*Final Report*

# Landfill 26 Soil Gas Feasibility Study
# Hamilton Army Airfield, Novato, California

Prepared for

U.S. Army Corps of Engineers

October 2007

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ES112006010SAC

DEPARTMENT OF THE ARMY
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO
CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

October 5, 2007

Ms. Theresa McGarry
California Department of Toxic Substances Control
8800 Cal Center Drive
Sacramento, CA 95826-3200

Dear Ms. McGarry:

Please find enclosed the Final, Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California, for your review and concurrance. Modifications to the feasibility study were made based on regulatory agency comments received on the draft final version of this document. Significant changes to the document include:

- Revised and expanded site, project, and regulatory history (Section 1), and

- Expanded information on the rationale for the location and extent of the passive gas collection system (Sections 1 and 4).

Formal responses to comments on the draft final are provided in Appendix E. We would like to obtain your concurrence on this document by November 5, 2007. If you have any questions regarding this document, please feel free to call me at (916) 557-6965.

Ray Zimny
Project Manager
Enclosure

cc: See Distribution list

**Distribution List**
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**Hamilton Army Airfield, Novato, California**

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# Landfill 26 Soil Gas Feasibility Study
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# Executive Summary

## Introduction

This Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Study (FS) for soil gas has been prepared to support a Record of Decision (ROD) amendment for Landfill (LF) 26 at the former Hamilton Army Airfield (HAAF) in Novato, California (Figure ES-1). The HAAF facilities surrounding the LF 26 site are shown on Figure ES-2. This FS focuses solely on landfill refuse-related soil gas contamination at the LF 26 site.

This FS addresses methane and volatile organic compounds (VOCs)[1] in soil gas. Pathways evaluated in this FS consisted of the following:

- Impacts to human health via inhalation of VOCs in indoor air
- Impacts to human health via inhalation of VOCs in outdoor air
- Explosive conditions caused by methane

Recent evaluations of potential risks to human health associated with VOCs in soil gas at LF 26 indicate that VOCs do not pose a potential risk to human health (via either the indoor or outdoor inhalation pathways; see Appendix A); therefore, methane has been identified as the sole contaminant of concern (COC) for soil gas at LF 26. This FS identifies and evaluates remedial technologies and alternatives to mitigate landfill refuse-related methane in soil gas resulting from past material disposal and handling and waste disposal practices at LF 26. The recommended remedial action will eventually be reflected in a ROD amendment and subsequent regulatory documents that will transition the landfill to the "postclosure care" status under Title 27 of the California Code of Regulations (27 CCR).

## Remedial Action Objectives

Remedial action objectives (RAOs) define the extent to which a site will require a remedy to meet the objectives of protecting human health and the environment. For this FS, the medium of concern is limited to soil gas. The only COC in soil gas at LF 26 is methane associated with LF 26 refuse (not naturally occurring methane). The primary risk to human health associated with methane is related to potential explosive conditions that could result from a buildup of methane to concentrations at or above the lower explosive limit (LEL). The following RAO reflects this conceptual model.

[1] For the purposes of this FS, VOCs are defined as non-methane volatile organic compounds. This distinction is consistent with the municipal landfill regulations in California Code of Regulations (CCR) Title 27, Division 2 (Solid Waste) that distinguishes methane from other "trace gases" (i.e., VOCs).

The RAO for soil gas at LF 26 is the protection of human health from explosive conditions that could result from the migration and buildup of methane. The objective of the remedy will be met if:

1. The concentration of methane associated with LF 26 refuse (not naturally occurring methane) is at or below the LEL (5 percent by volume) at the point of compliance (defined as the property boundary); and
2. The concentration of methane is at or below 25 percent of the LEL (1.25 percent by volume) in structures within the landfill boundary.

## Cleanup Goals for Methane

Cleanup goals for methane at LF 26 are dictated by the requirements of Title 27 of the CCR (27 CCR 20921) that specify that landfill owners must ensure that the concentration of methane gas does not exceed the LEL for methane (5 percent by volume) at the point of compliance, and 25 percent of the LEL (1.25 percent by volume) within structures inside the facility boundary. The RAOs incorporate these cleanup goals for methane. These goals will be used during the evaluation of the remedial alternatives to assess the remedy's ability to meet these goals. Ultimately, these goals will be used to demonstrate the effectiveness of the selected remedy.

## Remedial Alternatives

Technical process options (such as passive venting, vertical barriers, monitoring, and institutional controls) were assembled into remedial alternatives to address landfill refuse-related methane in soil gas at LF 26. The assembled alternatives were screened against the criteria of effectiveness, implementability, and cost. Alternatives with the most favorable composite evaluation of all factors were retained for more detailed evaluation against additional CERCLA criteria.

### Assembly of Alternatives

Five alternatives were identified. The assembled alternatives consist of the following:

- Alternative 1 – No Action
- Alternative 2 – Passive Venting System (Perimeter Trench)
- Alternative 3 – Active Collection System (Perimeter Wells)
- Alternative 4 – Active Collection System (Perimeter Trench)
- Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

Based on preliminary screening of alternatives using the criteria of cost, effectiveness, and implementability, Alternative 3 was eliminated from the selection because this alternative was not effective at attaining RAOs.

The four remaining alternatives were retained for detailed analysis and are summarized below:

- **Alternative 1 – No Action.** The No Action alternative provides a baseline for comparing other alternatives. No remedial activities are implemented, and no cost is associated with this alternative. The No Action alternative is required to serve as a baseline for comparison of other alternatives. This alternative is not considered viable because it does not satisfy the RAOs nor is it consistent with applicable or relevant and appropriate requirements (ARARs).
- **Alternative 2 – Passive Venting System (Perimeter Trench).** Under Alternative 2, a passive venting system utilizing a perimeter trench would be installed at LF 26 to control soil gas methane. For the purposes of this FS, it is assumed that the passive venting system with a perimeter trench would match the design of the existing trench system. In addition to the passive venting system, this alternative also includes institutional controls, vapor barriers, a vertical barrier, and monitoring.
- **Alternative 4 – Active Collection System (Perimeter Trench).** Under Alternative 4, an active collection system utilizing a perimeter trench would be installed at LF 26 to control soil gas methane. In addition to the active collection system, this alternative also includes institutional controls, vapor barriers, and monitoring.
- **Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment.** Alternative 5 consists of an active collection system utilizing a perimeter trench as presented under Alternative 4. However, Alternative 5 also includes treatment of the effluent soil gas prior to its discharge to the atmosphere. In addition to the active collection system with effluent treatment, this alternative also includes institutional controls, vapor barriers, and monitoring.

## Detailed and Comparative Analyses

The purpose of the detailed analysis is to provide sufficient information to allow for comparisons among the different alternatives based on the criteria specified in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (U.S. Environmental Protection Agency [EPA], 1988).

The nine CERCLA evaluation criteria are as follows:

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARs
3. Long-term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume through Treatment
5. Short-term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance

Criterion 8 (State Acceptance) and Criterion 9 (Community Acceptance) are evaluated following public comment on the FS and the Proposed Plan, and could be used to modify aspects of the preferred alternative when preparing the LF 26 ROD Addendum. Accordingly, only Criteria 1 through 7 are evaluated in the detailed and comparative analyses. The results of the analyses are summarized in Table ES-1 and Figure ES-3.

When compared with CERCLA remedy evaluation criteria and the other alternatives considered in this FS, Alternative 2 is protective of human health and provides the highest level of long-term effectiveness and permanence. Alternative 2 is also compliant with identified ARARs and is the most cost effective of the alternatives considered in this FS.

## Identification of the Preferred Alternative

Alternative 2 (Passive Venting System with Perimeter Trench) has been identified by the U.S. Army Corps of Engineers (USACE) as the preferred alternative for addressing landfill refuse-related methane in soil gas at LF 26. Alternative 2 achieves identified RAOs, and when compared to CERCLA remedy evaluation criteria and the other alternatives considered in this FS, Alternative 2 is protective and the most cost effective of the alternatives considered in this FS.

The primary components of Alternative 2 are the passive venting trench and impermeable barrier. These components of Alternative 2 have already been installed at LF 26. The remaining components of Alternative 2, consisting of vapor barriers, institutional controls, and monitoring, would be implemented as appropriate.

# Table

TABLE ES-1
Comparative Analysis Summary for Alternatives
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Criteria | Alternative 1: No Action | Alternative 2: Passive Venting System (Perimeter Trench) | Alternative 4: Active Collection System (Perimeter Trench) | Alternative 5: Active Collection System (Perimeter Trench) with Effluent Treatment |
|---|---|---|---|---|
| **Protection of Human Health and Environment** | Would not reduce risk to human health or the environment. | A passive venting trench provides a similar level of protection relative to Alternative 4, but slightly lower than Alternative 5. A passive venting of methane is not subject to interruptions in operation due to equipment and/or power failure. In addition, the impermeable barrier provides additional protection against the possible migration of methane beyond the trench. Vapor barriers, monitoring, and institutional controls also contribute to the overall protection of human health. | Alternative 4 is protective and it provides a similar level of protection relative to Alternative 2. The active collection system actively collects and removes methane from the area, but it does not include an impermeable barrier. Vapor barriers, monitoring, and institutional controls also contribute to the overall protection of human health. | Alternative 5 is protective. It provides a slightly higher level of protection compared with Alternatives 2 and 4 because Alternative 5 includes effluent treatment. Vapor barriers, monitoring, and institutional controls also contribute to the overall protection of human health. |
| **Compliance with ARARs** | Does not comply with ARARs. | Compliant with identified ARARs. | Compliant with identified ARARs. | Compliant with identified ARARs. |
| **Long-term Effectiveness and Permanence** | Does not provide long-term effectiveness or permanence. | A passive venting system provides a slightly higher degree of long-term protectiveness relative to Alternatives 4 and 5 because it relies on passive venting of methane that is not subject to interruptions due to equipment and/or power failures. The impermeable barrier provides additional protection against the possible migration of methane. Permanence is dependent on proper maintenance and monitoring of the passive venting system and the vertical barrier. Vapor barriers provide very good long-term protectiveness and permanence with respect to methane intrusion. | Alternative 4 provides a slightly lower overall level of long-term protectiveness relative to Alternative 2. The active collection system is subject to interruptions in operation due to equipment and/or power failures. Permanence is dependent on proper maintenance and monitoring of the passive venting system and the vertical barrier. Vapor barriers provide very good long-term protectiveness and permanence with respect to methane intrusion. | Alternative 5 provides a slightly lower overall level of long-term protectiveness relative to Alternative 2, but provides a similar level as Alternative 4. The active collection system is subject to interruptions in operation due to equipment and/or power failures. Permanence is dependent on proper maintenance and monitoring of the passive venting system and the vertical barrier. Vapor barriers provide very good long-term protectiveness and permanence with respect to methane intrusion. |
| **Reduction in Toxicity, Mobility, and Volume through Treatment** | Would not actively reduce toxicity, mobility, or volume. Reduction by natural degradation processes only. | Treatment is not a principle component of this alternative; however, some reduction in the volume of methane occurs because the venting trench facilitates aeration of surrounding soil and promotes biodegradation of methane. | Treatment is not a principle component of this alternative; however, some reduction in the volume of methane occurs because the collection trench facilitates aeration of surrounding soil and promotes biodegradation of methane. | Effluent treatment (the biofilter) will reduce the volume of methane. In addition, some in situ reduction in the volume of methane occurs because the collection trench facilitates aeration of surrounding soil and promotes biodegradation of methane. |
| **Short-term Effectiveness** | Not applicable for no action. | Passive venting systems and vertical barriers can be constructed relatively rapidly to provide protection of human health. Temporary engineered controls can be used to protect workers and the nearby community during construction. | Active collection systems can be constructed relatively rapidly to provide protection of human health. Temporary engineered controls can be used to protect workers and the nearby community during construction. | Active collection systems can be constructed relatively rapidly to provide protection of human health. Temporary engineered controls can be used to protect workers and the nearby community during construction. |
| **Implementability (Technical)** | Not applicable for no action. | Readily implementable; technical services and equipment readily available to construct passive venting system, vertical barrier, and vapor barriers. | Readily implementable; technical services and equipment readily available to construct active collection system and vapor barriers. | Readily implementable; technical services and equipment readily available to construct active collection system, treatment system, and vapor barriers. |
| **Implementability (Administrative)** | Not applicable for no action. | Implementable; would require coordination between the Army and regulatory agencies. | Implementable; would require coordination between the Army and regulatory agencies. | Implementable; would require coordination between the Army and regulatory agencies. |
| **Cost ($PV_{30}$)** | $0 | $1,897,000. Lowest overall cost. | $1,917,000. Overall cost is greater than Alternative 2, but lower than Alternative 5. | $2,047,000. Highest overall cost. |

