were included in the TCZ and the TCZ boundaries were drawn approximately half way between wells containing VOCs and peripheral wells which do not contain VOCs. As a result, the current capture zone was shifted slightly east and is approximately 800 feet wide (Figure 1).

The vertical extent of the TCZ is defined as the bottom of Unit A, which ranges from 101 to 116 feet bls, and averages approximately 107 bls. No VOCs have been detected in any Unit B monitor wells during several consecutive years of quarterly monitoring.

5.0 WATER LEVEL DATA

Water level data are collected on a monthly basis and water level contour maps for Unit A and Unit B are produced as part of the quarterly reporting process. For the capture zone analysis, the raw data used in constructing the water level maps were obtained in 2006 (October 2006) and included in the 2006 annual report (Hargis/Geosyntec, 2007). EPA guidance defines the analysis of water levels as the first line of evidence in the capture zone analysis.

Water level data from Unit A and Unit B indicate a downward hydraulic head potential between Unit A and Unit B. Data from six paired wells sets collected in August 2006 when the GRS was not pumping indicate that the head difference between Unit A and Unit B ranges from a low of 14.16 feet to a high of 17.50 feet and averages 15.75 feet across the site (Figures 2a and 2b).

Groundwater in Unit A beneath the site originally flowed in a southerly direction (Montgomery/CRA, 1991). Long term operation of the GRS system has modified the flow pattern in Unit A immediately beneath the site by causing and sustaining a relatively permanent localized decline in water levels in Unit A (Figure 2a). The result is that a southeastern flow component for at least part of Unit A exists immediately beneath the site downgradient from the extraction wells.

The flow lines depicted on Figure 2a indicate that capture by the extraction well system is occurring. The water level contours on Figure 2a were constructed using the pumping water levels obtained from the four Unit A extraction wells. No correction for well losses has been applied to the pumping water levels in Unit A as used on Figure 2a. Unit B water levels are found on Figure 2b.

An analysis of potential wells losses in Unit A extraction wells was done based on a review of Unit A aquifer test data collected during the RI (Montgomery/CRA, 1991). Aquifer test plots for seven Unit A monitor wells were reviewed to obtain an estimate of wells losses using the following approach. The maximum water level drawdown at the end of each test was noted. On the recovery curves, the initial water level at the beginning of recovery was also noted. It was assumed that when the pumping wells were shut down, the instantaneous water level rise

necessary to achieve the water level value at the beginning of recovery (one to two minutes after shut down) was a reasonable representation of total well losses. That is, the residual drawdown remaining in the well in very early recovery time represented the actual formation drawdown. Table 1 is an analysis of well losses using the above described technique for the seven UA wells tested. The average well efficiency was estimated by comparing the estimated formation drawdown to the maximum drawdown observed in the well.

Table 2 shows the average estimated Unit A well efficiency applied to the observed drawdown values for the four Unit A extraction wells. During an unplanned cessation of pumpage from the GRS during August 2006, static water levels were obtained from the four extraction wells. The October 2006 pumping water levels from the four Unit A extraction wells were subtracted from the August 2006 static water levels to obtain an estimate of total water level drawdown in each of the four wells. The average efficiency of the tested wells is 33.5 percent. The corrected drawdown values are judged to be conservative in that the tested wells were purposefully pumped at relatively high rates to stress the aquifer as much as possible. The extraction wells were designed to be fully penetrating and to operate at less than the maximum well output that could be achieved for a short time, as in the aquifer tests. Therefore, the estimated formation water level drawdowns are likely less than what actually occurs.

The corrected water level elevations for the Unit A extraction wells are shown on Figure 2c. The corrected pumping water levels in the Unit A extraction wells appear to be too high, based on the water levels observed in nearby monitor wells. For example, MW-04UA, located northwest of extraction well EW-04UA, has a measured water level that is lower than the estimated water level in the nearby extraction well, indicating the estimated pumping water level in well EW-04UA is therefore lower than depicted (Figure 2c). A similar situation occurs when the water level in monitor well MW-14UA is compared to the estimated water level in the nearby extraction well EW-04UA. Near extraction well EW-01UA, monitor well MW-13UA has a lower water level than the estimated value in the nearby pumping well. These discrepancies are likely the result of the extraction wells being more efficient than estimated from the aquifer test data on other Unit A monitor wells. Caution should therefore be exercised when considering this derived subsidiary line of evidence for capture. The attempt to estimate and correct for well losses in the extraction wells produces estimated water levels that do not match with data from nearby monitor wells indicating that the extraction wells are more efficient than estimated based on data from early aquifer tests.

Water level elevations, including the estimated elevations at the extraction wells corrected for well losses, depicted on Figure 2c were contoured. The water level elevation contours still indicate significant capture, despite the fact that the estimated extraction well elevations are too high.

Vertical capture is inferred by the facts that the Unit A extraction wells fully penetrate Unit A, the anisotropy ratios are very high (very low vertical hydraulic conductivity) and no VOCs are detected in groundwater samples from Unit B wells.

6.0 FLOW BUDGET AND EXTRACTION WELL CAPTURE ZONES

This section provides the results of the flow budget calculations (groundwater flux through the area affected by VOCs) and compares the results to the average 2006 pumpage rates for the GRS. This section also provides the results of the individual extraction well capture zone analysis, including an analysis of vertical capture. When combined, the individual capture zones form the composite capture zone for the entire extraction well field. This is the second line of evidence in the capture zone analysis.

6.1 FLOW BUDGET

The flow budget was calculated from the equation specified in the guidance document. The flow budget is the calculated groundwater flux through the area defined by all monitor wells in Unit A which currently have detectable concentrations of VOCs. The equation in the guidance for deriving the flow budget is:

$$Q = K\ (w)\ (b)\ (i)\ (\text{factor})$$

Where: Q = extraction rate (ft^3/day)
K = hydraulic conductivity (ft/day)
w = plume width (ft)
b = saturated thickness (ft)
i = undisturbed regional gradient (ft/ft)
factor = rule of thumb for accounting for other sources of water to the pumping well (river, etc.).

The values used in the site specific calculation for the above equation terms are:

- Average extraction well pumpage for the year 2006 was the sum of the daily pumpage from the four extraction wells divided by 365 and converted to ft^3/day. This is likely a conservatively low value as the extraction well field did not operate full time due to maintenance downtimes, a total of 37 days.
    - Average pumpage from EW-01UA was 1.30 gpm or 250 ft^3/day.
    - Average pumpage from EW-02UA was 0.90 gpm or 173 ft^3/day.
    - Average pumpage from EW-03UA was 0.50 gpm or 96 ft^3/day.

- Average pumpage from EW-04UA was 2.46 gpm or 474 ft^3/day.

- Hydraulic conductivity *(K)* values estimated in the RI and subsequent documents range from 60 gpd/ft^2 (8.0 ft/day) to 100 gpd/ft^2 (13.4 ft/day). The maximum documented value of 100 gpd/ft^2 (13.4 ft/day) was used in order to provide a conservative estimate (over estimate) of groundwater flux.

- A classic groundwater plume of VOCs does not exist at the site; rather a series of wells containing VOCs generally emanating from the vicinity of the source area prevails. *W* was selected as the width of the TCZ depicted on Figure 1, which contains all monitor wells with current, or recent, VOC concentrations. The TCZ is approximately 800 feet wide.

- The average saturated thickness of Unit A is approximately 25 feet and was used as the value for *b*.

- The regional gradient as depicted in Unit A was estimated for conditions prior to pumping by Montgomery as 0.0035 (Montgomery/CRA, 1995).

- A "*factor"* was not used in the equation because no sources of water to Unit A are known or suspected to exist. The only potential source of water to Unit A would be upwelling from Unit B due to extraction well pumpage. However, water level drawdown in the Unit A extraction wells ranges from 4.4 to 7.14 feet (Table 2) and head differences between Unit A and Unit B range from 10 to 16 feet and average 12.6 feet. Water level drawdowns in Unit A extraction wells are not believed sufficient to induce significant upward flow from Unit B, which would require gradient reversal.

The flow budget was calculated for a range of hydraulic conductivities from 8.0 ft/day to 13.4 ft/day. The amount of groundwater flowing through the area containing wells with detectable VOC concentrations under different hydraulic conductivity assumptions are as follows:

- Using a K value of 13.4 ft/day the flow budget is 4.86 gpm.
- Using a K value of 10.7 ft/day the flow budget is 3.33 gpm.
- Using a K value of 8.0 ft/day the flow budget is 2.48 gpm.

The average total pumpage from the extraction well field for 2006 was 5.16 gpm, which is greater than the most conservative calculated flow budget value of 4.86 gpm. The GRS average pumpage is likely biased low because the GRS system was not operating for 37 days or approximately 10 percent of the time and the average was calculated including the days when the system was not operating.

In summary, the calculated flow budget using conservative assumptions is less than the average pumpage of the GRS extraction well field. This result indicates that the GRS is capturing an amount of groundwater greater than the calculated flow budget for the width of the TCZ. Given the localized nature of detected VOC concentrations in wells, the result of the flow budget calculation also indicates groundwater in areas of Unit A not affected by VOCs is also being captured. Following EPA guidance, this is a component of the second line of evidence regarding capture and demonstrates that capture is occurring from a volume of flow perspective.

6.2 INDIVIDUAL EXTRACTION WELL CAPTURE ZONES

This section provides the results of the individual extraction well capture zone analyses. When combined, the individual capture zones form the composite capture zone for the entire extraction well field. Combined, the flow budget and the individual extraction well capture zones form the second line of evidence in the capture zone analysis.

Table 3 contains the input data and calculation of individual extraction well capture zones. Capture zone geometry for each well is defined by a series of equations, using site hydraulic data and well pumpage, which determine the downgradient stagnation point, the width of capture at the well and the maximum width of capture upgradient of the extraction well (EPA, 2004). Figure 3 contains a depiction of the individual extraction well capture zones for each of the four extraction wells. Figure 3 indicates that the individual capture zones overlap each other indicating complete capture of the TCZ with one minor exception (Figure 4).

Piezometer MW-20UA was installed to close a data gap and provide water level information in an area that was not previously monitored. MW-20A was sampled once in February 2006 and the sample contained VOCs and, for this reason, was included in the TCZ (Figure 1). Based on the capture zone calculation, piezometer MW-20UA lies just outside the individual capture zone of extraction well EW-04UA. MW-20UA is approximately 150 feet from extraction well EW-04UA and the capture zone extends approximately 127 feet in the direction of MW-20UA.

In order to achieve capture in the vicinity of piezometer MW-20UA, the pumpage from extraction well EW-04UA should be increased by 20 to 25 percent, based on the capture zone width

calculation. Currently extraction well EW-04UA pumps an average of 2.46 gpm; the rate would need to be in the range of 2.95 to 3.07 gpm to assure complete capture in the vicinity of MW-20UA, assuming the formation can sustain the increase in extraction well discharge.