# Figures

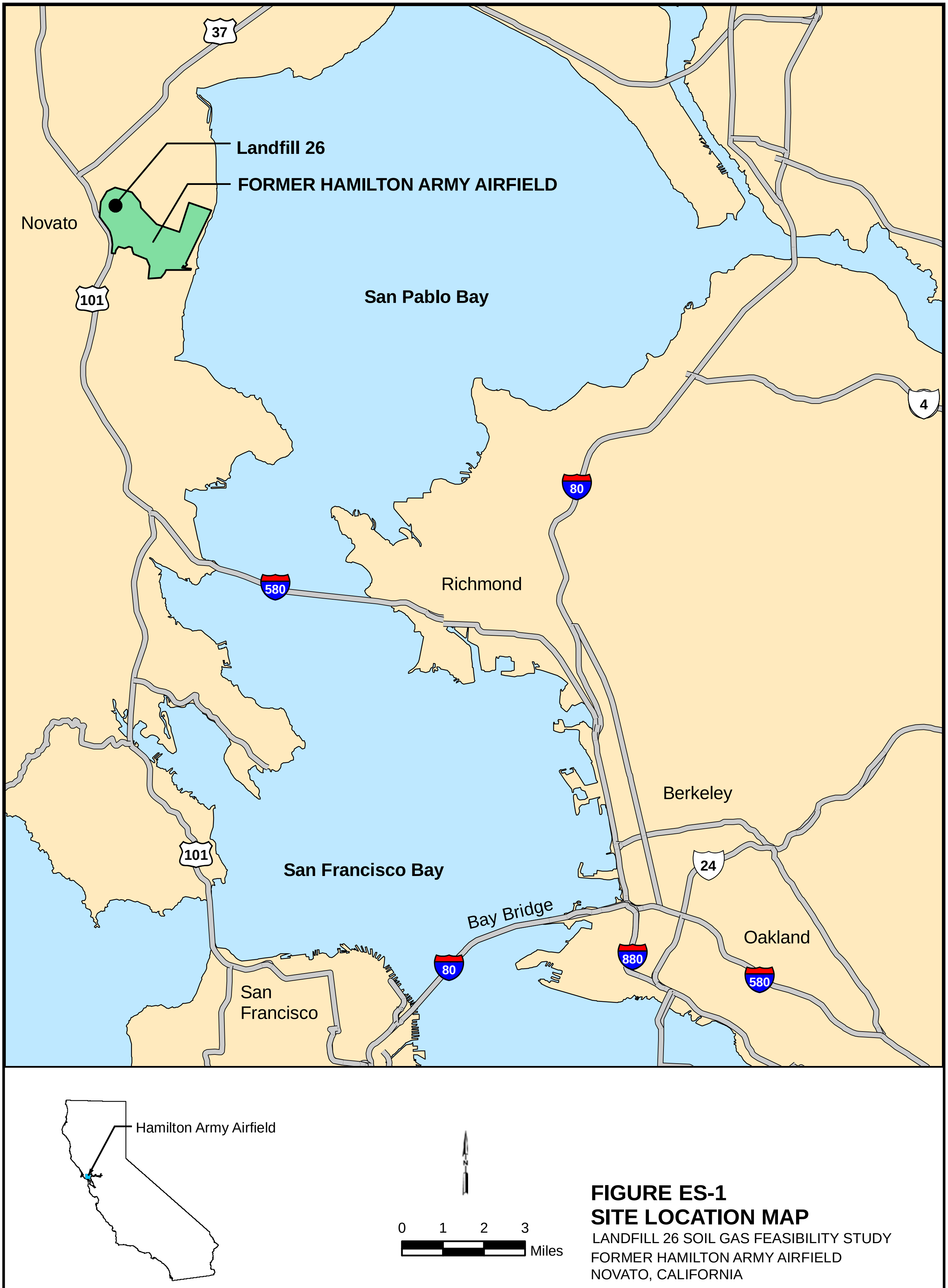


**FIGURE ES-1**
**SITE LOCATION MAP**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

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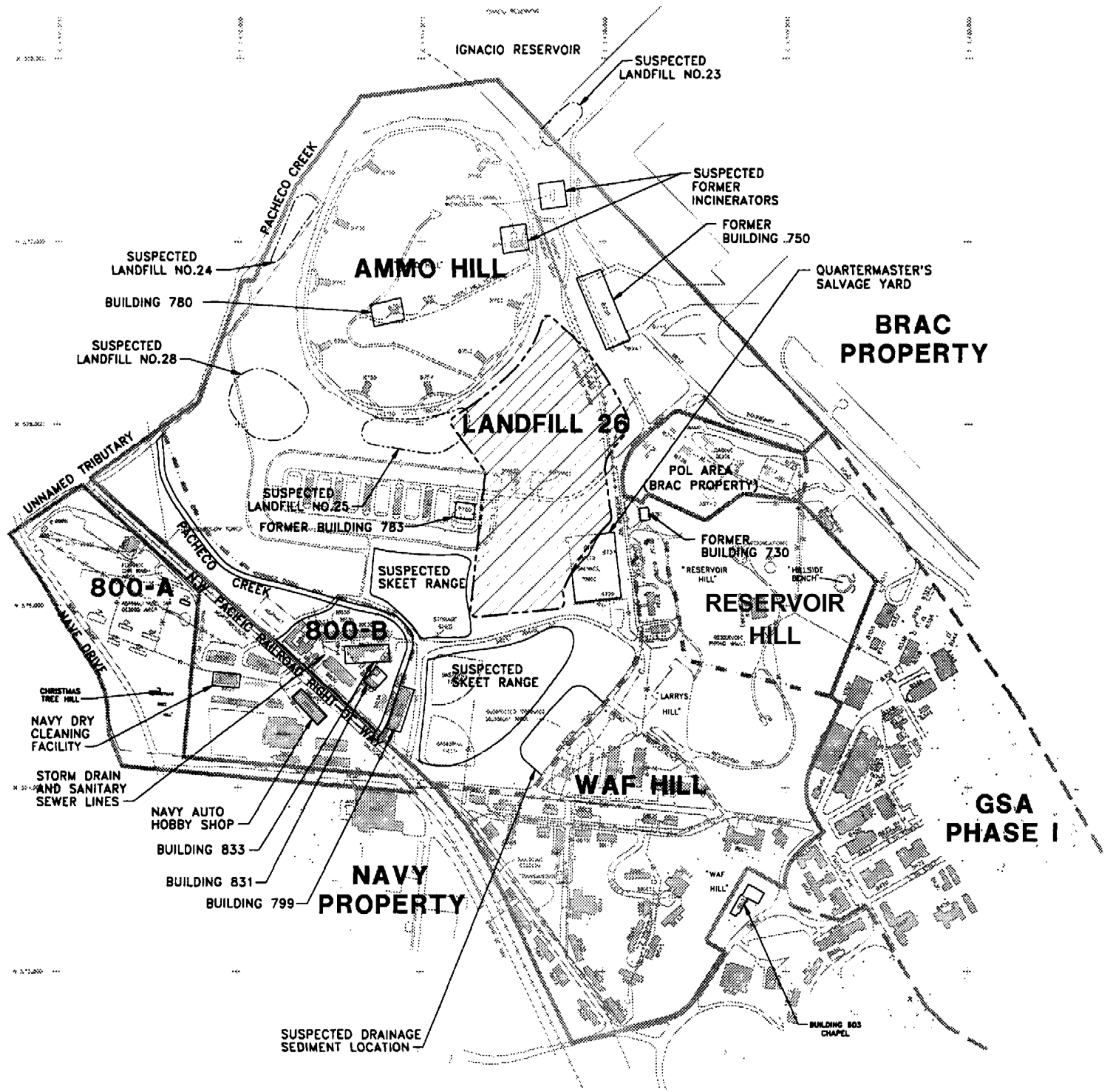


GENERAL SERVICES ADMINISTRATION (GSA) PHASE II SALE AREA BOUNDARY LINE

GSA PHASE II PARCEL BOUNDARY LINE

GSA PHASE I BOUNDARY LINE

APPROXIMATE LOCATION OF LANDFILL 26

**NOTE:** This figure depicts areas investigated for the GSA in the 1990s.

**FIGURE ES-2**
**LANDFILL 26 AREA AND SURROUNDING FACILITIES**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

**SOURCE:** Site Investigation Report 800-B and Ammo Hill Parcels, GSA Phase II Sale Area (IT, 1998a)

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Notes:

Alternative 2 – Passive Venting System with Perimeter Trench
Alternative 4 – Active Collection System with Perimeter Trench
Alternative 5 – Active Collection System with Perimeter Trench and Effluent Treatment

Criterion 4: Reductions in toxicity, mobility, and/or volume for methane under Alternatives 2 and 4 are due primarily to engineering controls or physical removal rather than treatment.
Criterion 2: Criterion 2 is not included on this table because all alternatives comply with ARARs.
Criterion 7: Ranked by Total Cost ($PV_{30}$)

**FIGURE ES-3**
**RELATIVE RANKING OF ALTERNATIVES**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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## Appendixes



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# Acronyms and Abbreviations

| | |
|---|---|
| ARARs | applicable or relevant and appropriate requirements |
| BAAQMD | Bay Area Air Quality Management District |
| bgs | below ground surface |
| BRAC | Base Realignment and Closure Act of 1988 |
| CAMU | corrective action management unit |
| CAO | Cleanup and Abatement Order |
| CCR | California Code of Regulations |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | *Code of Federal Regulations* |
| CIWMB | California Integrated Waste Management Board |
| COC | contaminant of concern |
| CSM | conceptual site model |
| DoD | U.S. Department of Defense |
| DTSC | Department of Toxic Substances Control |
| EPA | U.S. Environmental Protection Agency |
| ESD | Explanation of Significant Differences |
| FS | Feasibility Study |
| GMP | gas monitoring probe |
| GRA | general response action |
| GSA | General Services Administration |
| HAAF | Hamilton Army Airfield |
| HAFB | Hamilton Air Force Base |
| HDPE | high density polyethylene |
| HLA | Harding Lawson Associates |
| HVOC | halogenated volatile organic compound |
| HWCL | Hazardous Waste Control Law |
| IT | IT Corporation |

| | |
|---|---|
| ITSI | Innovative Technical Solutions, Inc. |
| LDPE | low density polyethylene |
| LDR | land disposal requirement |
| LEA | local enforcement agency |
| LEL | lower explosive limit |
| LF | landfill |
| msl | mean sea level |
| MTBE | methyl tert butyl ether |
| MWH | Montgomery Watson Harza |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NPDES | National Pollutant Discharge Elimination System |
| O&M | operations and maintenance |
| PCB | polychlorinated biphenyl |
| ppbv | part per billion by volume |
| PVC | polyvinyl chloride |
| RAO | remedial action objective |
| RCRA | Resource Conservation and Recovery Act |
| RI/FS | Remedial Investigation/Feasibility Study |
| ROD | Record of Decision |
| RWQCB | Regional Water Quality Control Board, San Francisco Bay Region |
| SLUC | State Land Use Covenant |
| TBC | to-be-considered |
| TDS | total dissolved solids |
| USACE | U.S. Army Corps of Engineers |
| USAF | United States Air Force |
| VLDPE | very low density polyethylene |
| VOC | volatile organic compound |
| WCC | Woodward Clyde Consultants |
| WDR | Waste Discharge Requirement |

**SECTION 1**

# Introduction

## 1.1 Purpose and Scope

This Feasibility Study (FS) for soil gas has been prepared to support a Record of Decision (ROD) amendment for Landfill (LF) 26 at the former Hamilton Army Airfield (HAAF) in Novato, California (Figure 1-1). LF 26 is not a National Priorities List (NPL) site; however, Department of Defense (DoD) policy requires that the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process be applied to environmental restoration activities at military facilities. As such, this FS was prepared in accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (U.S. Environmental Protection Agency [EPA], 1988). The HAAF facilities surrounding the LF 26 site are shown on Figure 1-2. This FS focuses solely on landfill refuse-related soil gas contamination at the LF 26 site (see Section 1.3).

This FS addresses methane and volatile organic compounds (VOCs)[1] in soil gas. Pathways evaluated in this FS consist of the following:

- Impacts to human health via inhalation of VOCs in indoor air
- Impacts to human health via inhalation of VOCs in outdoor air
- Explosive conditions caused by methane

This FS identifies and evaluates remedial technologies and alternatives to mitigate landfill refuse-related contaminants in soil gas resulting from past material disposal and handling and waste disposal practices at LF 26. The recommended remedial action will eventually be reflected in a ROD amendment and subsequent regulatory documents that will transition the landfill to the "postclosure care" status under Title 27 of the California Code of Regulations (27 CCR).

## 1.2 Document Organization

This report is organized into the following sections:

- **Executive Summary** – Presents a summary of the purpose and key findings.
- **Section 1: Introduction** – Provides the report purpose, document organization, site information, history of investigations, and monitoring program summary.
- **Section 2: Derivation of Remedial Requirements** – Describes the remedial action objectives (RAOs), applicable or relevant and appropriate requirements (ARARs), and cleanup goals used to develop and evaluate the remedial actions.

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[1] For the purposes of this FS, VOCs are defined as non-methane volatile organic compounds. This distinction is consistent with the municipal landfill regulations in California Code of Regulations (CCR) Title 27, Division 2 (Solid Waste) that distinguishes methane from other "trace gases" (i.e., VOCs).

- **Section 3: Identification and Screening of Technologies** – Identifies general response actions (GRAs), technologies, and process options. Presents the initial screening and evaluation of these components.
- **Section 4: Assembly and Screening of Alternatives** – Describes the assembly and screening of the remedial alternatives on the basis of effectiveness, implementability, and cost.
- **Section 5: Detailed Analysis of Alternatives** – Presents a detailed analysis of each remedial alternative using seven of the nine evaluation criteria defined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).
- **Section 6: Comparative Analysis of Alternatives** – Presents a detailed comparative analysis of each remedial alternative based on the analysis presented in Section 5.
- **Section 7: Identification of the Preferred Alternative** – Summarizes the findings of the FS and identifies the preferred remedial action alternative.
- **Section 8: Works Cited** – Presents reference information for works cited in this document.
- **Appendix A: Assessments of Risk Associated with VOCs in Soil Gas at LF 26**
- **Appendix B: Landfill 26 Analytical Data (1985-2006)**
- **Appendix C: Compliance Monitoring Technical Memorandum**
- **Appendix D: Cost Estimates for Alternatives**
- **Appendix E: Responses to Comments**

## 1.3 Regulatory History and Status

The United States Army (Army) is the lead agency for environmental restoration of LF 26. HAAF is not an NPL site, and is not regulated under CERCLA as a Superfund site. However, the Army is using its lead agency status and authority under CERCLA to implement the environmental restoration activities at HAAF. The FS has been prepared in accordance with CERCLA, as amended by the Superfund Amendments Reauthorization Act of 1986 (SARA) (42 USC Section 9601 et seq.), and, to the extent practicable, the NCP (40 *Code of Federal Regulations* [*CFR*] 300.430). This FS was prepared using EPA CERCLA guidance (EPA, 1988) and EPA *Rules of Thumb for Superfund Remedy Selection* (EPA, 1997).

The California Department of Toxic Substances Control (DTSC), Office of Military Facilities, is the lead regulatory agency, and is responsible for managing site closure in accordance with the provisions of California Health and Safety Code. Other regulatory agencies that work in conjunction with the DTSC to facilitate the restoration, closure, and postclosure processes include the San Francisco Bay Region of the California Regional Water Quality Control Board (RWQCB), the California Integrated Waste Management Board (CIWMB), and the local enforcement agency (LEA) (i.e., the Environmental Health Services Division of the Marin County Community Development Agency).

Site characterization activities at LF 26 began in 1985. In 1989, the Army prepared a ROD for LF 26 (U.S. Army Corps of Engineers [USACE], 1989) based on the site characterization data collected up until that time. The 1989 ROD specified soil solidification and construction of a cap over the landfill to address contamination in soil, and a groundwater extraction and treatment system to mitigate groundwater contamination. In 1992, the Army issued an Explanation of Significant Differences (ESD) for LF 26 (USACE, 1992). Based on additional data collected during the pre-design phase, it was determined that an upgraded landfill cap design would be sufficient alone to prevent exposure to wastes within the landfill, and that solidification was not necessary. The ESD documented modifications made to the design of the groundwater extraction and treatment system that were anticipated to more effectively treat contaminants as identified at that time. In 1992, RWQCB Order No. 92-029 was also issued that stipulated the construction of the landfill cap and the groundwater extraction and treatment system at LF 26.

The groundwater extraction and treatment system was constructed during 1992 and 1993 (see Section 1.6.1 for additional details on this system), and a Resource Conservation and Recovery Act (RCRA)-type landfill cap was constructed during 1994 and 1995 (see Section 1.6.2 for additional details on the cap). Although the groundwater extraction and treatment system was installed at LF 26, the system was never operated because it was determined that operation of the system was not necessary to protect human health and the environment (see Section 1.6.1). During this time period, the 150- to 200-foot buffer zone was established around LF 26, providing separation between the landfill and adjacent land.

In 1996, RWQCB Order No. 96-113 was issued that required submittal of a closure and postclosure maintenance plan and required that closure and postclosure activities be performed per CCR Titles 14 and 24 (now Title 27) in effect at that time. The closure activities already completed and the basis for these activities were also to be documented in the closure and postclosure maintenance plan pursuant to 27 CCR guidelines. Once approved, the closure and postclosure maintenance plan would serve as the guide for monitoring and maintenance of LF 26 during the postclosure care period, a minimum of 30 years. The Army prepared and submitted a draft closure and postclosure maintenance plan to the RWQCB, CIWMB, and LEA in 1999. However, this document was never finalized because soil gas conditions at LF 26 appeared to be changing as evidenced by routine soil gas monitoring data.

Following installation of the RCRA-type cap, subsequently collected soil gas data indicated that methane was present in some areas outside the boundary of the landfill at concentrations exceeding 5 percent by volume. In 2001, due to concerns regarding potential soil gas migration at LF 26, the RWQCB issued Cleanup and Abatement Order (CAO) No. 01-139 and time schedule Order No. 01-140 that required and set a time schedule for the development and implementation of corrective action plans for addressing landfill gas (particularly methane), postclosure maintenance activities, and improved groundwater and soil gas monitoring. In response to CAO No. 01-139 and time schedule Order No. 01-140, and to address methane migration at LF 26, a passive venting system was installed during 2002 and 2003 (see Section 1.6.3 for details on this system). Because the passive venting system was not conceived as part of the 1989 ROD or the 1992 ESD, the system was installed as an interim remedy. This focused FS (i.e., focused solely on the soil gas media) was prepared to evaluate potential remedies for methane and document the final selected remedy for soil gas.

Issued by the RWQCB on October 11, 2006, Order No. R2-2006-0064 contains updated waste discharge requirements (WDRs) and outlines a regulatory framework for bringing LF 26 to postclosure status, including the preparation of this FS. RWQCB Order No. R2-2006-0064 also rescinds Order No. 96-113 (WDRs), Order No. 01-139 (CAO), and Order No. 01-140 (time schedule). The USACE is also in the process of preparing a comprehensive 5-Year Review for LF 26 following CERCLA guidelines as required in Order No. R2-2006-064. The 5-Year Review will address the process of moving LF 26 into postclosure status and how currently implemented remedies will be integrated into that process. This FS and the 5-Year Review will be used to support the preparation of a Proposed Plan (PP) and ROD Amendment for LF 26. The purpose of the PP and ROD Amendment will be to document the final remedies for each media of concern (i.e., soil, soil gas, and groundwater) at LF 26. Following completion of the ROD Amendment, subsequent CERCLA activities would likely be limited to periodic 5-Year Reviews. Additionally, to put LF 26 into official postclosure status with the RWQCB, CIWMB, and LEA, the closure and postclosure maintenance plan will be finalized to reflect current conditions and the anticipated postclosure maintenance schedule. Continued routine maintenance and monitoring of LF 26 would be facilitated as part of postclosure care under 27 CCR and as documented in the approved final postclosure maintenance plan.

In accordance with CERCLA, a public participation process has been established for the LF 26 project. The public participation process for LF 26 includes routine project updates to the Restoration Advisory Board (RAB) and periodic public meetings. In addition, during the PP stage, public participation activities will include preparation and distribution of a project Fact Sheet, a public meeting, and a 30- to 60-day public comment period.

## 1.4 Facility Background

### 1.4.1 Site Description

LF 26 is located at HAAF, a former military installation in the City of Novato, Marin County, California, approximately 22 miles north of San Francisco. HAAF is bordered by U.S. Highway 101 on the west, private development to the north and south, and San Pablo Bay on the east (Figure 1-1). HAAF is inactive as a military facility, and parts of the property have been transferred to private developers and the City of Novato.

LF 26 is located within former marshland and floodplain for Novato Creek along the margin of San Pablo Bay. LF 26 was used as a disposal area from the 1940s to the 1970s. There were no records kept of the disposal practices at LF 26. However, based on evaluations of a number of field investigations, LF 26 received approximately 171,000 cubic yards of waste, including approximately 20,000 cubic yards of oily sludge.

Currently, LF 26 itself covers approximately 26 acres. In addition, a 150- to 200-foot-wide buffer zone (22 acres in total area) was established around the perimeter of the landfill (Figure 1-3). The Army retains possession of both the landfill and buffer zone. LF 26 is surrounded to the west and north by primarily undeveloped land; however, the Hamilton Meadows residential housing development directly borders LF 26 to the south and southeast. LF 26 is currently covered with a RCRA-type cap (see Section 1.6.2 for details on the cap). The surface of the landfill is relatively flat and is covered with grass and low brush. An unpaved road runs around the perimeter of the landfill. Vehicle access to the cap area is controlled by locked gates. Pedestrians have access to the LF 26 area and the area is currently used for recreational purposes (e.g., walking, bicycling, etc.). The only structure currently within the landfill area is the groundwater treatment plant building, which is within the buffer zone, just east of the landfill.

### 1.4.2 Environmental Setting

The climate in the vicinity of HAAF LF 26 is typical for much of the San Francisco Bay Area. Summers are hot and dry, winters are cool and rainy, and spring and fall are mild with periods of rain. The Marin County Civic Center weather station, approximately 7 miles south of the site, has provided climatological information for various studies and designs.

Rainfall data for the Marin County Civic Center indicate an average annual precipitation of approximately 35 inches. Typically, the rainy season is from November through March. The winter rains have a pronounced impact on surface water flow and also cause elevated groundwater conditions in some years.

Temperature data show normal lows and highs in January (coolest month) of 40.6°F and 56.9°F and in August (warmest month) of 54.2°F and 81.5°F. Temperatures of 100°F are common in late summer.

Much of HAAF lies on fairly flat land (reclaimed mudflats) with elevations generally below sea level. However, some portions of HAAF lie on steep, highly eroded hills (composed of bedrock) such as Ammo Hill and Reservoir Hill. Immediately to the west of HAAF, steep coastal range mountains rise to more than 1,500 feet mean sea level (msl). HAAF is bounded by a system of dikes and levees on the north and east sides. Currently, a perimeter ditch and system of drains and pumps keep the water table at a depth of at least 2 feet below ground surface (bgs). LF 26 is situated in a valley between Ammo Hill and Reservoir Hill (Figure 1-2). LF 26 surface elevations currently range from approximately 4 to 28 feet msl.

### 1.4.3 Facility History

Hamilton Airfield, as it was first known, was constructed by the Army Air Corps on land acquired from Marin County and private landowners in the early 1930s. The airfield served as a base for fighter, bomber, and transport aircraft in the 1930s and 1940s. The base also served an important role as a training facility for fighter and bomber pilots and as a staging area for Pacific operations during World War II. The facility was renamed Hamilton Air Force Base (HAFB) when the Army Air Corps was reformed into the United States Air Force (USAF).

HAFB was used as a fighter installation until 1974, when the site was deemed surplus property by the DoD. Over the next 10 years, portions of the base were transferred to the Navy, the General Services Administration (GSA), the Coast Guard, the Army, and the State of California. In 1984, many portions of the base were transferred to the Army and the base was renamed Hamilton Army Airfield. Several portions of the base were offered for sale to the private sector by the Army under the GSA. The airfield portion of HAAF was included in the first group of sites to be targeted for closure under the Base Realignment and Closure Act (BRAC) of 1988.

### 1.4.4 Waste Disposal at Landfill 26

The landfill began receiving refuse in the early 1940s. It was expanded throughout the 1960s and 1970s. Household, commercial, industrial, and construction wastes are believed to have been deposited in the landfill (USACE, 1993). Methods of disposal within LF 26 were not documented. The landfill has been inactive since 1974, when the base was listed as surplus property.

At LF 26, the refuse consists primarily of construction debris, domestic refuse, and petroleum-contaminated soil from fuel spill cleanups. Wastes observed from borings and trenches include wood, bottles, paper and household trash, airplane parts, scrap metal, wire, concrete, steel and other construction debris, and oily sludge (WCC, 1987; WCC, 1997). It can be surmised from the activities conducted at the base, as well as from the contaminants found in the soil/refuse, that waste products (industrial/commercial) generated from aircraft maintenance and base operations were also placed within LF 26. Additionally, Army records indicate that petroleum-contaminated soils obtained from cleanup of multiple petroleum spills in the 1970s were disposed of at LF 26.

Estimates of the areal extent and volume of refuse vary considerably in a number of historical site documents. The actual refuse is thought to be approximately 15 acres in extent (Figure 1-3). Borings drilled within the landfill have indicated refuse zone thicknesses of 0 to 11 feet (WCC, 1997), and the refuse is saturated by groundwater in some areas. The total estimated volume of refuse is 151,500 cubic yards, and the volume of the oily sludge is estimated to be 20,000 cubic yards. Therefore, the total estimated volume of LF 26 is 171,500 cubic yards.

### 1.4.5 Investigative History

Numerous investigations and remedial actions have been conducted at LF 26 and the surrounding areas as summarized in Table 1-1. Previous construction, earth moving, and remedial actions conducted in the past are shown in Table 1-2. These activities have resulted in an extremely large amount of site data that are stored in the LF 26 database maintained by CH2M HILL. This data set currently contains groundwater, soil gas, soil, and other data gathered at the site for the period of August 23, 1985, through December 12, 2006. Summary information from the LF 26 database is presented in Table 1-3.

#### 1.4.5.1 Previous Investigations

Extensive data are available for LF 26 from a broad range of studies and investigations performed since 1985. Table 1-1 summarizes previous investigations and the key findings at LF 26 and surrounding areas. A timeline illustrating the sequence of investigations is shown on Figure 1-4. A detailed chronology of these investigations can also be found in the following documents:

- *Final Report, Investigation of Methane and Volatile Organic Compounds at LF 26 and Hamilton Meadows* (USACE, 2004)
- *Final Closure and Post Closure Maintenance Plan for LF 26* (Closure Plan) (CH2M HILL, 1999)

#### 1.4.5.2 Previous Construction and Earth-moving Activities

Table 1-2 presents the chronology of events for each construction and earth-moving action. Major construction and earth-moving actions at LF 26 were performed to support remedial actions as described below.

Between 1992 and 1993, a groundwater treatment and extraction system was installed at LF 26. Construction was completed in 1995. During construction of the cap, 18 groundwater wells were abandoned, the casings of 10 wells were extended, and 2 damaged wells were repaired. Fourteen groundwater extraction wells were installed to provide hydraulic containment. The RWQCB provided guidance on specific analytical methods to use in the monitoring program. Quarterly groundwater monitoring was initiated under WDR 92-029. The groundwater extraction and treatment system is discussed further in Section 1.6.1.

A RCRA-type final cover system was constructed between 1994 and 1995, including drainage and erosion control appurtenances. Grading and drainage improvements were completed in 1998. This work included seep repairs and is documented in the *Construction Quality Assurance (CQA) Report, Hamilton Army Airfield, Landfill 26, Grading and Drainage Adjustments* (Grading and Drainage Adjustments Report) (CH2M HILL, 1998c). The cover system is undergoing postclosure monitoring and maintenance in accordance with the Final *Closure and Postclosure Maintenance Plan* (CH2M HILL, 1999). More details regarding the RCRA-type cap can be found in Section 1.6.2.

Primarily based on findings presented in the soil gas monitoring reports (ITSI, 1999, 2000a, 2000b, 2001), the RWQCB issued CAO No. 01-139, which requested immediate implementation of interim measures to intercept landfill gas migrating to the south and east of the site. A *Methane Remedial Measures Study* (CH2M HILL, 2002) was completed in 2002 to evaluate conceptual measures for remediating and containing methane within the landfill and landfill buffer zone. The chosen alternative, an interim passive venting system, was constructed in late 2002 and early 2003 and is documented in the *Completion Report, Interim Landfill Gas Migration Control Trench, LF 26* (ITSI, 2003). Evaluation of data indicates that the trench operates effectively (USACE, 2004). Additional details regarding the passive venting are provided in Section 1.6.3.

## 1.5 Conceptual Site Model

A conceptual site model (CSM) is used to develop an understanding of a site and to evaluate potential risks to human health and the environment. Because this FS addresses only soil gas, the CSM for LF 26 included in this document focuses only on the soil gas medium. The information regarding contaminant sources, transport pathways, and receptors is simplified and depicted schematically to enable the model to aid in remedy selection.

### 1.5.1 Geology

The geology of the LF 26 area consists of bedrock overlain by thin alluvial, colluvial, and fill sediments. Cross sections of the landfill area are provided on Figures 1-5 and 1-6. The Franciscan bedrock is continuous beneath LF 26 and outcrops at Ammo and Reservoir Hills.

Overlying the bedrock are unconsolidated sediments no greater than 50 feet in total thickness. These sediments consist of the following:

- Younger alluvium, composed primarily of sandy clay and clayey sand with discontinuous zones of cohesionless poorly graded sand and gravel
- Older oxidized alluvium deposits, composed of oxidized clays, silts, silty sands, and clayey sands, which are not clearly distinguished from fine colluvium or highly weathered bedrock
- The Bay Mud Formation and reduced clay units (Gray Clays), containing fine-textured, laterally extensive distinct units
- Colluvium, consisting of alluvial fan material weathered from the Franciscan sandstone of Ammo and Reservoir Hills

The LF 26 area has historically been subject to both fresh water and marine environments as sea levels rose and fell during the Quaternary period. The resulting variation in depositional environments has resulted in complex stratigraphy consisting of reworked and overlapping sediments with trapped organic matter and saline pore water. These Quaternary depositional patterns have created conditions that significantly affect groundwater and soil gas flow and chemistry. The following are examples of these conditions:

- Naturally occurring organic material in fine sediments degrades anaerobically in the subsurface to produce methane.
- Groundwater chemistry appears to be influenced by pore water and inorganic compounds deposited in marine and brackish marsh environments.