It is also apparent from the capture zone analysis that continued extraction and treatment of groundwater using extraction wells EW-01UA and EW-02UA may be unnecessary. Groundwater samples from both of these wells have indicated for some time that the wells do not extract groundwater containing VOCs. However, in order to continue to capture the current TCZ, defined in this vicinity by a single upgradient monitor well MW-01UA, it is currently recommended that only extraction well EW-01UA be shut down, and the extraction rate from extraction well EW-02UA be increased from an average of 0.9 gpm to 1.4 gpm, assuming this discharge rate can be sustained without excessive water level drawdown in well EW-02UA.

6.3 VERTICAL CAPTURE ANALYSIS

The capture zone guidance document notes that the capture zone evaluation should include information on the extent of vertical capture. Groundwater samples from Unit B monitor wells do not contain detectable concentrations of VOCs. This indicates that, while there is potential for vertical movement of water between Units A and B, vertical transport of VOCs to Unit B has not occurred in concentrations above laboratory detection limits. Because the vertical transport of detectable amounts of VOCs to Unit B monitor wells has not occurred, as evidenced by the data, an evaluation of vertical capture must be based on that premise.

In order to evaluate the extent of vertical capture generated by the GRS, a simple, conservative analytical methodology was used to determine if the potential vertical transport of VOCs is limited by the anisotropy of the Unit A system. If the vertical transport of VOCs is limited by the low vertical hydraulic conductivities typically associated with alluvial aquifers in the Basin and Range physiographic province it would provide an explanation of why VOCs are not detected in groundwater samples from Unit B wells and confirm vertical capture of Unit A groundwater containing VOCs by the GRS.

Laboratory vertical hydraulic conductivity values were obtained from Unit A soil samples collected near or below the water table in Unit A (Montgomery/CRA, 1991) (Table 6).

These values of vertical hydraulic conductivity in Unit A range from a high of 4.74E-03 ft/day to a low of 1.26E-04 ft/day. Unit A horizontal hydraulic conductivities have been derived from aquifer tests, the operation of a pilot GRS, and the longer term full scale operation of the GRS. When compared to Unit A estimated horizontal hydraulic conductivities, which range from 8.0 to 13.4 ft/day, the ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity ranges from 10,000 to 100,000. In its simplest form this means that for every foot Unit A groundwater travels horizontally it also theoretically travels from 0.0001 feet to 0.00001 feet vertically.

Groundwater velocity calculations recognize two primary types of groundwater flow and therefore two different concepts of velocity: macro-velocities associated with the average groundwater velocity through the aquifer matrix as a whole and micro-velocities which are the rates of groundwater movement through the interconnected pore spaces within the aquifer matrix. Micro-velocities are commonly used to estimate solute travel times within the interstices of the aquifer. Because water can only flow through the open portions of the aquifer matrix, the micro-velocity (interstitial velocity) is calculated by dividing the macro-velocity by the effective porosity of the matrix. The effective porosity was estimated to be 0.10 but the basis for this estimate is unclear (Montgomery/CRA,1995). This is a very conservative value for a unit comprised primarily of silts and clays and a more likely value of effective porosity would be in the range of 0.25 to 0.35.

Empirically, the actual velocity of solute transport is typically somewhere between the macro- and micro-velocity. Use of the micro-velocity therefore provides a conservative estimate of solute travel times; that is, the micro-velocity predicts that solute travel times are likely faster than that which actually occurs in the aquifer.

A range of vertical micro-velocities for Unit A were derived based on using three values of horizontal hydraulic conductivity, three different anisotropy ratios and two different values for effective porosity (Table 7). This analysis indicated that vertical micro-velocities within Unit A potentially ranged from a high of 0.134 feet/day to a low of 0.00032 ft/day, a range of five orders of magnitude

Recognizing the ratio of the horizontal to vertical hydraulic conductivities and the selection of the effective porosity value provide a very wide range of potential vertical velocities, a simplified analytical model was developed to derive a maximum site specific micro-velocity for the vertical component of potential groundwater flow through Unit A. This methodology allows a better estimation of the actual vertical transport velocities associated with the site by narrowing the range of potential values. The methodology utilizes the following conservative assumptions:

- Waste disposal ceased in October 1980; VOC containing vapors are assumed to have immediately contacted the Unit A groundwater surface in 1980.
- Unit A is 35 feet thick and Unit A was completely saturated in 1980.
- A report on hydraulic containment estimated that an "effective" porosity for Unit A was 0.10; the basis for this estimate is unclear. This is a very conservative value for a unit comprised primarily of silts and clays and a more likely value of effective porosity would be in the range of 0.25 to 0.35. However, the earlier estimate of effective porosity was used as this tends to maximize the micro-velocity associated with vertical flow within Unit A and is therefore conservative.
- The vertical hydraulic gradient was assumed to be 1:1.
- Constant pumpage of the GRS began in 1994 indicating a 14 year time frame within which vertical transport of groundwater would be occurring without the influences of pumping the GRS.
- Estimates of Unit A horizontal hydraulic conductivities range from 8.0 to 13.4 ft/day. The lower value was the estimate derived from operational testing of the GRS, an evaluation of hydraulic capture conducted after the GRS had operated for approximately one year, and a refinement of the digital model used for demonstrating capture. For purposes of this analysis, the highest horizontal hydraulic conductivity value was used in the derivation of potential vertical hydraulic conductivity values.
- No chemical degradation, dilution, dispersion, adsorption or other factors which tend to reduce VOC concentrations as a result of transport were considered.
- Vertical VOC transport was assumed to have occurred throughout the entire thickness of Unit A during the 14 year period prior to the full scale implementation of the GRS.

Using the above assumptions and values from Table 7, a range of calculations for the maximum estimated depth of potential vertical transport were performed to narrow the range of the anisotropy ratio based on known site specific conditions. Many of the higher estimated vertical velocities produced absurd results, e.g., using the highest estimated vertical velocity indicated a

potential depth of VOC transport of approximately 685 feet over 14 years. Because VOCs have not been detected in groundwater samples from Unit B monitor wells, the analysis was modified to limit vertical travel to the bottom of Unit A within the 14 year time. This independent analysis yielded the result that a range for the anisotropy ratio, under the conservative assumption of an effective porosity of 0.10, was likely between 10,000 and 100,000, which agrees reasonably well with the laboratory derived values for vertical hydraulic conductivity (Table 6).

Further refinement of a site specific value for vertical hydraulic conductivity was conducted by assuming a 14 year travel time and a maximum vertical travel distance of 35 feet, the thickness of Unit A. This resulted in an estimated vertical micro-velocity of 0.0068 ft/day under the assumption of an effective porosity of 0.10. This value falls between the calculated vertical velocities associated with anisotropy ratios of 10,000 and 100,000. Further refinement indicates a calculated value of the anisotropy ratio using the vertical velocity of 0.0068 ft/day is approximately 20,000. Using the same techniques described above, the analysis for the anisotropy ratio using an effective porosity value of 0.25 yielded an anisotropy ratio of approximately 8000.

Table 6 indicates that if the high and low laboratory vertical hydraulic conductivity values are discarded, the average vertical hydraulic conductivity in Unit A is 0.0007 ft/day. Considering the effective porosity value of 0.10 and converting to the vertical micro-velocity, a value of 0.007 is obtained which is virtually a match with the estimated value necessary to allow VOC transport throughout the thickness of Unit A.

Because groundwater samples from Unit B monitor wells do not contain VOCs, estimated historical vertical travel times are bounded by the conditions described above. When the GRS system began operating, local horizontal Unit A groundwater gradients increased and water levels in Unit A declined in response to GRS pumpage. These conditions increased the horizontal velocity of groundwater locally in Unit A which made the vertical velocity vector an even smaller fraction of the overall groundwater flow direction and increased the potential for capture. All of the GRS extraction wells fully penetrate Unit A and therefore VOC concentrations detected in groundwater samples from Unit A monitor wells are captured by the GRS.

The pumpage from the GRS also locally decreased the water level elevation differences between Unit A and Unit B in locations near the extraction wells, further reducing the potential for vertical transport of VOCs, and increasing the potential for vertical capture.

The Unit A extraction wells fully penetrate the saturated portions of Unit A. When compared to Unit B water levels, the Unit A water levels are reflective of the high degree anisotropy that exists within Unit A. Despite the high degree of anisotropy it is believed that some limited amount of water from beneath Unit A is likely upwelling in the immediate vicinity of the GRS extraction wells. While likely a minor component of vertical capture, this adds weight to the conclusion that vertical capture is being achieved.

The following observations and conclusions are derived from the analysis of vertical capture:

- Unit B monitor wells do not have detectable concentrations of VOCs therefore any vertical flow component that existed, or currently exists, is not sufficient to transport VOCs to Unit B prior to capture by the GRS.
- Laboratory vertical hydraulic conductivity data document anisotropy ratios ranging between 10,000 and 100,000.
- The observed difference in water level elevations between Unit A and Unit B is further evidence of significant anisotropy.
- Significant anisotropy exists within Unit A and significantly reduces the potential for vertical transport of VOCs despite the water level elevation differences between Unit A and Unit B. Thus, horizontal groundwater transport velocities overwhelm the potential for vertical transport.
- An independent derivation of the maximum potential vertical rate of solute transport through Unit A indicates that the anisotropy ratio is approximately 20,000.
- A comparison of the vertical hydraulic conductivity value derived from the analysis above agrees very well with an average value of laboratory derived vertical hydraulic conductivities in Unit A.
- Pumpage from the GRS captures the full saturated thickness of Unit A and the significant vertical anisotropy assures that vertical capture of the groundwater that contains VOCS in Unit A is occurring and will continue.

The observations and conclusions above demonstrate that, as a result of the significant difference between potential horizontal transport velocities and vertical transport velocities, the

extraction of groundwater from Unit A via the GRS achieves vertical capture of VOCs in the portion of the aquifer system that contains measurable concentrations of VOCS.

The overall capture zone analysis, based on converging lines of evidence, indicates that virtually all of the groundwater affected by VOCs is intercepted by the GRS extraction well field. A minor exception is the area east of extraction well EW-04UA near piezometer MW-20UA. A moderate increase in pumpage from EW-04UA would provide capture in that area based on the calculations for individual extraction well capture zones (Table 3). With an increase in pumpage from EW-04UA, the flow budget and the capture zone analysis indicate that complete capture of the TCZ would occur.

7.0 VOC CONCENTRATION TRENDS DOWNGRADIENT OF THE TCZ

This section analyzes the VOC concentration trends in Unit A monitor wells located downgradient of the TCZ. The guidance suggests that downgradient monitor wells are divided into two groups: downgradient performance monitoring wells and sentinel wells. The analysis of concentration trends in downgradient extraction and monitor wells is the third line of evidence in the capture zone analysis.