Complex sediment stratigraphy acts to attenuate contaminant migration because permeable materials are discontinuous and separated by silt and clay deposits with low bulk hydraulic conductivity.

### 1.5.2 Hydrogeology

The water flow system of the LF 26 region consists of three interconnected components including groundwater, surface water, and atmospheric water. The atmosphere is a significant contributor to (through rainfall) and a sink for (through evaporation) groundwater in the vicinity of LF 26. Surface water flow is less significant to the CSM at this site because the surface flow is predominantly channelized around LF 26 and the presence of the RCRA-type cap prohibits direct infiltration of precipitation. Atmospheric water and surface water do not come into direct contact with LF 26 refuse.

Groundwater at LF 26 primarily flows through alluvium and fill sediments of modest yield and poor water quality (Sirrine, 1991; WCC, 1997). The overall flow direction at LF 26 is from south to north. Groundwater flow occurs through one connected zone throughout most of the LF 26 area; however, shallow groundwater exists above the clays in the northern part of LF 26 and buffer zone. This shallow flow zone exists only under the RCRA-type cap at the northern end of LF 26. A majority of groundwater migrating downgradient of LF 26 is consumed through evapotranspiration in the area directly beyond the northern boundary of the landfill cap.

Groundwater chemistry changes dramatically toward the northern end of LF 26. As groundwater migrates northward, the chemistry transitions from low-salinity, brackish water chemically similar to precipitation to hyper-saline water chemically similar to sea water but with increased total dissolved solids resulting from evaporation processes. This change is caused by the interaction of groundwater with both fine sediments deposited under saline marsh environments and saline pore water trapped in the sediments at the time of their deposition.

### 1.5.3 Vadose Zone

The vadose zone sediments in the LF 26 area are dissected by impermeable landfill cover materials and the perimeter passive vent trench system. Shallow unsaturated soil materials in the area are highly variable and have been reworked by natural processes and during different phases of construction at the site. However, these materials generally become more fine-grained north of the landfill and become sandy south of the landfill. The thickest and most permeable portion of the vadose zone lies southeast of LF 26, in the Hamilton Meadows area (Figure 1-5). Following installation of the perimeter passive vent trench system to the east and southeast of the landfill (see Section 1.6.3), the vadose zone within LF 26 is no longer connected to the vadose zone beyond the trench system and in the Hamilton Meadows area.

### 1.5.4 Sources of Contamination and Contaminants of Concern

This section describes sources of contamination for the LF 26 area and identifies contaminants of concern (COCs) for soil gas. Potentially complete exposure pathways for soil gas associated with LF 26 are identified on Figure 1-7.

#### 1.5.4.1 Sources of Contamination

Contamination sources affecting the LF 26 region include the following:

- LF 26 Sources – Disposed materials are a source of detected chemicals in soil gas within the LF 26 boundary and buffer zone. Soil gas containing contaminants derived from or generated within landfill-related refuse materials within LF 26 has the potential to transport contamination beyond the LF 26 boundary.
- Non-LF 26 Sources – There are several other known sources of chemicals from historical uses in the area that are not related to the LF 26 refuse. These documented spills or releases from historical activities in the vicinity of LF 26 and buffer zone area consist of multiple, uncontrolled spill sites, former aboveground and underground storage tank sites, and other activities that involved the routine use of chemicals that were released to the environment at about a dozen locations around LF 26. These other sources are well documented and have impacted soil gas quality in the LF 26 area.
- Natural and Ambient Sources – Four types of natural and ambient sources of chemicals are known to have impacted soil gas quality. These sources generally involve natural chemical reactions occurring in native soils and groundwater. The natural sources of chemicals detected in media in the area surrounding and within LF 26 include decomposition of naturally occurring organic matter present in sediments, ion exchange of inorganic minerals in soil, and atmospheric VOCs. In addition, there are other

potential, but fairly well defined, anthropogenic sources of chemicals in the atmosphere near LF 26. These natural and ambient sources of chemicals are known to contribute to observed levels of some chemicals (e.g., methane from decomposition of naturally occurring organic matter in sediments) in the LF 26 area.

#### 1.5.4.2 Contaminants of Concern

The selection of COCs is a process by which those contaminants that pose significant risk to human health and environment are identified and retained for further evaluation (as COCs). The COC selection process also allows for some contaminants that do not pose a significant risk to be removed from further consideration. This process helps to focus further evaluations on only those contaminants that pose the greatest risk (i.e., the risk drivers). Methane and VOCs are the only contaminants present in the soil gas medium at LF 26 and are discussed below.

Methane is present within soil gas in the landfill area at concentrations exceeding the lower explosive limit (LEL) of 5 percent by volume. Potential explosive conditions could result from the presence of methane at concentrations at or above the LEL. Therefore, methane is considered to be a COC for soil gas at LF 26. It has been determined that both landfill refuse-related and naturally occurring methane are present within LF 26, but that a majority of the methane may be naturally generated (USACE, 2004). However, for the purposes of this FS, all methane generated within the landfill will be considered to potentially originate from the refuse and will be addressed by the remedy. Methane generated by natural processes located outside the LF 26 boundary is not associated with the landfill, and therefore, will not be considered in this FS or the remedy.

VOCs are also present in soil gas in the LF 26 area. However, conservative evaluations were performed of potential risks to human health associated with current VOC concentrations in soil gas for both the outdoor air and indoor air exposure pathways (see Appendix A). The conclusions of these assessments indicate that risks associated with current VOC concentrations in soil gas within the landfill are well below the CERCLA point of departure of $1 \times 10^{-6}$ or a hazard quotient of 1. Therefore, because VOC concentrations in soil gas at LF 26 do not pose a significant risk to human health, VOCs are not considered to be COCs for soil gas at LF 26.

### 1.5.5 Potential Migration Pathways, Receptors, and Exposure Routes

The primary potential migration pathway for soil gas at LF 26 consists of the movement of soil gas outward from LF 26 materials to the surrounding vadose zone. Another potential migration pathway is the infiltration and percolation of contaminants to groundwater, subsequent groundwater movement outward from the landfill, and then partitioning of volatiles from groundwater to soil gas in the overlying vadose zone. Once in the vadose zone outside the landfill, contaminants in soil gas could be released to ambient (outdoor) air or to indoor air within overlying structures (e.g., utility trenches, buildings). Once in ambient or indoor air, receptors could be exposed to contaminants through inhalation. Potential receptors include workers, site visitors (including recreational users), and residents. No threatened or endangered species have been identified at LF 26. LF 26 is a highly disturbed area. The roadway and the rip-rap at the margins of the landfill are maintained, and the surface cover (grass and bush) is routinely mowed. As such, the landfill area does not represent significant ecological habitat. Therefore, there are no ecological receptors of concern at LF 26.

As discussed in Section 1.5.4.2, the only COC for soil gas at LF 26 is methane. Although methane could cause asphyxiation at very high concentrations, it is essentially not toxic to humans. The primary risk to human health associated with methane is related to potential explosive conditions that could result from a buildup in methane to concentrations at or above the LEL. Methane is explosive at concentrations well below the concentration required for it to be an asphyxiant.

Because soil gas-derived methane is unlikely to become present in ambient air at concentrations above the LEL or at concentrations that would cause asphyxiation due to dispersion and dilution, the ambient air pathway is considered to be potentially complete, but insignificant. The indoor air pathway is considered to be potentially complete. Although inhalation of methane by human receptors and asphyxiation is possible, explosive conditions are a much greater risk to human health.

### 1.5.6 Methane Production at Landfill 26

Landfill wastes produce methane under anaerobic conditions. The duration of methane gas generation in a typical municipal solid waste landfill can range from a few years to several decades depending on a variety of conditions, including the moisture content and degradable waste content. At LF 26, only relatively low methane production rates and concentrations in soil gas have been observed. Current and historical data and investigations have not shown LF 26 to be generating methane at levels typical of a municipal solid waste landfill, as indicated:

- Methane Quantity: Based on data from a 1992 landfill gas survey, the rate of methane emissions from LF 26 was calculated to be 55,000 cubic feet per year (WCC, 1997). As part of the *Methane Remedial Measures Stud*y report (CH2M HILL, 2002), landfill gas emissions for a landfill the size of LF 26 were modeled. The model results projected that a typical municipal solid waste landfill the size and age of LF 26 would be expected to generate approximately 1.3 million cubic feet per year in 1992, well above the 55,000 cubic feet per year calculated by WCC. This indicates that LF 26 is producing much less methane than a typical municipal solid waste landfill.
- Soil Gas Pressure: If LF 26 were generating typical quantities of landfill gas for a landfill of its size, the landfill gas would build up and result in considerable soil gas pressure within the landfill. Little to no soil gas pressure has been measured in probes installed to monitor the perimeter of LF 26.
- Methane Origin: Evaluation of landfill gas at LF 26 by the USACE using carbon dating and speciation indicated that much if not most of the methane at LF 26 appears to have been generated by natural degradation of organic materials contained in Bay Mud sediments underlying the landfill and adjacent areas (USACE, 2004).

In addition to the information presented above, the USACE detected low methane emission rates from LF 26 during the design of the LF 26 cap (USACE, 2004). All of these points are consistent with other information about the landfill, including the following:

- The large proportion of non-degradable waste (e.g., demolition wastes such as bricks, glass, and structural materials).
- The high percentage of soil documented in the refuse layer.
- The relatively small concentrations of methane in samples from gas probes for the first year after cap installation.
- The age of the landfill (waste was placed from the early 1940s through approximately 1974).

### 1.5.7 Naturally Occurring Methane

The presence of naturally occurring methane in and around the LF 26 area has been well documented (USACE, 2004). Stable isotope data, as well as other lines of evidence, indicate that much of the methane detected in the LF 26 area is not typical of methane that is generated from landfill refuse, but that it originates from the degradation of organic material in fine-grained sediments that are associated with natural historical marsh conditions. Naturally occurring methane is generated beneath LF 26 and in surrounding areas including the Hamilton Meadows residential area.

## 1.6 Existing Remedies

To address contamination at LF 26 and potential risks to human health and the environment, several remedies have been implemented at the site. Existing remedies consist of a groundwater extraction and treatment system, a RCRA-type cap, and a perimeter passive venting trench. These remedies are described below.

### 1.6.1 Groundwater Extraction and Treatment System

A groundwater extraction and treatment system was installed at LF 26 in response to the 1989 LF 26 ROD, the 1992 LF 26 ESD, and RWQCB Order No. 92-029. The extraction system was designed and installed to capture groundwater flowing northward within the landfill.

Constructed in 1992 and 1993, the groundwater extraction and treatment system consists of 14 extraction wells located within the landfill. The extraction wells are piped to an onsite groundwater treatment plant (Figure 1-8). The treatment plant along Aberdeen Road (east of the landfill) was designed to remove low levels of petroleum contamination, trace organics, and metals using an activated carbon filter system with preliminary aeration and skimmers. The extraction portion of the system was start-up tested in April 1995.

In the Summary Technical Report (WCC, 1997), WCC concluded that contaminants from LF 26 have not significantly impacted groundwater outside the LF 26 boundary based on a comprehensive evaluation of several years of post-RCRA-type cap installation groundwater monitoring data. It was further concluded that extraction and treatment is not currently necessary to protect human health and the environment (WCC, 1997). Groundwater monitoring data collected since 1997 also demonstrate that contaminants in LF 26 have not significantly impacted groundwater outside of the LF 26 boundary (CH2M HILL, 2006). Therefore, with the concurrence of the regulatory agencies, the groundwater extraction and treatment system was never put into service.

The USACE commissioned a draft Groundwater Treatment System Decommissioning Study in 1998. The purpose of this study was to establish appropriate parameters to decommission the existing LF 26 treatment plant and extraction well system. The study presented the scope of work and specific procedures required to decommission the groundwater treatment plant at LF 26. The CERCLA 5-Year Review currently being prepared for LF 26 will update this decommissioning study and establish a process for achieving consensus on system decommissioning.

### 1.6.2 RCRA-type Cap

A RCRA-type landfill cap was constructed at LF 26 in response to the 1989 LF 26 ROD, the 1992 LF 26 ESD, and the RWQCB Order No. 92-029 containing the WDRs for LF 26. The RCRA-type cap was installed at LF 26 during 1994 and 1995, and it covers an area of approximately 26 acres (Figure 1-8). The eight-layer cap includes (from bottom to top):

- A minimum 2- to 4.5-foot-thick foundation layer.
- A minimum 1- to 2-foot-thick compacted low-permeability clay layer.
- A geomembrane liner consisting of 40-mil very-low-density polyethylene (VLDPE) and high-density polyethylene (HDPE) composite on the side slopes and VLDPE on the top deck. The composite membrane is VLDPE on the outer surfaces. Membrane material is smooth on minimum slopes (top deck) and textured on both sides on the 4:1 side slopes.
- A drainage layer (composite drainage net with subdrainage piping).
- A minimum 18-inch-thick protective layer (topsoil and vegetation).

The cap includes drainage features and erosion control devices to prevent deterioration of landfill and ensure cap integrity. In addition, a 150- to 200-foot-wide buffer zone (22 acres in total area) was established around the perimeter of the cap. Access and intrusive activities are restricted within the buffer zone to protect the integrity of the cap and other landfill-related facilities (Figure 1-3).

Figure 1-9 depicts landfill and other local topography as of December 1996. This topography represents the landfill grades following closure. Some minor construction for drainage improvements occurred in 1998, but these changes did not significantly affect overall topography in the landfill area. Landfill surface elevations range from approximately 4 to 21 feet msl around the perimeter to approximately 28 feet msl at the crest.