Figure 1 depicts the TCZ and show that five wells are located immediately downgradient of the TCZ. Extraction wells EW-01UA and EW-02UA and monitor well MW-13UA are located in the southwest corner of the site (Figure 1). Wells affected by VOCs within the individual capture zones for extractions wells EW-01UA and EW-02UA are wells MW-01UA and MW-07UA.

Recent VOC data for wells EW-01UA, EW-02UA and MW-13UA indicate that none of the samples from the wells contain VOCs with the exception of the detection of 11 micrograms/liter (µg/l) total VOCs in one sample from MW-13UA in October 2005. Groundwater samples from monitor well MW-13UA obtained in April 2005, April 2006 and October 2006 indicate no detections of any VOCs (Table 4).

Figure 1 depicts monitor wells MW-02UA and MW-03 UA downgradient of the TCZ. Recent analytical results for groundwater samples from these wells indicate that VOCs are not present in samples from either of the two monitor wells (Table 4).

When originally installed, monitor well MW-08UA and MW-09UA were downgradient of the original source area, prior to alteration of the flow pattern in Unit A by the operation of the GRS extraction wells (Figure 1). Historical data from the RI for monitor wells MW-08UA and MW-09UA indicate that these wells did not contain site related VOCs as early as 1990. Recent analytical data indicate that groundwater samples from these wells have not been affected by VOCs (Table 4). Because the operation of the GRS extraction well field has substantially altered the local flow pattern in Unit A, monitor wells MW-08UA and MW-09UA are no longer downgradient of areas affected by VOCs. It is not necessary to continue to monitor wells MW-

08UA and MW-09UA for chemical quality as no affected site groundwater remains up gradient of these wells (Figure 1).

Monitor well MW-10UA is located downgradient of the extraction well field in the extreme southeast corner of the site and is a sentinel well. Historical data from the RI for monitor well MW-10UA indicate that these wells did not contain site related VOCs as early as 1990. Recent analytical data indicate that groundwater samples from MW-10UA have not been affected by VOCs (Table 4).

In summary, the chemical quality trend evaluation is very straight forward. None of the groundwater samples from downgradient monitor wells or sentinel wells contain VOCs.

This indicates from a chemical trend standpoint that complete capture is occurring due to the operation of the extraction wells associated with the GRS.

8.0 SUMMARY OF CONVERGING LINES OF EVIDENCE

This section summarizes and combines the different lines of evidence by comparing the interpreted capture zone(s) to the TCZ, assessing uncertainties in the analysis, discussing potential data gaps, and evaluating the need to adjust extraction rates and/or extraction locations. Based on the analysis of the converging lines of evidence, recommendations regarding the GRS are made.

8.1 TARGET CAPTURE ZONE

The original TCZ was developed in the preliminary design stages of the Unit A hydraulic containment system and was outlined based on data available through early 1992. The original TCZ was defined as *"…the part of Unit A currently targeted for hydraulic control and capture by…extraction wells…" (*Montgomery/CRA, 1992). The original TCZ was approximately 750 feet wide.

The current TCZ used in the capture analysis was based on the same premise as the original TCZ (Figure 1). However, the current TCZ was modified to insure that all Unit A wells currently or recently containing VOCs were included in the TCZ. Thus, the current capture zone was shifted slightly east and is approximately 800 feet wide (Figure 1).

The vertical extent of the TCZ is defined as the bottom of Unit A. The anisotropy ratio of the alluvial sediments indicates that the vertical hydraulic conductivities are several orders of magnitude less than the horizontal hydraulic conductivity and this is a line of evidence that suggests vertical transport, if it occurs, would be extremely slow. A stronger line of evidence is that no VOCs have been detected in any Unit B monitor wells during several consecutive years of quarterly monitoring; therefore VOCs are only known to be present in portions of Unit A.

8.2 WATER LEVEL DATA

Analysis and contouring of the water level data indicate that capture is being achieved. An attempt to correct the extraction well dynamic water levels to account for well losses, based on early aquifer test data from the RI, resulted in estimated dynamic water levels higher than those measured in nearby monitor wells. This indicates that the attempt to correct for wells losses was very conservative. However, the resulting water level contour map still indicates that significant capture is still occurring using the estimated formation drawdown data for the extraction wells. (Figure 2c).

8.3 FLOW BUDGET AND WELL CAPTURE ZONE ANALYSIS

The flow budget was calculated from the equation specified in the guidance document. The flow budget is the calculated groundwater flux through the area defined by all monitor wells in Unit A which currently have detectable concentrations of VOCs.

The average total pumpage from the extraction well field for 2006 was 5.16 gpm, which is greater than the most conservative calculated flow budget value of 4.86 gpm.

The calculated flow budget is less than the average pumpage of the GRS extraction well field.

This result indicates that the GRS is capturing an amount of groundwater greater than the calculated flow budget for the width of the TCZ. This component of the second line of evidence demonstrates that effective capture is occurring from a volume of flow perspective.

8.4 EXTRACTION WELL CAPTURE ZONE ANALYSIS

When combined, the individual capture zones form the composite capture zone for the entire extraction well field. Combined, the flow budget and the individual extraction well capture zones form the second line of evidence in the capture zone analysis.

The individual capture zones overlap each other indicating complete capture of the TCZ with one minor exception (Figure 4). Based on the capture zone calculation, piezometer MW-20UA lies just outside the individual capture zone of extraction well EW-04UA. MW-20UA is approximately 150 feet east of extraction well EW-04UA and the capture zone extends approximately 127 feet in the direction of MW-20UA.

In order to achieve capture in the vicinity of piezometer MW-20UA, the pumpage from extraction well EW-04UA would need to be increased by 20 to 25 percent, based on the capture zone width calculation. Currently extraction well EW-04UA pumps an average of 2.46 gpm; the rate would need to be in the range of 2.95 to 3.07 gpm to assure complete capture in the vicinity of MW-20UA.

In summary, the capture zone analysis indicates that virtually all of the groundwater affected by VOCs is intercepted by the GRS extraction well field. A minor exception is the area east of extraction well EW-04UA near piezometer MW-20UA. A moderate increase in pumpage from EW-04UA would assure the flow budget and the capture zone analyses indicate that complete capture of the TCZ would occur.

8.5 VOC CONCENTRATION TREND ANALYSIS

The analysis of concentration trends in downgradient extraction and monitor wells is the third line of evidence in the capture zone analysis. The chemical quality trend evaluation for monitor and extraction wells located downgradient of the TCZ is very straight forward. None of the groundwater samples from downgradient monitor wells or sentinel wells contain VOCs. This indicates from a chemical trend standpoint, that complete capture is occurring due to the operation of the extraction wells associated with the GRS.

No VOC concentrations have been detected in groundwater samples from Unit B wells indicating from the chemical perspective that successful vertical capture has been achieved in Unit A.

Table 5, as suggested in the draft guidance, summarizes the results of the capture zone analysis conducted for the Unit A GRS.

8.6 RECOMMENDATIONS

Available data collected as part of the routine quarterly monitoring program are sufficient to delineate capture based on the converging lines of evidence techniques outlined in the guidance document. No new data points are necessary to demonstrate capture of affected groundwater in Unit A.

It is recommended that the water level elevation contour maps produced for the quarterly reports use the outcome of the capture zone analysis when interpreting the water level portion of the quarterly monitoring program.

Monitor wells MW-08UA and MW-09UA are no longer downgradient of the areas of the site containing VOCs in groundwater. It is recommended that the wells be dropped from the water quality portion of the monitoring program.

It is recommended that the pumping rate from extraction well EW-04UA be adjusted upward by 20-25 percent to assure capture in the vicinity of piezometer MW-20UA.

It is recommended that extraction well EW -01UA be shut down. To maintain capture in this area, it is recommended that extraction well EW-02UA pumpage be increased from 0.9 gpm to 1.4 gpm, assuming this does not cause excessive water level drawdown in the well.

9.0 REFERENCES

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TABLE 1
WELL LOSSES

WELL	MAX DD (ft)	INITIAL WL REBOUND (ft)	FORMATION DD (ft)	% EFFICIENCY
MW-2UA	9.77	~7.8	1.97	20
MW-4UA	15.13	~7.6	7.53	49.8
MW-5UA	12.41	~8.15	4.26	34.3
MW-6UA	14.54	~12.2	2.34	16.1
MW-7UA	9.73	~7.0	2.73	28
MW-9UA	8.33	~4.5	4.03	48.4
MW-10UA	8.99	~5.6	3.39	37.7
				AVERAGE = 33.5

TABLE 2
ESTIMATED DYNAMIC WATER LEVELS

EXTRACTION WELL	AUGUST 2006 STATIC WL (ft)	OCTOBER 2006 DYNAMIC WL (ft)	DD	CORRECTED DD[1]	CORRECTION ELEVATION (ft)
EW-01UA	834.88	827.74	7.14	2.39	832.49
EW-02UA	833.94	828.67	5.27	1.76	832.18
EW-03UA	834.38	829.98	4.4	1.47	832.91
EW-04UA	834.66	828.63	6.03	2.02	832.64

[1]Corrected DD uses the Average Well Efficiency from Table 1

Notes:
DD = Drawdown
WL = Water Level
ft = feet

TABLE 3
CAPTURE ZONE WIDTH CALCULATIONS

WELL ID	PUMPAGE		X_o	Y_{max}	Y_{well}
	gpm	ft^3/day			
EW-1	1.3	250	-250/6.28(267)(0.0035) = -250/5.869 = 42.6'	± 250/2(267)(0.0035) = ±250/1.869 = 133.8'	± 250/4(267)(0.0035) = ±250/3.738 = 66.9'
EW-2	0.9	173	-173/5.869 = 29.5'	± 173/1.869 = 92.6	± 173/3.738 = 46.3'
EW-3	0.5	96	-96/5.869 = 16.4'	± 96/1.869 = 51.4'	± 96/3.738 = 25.7'
EW-4	2.46	474	-474/5.869 = 80.8'	± 474/1.869 = 254'	± 474/3.738 = 127'

Notes:
Gradient = 0.0035
T = 267 ft^2/day

HARGIS + ASSOCIATES, INC.