### 1.6.3 Perimeter Passive Venting System

A perimeter passive venting system was installed at LF 26 in response to RWQCB CAO No. 01-139 and time schedule Order No. 01-140. The purpose of the trench was to control the lateral migration of landfill gas through the vadose zone. Prior to the construction of the passive venting system, three discrete areas with methane concentrations greater than 5 percent in soil gas or 1,000 micrograms per liter (µg/L) in groundwater were identified based on comprehensive landfill gas migration studies (ITSI, 2001, 2002a). The areas were located along the southern and southeastern boundaries of LF 26 (Figure 1-8):

- Along the southern edge of the landfill cap (near GMP-13), methane concentrations greater than 5 percent have been detected at a distance of 145 feet beyond the southern edge of the landfill. The presence of methane in this area appears to be a function of a combination of permeable soils with groundwater levels that seasonally fall below the estimated level of the toe of the synthetic liner. Methane in soil gas in this area may be only a seasonal occurrence.
- In the area near GMP-8 and GMP-9, methane concentrations in soil gas greater than 5 percent have extended at least 70 feet east of the landfill. This area appears to represent the largest geographic extent of the methane extending beyond the limits of the landfill cap, and appears to be related to transport through permeable subsurface materials (alluvium and channel sands).
- In the area around GMP-5, localized concentrations of methane greater than 5 percent in soil gas have reached distances of at least 90 feet from the landfill. Groundwater levels are below the toe of the synthetic liner in this area during a portion of the year. The extent of contribution to methane concentrations in this area from the underlying Bay Mud is not known.

The extent of the trench necessary to prevent landfill refuse-related methane migration was developed initially as part of the *Methane Remedial Measures Study* (CH2M HILL, 2002). Based on soil gas data available at the time, as well as lithologic and hydrogeologic information, it was recommended that the trench extend from the southern end of LF 26 to the southeastern portion of LF 26. The report further indicated that the trench could be divided into two distinct sections, one along the southern edge of the landfill between MW-089 and GMP-14 (approximately), around GMP-13, and the other on the southeastern edge between GMP-10 and GMP-8 (approximately), near GMP-8 and GMP-9. These locations were selected based on the areas where methane had been detected outside the landfill limits that could possibly have been associated with migration of landfill refuse-related methane from LF 26. For final design and construction purposes, USACE took a more conservative approach to methane migration control and extended the trench to cover the entire landfill perimeter both within and between these two sections (Figure 1-10).

During construction of the trench, shallow bedrock was encountered along the eastern boundary of LF 26, just north of GMP-07, which prevented construction of the trench further to the north into the GMP-05 area. However, soil gas data collected following installation of the trench indicates that methane has not been detected at concentrations greater than 0.05 percent in GMP-05. These data suggest that previous detections of methane from GMP-5 may have been the result of migration of methane from the southeastern portion of LF 26. Because the methane along southern and southeastern portions of LF 26 is currently being controlled by the RCRA-type cap and the venting system, northward migration of methane into the low-permeable soils and bedrock along the northeastern boundary of the landfill is no longer occurring. Continued monitoring for methane and other VOCs along the northeastern portion of LF 26 will continue to assess potential methane migration and ensure the protection of human health. The existing monitoring system for LF 26 and the adequacy of the system are discussed further in Section 1.7.

In addition to determining where the trench would be most effective, it was determined that a trench was not necessary along the western and northern boundaries of the landfill because elevated methane concentrations in soil gas have not been detected beyond the LF 26 boundaries in these areas (CH2M HILL, 2006). Along the western and northern portions of the site, the toe of the synthetic liner of RCRA-type cap is either below groundwater all year long or at certain times of the year. If any landfill gas were present in these areas, it would be trapped within the area below the landfill cap when the water table is higher than the base of the cap, preventing offsite soil gas migration. Because methane is only slightly soluble in water, it is transported through saturated zones in only minute quantities (CH2M HILL, 2006). Figure 1-11 shows the approximate area of the LF 26 cap that is below groundwater during a majority of the year. As previously indicated, monitoring soil gas in the western and northern portions of LF 26 will continue to assess potential methane migration and ensure the protection of human health (see Section 1.7).

#### 1.6.3.1 Venting System Construction Details

The perimeter passive venting system (including a venting trench and geomembrane trench liner) was installed along the southern and southeastern boundaries in 2002 and 2003 (Figure 1-10). The first phase of the venting trench construction was completed in February 2002. The remainder of the venting trench was finished in August 2002, and the geomembrane liner installation was completed by January 2003. Details of the design and construction of the passive venting system are provided in the *Completion Report, Interim Landfill Gas Migration Control Trench (*ITSI, 2003) and are summarized below.

The trench is designed to allow landfill gas to passively flow through the gravel fill in the trench, into the horizontally perforated collection pipe, and then to the surface where it naturally vents to the atmosphere through a series of vertical risers. This natural flow occurs as the landfill gas migrates from an area of higher pressure to an area of lower pressure. This pressure gradient causes vadose zone gases to flow into the trench collection pipe and out the vertical vents. A schematic of the vent trench is presented on Figure 1-10.

The trench was divided into eight sections (trench sections 1 through 8) to minimize the migration of groundwater along the trench. The 2- to 3-foot-wide trench was installed to a depth of approximately 3 feet below the lowest observed groundwater table elevation (Sections 5 through 8) or to bedrock (Sections 1 through 4). The depth of the trench ranges from approximately 2 feet bgs in Section 1 where shallow bedrock was encountered to approximately 15.5 feet bgs in Sections 6 through 8. Concrete vertical barriers are located between each trench section. The barriers are wider and deeper than the adjacent trench, and are designed to hydraulically isolate each trench section from the adjacent sections.

The trench is lined with a non-woven poly propylene geotextile (Contech C-60NW) to minimize the intrusion of fine-grained sediments. The trench sections are filled with a gravel pack consisting of 3/4–inch drain rock from the base of the trench to approximately 2 feet below grade. A 6-inch HDPE slotted conveyance pipe is installed within the drain rock to facilitate gas venting (this piping also allows for conversion of the passive venting trench to active collection trench in the future, if necessary). The conveyance pipe extends along the entire length of each trench segment and a riser pipe (trench vent) is connected to each end. Each riser pipe extends to approximately 10 feet above ground surface.

An impermeable vertical barrier (i.e., a trench liner system) is installed in each of the trench segments on the outboard (i.e., the side furthest from the landfill) of the trench to a depth of approximately 1 foot above the bottom of the constructed trench. The impermeable barrier consists of interlocking, rigid HDPE panels (GSG GundWall®) driven in place following initial construction of the trench.

# 1.7 Soil Gas Monitoring Network

## 1.7.1 Previous and Current Monitoring Activities

The Army maintains an active program to monitor soil gas in the LF 26 area. The current monitoring program is described in Table 1-4 and current monitoring locations are shown on Figure 1-12. All of the analytical data for soil gas (as well as all other sampled media) collected to date at LF 26 are provided in electronic format on CD in Appendix B.

## 1.7.2 Recent Monitoring Results

Soil gas data collected during 2006 are the most recent data currently available for evaluation. Soil gas samples from the current monitoring well network and the trench vents were collected and analyzed for methane on a quarterly basis in 2006. In addition, soil gas samples from the monitoring well network and the trench vents were analyzed for VOCs during the September 2006 sampling event. Soil gas monitoring wells at LF 26 in the SGP series are generally screened from about 5 to 6 feet bgs. Monitoring wells in the GMP series are generally screened from about 6 to 8 feet, but sometimes extend to 10 or 12 feet bgs.

### 1.7.2.1 Methane

Monitoring results for methane for all four sampling events performed in 2006 are summarized in Table 1-5 and are presented on Figures 1-13a through 1-13d.

The highest concentration of methane detected in a monitoring well during the March 2006 sampling event was 0.065 percent by volume in well GMP-32, located on the eastern perimeter of LF 26. All other detected methane concentrations in monitoring wells range from 0.001 to 0.039 percent by volume.

Data from the June 2006 sampling event indicate that the highest concentration of methane (39 percent by volume) was detected in monitoring well GMP-30, located in the buffer zone to the south of LF 26. Well MW-30 has historically contained relatively high concentrations of naturally occurring methane. Well GMP-38 contained methane at 2.45 percent by volume. Well GMP-38 is also located to the south of LF 26 in an area of naturally occurring methane. All other detected concentrations of methane in monitoring wells range from 0.001 to 0.46 percent by volume.

In the September 2006 sampling event, the highest detected concentrations of methane were found in wells GMP-30 (32 percent by volume), GMP-09 (18 percent by volume), and SGP-022 (2.7 percent by volume). As previously indicated, GMP-30 is located to the south of LF 26 in an area of naturally occurring methane. Well GMP-09 is located directly adjacent to the eastern edge of LF 26 and inboard of the passive venting trench. Well SGP-022 is located on the northern side of LF 26. Historical concentrations of methane in SGP-022 and subsequent concentrations (i.e., December 2006) all range from 0.001 to 0.2 percent by volume. Therefore, the detection of 2.7 percent by volume methane is anomalous. All other detected concentrations of methane in monitoring wells range from 0.005 to 0.09 percent by volume.

In the December 2006 sampling event, the highest detected concentration of methane at 0.55 percent by volume was at monitoring well GMP-01, located at the northern edge of LF 26. Along the southern and southeastern perimeter of LF 26 where the passive venting trench is located and where methane hot spots have historically been observed, methane concentrations in monitoring wells range from 0.003 to 0.054 percent by volume. Methane was detected between 0.01 and 0.038 percent by volume at all other monitoring well locations.

#### 1.7.2.2 VOCs

The most current soil gas monitoring data available for VOCs are from the September 2006 monitoring event. September 2006 monitoring results for VOCs are summarized in Table 1-6 and are presented on Figure 1-14. A copy of the complete analytical results for VOCs for this monitoring event is provided in Appendix B.

Only low concentrations of VOCs were detected in soil gas during the September 2006 sampling event. Of the detected concentrations of VOCs, 39 percent of the detected concentrations are less than 1 part per billion by volume (ppbv), and 92 percent of the detected concentrations are less than 10 ppbv. Only 17 out of 234 detections (8 percent) are greater than 10 ppbv.

VOCs detected in soil gas include various chlorinated hydrocarbons (e.g., tetrachloroethene and Freon) and several fuel constituents (e.g., benzene and toluene). The most frequently detected VOCs include 2-butanone (methyl ethyl ketone), acetone, carbon disulfide, and chloroform. The highest detected concentration of any VOC was 160 ppbv of methyl tert butyl ether (MTBE) identified in GMP-38 (located at the southwest corner of LF 26). MTBE is a fuel component that is not associated with LF 26, but rather it is derived from a groundwater plume emanating from a former gasoline service station located hydraulically upgradient of the LF 26 site.

#### 1.7.2.3 Potential Correlations Between Methane and VOCs

Potential correlations between detected methane and VOC concentrations were also evaluated. The three monitoring wells that typically contain relatively high concentrations of methane are GMP-30, GMP-09, and GMP-38. Although well SGP-22 does not typically contain relatively high concentrations of methane, it is included in this discussion.

In 2006, the highest detected concentrations of methane in GMP-30 occurred in June (39 percent by volume) and September (32 percent by volume). In September 2006, GMP-30 contained detectable concentrations of several VOCs; however, the concentrations of all of the detected VOCs were relatively low. Therefore, there does not appear to be a distinct correlation between methane and VOC concentrations in MW-30, nor would one be expected because methane in MW-38 is naturally occurring and not thought to be related to soil gas emanating from LF-26.

The highest detected concentration of methane was detected in well GMP-09 in September 2006 at 18 percent by volume. In September 2006, several VOCs including chlorinated hydrocarbons and fuel constituents were detected in well GMP-09 ranging from 0.5 to 88 ppbv. Acetone was detected at the highest concentration (88 ppbv). GMP-09 is located in an area where VOCs have frequently been detected in the past. A correlation between methane and VOCs in soil gas may exist in this area as both may be attributable to previous waste disposal.

The highest detected concentration of methane was detected in well GMP-38 in June 2006 at 2.45 percent by volume. In September 2006, several VOCs including chlorinated hydrocarbons and fuel constituents were detected in well GMP-38 ranging from 1 to 160 ppbv. MTBE was detected at the highest concentration (160 ppbv). Because methane in well GMP-038 is thought to be naturally occurring, a correlation between detected methane and MTBE (derived from an offsite originating groundwater plume) is unlikely.

The highest concentration of methane detected in well SGP-22 was 2.7 percent by volume in September 2006 (historical concentrations of methane in SGP-022 and subsequent concentrations all range from 0.001 to 0.2 percent by volume). In September 2006, nine VOCs including chlorinated hydrocarbons and fuel constituents were detected in well SGP-22 ranging from 0.58 (cis-1,2-dichloroethene) to 14 (acetone) ppbv. The number of VOCs detected and VOC concentrations in September 2006 are higher than previously detected in December 2005 (December 2005 is the only other time SGP-022 has been sampled for VOCs). Because generally higher concentrations of both methane and VOCs were detected in SGP-022 in September 2006, a correlation between methane and VOCs in soil gas may exist in this area as both may be attributable to previous waste disposal with LF 26.

### 1.7.3 Adequacy of the Soil Gas Monitoring Network

The adequacy of the soil gas monitoring network was evaluated in detail after completion of the vent trench to determine if the current system could detect possible soil gas contaminant migration beyond LF 26. This detailed evaluation is included in the *Landfill 26 Corrective Action Investigation Work Plan* (CH2M HILL, 2005). Locations, construction details, and relationship to groundwater of existing landfill gas monitoring probes, select groundwater monitoring wells, and piezometers were evaluated. The evaluation also included a review of the system with respect to the 27 CCR Section 20925 (Perimeter Monitoring Network) requirement that the maximum spacing of perimeter monitoring probes around a landfill be every 1,000 feet.

The conclusions of the review were that several minor gaps existed in the monitoring network at that time. These gaps were then subsequently addressed by the installation of a series of new gas monitoring probes. This report concluded that the current network, which included the additional probes installed in 2003, was adequate for detecting possible soil gas migration (CH2M HILL, 2005).

The adequacy of the monitoring network was again evaluated and the findings were included in Appendix C of the *Landfill 26 Conceptual Site Model Update* (CH2M HILL, 2006). This evaluation concluded that the soil gas monitoring network is adequate to ensure that methane migration beyond the LF 26 boundaries is not occurring. Additional details can be found in the *Landfill 26 Conceptual Site Model Update* (CH2M HILL, 2006).