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
TREATMENT SYSTEM														
EFFLUENT	EFFLUENT-0105	POA0358-02	01/14/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	EFFLUENT-0105A	POA0358-03	01/14/2005	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0214	POB0363-02	02/14/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent 0314	POC0404-02	03/14/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0405	POD0805-08	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent 0505	POE0626-02	05/23/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	EFFLUENT 0613	POF0393-02	06/13/2005	DMAR-PHX	REG		3.3	ND	3.3	ND	ND	ND	ND	ND
EFFLUENT	Effluent 71905	POG0474-02	07/19/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	EFFLUENT 081605	POH0449-02	08/16/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent 091305	POI0331-02	09/13/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	EFFLUENT-1005	POJ0706-07	10/25/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent 112105	POK0623-02	11/21/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	EFF121905	POL0567-02	12/19/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent - 0106	PPA0410-03	01/16/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0206	PPB0551-02	02/16/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0106	PPB0784-06	02/23/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0306	PPC0561-02	03/17/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0406	PPD0658-08	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0506	PPE0615-02	05/17/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0606	PPF0459-02	06/15/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	EFFLUENT-0706	PPG0658-14	07/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0822	PPH0640-02	08/22/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-0917	PPI0555-02	09/17/2006	TAMP	REG		13	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-1006	PPJ0772-15	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-1106	PPK0660-02	11/20/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EFFLUENT	Effluent-1219	PPL0518-02	12/19/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
INFLUENT	INFLUENT-0105	POA0358-04	01/14/2005	DMAR-PHX	REG		632	430	30	10	6.1	120	5.5	16
INFLUENT	Influent-0405	POD0805-07	04/27/2005	DMAR-PHX	REG		1187	670	35	13	7.5	420	6.2	18
INFLUENT	Influent 71905	POG0474-03	07/19/2005	DMAR-PHX	REG		497	270	19	5.9	3.2	180	2.6	7.9
INFLUENT	INFLUENT-1005	POJ0706-05	10/25/2005	DMAR-PHX	REG		948	650	40	13	6.9	200	6.5	20
INFLUENT	Influent - 0106	PPA0410-02	01/16/2006	DMAR-PHX	REG		1052	630	31	11	5.5	340	5.0	15
INFLUENT	Influent-0106	PPB0784-05	02/23/2006	DMAR-PHX	REG		51	ND	9.4	ND	ND	42	ND	ND
INFLUENT	Influent-0406	PPD0658-06	04/24/2006	DMAR-PHX	REG		1136	680	33	12	5.5	370	5.4	17

HARGIS + ASSOCIATES, INC.

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
TREATMENT SYSTEM (Continued)														
INFLUENT	PL-501-0406	PPD0658-07	04/24/2006	DMAR-PHX	FD		1095	650	33	11	5.6	360	5.4	17
INFLUENT	INFLUENT-0706	PPG0658-13	07/24/2006	TAMP	REG		878	520	31	10	4.9	280	5.1	15
INFLUENT	Influent-1006	PPJ0772-13	10/24/2006	TAMP	REG		1258	740	41	13	6.2	410	6.6	20
EXTRACTION WELLS UNIT A														
EW-01UA	EW-1UA-0405	POD0805-02	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-01UA	EW-1UA-1005	POJ0706-02	10/25/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-01UA	EW-01UA-0406	PPD0658-02	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-01UA	EW-01UA-1006	PPJ0739-02	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-02UA	EW-2UA-0405	POD0805-03	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-02UA	EW-2UA-1005	POJ0794-12	10/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-02UA	EW-02UA-0106	PPB0784-02	02/23/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-02UA	EW-02UA-0406	PPD0658-03	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-02UA	EW-02UA-0706	PPG0658-10	07/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-02UA	EW-02UA-1006	PPJ0739-03	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
EW-03UA	EW-3UA-0405	POD0805-04	04/27/2005	DMAR-PHX	REG		238	71	33	3.6	ND	130	ND	ND
EW-03UA	PL-501-0405	POD0805-05	04/27/2005	DMAR-PHX	FD		224	69	32	3.4	ND	120	ND	ND
EW-03UA	EW-3UA-1005	POJ0706-03	10/25/2005	DMAR-PHX	REG		298	90	34	3.7	ND	170	ND	ND
EW-03UA	EW-03UA-0106	PPB0784-03	02/23/2006	DMAR-PHX	REG		330	100	40	4.2	ND	180	ND	ND
EW-03UA	EW-03UA-0406	PPD0658-04	04/24/2006	DMAR-PHX	REG		271	74	33	3.5	ND	160	ND	ND
EW-03UA	EW-03UA-0706	PPG0658-11	07/24/2006	TAMP	REG		197	ND	33	3.8	ND	160	ND	ND
EW-03UA	EW-03UA-1006	PPJ0739-04	10/23/2006	TAMP	REG		247	ND	38	3.9	ND	200	ND	ND
EW-04UA	EW-4UA-0405	POD0805-06	04/27/2005	DMAR-PHX	REG		2825	1600	73	31	19	1000	15	41
EW-04UA	EW-4UA-1005	POJ0706-04	10/25/2005	DMAR-PHX	REG		2918	1700	79	30	16	1000	13	41
EW-04UA	EW-4UA-0106	PPC0131-02	03/03/2006	DMAR-PHX	REG		3704	2200	110	39	21	1200	19	57
EW-04UA	EW-04UA-0406	PPD0658-05	04/24/2006	DMAR-PHX	REG		2760	1600	75	30	15	950	13	41
EW-04UA	EW-04UA-0706	PPG0658-12	07/24/2006	TAMP	REG		2510	1500	67	27	13	820	13	36
EW-04UA	EW-04UA-1006	PPJ0739-05	10/23/2006	TAMP	REG		3133	1800	74	28	12	1100	14	40

HARGIS + ASSOCIATES, INC.

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
MONITOR WELLS UNIT A														
MW-01UA	MW-1UA-0405-94.8	POE0021-08	05/02/2005	DMAR-PHX	REG	PDB	344	130	4.0	13	2.0	ND	180	ND
MW-01UA	MW-1UA-0405-96.5	POE0021-09	05/02/2005	DMAR-PHX	REG	PDB	321	120	4.0	12	2.2	ND	170	ND
MW-01UA	MW-1UA-1005	POJ0793-04	10/26/2005	DMAR-PHX	REG		46	17	3.4	ND	ND	ND	26	ND
MW-01UA	MW-01UA-94.8-0106	PPB0784-07	02/23/2006	DMAR-PHX	REG	PDB	269	71	3.2	11	2.1	ND	170	ND
MW-01UA	MW-01UA-94.8-0406	PPD0738-06	04/26/2006	DMAR-PHX	REG	PDB	212	69	2.7	9.9	ND	ND	130	ND
MW-01UA	MW-01UA-94.8-0706	PPG0658-03	07/24/2006	TAMP	REG	PDB	86	31	4.8	3.4	ND	ND	47	ND
MW-01UA	MW-01UA-94.8-1006	PPJ0772-20	10/24/2006	TAMP	REG	PDB	114	38	4.0	5.9	ND	ND	66	ND
MW-02UA	MW-2UA-0405	POD0805-12	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UA	MW-2UA-1005	POJ0706-09	10/25/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UA	MW-02UA-0406	PPD0658-12	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UA	MW-02UA-1006	PPJ0739-10	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UA	PL-503-0406	PPJ0739-14	10/23/2006	TAMP	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UA	MW-3UA-0405	POD0862-04	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UA	MW-3UA-1005	POJ0794-08	10/26/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UA	MW-03UA-0406	PPD0658-14	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UA	MW-03UA-1006	PPJ0739-12	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND UJV	ND	ND
MW-04UA	MW-4 UA 86.0	POB0673-02	02/23/2005	DMAR-PHX	REG	PDB	4519	2600	78	18	19	1700	3.5	ND
MW-04UA	MW-4 UA 88.9	POB0673-03	02/23/2005	DMAR-PHX	REG	PDB	4202	2500	72	14	18	1500	3.2	ND
MW-04UA	MW-4 UA 91.8	POB0673-04	02/23/2005	DMAR-PHX	REG	PDB	3995	2400	69	13	17	1400	3.2	ND
MW-04UA	MW-4UA-0405-91.8	POE0021-10	05/02/2005	DMAR-PHX	REG	PDB	1108	590	37	6.9	3.9	450	ND	ND
MW-04UA	MW-4UA-0405-pump-U	POE0021-12	05/02/2005	DMAR-PHX	REG		1553	840	36	9.8	6.5	630	ND	ND
MW-04UA	MW-4UA-pump-S	POE0021-13	05/02/2005	DMAR-PHX	REG		366	160	7.6	2.1	ND	190	ND	ND
MW-04UA	MW-4UA-1005	POJ0793-02	10/26/2005	DMAR-PHX	REG		259	110	8.6	ND	ND	140	ND	ND
MW-04UA	MW-04UA-86.0-0106	PPB0784-08	02/23/2006	DMAR-PHX	REG	PDB	1660	830	50	ND	ND	780	ND	ND
MW-04UA	MW-4UA-86.0-0406	PPD0738-07	04/26/2006	DMAR-PHX	REG	PDB	650	360	34	5.4	ND	240	ND	ND
MW-04UA	MW-04UA-86.0-0706	PPG0658-05	07/24/2006	TAMP	REG	PDB	447	260	26	3.7	ND	150	ND	ND
MW-04UA	PL-501-0706	PPG0658-06	07/24/2006	TAMP	FD	PDB	437	260	26	3.5	ND	140	ND	ND
MW-04UA	MW-04UA-86.0-1006	PPJ0772-21	10/24/2006	TAMP	REG	PDB	561	320	27	4.4	ND	200	ND	ND

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
MONITOR WELLS UNIT A (continued)														
MW-05UA	MW-5UA-0405	POD0805-16	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-05UA	MW-05UA-0406	PPD0658-18	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-05UA	PL-504-0406	PPD0658-19	04/24/2006	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-06UA	MW-6 UA 86.15	POB0673-05	02/23/2005	DMAR-PHX	REG	PDB	1739	1100	18	8.7	5.7	560	5.6	ND
MW-06UA	MW-6 UA 90.01	POB0673-06	02/23/2005	DMAR-PHX	REG	PDB	1701	1100	16	6.8	5.3	530	5.1	ND
MW-06UA	MW-6 UA 93.87	POB0673-07	02/23/2005	DMAR-PHX	REG	PDB	1644	1100	17	6.5	5.7	470	5.4	ND
MW-06UA	MW-20 86.15	POB0673-21	02/23/2005	DMAR-PHX	FD	PDB	1609	1100	19	8.9	5.8	430	5.5	ND
MW-06UA	MW-6UA-0405-86.2	POE0021-17	05/02/2005	DMAR-PHX	REG	PDB	1301	820	11	5.1	2.6	430	2.2	ND
MW-06UA	MW-6UA-1005	POJ0793-09	10/26/2005	DMAR-PHX	REG		499	320	5.6	2.8	ND	160	ND	ND
MW-06UA	PL-504-1005	POJ0793-10	10/26/2005	DMAR-PHX	FD		511	320	5.8	3.1	ND	170	ND	ND
MW-06UA	MW-06UA-86.2-0106	PPB0784-09	02/23/2006	DMAR-PHX	REG	PDB	570	240	ND	ND	ND	330	ND	ND
MW-06UA	MW-6UA-86.2-0406	PPD0738-09	04/26/2006	DMAR-PHX	REG	PDB	526	300	4.6	3.0	ND	210	ND	ND
MW-06UA	MW-06UA-86.2-0706	PPG0658-09	07/24/2006	TAMP	REG	PDB	75	57	ND	ND	ND	18	ND	ND
MW-06UA	MW-06UA-86.2-1006	PPJ0772-23	10/24/2006	TAMP	REG	PDB	210	100	ND	ND	ND	110	ND	ND
MW-07UA	MW-7 UA 91.34	POB0673-08	02/23/2005	DMAR-PHX	REG	PDB	1400	410	120	11	2.6	830	2.3	ND
MW-07UA	MW-7 UA 94.64	POB0673-09	02/23/2005	DMAR-PHX	REG	PDB	1328	410	120	9.5	2.6	760	2.2	ND
MW-07UA	MW-7 UA 97.94	POB0673-10	02/23/2005	DMAR-PHX	REG	PDB	1257	420	110	7.6	2.6	690	2.3	ND
MW-07UA	MW-7UA-0405-91.3	POE0021-19	05/02/2005	DMAR-PHX	REG	PDB	1103	350	110	10	2.4	600	ND	ND
MW-07UA	MW-7UA-1005	POJ0793-03	10/26/2005	DMAR-PHX	REG		1192	320	140	15	3.2	690	2.3	ND
MW-07UA	MW-07UA-91.3-0106	PPB0784-10	02/23/2006	DMAR-PHX	REG	PDB	1270	380	140	ND	ND	750	ND	ND
MW-07UA	MW-7UA-91.3-0406	PPD0738-11	04/26/2006	DMAR-PHX	REG	PDB	1072	340	120	13	2.1	580	2.1	ND
MW-07UA	MW-07UA-91.3-0706	PPG0658-18	07/24/2006	TAMP	REG	PDB	881	290	98	11	ND	470	ND	ND
MW-07UA	MW-07UA-91.3-1006	PPJ0772-25	10/24/2006	TAMP	REG	PDB	725	250	79	7.0	ND	380	ND	ND
MW-08UA	MW-8UA-0405	POD0862-16	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-08UA	MW-8UA-1005	POJ0794-04	10/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-08UA	PL-507-1005	POJ0794-05	10/27/2005	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-08UA	MW-08UA-0406	PPD0706-06	04/25/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-08UA	MW-08UA-1006	PPJ0772-06	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UA	MW-9UA-0405	POD0862-17	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UA	MW-9UA-1005	POJ0794-06	10/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UA	MW-09UA-0406	PPD0851-02	04/28/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UA	PL-505-0406	PPD0851-03	04/28/2006	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UA	MW-09UA-1006	PPJ0772-03	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
MONITOR WELLS UNIT A (continued)														
MW-10UA	MW-10UA-0405	POD0862-15	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-10UA	MW-10UA-1005	POJ0794-02	10/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-10UA	MW-10UA-0406	PPD0706-02	04/25/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-10UA	MW-10UA-1006	PPJ0772-02	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-11UA	MW-11UA-0405 84.1	POD0862-09	04/28/2005	DMAR-PHX	REG	PDB	545	35	ND	ND	ND	510	ND	ND
MW-11UA	MW-11UA-0405 88.6	POD0862-10	04/28/2005	DMAR-PHX	REG	PDB	568	38	ND	ND	ND	530	ND	ND
MW-11UA	MW-11UA-0405 93.1	POD0862-11	04/28/2005	DMAR-PHX	REG	PDB	674	33	ND	ND	ND	620	ND	ND
MW-11UA	MW-11UA-0405 97.6	POD0862-12	04/28/2005	DMAR-PHX	REG	PDB	425	15	ND	ND	ND	400	ND	ND
MW-11UA	MW-11UA-0405	POD0862-14	04/28/2005	DMAR-PHX	REG		210	ND	ND	ND	ND	210	ND	ND
MW-11UA	MW-11UA-1005	POJ0794-11	10/27/2005	DMAR-PHX	REG		454	14	ND	ND	ND	440	ND	ND
MW-11UA	MW-11UA-93.1-0106	PPB0784-11	02/23/2006	DMAR-PHX	REG	PDB	490	ND	ND	ND	ND	490	ND	ND
MW-11UA	MW-11UA-93.1-0406	PPD0706-07	04/25/2006	DMAR-PHX	REG	PDB	32	ND	ND	ND	ND	32	ND	ND
MW-11UA	MW-11UA-93.1-0706	PPG0658-19	07/24/2006	TAMP	REG	PDB	83	5.9	ND	ND	ND	77	ND	ND
MW-11UA	MW-11UA-93.1-1006	PPJ0772-07	10/24/2006	TAMP	REG	PDB	76	5.0	ND	ND	ND	71	ND	ND
MW-12UA	MW-12 UA 80.81	POB0673-11	02/23/2005	DMAR-PHX	REG	PDB	374	230	8.8	3.1	ND	120	ND	2.9
MW-12UA	MW-12 UA 83.90	POB0673-12	02/23/2005	DMAR-PHX	REG	PDB	312	200	5.6	ND	ND	100	ND	ND
MW-12UA	MW-12 UA 87.0	POB0673-13	02/23/2005	DMAR-PHX	REG	PDB	298	200	5.8	ND	ND	86	ND	ND
MW-12UA	MW-21 80.81	POB0673-22	02/23/2005	DMAR-PHX	FD	PDB	392	260	8.1	2.5	ND	110	ND	3.0
MW-12UA	MW-12UA-0405-87.0	POE0021-04	05/02/2005	DMAR-PHX	REG	PDB	309	220	5.4	ND	ND	76	ND	ND
MW-12UA	MW-12UA-0405-pump-U	POE0021-06	05/02/2005	DMAR-PHX	REG		262	160	4.3	ND	ND	92	ND	ND
MW-12UA	MW-12UA-pump-S	POE0021-07	05/02/2005	DMAR-PHX	REG		441	300	7.0	3.6	ND	120	ND	ND
MW-12UA	MW-12UA-1005	POJ0793-07	10/26/2005	DMAR-PHX	REG		680	440 JV	12	5.2	ND	200	ND	2.7
MW-12UA	MW-12UA-80.8-0106	PPB0784-12	02/23/2006	DMAR-PHX	REG	PDB	790	530	ND	ND	ND	260	ND	ND
MW-12UA	MW-12UA-80.8-0406	PPD0738-05	04/26/2006	DMAR-PHX	REG	PDB	488	380	10	2.0	ND	88	ND	ND
MW-12UA	MW-12UA-80.8-0706	PPG0658-21	07/24/2006	TAMP	REG	PDB	1107	740	17	6.8	ND	320	ND	ND
MW-12UA	PL-506-0406	PPJ0772-08	10/24/2006	TAMP	FD	PDB	1166	600	11	5.6	ND	520	ND	ND
MW-12UA	MW-12UA-80.8-1006	PPJ0772-19	10/24/2006	TAMP	REG	PDB	1141	580	10	5.3	ND	520	ND	ND
MW-13UA	MW-13UA-0405	POD0805-09	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-13UA	MW-13UA-1005	POJ0706-12	10/25/2005	DMAR-PHX	REG		11	ND	ND	ND	ND	ND	ND	ND
MW-13UA	MW-13UA-0406	PPD0658-09	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-13UA	MW-13UA-1006	PPJ0739-07	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
MONITOR WELLS UNIT A (continued)														
MW-14UA	MW-14UA-0405	POD0862-07	04/28/2005	DMAR-PHX	REG		9.1	6.9	ND	ND	ND	ND	ND	2.2
MW-14UA	PL-505-0405	POD0862-08	04/28/2005	DMAR-PHX	FD		11	8.4	ND	ND	ND	ND	ND	2.1
MW-14UA	MW-14UA-1005	POJ0794-10	10/27/2005	DMAR-PHX	REG		17	13	2.0	ND	ND	ND	ND	2.0
MW-14UA	MW-14UA-87.6-0406	PPD0706-09	04/25/2006	DMAR-PHX	REG	PDB	40	32	4.2	ND	ND	ND	ND	3.9
MW-14UA	MW-14UA-90.9-0406	PPD0706-10	04/25/2006	DMAR-PHX	REG	PDB	45	36	4.7	ND	ND	ND	ND	4.2
MW-14UA	MW-14UA-94.2-0406	PPD0706-11	04/25/2006	DMAR-PHX	REG	PDB	46	37	4.7	ND	ND	ND	ND	4.2
MW-14UA	MW-14UA-94.2-1006	PPJ0772-09	10/24/2006	TAMP	REG	PDB	87	64	6.9	ND	ND	11	ND	4.6
MW-16UA	MW-16UA	POA0536-04	01/21/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16 UA 81.34	POB0673-14	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16 UA 85.71	POB0673-15	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16 UA 90.08	POB0673-16	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16 UA 94.45	POB0673-17	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16UA-0405-81.3	POE0021-02	05/02/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16UA-1005	POJ0793-08	10/26/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16UA-81.3-0106	PPB0784-13	02/23/2006	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16UA-81.3-0406	PPD0738-02	04/26/2006	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16UA-81.3-0706	PPG0658-22	07/24/2006	TAMP	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-16UA	MW-16UA-81.3-1006	PPJ0772-17	10/24/2006	TAMP	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA	POA0536-03	01/21/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17 UA 85.27	POB0673-18	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17 UA 90.97	POB0673-19	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17 UA 96.67	POB0673-20	02/23/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA-0405-85.3	POE0021-03	05/02/2005	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA-1005	POJ0793-06	10/26/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA-85.3-0106	PPB0784-14	02/23/2006	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA-85.3-0406	PPD0738-03	04/26/2006	DMAR-PHX	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA-85.3-0706	PPG0658-20	07/24/2006	TAMP	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-17UA	MW-17UA-85.3-1006	PPJ0772-18	10/24/2006	TAMP	REG	PDB	ND	ND	ND	ND	ND	ND	ND	ND
MW-18UA	MW-18UA-0106	PPB0784-15	02/23/2006	DMAR-PHX	REG		19780	7600	250	140	2900	6700	130	56
MW-18UA	MW-18UA-85.3-0406	PPD0706-15	04/25/2006	DMAR-PHX	REG	PDB	6904	3600	140	55	180	2800	17	17
MW-18UA	MW-18UA-88.6-0406	PPD0706-17	04/25/2006	DMAR-PHX	REG	PDB	5944	3700	140	53	220	1700	17	17
MW-18UA	MW-18UA-91.9-0406	PPD0706-18	04/25/2006	DMAR-PHX	REG	PDB	7233	4900	150	26	750	1200	70	24