### 1.7.4 Future Soil Gas Monitoring Activities

Currently, soil gas samples are collected from numerous monitoring locations at LF 26. Methane is sampled for on a quarterly basis and VOCs sampled for on an annual basis. The current sampling program was established during the investigation/characterization phase of the project, a phase that typically requires the collection of relatively large amounts of data. However, once the nature and extent of contamination has been established and potential migration routes and rates are understood, significantly less data are needed to monitor the plume. The current sampling program greatly exceeds minimum standards contained in 27 CCR requirements for closed landfill perimeter landfill gas monitoring. Future soil gas monitoring activities will be limited to compliance and remedy monitoring. Compliance monitoring must be performed to demonstrate that landfill-related gas is being controlled and that methane does not exceed a concentration of 5 percent by volume at the property line. Remedy monitoring will be used to assess the continued protectiveness of the landfill refuse-related gas control system with respect to nearby sensitive receptors. Compliance and remedy monitoring of the soil gas at LF 26 will continue into the postclosure period. A detailed discussion of the proposed postclosure point of compliance and remedy monitoring programs is included in Appendix C of this FS.

# Tables

TABLE 1-1
Summary of Previous Investigations
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Description | Key Findings |
|---|---|
| 1985 – The Army begins confirmation study of surface and subsurface hazardous material contamination of the GSA Phase I and II Sale Areas (WCC, 1997). | The study reported the presence of trace levels of metals and priority pollutants. Trace levels of gross-alpha and beta radionuclides detected were believed to be related to the high TDS content of the water. |
| 1986 – WCC conducted a preliminary investigation that included a methane study, detailed topographic and geophysical surveys, base map preparation, soil borings, groundwater monitoring wells, trenching operations, and sampling of soils and groundwater (WCC, 1997). | Concluded that LF 26 was nonmethanogenic and the refuse zone was in a state of near-perennial saturation. Four primary horizons were characterized, and groundwater-level fluctuations were recorded and correlated with seasonal changes in precipitation. The investigation also identified an area of oily sludge and detections of several organic and inorganic constituents that warranted further investigation.<br><br>The investigation also concluded that none of the contaminants should present a significant threat to human health by inhalation or dermal contact. The assessment also concluded that groundwater contaminants did not present a significant threat to humans because groundwater from LF 26 was not being used, and would probably never be used, as drinking water. |
| 1990 – Sirrine Environmental Consultants began a 1-year assessment of the groundwater, surface water, and surface sediment quality in the vicinity of LF 26. The objective was to evaluate the effect of LF 26 on water and sediment quality in the vicinity (WCC, 1997). | Sirrine concluded that the presence of LF 26 results in impacts to groundwater and possibly surface water and sediments. Due to the presence of contaminants, particularly petroleum hydrocarbons, in background groundwater monitoring wells and in hydraulically upgradient surface water and sediments, Sirrine concluded that it was not possible to determine the portions of the impacts to groundwater and surface water that could be solely attributed to LF 26 (WCC, 1997). |
| 1991 – The Army collected additional soil and groundwater data that more accurately characterized the site and clarified some ambiguities in the selected remedy (WCC, 1997). | The remedy was based on the premise that LF 26 contains high levels of contaminants throughout. The additional studies suggested that contamination within LF 26 was restricted to a number of small "hot spots." The USACE noted that accurately locating these areas for solidification could be eliminated and that an upgraded RCRA-type cap placed on LF 26 would substantially diminish the possibility of exposure to the waste in LF 26. The modified remedy would provide a more effective cap on LF 26 than extraction and treatment of groundwater. |
| 1992 – Quadrel Services conducted a methane survey of LF 26 from September 14 to September 18. | The goal of this investigation was to quantify the amount of methane being generated at LF 26 and to further delineate LF 26's boundaries. This investigation was completed prior to the installation of the RCRA-type cap. |
| 1994 to 1996 – The Army collected and analyzed landfill gas on a monthly basis beginning in August 1994 (WCC, 1997). | The landfill gas samples were analyzed in the field for oxygen, nitrogen, carbon dioxide, methane, methylene chloride, and benzene using a portable gas chromatograph.<br><br>Landfill gas was collected and analyzed on a monthly basis from August 1994 through September 1995. Landfill gas monitoring probes (GMPs) GMP-3 and GMP-5 were destroyed in May 1995 during construction around the LF 26 perimeter and were reinstalled in July 1995.<br><br>Landfill gas was collected and analyzed one time in 1996. |

TABLE 1-1
Summary of Previous Investigations
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Description | Key Findings |
|---|---|
| 1997 – USACE Sacramento District investigated the GSA Phase II Sale Area around LF 26 (IT Corporation [IT], 1998a). | The results of the investigation indicated that the source of halogenated volatile organic compound (HVOC) contamination on the west side of LF 26 originates from source(s) outside of LF 26. |
| 1999 – ITSI performed landfill gas sampling for September and December (ITSI, 2000a). | GMP-4 through GMP-13 were monitored during September; all GMPs that could be monitored were monitored during each of two sampling events in December. Some GMPs were unable to be monitored because of high groundwater levels. |
| 1999 – Harding Lawson Associates (HLA), on behalf of the Hamilton Meadows property developer (Shea Homes), sampled 12 GMPs for methane in March and all GMPs in 2 probe locations during October (HLA, 1999). | The highest methane concentration was 0.078 percent by volume in March and 0.6 percent in October. |
| 1999 – The Army performed supplemental gas monitoring (ITSI, 1999). | Twenty-three GMPs were field monitored and 20 were sampled. Methane concentrations were less than 1 percent at all GMPs. |
| 2000 – The Army completed a supplemental soil gas program (ITSI, 2001). | The program consisted of nine events, which included sampling of temporary and permanent soil gas probes. Methane was detected at levels ranging from 5 to 50 percent by volume in areas between the eastern margin of the landfill and the southeastern edge of the buffer zone near GMP-17. |
| 2000 – The Army conducted annual landfill monitoring event (ITSI, 1999). | Ten GMPs were sampled. Methane was detected at 1 percent by volume at GMP-5 and 21 percent by volume at GMP-9. |
| 2001 – The Army conducted additional investigation of methane and VOCs in the landfill southern buffer area and at Hamilton Meadows (ITSI, 2002a). | Chemical, geochemical, and geologic data were gathered from GMPs, monitoring wells, boreholes, and trenches.<br><br>Soil gas data from 2001 to 2003 are presented in the USACE Methane Investigation Report, which stated that many contaminated sections beyond the landfill boundary could be attributed to outside sources. |
| 2003 – Shea Homes conducted additional investigations in the Hamilton Meadows area (near Lot 30). | Additional geologic information was obtained from boreholes and trenches, and included soil sampling and testing for methane-producing bacteria. |
| 2003 – Montgomery Watson Harza (MWH) conducted groundwater and soil gas monitoring from October to November to determine the effectiveness of the RCRA-type cap in preventing the movement of target analytes (MWH, 2005). | The highest frequency of organic analyte detections was reported for wells screened in the Refuse Zone. The highest concentrations of organic analytes were detected in wells/piezometers screened in the Cross-Gradient West and Upgradient Zone materials and located southwest of the landfill boundary. |
| 2004 – MWH conducted a soil gas monitoring event in April (MWH, 2004). | Trends of the April 2004 event were consistent with previous monitoring at LF 26. The highest frequency of organic analyte detections was reported in wells screened in the Refuse Zone, within the landfill boundary. |

TABLE 1-2
Previous Construction and Earth-moving Activities and Supporting Studies
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Date | Remedial Action |
|---|---|
| 1986 (WCC, 1997) | As part of the 1986 investigation, a preliminary hazard assessment was conducted according to U.S. Environmental Protection Agency (EPA) guidelines. The assessment concluded that none of the contaminants should present a significant threat to human health by inhalation or dermal contact. The assessment also concluded that groundwater contaminants did not present a significant threat to humans because groundwater from LF 26 was not being used, and would probably never be used, as drinking water. However, since LF 26 and the surrounding suspected landfills were included in the parcel offered for sale by the GSA, it was reasonable to assume that the land and groundwater usage could change. Therefore, the USACE was required to complete a Remedial Investigation/Feasibility Study (RI/FS) and prepare a remedial plan to properly close LF 26. |
| 1987 (WCC, 1987) | WCC conducted and completed the RI to estimate the volume and extent of contamination and to define potential treatment options in the FS. The RI reported approximately 151,500 cubic yards of refuse in LF 26; however, because the soil and fill contamination exceeded LF 26's aerial boundary, the volume of contaminated material within LF 26 was estimated at approximately 233,000 cubic yards (based on preliminary cleanup criteria developed as part of the FS). |
| 1988 (WCC, 1997) | WCC completed the FS that evaluated the alternatives for remediation at LF 26. The FS substantially complied with EPA guidance under CERCLA.<br><br>The FS included both human health and environmental risk assessments, developed cleanup criteria for remediation of contaminated groundwater and soil/refuse, and presented detailed analysis and evaluation of various remedial alternatives.<br><br>A preliminary assessment of the site remediation criteria revealed that compliance with ARARs for the site would govern the selection of alternatives because the site contains solid waste, which must be managed in accordance with California regulations.<br><br>The health risk assessment was considered to be a "worst-case" analysis and suggested that chronic exposures (via ingestion) of deposited airborne dust emitted from LF 26 may represent significant risk to persons who were currently living and working at HAAF. USACE later re-evaluated the risks to human health under the existing land-use scenario using a dispersion model that they felt more closely represented the actual conditions at HAAF. This re-evaluation concluded that the risk associated with exposure to airborne dust would be insignificant under the existing land use scenario. |
| 1989 (WCC, 1997) | On August 11, a ROD for LF 26 was signed that included eight remedial alternatives. The ROD described the selected remedial alternative based on the FS conducted in 1988. Chemical fixation and Class II closure with a variance was selected as the proposed remedy. This ROD was subsequently supplemented and modified by the ESD (1992). |
| 1992 (ITSI, 2000b) | The ESD that proposed capping the landfill and groundwater extraction/treatment was signed. RCRA-type cap and groundwater extraction system / hydraulic containment system construction was performed between 1994-95 and 1992-93, respectively. During construction of the RCRA-type cap, 18 groundwater wells were abandoned, the casings of 10 wells were extended, and 2 damaged wells were repaired. During construction of the extraction system, a total of 14 groundwater extraction wells were installed to provide hydraulic containment. |
| 1993 (ITSI, 2000b) | USACE Omaha District proposed the groundwater monitoring and analytical program. The RWQCB provided guidance on specific analytical methods to use in the monitoring program. Quarterly groundwater monitoring was initiated under WDR #92-029. USACE Sacramento District contracted WCC to conduct seven rounds of quarterly sampling beginning in December 1993. |
| 1995 (ITSI, 2000b) | USACE Sacramento District proposed reductions in the groundwater monitoring program based on target analyte trends established from the initial 10 quarters of monitoring. |
| 1995 (ITSI, 2000b) | RWQCB issued WDR #95-188 requiring a National Pollutant Discharge Elimination System (NPDES) permit for the discharge of treated groundwater to the local storm sewer system. |

TABLE 1-2
Previous Construction and Earth-moving Activities and Supporting Studies
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Date | Remedial Action |
|---|---|
| 1996 (ITSI, 2000b) | USACE Sacramento District notified RWQCB that analysis of groundwater monitoring data indicated that target analytes had not migrated beyond the edge of the landfill. USACE Sacramento District proposed changes to the groundwater monitoring program, including the reduction of monitoring frequency to annually (from quarterly), and elimination of HVOCs by EPA Method 8010 and pesticides/polychlorinated biphenyls (PCBs) by EPA Method 8080 from the target analyte list. The RWQCB approved the proposed changes to the groundwater monitoring program. |
| 1996 (ITSI, 2000b) | RWQCB and Department of Toxic Substance Control (DTSC) determined the need for a Summary Technical Report to facilitate its evaluation of USACE Sacramento District's proposal to forego groundwater extraction/treatment and reduce the scope of groundwater monitoring. |
| 1996 (WCC, 1997) | The RWQCB issued WDR #96-113 requiring continued groundwater monitoring and preparation of the *Summary Technical Report*. The Technical Report would re-evaluate the need for hydraulic containment, propose the final closed landfill design, and perform statistical tests to determine the source(s) of groundwater contamination detected outside LF 26. |
| 1997 (WCC, 1997) | The *Summary Technical Report* was completed. This report includes extensive data from a broad range of studies and investigations performed since 1985. The *Summary Technical Report* concluded that hydraulic containment was not needed at that time and contamination detected in wells outside LF 26 originates from sources outside the landfill. |
| 1998 (CH2M HILL, 1998a) | The *Construction Quality Assurance (CQA) Report, Hamilton Army Airfield, Landfill 26, Final Cover System* was prepared. This report summarizes the construction, installation, and quality control activities employed during the construction of the LF 26 final cover system completed in 1995. This report documents that the LF 26 final cover system was consistent with the goals of the project plans and technical specifications. |
| 1998 (CH2M HILL, 1998a) | The *Groundwater Treatment System Decommissioning Study* was conducted. The purpose of this study was to decommission ("mothball") the existing LF 26 treatment plant and extraction well system. Data from ongoing groundwater monitoring suggested that contaminants in LF 26 have not significantly impacted groundwater outside of the LF 26 boundary. The study presents the scope of work and specific procedures required to decommission the groundwater treatment plant at LF 26. |
| 1998 (CH2M HILL, 1998b) | The *HAAF Landfill 26, Perimeter Grading and Drainage Modifications Alternatives* was prepared to evaluate three perimeter grading modification options to improve drainage and access to the LF 26 top deck and to repair erosion damage and a side slope seep. The original LF 26 design was based on a surface water drainage system that will be significantly altered by the proposed BRAC property development plan. Drainage adjustments were made to prevent flooding of LF 26 during a 100-year storm event. The grading/drainage alternative that was selected and implemented is discussed in detail in the CQA Report referenced below. |
| 1998 (CH2M HILL, 1998a) | The LF 26 drainage control berm was constructed to protect the landfill from Pacheco Creek overflow during major flood events. Erosion-damaged areas along the northwest edge of the landfill and seep areas near the north toe of the landfill were also repaired. |
| 1998 (CH2M HILL, 1998c) | The *Construction Quality Assurance (CQA) Report, Hamilton Army Airfield, Landfill 26, Grading and Drainage Adjustments* was prepared to summarize the construction, installation, and quality control activities employed during the implementation of the LF 26 grading and drainage improvements. |
| 1999 (CH2M HILL, 1999) | The Land Use Restrictions and Maintenance Requirements for Conditional Use Permit was submitted. This document was prepared to provide supporting discussion and documentation for preparation of the Conditional Use Permit for the City of Novato's use of LF 26. USACE Sacramento District prepared the actual Conditional Use Permit. This document summarizes various restrictions and monitoring and maintenance requirements associated with use of LF 26 as a park. |