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
MONITOR WELLS UNIT A (continued)														
MW-18UA	MW-18UA-91.9-0706	PPG0658-15	07/24/2006	TAMP	REG	PDB	8788	4900	150	38	44	3500	28	25
MW-18UA	PL-503-0706	PPG0658-16	07/24/2006	TAMP	FD	PDB	10034	5400	130	34	39	4300	25	23
MW-18UA	MW-18UA-91.9-1006	PPJ0772-12	10/24/2006	TAMP	REG	PDB	12776	6100	230	87	51	6100	30	45
MW-19UA	MW-19UA-0106	PPB0784-17	02/23/2006	DMAR-PHX	REG		3018	740	78	66	750	720	130	65
MW-19UA	PL-503-0106	PPB0784-18	02/23/2006	DMAR-PHX	FD		2917	730	67	59	760	690	110	53
MW-19UA	MW-19UA-85.9-0406	PPD0706-12	04/25/2006	DMAR-PHX	REG	PDB	5884	3600	320	73	800	580	87	250
MW-19UA	MW-19UA-89.6-0406	PPD0706-13	04/25/2006	DMAR-PHX	REG	PDB	7286	4600	400	80	1000	570	110	310
MW-19UA	MW-19UA-93.3-0406	PPD0706-14	04/25/2006	DMAR-PHX	REG	PDB	11070	7300	430	50	1800	500	190	380
MW-19UA	MW-19UA-93.3-0706	PPG0658-17	07/24/2006	TAMP	REG	PDB	6711	4900	410	56	110	710	90	360
MW-19UA	MW-19UA-93.3-1006	PPJ0772-10	10/24/2006	TAMP	REG	PDB	8154	5800	470	87	91	1100	110	360
MW-20UA	MW-20UA-0106	PPB0830-02	02/24/2006	DMAR-PHX	REG		117	57	4.2	2.1	22	32	ND	ND
MONITOR WELLS UNIT B														
MW-01UB	MW-1UB-0405	POD0805-10	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-01UB	MW-1UB-1005	POJ0706-14	10/25/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-01UB	MW-01UB-0106	PPB0784-19	02/23/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-01UB	MW-01UB-0406	PPD0658-10	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-01UB	MW-01UB-0706	PPG0658-02	07/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-01UB	MW-01UB-1006	PPJ0739-08	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-01UB	PL-502-1006	PPJ0739-09	10/23/2006	TAMP	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UB	MW-2UB-0405	POD0805-13	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UB	MW-2UB-1005	POJ0706-10	10/25/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UB	PL-501-1005	POJ0706-11	10/25/2005	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UB	MW-02UB-0406	PPD0658-13	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-02UB	MW-02UB-1006	PPJ0739-11	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UB	MW-3UB-0405	POD0862-05	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UB	MW-3UB-1005	POJ0794-09	10/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UB	MW-03UB-0406	PPD0658-15	04/24/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UB	PL-503-0406	PPD0658-16	04/24/2006	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-03UB	MW-03UB-1006	PPJ0739-13	10/23/2006	TAMP	REG		ND	ND	ND	ND	ND	ND UJV	ND	ND

TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method								
MONITOR WELLS UNIT B (Continued)														
MW-04UB	MW-4UB-pump-U	POE0021-15	05/02/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-04UB	MW-4UB-pump-S	POE0021-16	05/02/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-04UB	MW-04UB-0106	PPB0784-20	02/23/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-04UB	PL-504-0106	PPB0784-21	02/23/2006	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-04UB	MW-4UB-0406	PPD0738-08	04/26/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-04UB	MW-04UB-0706	PPG0658-04	07/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-04UB	MW-04UB-1006	PPJ0772-22	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-06UB	MW-6UB-0405	POE0021-18	05/02/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-06UB	MW-06UB-0106	PPB0784-22	02/23/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-06UB	MW-6UB-0406	PPD0738-10	04/26/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-06UB	MW-06UB-0706	PPG0658-07	07/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-06UB	MW-06UB-1006	PPJ0772-24	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UB	MW-9UB-0405	POD0862-03	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UB	MW-9UB-1005	POJ0794-07	10/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UB	MW-09UB-0406	PPD0706-05	04/25/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-09UB	MW-09UB-1006	PPJ0772-05	10/24/2006	TAMP	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-10UB	MW-10UB-0405	POD0862-02	04/28/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-10UB	MW-10UB-0406	PPD0706-03	04/25/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-15UB	MW-15UB-0405	POD0805-14	04/27/2005	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND
MW-15UB	PL-503-0405	POD0805-15	04/27/2005	DMAR-PHX	FD		ND	ND	ND	ND	ND	ND	ND	ND
MW-15UB	MW-15UB-0406	PPD0706-04	04/25/2006	DMAR-PHX	REG		ND	ND	ND	ND	ND	ND	ND	ND

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TABLE 4
LABORATORY CHEMICAL RESULTS FOR VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER SAMPLES

Location	Field Sample ID	Lab Sample ID	Date	Lab Name	Sample Purpose	Sampling Method	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Parameter Code	TVOC	11DCE	TCE	PCE	111TCA	TCTFA	11DCA	12DCP
						Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l

Parameter Code Abbreviations

11DCA = 1,1-Dichloroethane
12DCP = 1,2-Dichloropropane
11DCE = 1,1-Dichloroethene
PCE = Tetrachloroethene
111TCA = 1,1,1-Trichloroethane
TCE = Trichloroethene
TCTFA = Trichlorotrifluoroethane (Freon-113®)
TVOC = Total volatile organic compounds - calculated by adding the numerical values of all detected compounds, include J flagged values

Sampling Method

PDB = sample collected by passive diffusion bag
Blank = submersible pump

Other Abbreviations

REG = original
FD = field duplicate

DMAR-PHX = DEL MAR Analytical, Phoenix, Arizona
TAMP = Test America Analytical, Phoenix, Arizona
ND = not detected
J = numerical value estimated
UJ = analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate.
V = qualified during data validation
µg/l = micrograms per liter
* = TVOC calculation adjusted for presence of blank contaminant

TABLE 5
RESULTS OF CAPTURE ZONE EVALUATION
HASSAYAMPA LANDFILL, MARICOPA COUNTY, ARIZONA

Line of Evidence	Is Capture Sufficient?	Comments
Water Levels ▪ Potentiometric surface maps ▪ Water level pairs * consider horizontal and vertical	Potentiometric surface maps of Unit A indicate capture is occurring. Water level data for Unit A and Unit B indicate a downward gradient from Unit A to B. Significant anisotropy significantly retards the potential for vertical flow to occur.	No additional water level monitoring points are necessary to demonstrate capture in Unit A. No additional Unit B water level monitoring points are necessary.
Calculations ▪ Flow budget calculations ▪ Capture zone width calculations ▪ Groundwater flow modeling with particle tracking	Flow budget calculations indicate that complete capture is being achieved in Unit A under conservative assumptions. Individual well capture zone analysis indicates that a small area near piezometer MW-20UA may not be captured. No groundwater flow modeling is necessary to evaluate capture.	It is recommended that the pumping rate of extraction well EW-04UA be increased by 20-25 percent to effect capture in the vicinity of piezometer MW-20UA.
Concentration Trends/Tracers ▪ Sentinel wells ▪ Downgradient performance monitoring wells ▪ Tracers	The downgradient sentinel wells indicate that complete capture of the Unit A groundwater affected by VOCs is occuring. Wells immediately downgradient of the affected area (TCZ) in Unit A are consistently non-detect for VOCs. The use of tracers is not necessary to demonstrate capture.	No additional water quality monitoring points are necessary to demonstrate capture.

Overall Conclusion

▪ *Is capture sufficient, based on "converging lines of evidence"?* Based on converging lines of evidence, a minor modification to the pumping rate from one extraction well will assure that complete capture is occuring. All other lines of evidence indicate capture is occuring.

▪ *Key uncertainties/data gaps:* No data gaps exist and there is little, if any, uncertainty associated with the capture zone analysis.

▪ *Recommendations to collect additional data, install new monitoring wells, change current extraction rates, etc* .: No addtional data points or data collection activities are necessary to evaluate capture. Based on the capture zone analysis it is recommended that two wells be dropped from the water quality portion of the monitoring program; that the quarterly report water level interpretations consider the results of the capture zone analysis; and that the pumping rate from extraction well EW-04UA be increased by 20-25 percent.

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TABLE 6
LABORATORY VERTICAL HYDRAULIC CONDUCTIVITY VALUES

Location	Depth (ft)[a]	K (ft/yr) (average)	K (ft/Day)
MW-2UA	75	0.046	1.26×10^{-4}
MW-2UA	86	0.04	1.09×10^{-3}
MW-3UA	72	0.19	5.2×10^{-4}
MW-3UA	83	0.23	6.3×10^{-4}
MW-4UA	72	0.44	1.2×10^{-3}
MW-4UA	81.5	0.11	3.0×10^{-4}
MW-5UA	74.5	0.19	5.2×10^{-4}
MW-5UA	90.5	1.73	4.74×10^{-3}
$\bar{A}_8$	NA	0.42	1.14×10^{-3}
$\bar{A}_6$[b]	NA	0.26	7.1×10^{-4}

Footnotes:
a = Near or Below Water Table
b= Average, Discarding High and Low Value

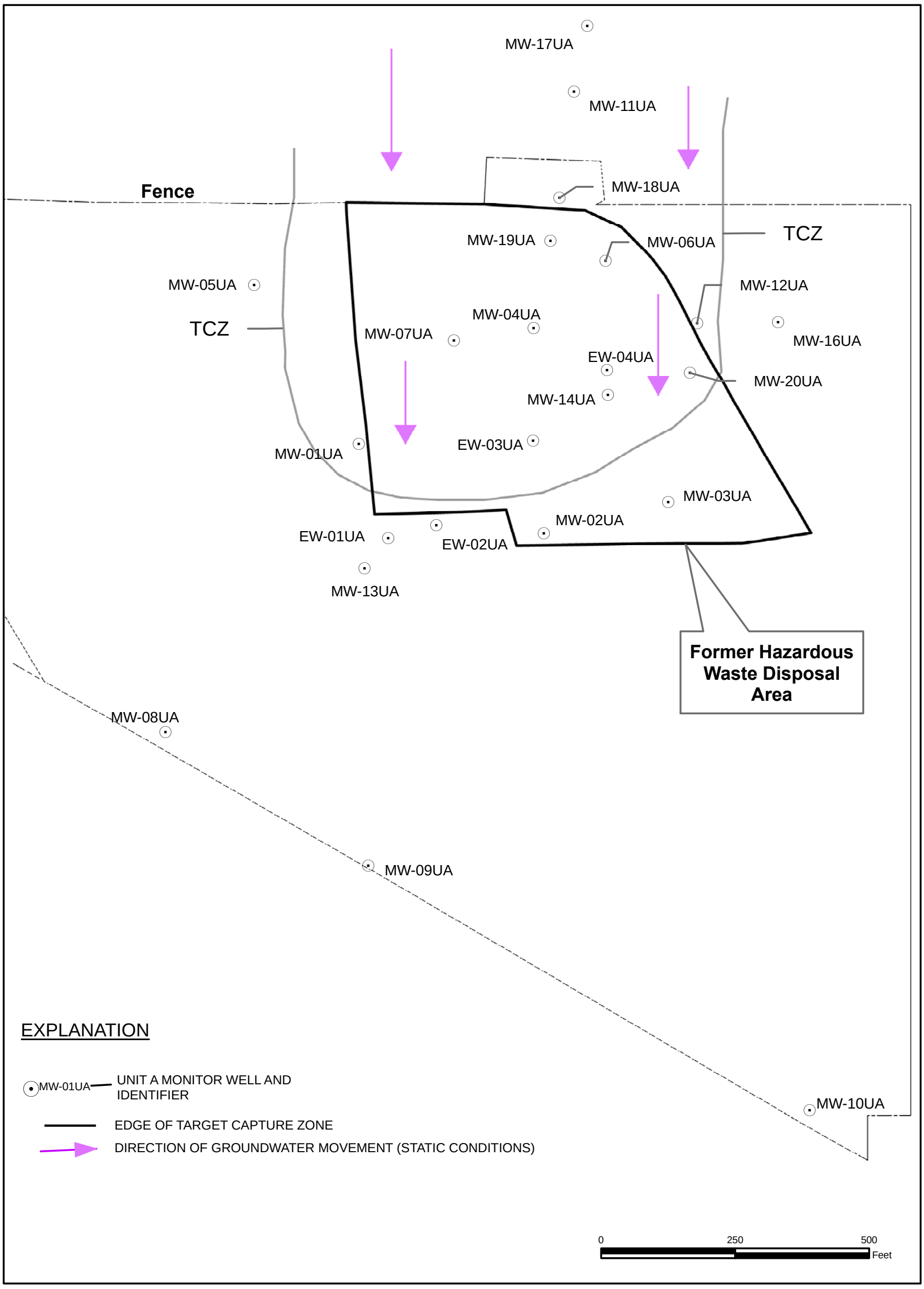

Fig Figure 1 Target Capture Zone Apr 2006.MXD 4/13/2007

FIGURE 1. TARGET CAPTURE ZONE
HASSAYAMPA LANDFILL EPA SUPERFUND SITE

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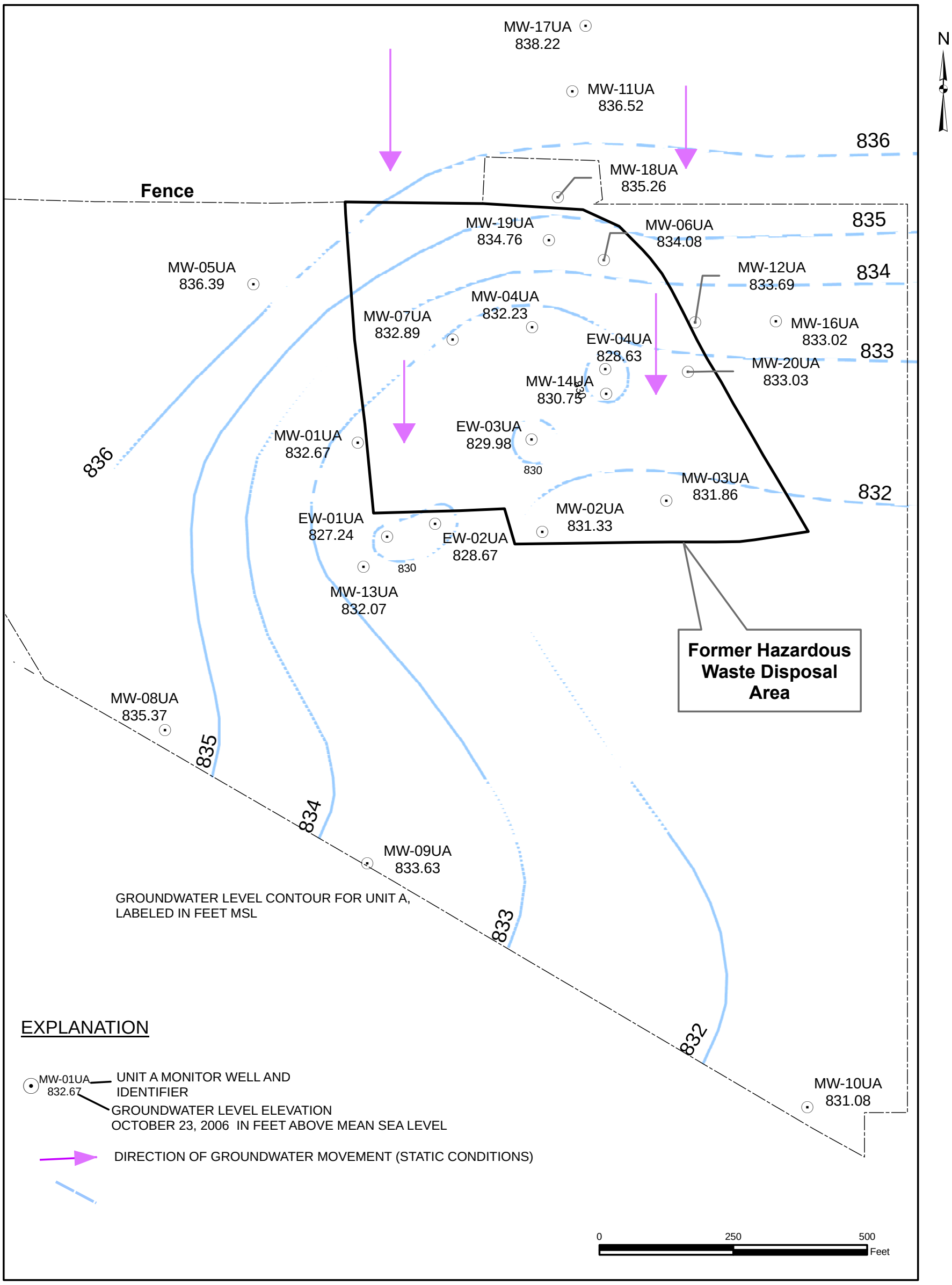

Fig 2A Groundwater Unit A.MXD 4/13/2007

FIGURE 2A. UNIT A GROUNDWATER LEVELS, OCTOBER 2006
HASSAYAMPA LANDFILL EPA SUPERFUND SITE

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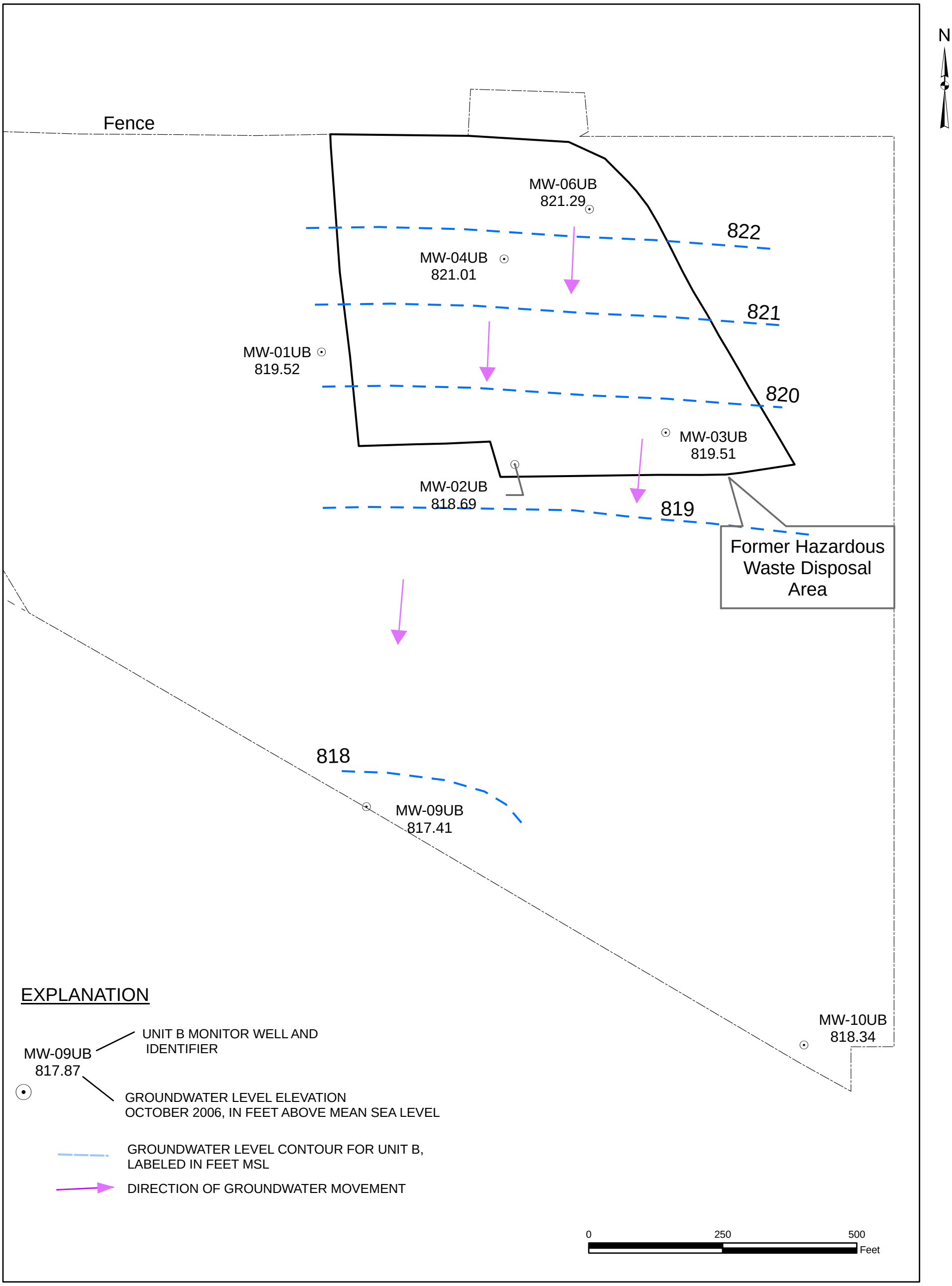