TABLE 1-2
Previous Construction and Earth-moving Activities and Supporting Studies
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Date | Remedial Action |
|---|---|
| 1999 (ITSI, 2000b) | USACE Sacramento District prepared the *Boring Log for New LF 26 Monitoring Well*, which documents the installation of a downgradient groundwater monitoring well (MW), MW-L26-1, to provide an additional downgradient monitoring point outside the edge of LF 26. |
| 1999 (CH2M HILL, 1999) | The *Final Closure and Post-Closure Maintenance Plan* was completed. The plan includes a groundwater analytical program focused only on known landfill COCs with samples collected on a yearly basis. The plan includes a landfill gas monitoring program to analyze for methane and other landfill gases on a yearly basis. |
| 2001 (ITSI, 2001) | In January, ITSI completed the *Draft Landfill Gas Migration Study: An Evaluation of the Presence and Distribution of Landfill Gas Along the Eastern Margin of Landfill 26, Hamilton Army Airfield, Novato, California.* The purpose of the study was to evaluate the presence, distribution, and migration of landfill gas along the eastern margin of LF 26. Significant additional gas monitoring was conducted for this study. |
| 2001 | The RWQCB issued Order No. 01-139 and Time and Schedule Order No. 01-140 requiring investigation and remediation of methane originating from LF 26. |
| 2002-2003 (ITSI, 2003) | The vent trench was installed in the landfill buffer zone. The first phase of the gravel-filled trench (GMP-07 to GMP-11) was completed in February. The remainder of the trench was finished in August, with the geomembrane installation completed in January 2003. |
| 2005 (CH2M HILL, 2005) | The Landfill 26 Corrective Action Investigation Work Plan was completed, which recommended the installation of one groundwater monitoring well and the addition of analytical methods and procedures to ongoing monitoring programs. In addition, the Work Plan concluded that the vent trench continues to be effective in intercepting soil gas movement away from LF 26 and the buffer zone in the southern landfill area. |
| 2006 (CH2M HILL, 2006) | The Landfill 26 Conceptual Site Model Update was prepared to update the Conceptual Site Model presented in the Landfill 26 Corrective Action Investigation Work Plan (CH2M HILL, 2005). The CSM Update presents the subsurface conditions at LF 26 and the buffer zone as they relate to the fate and transport of landfill and other present contamination and presents concentrations and trends of detected contaminants at LF 26. The CSM Update also provides evidence supporting the trench location and the adequacy of the soil gas monitoring network to detect soil gas migration. |

TABLE 1-3
Data Used for Evaluation of Soil Gas Concentrations
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Metric | Soil Gas |
|---|---|
| Chemical data points | > 43,000[a] |
| Monitoring events | 118 |
| Monitoring locations | 499[b] |
| Laboratory analytical methods | 2 |
| Laboratory analytes | 118 |
| Field meter readings | 4 parameters for fixed gases, plus gas pressure |

Notes:

[a] Number includes analytical data from samples collected in the Hamilton Meadows area.
[b] Number includes sample locations in the Hamilton Meadows area.

TABLE 1-4
Landfill 26 Current Landfill Gas Monitoring Program
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Monitoring Points | Objectives | Frequency |
|---|---|---|
| TV-01 to TV-16 | Monitor potential migration of landfill gas. Measure concentrations of methane and VOCs in soil gas. | Oxygen and methane: quarterly<br>VOCs: annually |
| GMP-1 to GMP-38*, and SGP-1 to SGP-20 | Monitor potential migration of landfill gas. Measure concentrations of methane and VOCs in soil gas. | Oxygen and methane: quarterly<br>VOCs: annually |

Note:

* Certain probes cannot be sampled during some events due to high groundwater levels.

TABLE 1-5
Detected Concentrations of Methane (2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | 27-Mar-06 | | 7-Jun-06 | | 19-Sep-06 | | 12-Dec-06 | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** |
| GMP-01 | ns | ns | 0.005 U | 3,272 U | ns | ns | 0.550 | 359,918 |
| GMP-02 | a | a | a | a | a | a | a | a |
| GMP-03 | a | a | a | a | a | a | a | a |
| GMP-04 | 0.006 | 3,926 | 0.008 | 5,235 | 0 | 2,356 | 0.034 | 22,249 |
| GMP-05 | 0.005 U | 3,272 U | ns | ns | 0 | 157 | 0.011 | 7,198 |
| GMP-06 | 0.008 | 5,235 | 0.002 | 1,309 | 0.00019 J | 124 J | ns | ns |
| GMP-07 | ns | ns | 0.015 | 9,816 | ns | ns | ns | ns |
| GMP-08 | ns | ns | 0.001 | 654 | 0 | 183 | 0.005 | 3,272 |
| GMP-09 | 0.003 | 1,963 | ns | ns | 18 J | 11,779,141 J | ns | ns |
| GMP-10 | 0.002 | 1,309 | 0.027 | 17,669 | 0.00024 J | 157 J | 0.007 | 4,581 |
| GMP-11 | ns | ns | 0.025 | 16,360 | ns | ns | 0.003 | 1,963 |
| GMP-12 | ns | ns | 0.005 U | 3,272 U | ns | ns | ns | ns |
| GMP-13 | ns | ns | 0.005 U | 3,272 U | ns | ns | ns | ns |
| GMP-14 | 0.005 U | 3,272 U | 0.011 | 7,198 | 0 | 4,515 | 0.014 | 9,162 |
| GMP-15 | ns | ns | 0.005 U | 3,272 U | ns | ns | 0.020 | 13,088 |
| GMP-16 | ns | ns | 0.005 U | 3,272 U | ns | ns | 0.010 | 6,544 |
| GMP-17 | ns | ns | 0.001 | 654 | ns | ns | 0.022 | 14,397 |
| GMP-18 | ns | ns | 0.005 U | 3,272 U | ns | ns | 0.023 | 15,051 |
| GMP-19 | ns | ns | ns | ns | ns | ns | ns | ns |
| GMP-20 | ns | ns | ns | ns | ns | ns | ns | ns |
| GMP-21 | ns | ns | ns | ns | ns | ns | ns | ns |

TABLE 1-5
Detected Concentrations of Methane (2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | 27-Mar-06 | | 7-Jun-06 | | 19-Sep-06 | | 12-Dec-06 | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** |
| GMP-22 | ns | ns | ns | ns | ns | ns | ns | ns |
| GMP-23 | ns | ns | ns | ns | ns | ns | ns | ns |
| GMP-24 | 0.005 | 3,272 | 0.008 | 5,235 | 0 | 144 | 0.005 | 3,272 |
| GMP-25 | 0.004 | 2,618 | 0.013 | 8,507 | 0.0001 J | 65.43 J | 0.015 | 9,816 |
| GMP-26 | 0.004 | 2,618 | 0.037 | 24,213 | 0.00021 J | 137 J | 0.013 | 8,507 |
| GMP-27 | ns | ns | 0.028 | 18,323 | 0.00018 J | 118 J | 0.018 | 11,779 |
| GMP-28 | ns | ns | 0.016 | 10,470 | ns | ns | 0.150 | 98,160 |
| GMP-29 | ns | ns | 0.015 | 9,816 | ns | ns | 0.013 | 8,507 |
| GMP-30 | 0.004 | 2,618 | 39.000 | 25,521,472 | 32 J | 20,940,695 J | 0.025 | 16,360 |
| GMP-31 | 0.005 | 3,272 | 0.037 | 24,213 | 0 | 144 | 0.003 | 1,963 |
| GMP-32 | 0.065 | 42,536 | 0.019 | 12,434 | 0.0002 J | 130 J | 0.007 | 4,581 |
| GMP-33 | 0.027 | 17,669 | 0.460 | 301,022 | 0.00094 J | 615 J | 0.008 | 5,235 |
| GMP-34 | ns | ns | 0.005 U | 3,272 U | ns | ns | 0.054 | 35,337 |
| GMP-35 | 0.012 | 7,853 | 0.025 | 16,360 | 0.00014 J | 92 J | 0.023 | 15,051 |
| GMP-36 | ns | ns | 0.015 | 9,816 | ns | ns | 0.012 | 7,853 |
| GMP-37 | ns | ns | 0.020 | 13,088 | ns | ns | 0.046 | 30,102 |
| GMP-38 | 0.015 | 9,816 | 2.450 | 1,603,272 | 0.00007 J | 46 J | 0.040 | 26,176 |
| SG-01 | ns | ns | ns | ns | ns | ns | 0.011 | 7,198 |
| SG-02 | a | a | a | a | a | a | a | a |
| SG-03 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-03D | ns | ns | ns | ns | ns | ns | ns | ns |

TABLE 1-5
Detected Concentrations of Methane (2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | 27-Mar-06 | | 7-Jun-06 | | 19-Sep-06 | | 12-Dec-06 | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** | **% by volume** | **µg/m³** |
| SG-04 | a | a | a | a | a | a | a | a |
| SG-04D | a | a | a | a | a | a | a | a |
| SG-05 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-06 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-07 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-08 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-08D | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-09 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-10 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-11 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-12 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-13 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-14 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-15 | ns | ns | ns | ns | ns | ns | 0.005 U | 3,272 U |
| SG-16 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-17 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-18 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-19 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-20 | ns | ns | ns | ns | ns | ns | ns | ns |
| SG-21 | 0.005 | 3,272 | 0.009 | 5,890 | ns | ns | ns | ns |
| SGP-22 | 0.003 | 1,963 | 0.019 | 12,434 | 2.7 | 1,766,871 | 0.038 | 24,867 |

TABLE 1-5
Detected Concentrations of Methane (2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | 27-Mar-06 | | 7-Jun-06 | | 19-Sep-06 | | 12-Dec-06 | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **% by volume** | **µg/m$^3$** | **% by volume** | **µg/m$^3$** | **% by volume** | **µg/m$^3$** | **% by volume** | **µg/m$^3$** |
| SGP-23 | 0.005 U | 3,272 U | 0.008 | 5,235 | 0.00017 J | 111 J | 0.019 | 12,434 |
| SGP-24 | 0.005 U | 3,272 U | 0.012 | 7,853 | 0.00034 J | 222 J | 0.011 | 7,198 |
| SGP-25 | 0.039 | 25,521 | 0.017 | 11,125 | 0.00016 UJ | 105 UJ | 0.003 | 1,963 |
| SGP-26 | 0.002 | 1,309 | 0.026 | 17,014 | 0.0034 J | 2,225 J | 0.003 | 1,963 |
| SGP-27 | 0.017 | 11,125 | 0.033 | 21,595 | 0.00017 J | 111 J | 0.042 | 27,485 |
| SGP-28 | 0.003 | 1,963 | 0.025 | 16,360 | 0.0002 J | 131 J | 0.011 | 7,198 |
| SGP-29 | 0.005 | 3,272 | 0.033 | 21,595 | 0.00018 UJ | 118 UJ | 0.012 | 7,853 |
| SGP-30 | 0.001 | 654 | 0.022 | 14,397 | 0.00019 J | 124 J | 0.017 | 11,125 |
| SGP-31 | 0.005 U | 3,272 U | 0.020 | 13,088 | 0.0002 UJ | 131 UJ | 0.022 | 14,397 |
| SGP-32 | 0.003 | 1,963 | 0.039 | 25,521 | 0.00019 UJ | 124 J | 0.004 | 2,618 |
| SGP-33 | 0.005 U | 3,272 U | 0.023 | 15,051 | 0.0003 J | 196 J | 0.005 U | 3,272 U |
| SGP-34 | 0.005 U | 3,272 U | 0.005 U | 3,272 U | 0.00016 UJ | 105 UJ | 0.005 U | 3,272 U |
| SGP-35 | 0.001 | 654 | 0.005 U | 3,272 U | 0.00014 UJ | 92 UJ | 0.009 | 5,890 |
| SGP-36 | 0.004 | 2,618 | 0.455 | 297,751 | 0.02 J | 13,088 J | 0.013 | 8,507 |
| SGP-37 | 0.003 | 1,963 | 0.045 | 29,448 | 0.00026 J | 170 J | 0.010 | 6,544 |
| SGP-38 | 0.001 | 654 | 0.440 | 287,935 | 0.00018 UJ | 118 UJ | 0.015 | 9,816 |
| SGP-39 | 0.005 U | 3,272 U | 0.031 | 20,286 | 0.00018 UJ | 118 UJ | 0.011 | 7,198 |
| SGP-40 | 0.005 U | 3,272 U | 0.014 | 9,162 | 0.0071 J | 4,646 J | 0.014 | 9,162 |
| SGP-41 | 0.002 | 1,309 | 0.025 | 16,360 | 0.0003 J | 196 J | 0.013 | 8,507 |
| TV-01 | 0.005 U | 3,272 U | 0.010 | 6,544 | 0.00018 J | 118 UJ | 0.001 | 654 |
| TV-02 | 0.003 | 1,963 | 0.016 | 10,470 | 0.0002 J | 131 J | 0.003 | 1,963 |

TABLE 1-5
Detected Concentrations of Methane (2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | 27-Mar-06 | | 7-Jun-06 | | 19-Sep-06 | | 12-Dec-06 | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **% by volume** | **µg/m$^3$** | **% by volume** | **µg/m$^3$** | **% by volume** | **µg/m$^3$** | **% by volume** | **µg/m$^3$** |
| TV-03 | 38.000 | 24,867,076 | 4.200 | 2,748,466 | 0.051 J | 33374 J | 0.002 | 1,309 |
| TV-04 | 0.002 | 1,309 | 3.500 | 2,290,389 | 0.1 J | 65,440 J | 0.005 U | 3,272 U |
| TV-05 | 0.003 | 1,963 | 0.028 | 18,323 | 0.00027 J | 177 J | 0.003 | 1,963 |
| TV-06 | 0.005 | 3,272 | 0.600 | 392,638 | 0.35 J | 229,039 J | 0.005 U | 3,272 U |
| TV-07 | 0.005 | 3,272 | 0.012 | 7,853 | 0.00014 J | 92 J | 0.071 | 46,462 |
| TV-08 | 0.007 | 4,581 | 0.019 | 12,434 | 0.00017 J | 111 J | 0.010 | 6,544 |
| TV-09 | 0.006 | 3,926 | 0.019 | 12,434 | 0.00018 J | 118 UJ | 0.006 | 3,926 |
| TV-10 | 0.007 | 4,581 | 0.021 | 13,742 | 0.0002 J | 131 UJ | 0.007 | 4,581 |
| TV-11 | 0.001 | 654 | 0.027 | 17,669 | 0.00019 J | 124 J | 0.005 U | 3,272 U |
| TV-12 | 0.005 U | 3,272 U | 0.220 | 143,967 | 0.00018 J | 118 UJ | 0.003 | 1,963 |
| TV-13 | 0.005 U | 3,272 U | 0.008 | 5,235 | 0.0002 J | 131 UJ | 0.003 | 1,963 |
| TV-14 | 0.001 | 654 | 0.006 | 3,926 | 0.00013 J | 85 J | 0.007 | 4,581 |
| TV-15 | 0.005 U | 3,272 U | 0.021 | 13,742 | 0.00021 J | 137 J | 0.011 | 7,198 |
| TV-16 | 0.001 | 654 | 0.005 U | 3,272 U | 0.00017 J | 111 J | 0.005 | 3,272 |

Notes:

a = abandoned
ns = not sampled

For the March, June, and December sampling events, methane was analyzed in the field using a Gasurveyor 442 portable gas detector.
For the September sampling event, methane was analyzed in an offsite laboratory using ASTM Method D-1946.