Fig 9 WI contours and VOCs B Apr 2006.MXD 03/11/2007

FIGURE 2B. GROUNDWATER LEVEL UNIT B, OCTOBER 2006, HASSAYAMPA LANDFILL EPA SUPERFUND SITE

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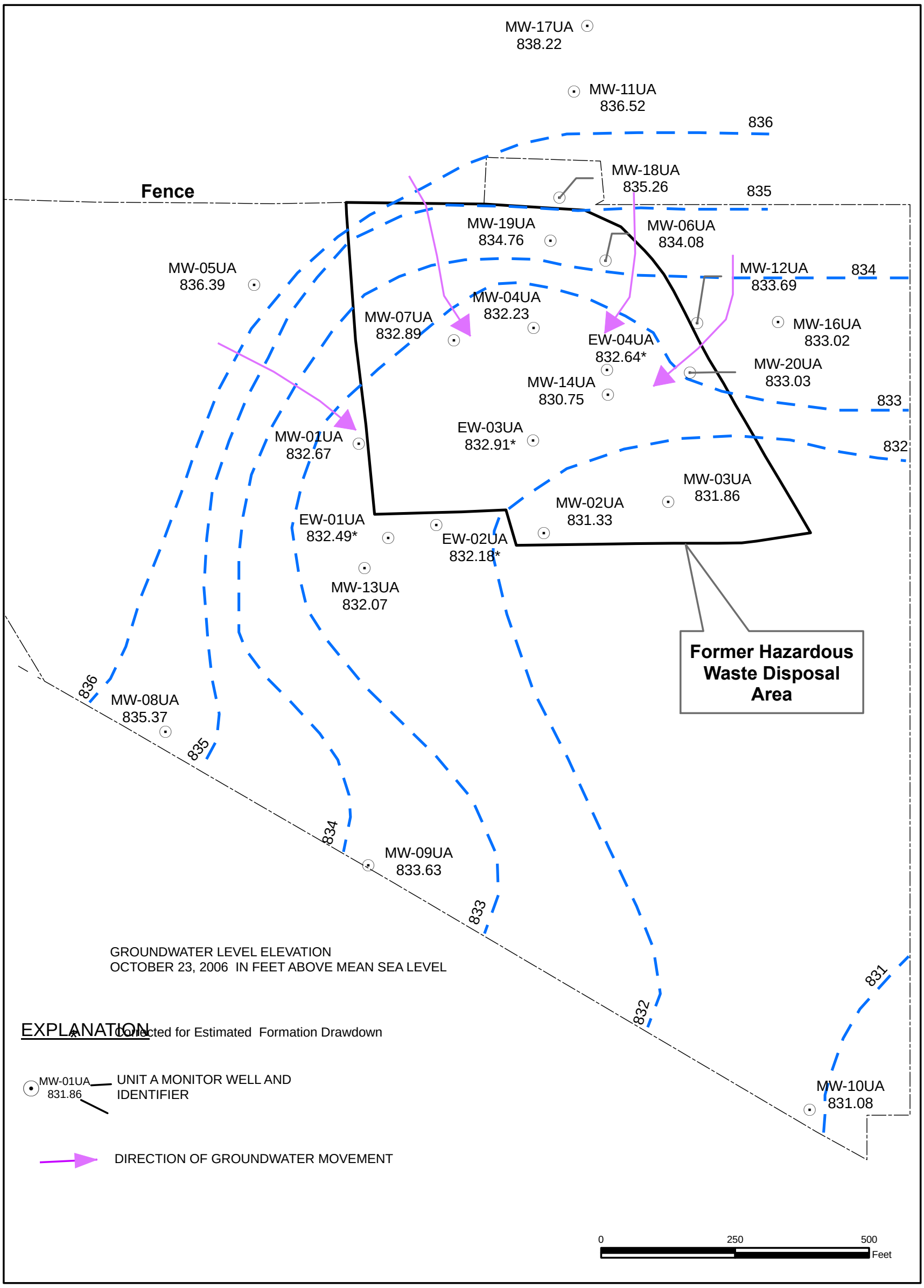

FIGURE 2C. ESTIMATED WELL LOSS CORRECTION GROUNDWATER CONTOURS
HASSAYAMPA LANDFILL EPA SUPERFUND SITE

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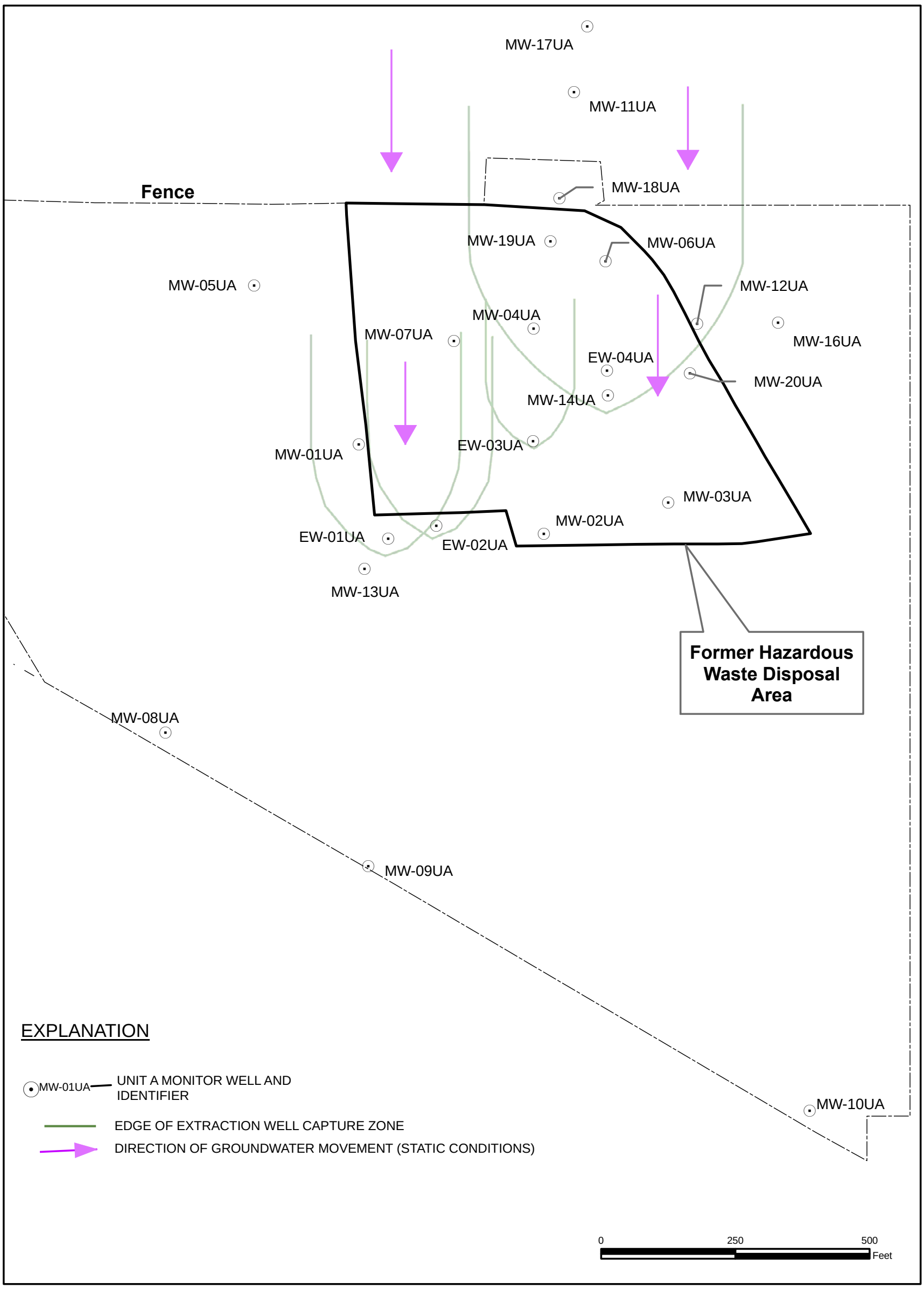

Fig 3 Capture Zone.MXD 4/13/2007

FIGURE 3. EXTRACTION WELL CAPTURE ZONES
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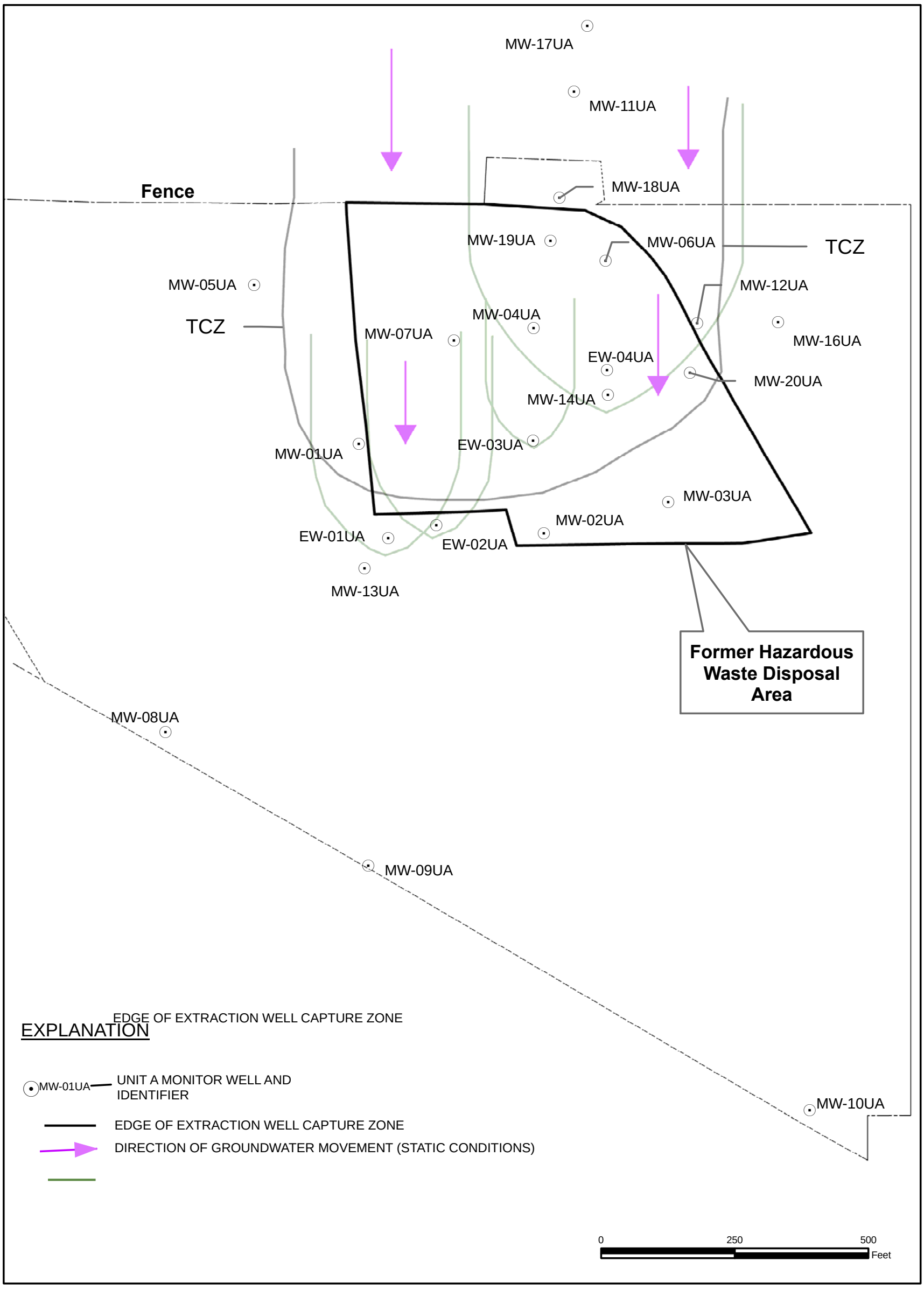

Fig 4 UNIT A Target Capture Zone.MXD 4/13/2007

FIGURE 4. EXTRACTION WELL AND TARGET CAPTURE ZONES
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