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result (µg/m$^3$) |
|---|---|---|---|
| GMP-04 | 2-Butanone (methyl ethyl ketone) | 2 | 5.89 |
| | Acetone | 8.5 | 20.19 |
| | Carbon disulfide | 8.7 | 27.08 |
| | Tetrahydrofuran | 0.79 J | 2.32 J |
| GMP-05 | 2-Butanone (methyl ethyl ketone) | 1.1 | 3.24 |
| | Acetone | 9.5 | 22.56 |
| | Carbon disulfide | 2.4 | 7.47 |
| GMP-06 | 2-Butanone (methyl ethyl ketone) | 1.6 | 4.71 |
| | Acetone | 7.9 | 18.76 |
| | Benzene | 0.54 J | 1.72 J |
| | Carbon disulfide | 6.8 | 21.17 |
| | Tetrachloroethene | 0.58 J | 4.02 J |
| | Tetrahydrofuran | 0.56 J | 1.65 J |
| GMP-08 | Acetone | 2.9 J | 6.88 J |
| | Heptane | 0.73 J | 2.99 J |
| | Tetrahydrofuran | 0.56 J | 1.65 J |
| | Toluene | 1.8 | 6.78 |
| GMP-09 | 1,2-Dichlorotetrafluoroethane (Freon-114) | 11 | 76.89 |
| | 2-Butanone (methyl ethyl ketone) | 1.5 | 4.42 |
| | Acetone | 88 | 209.04 |
| | Benzene | 0.5 J | 1.59 J |
| | Carbon disulfide | 7.8 | 24.28 |
| | Cyclohexane | 13 | 44.74 |
| | Dichlorodifluoromethane (Freon-12) | 25 | 123.62 |
| | Hexane | 2.7 | 9.51 |
| GMP-10 | Acetone | 3.8 | 9.02 |
| GMP-14 | Acetone | 2.3 J | 5.46 J |
| | Carbon disulfide | 6 | 18.67 |
| | Methyl tert-butyl ether (MTBE) | 15 | 54.07 |
| GMP-24 | 2-Butanone (methyl ethyl ketone) | 1.6 | 4.71 |
| | Acetone | 7.5 | 17.81 |
| | Carbon disulfide | 11 | 34.24 |
| | Trichloroethene | 2 | 10.74 |
| GMP-25 | Carbon disulfide | 1.2 | 3.73 |
| | Dichlorodifluoromethane (Freon-12) | 0.66 J | 3.26 J |
| GMP-26 | Carbon disulfide | 3.2 | 9.96 |
| | Chloroform | 0.57 J | 2.78 J |
| | Tetrachloroethene | 0.56 J | 3.88 J |

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result ($\mu g/m^3$) |
|---|---|---|---|
| GMP-27 | Acetone | 3.2 J | 7.6 J |
| | Carbon disulfide | 1.6 | 4.98 |
| GMP-30 | 2-Butanone (methyl ethyl ketone) | 0.86 | 2.53 |
| | Acetone | 2.7 J | 6.41 J |
| | Carbon disulfide | 1.8 | 5.6 |
| | Cyclohexane | 4 | 13.76 |
| | Heptane | 0.96 | 3.93 |
| | Hexane | 2.7 | 9.51 |
| | m,p-Xylene | 0.54 J | 2.34 J |
| | Toluene | 1.8 | 6.78 |
| GMP-31 | Acetone | 6.9 | 16.39 |
| | Carbon disulfide | 6.2 | 19.3 |
| GMP-32 | 1,1,1-Trichloroethane | 0.73 J | 3.98 J |
| | Acetone | 2.6 J | 6.17 J |
| | Carbon disulfide | 1.2 | 3.73 |
| | Dichlorodifluoromethane (Freon 12) | 0.68 J | 3.36 J |
| | Trichloroethene | 4.2 | 22.57 |
| GMP-33 | Carbon disulfide | 6.6 | 20.54 |
| GMP-35 | Carbon disulfide | 3.1 | 9.65 |
| | Chloroform | 0.54 J | 2.63 J |
| GMP-38 | Acetone | 2.7 J | 6.41 J |
| | Carbon disulfide | 2.4 | 7.47 |
| | Carbon tetrachloride | 1 | 6.29 |
| | Chloroform | 1 | 4.88 |
| | Methyl tert-butyl ether (MTBE) | 160 | 576.85 |
| | Tetrachloroethene | 1.4 | 9.72 |
| SGP-22 | 2-Butanone (methyl ethyl ketone) | 2.9 | 8.55 |
| | Acetone | 14 | 33.25 |
| | Benzene | 1.2 | 3.83 |
| | Carbon disulfide | 0.82 J | 2.55 J |
| | cis-1,2-Dichloroethene | 0.58 J | 2.29 J |
| | Cyclohexane | 2.4 | 8.26 |
| | Heptane | 2.4 | 9.83 |
| | Hexane | 3.8 | 13.39 |
| | Toluene | 0.65 J | 2.44 J |

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result (µg/m$^3$) |
|---|---|---|---|
| SGP-23 | Acetone | 7.4 | 17.57 |
| | Carbon disulfide | 3.3 | 10.27 |
| | Methyl tert-butyl ether (MTBE) | 0.9 J | 3.24 J |
| | Tetrachloroethene | 0.61 J | 4.23 J |
| | Toluene | 1.1 | 4.14 |
| SGP-24 | Acetone | 4.6 | 10.92 |
| | Carbon disulfide | 0.84 | 2.61 |
| | Cyclohexane | 3.6 | 12.39 |
| | Dichlorodifluoromethane (Freon-12) | 0.98 | 4.84 |
| | Heptane | 14 | 57.37 |
| | Hexane | 1 | 3.52 |
| | m,p-Xylene | 0.58 J | 2.51 J |
| | Toluene | 5.4 | 20.34 |
| SGP-25 | 1,4-Dichlorobenzene | 1 | 6.01 |
| | Dichlorodifluoromethane (Freon-12) | 1.1 | 5.43 |
| SGP-26 | 1,2-Dichlorotetrafluoroethane (Freon-114) | 2.4 | 16.77 |
| | Carbon disulfide | 2.1 | 6.53 |
| | Dichlorodifluoromethane (Freon-12) | 7.8 | 38.57 |
| SGP-27 | 1,1-Dichloroethene | 0.71 J | 2.81 J |
| | Carbon disulfide | 1.6 | 4.98 |
| | Chloroform | 2.9 | 14.15 |
| | Trichloroethene | 4.2 | 22.57 |
| SGP-28 | Acetone | 4.9 | 11.63 |
| | Carbon disulfide | 3.9 | 12.14 |
| | Chloroform | 1.1 | 5.37 |
| SGP-29 | Carbon disulfide | 0.98 | 3.05 |
| | Chloroform | 1.8 | 8.78 |
| SGP-30 | Acetone | 2.2 J | 5.22 J |
| | Carbon disulfide | 12 | 37.35 |
| | Chloroform | 2 | 9.76 |
| | Ethanol | 3.2 | 6.03 |
| | Hexane | 1.3 | 4.58 |
| | Methylene chloride | 6.9 | 23.96 |
| | Trichlorofluoromethane (Freon-11) | 0.58 J | 3.25 J |
| SGP-31 | Carbon disulfide | 3.9 | 12.14 |
| | Chloroform | 0.99 J | 4.83 J |
| | Trichlorofluoromethane (Freon-11) | 0.52 J | 2.92 J |
| SGP-32 | Carbon disulfide | 0.96 | 2.98 |

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result (µg/m$^3$) |
|---|---|---|---|
| SGP-33 | 1,2,4-Trimethylbenzene | 0.62 J | 3.04 J |
| | 2-Butanone (methyl ethyl ketone) | 0.96 | 2.83 |
| | 2-Propanol | 2.5 J | 6.14 J |
| | 4-Ethyltoluene | 0.51 J | 2.5 J |
| | Acetone | 3.1 | 7.36 |
| | Benzene | 0.64 J | 2.04 J |
| | Carbon disulfide | 1.6 | 4.98 |
| | Chloroform | 0.54 J | 2.63 J |
| | cis-1,2-Dichloroethene | 0.85 | 3.37 |
| | Cyclohexane | 2.6 | 8.94 |
| | Dichlorodifluoromethane (Freon-12) | 1.5 | 7.41 |
| | Ethanol | 2.7 J | 5.08 J |
| | Ethylbenzene | 1.2 | 5.21 |
| | Heptane | 1.1 | 4.5 |
| | Hexane | 2.2 | 7.75 |
| | m,p-Xylene | 4.1 | 17.8 |
| | Methylene chloride | 0.92 | 3.19 |
| | o-Xylene | 1.4 | 6.07 |
| | Toluene | 26 | 97.98 |
| | Trichloroethene | 0.6 J | 3.22 J |
| SGP-34 | 2-Butanone (methyl ethyl ketone) | 0.85 | 2.5 |
| | Carbon disulfide | 1 | 3.11 |
| | Chloroform | 1.3 | 6.34 |
| SGP-35 | 1,2,4-Trimethylbenzene | 0.54 J | 2.65 J |
| | 2-Butanone (methyl ethyl ketone) | 1.8 | 5.3 |
| | 2-Propanol | 2.7 J | 6.63 J |
| | Acetone | 4 | 9.5 |
| | Benzene | 0.88 | 2.81 |
| | Carbon disulfide | 14 | 43.58 |
| | Chloroform | 5.1 | 24.9 |
| | Cyclohexane | 1.2 | 4.13 |
| | Dichlorodifluoromethane (Freon-12) | 1.3 | 6.42 |
| | Ethylbenzene | 0.84 | 3.64 |
| | Heptane | 0.81 | 3.31 |
| | Hexane | 1.8 | 6.34 |
| | m,p-Xylene | 2.8 | 12.15 |
| | Methylene chloride | 0.76 | 2.63 |
| | o-Xylene | 0.92 | 3.99 |
| | Styrene | 0.6 J | 2.55 J |
| | Tetrahydrofuran | 0.54 J | 1.59 J |
| | Toluene | 12 | 45.22 |

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result (µg/m$^3$) |
|---|---|---|---|
| SGP-36 | Carbon disulfide | 1.6 | 4.98 |
| | Cyclohexane | 2.6 | 8.94 |
| | Dichlorodifluoromethane (Freon-12) | 1.1 | 5.43 |
| | Ethylbenzene | 0.78 | 3.38 |
| | Heptane | 0.74 | 3.03 |
| | Hexane | 1.3 | 4.58 |
| | m,p-Xylene | 2.3 | 9.98 |
| | o-Xylene | 0.93 | 4.03 |
| SGP-37 | 2-Butanone (methyl ethyl ketone) | 0.84 J | 2.47 J |
| | Acetone | 5.3 | 12.58 |
| | Carbon disulfide | 6.8 | 21.17 |
| | Chloroform | 2.9 | 14.15 |
| | Tetrahydrofuran | 0.63 J | 1.85 J |
| SGP-38 | 2-Butanone (methyl ethyl ketone) | 0.73 J | 2.15 J |
| | Carbon disulfide | 1.2 | 3.73 |
| | Toluene | 0.57 J | 2.14 J |
| SGP-39 | 2-Butanone (methyl ethyl ketone) | 1.8 | 5.3 |
| | Acetone | 8.4 | 19.95 |
| | Bromodichloromethane | 1 | 6.7 |
| | Carbon disulfide | 1.6 | 4.98 |
| | Chloroform | 15 | 73.23 |
| | cis-1,2-Dichloroethene | 0.81 J | 3.21 J |
| | m,p-Xylene | 0.66 J | 2.86 J |
| | Toluene | 1.1 | 4.14 |
| | Trichloroethene | 0.84 J | 4.51 J |
| SGP-40 | 2-Butanone (methyl ethyl ketone) | 1.1 | 3.24 |
| | Acetone | 6.5 | 15.44 |
| | Carbon disulfide | 2.2 | 6.84 |
| | Methyl tert-butyl ether (MTBE) | 1.5 | 5.4 |
| SGP-41 | 2-Butanone (methyl ethyl ketone) | 1.9 | 5.6 |
| | Acetone | 9.7 | 23.04 |
| | Carbon disulfide | 6.1 | 18.99 |
| | Chloroform | 1 | 4.88 |
| | Dichlorodifluoromethane (Freon-12) | 1 | 4.94 |
| | Hexane | 0.76 J | 2.67 J |
| | m,p-Xylene | 1 | 4.34 |
| | Toluene | 4.1 | 15.45 |

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result (µg/m$^3$) |
|---|---|---|---|
| TV-01 | 2-Butanone (methyl ethyl ketone) | 1.7 | 5.01 |
| | Acetone | 3.7 | 8.78 |
| | Carbon disulfide | 14 | 43.58 |
| | Chloroform | 0.92 | 4.49 |
| TV-02 | 2-Butanone (methyl ethyl ketone) | 2.1 | 6.19 |
| | Acetone | 12 | 28.5 |
| | Carbon disulfide | 7.7 | 23.97 |
| TV-03 | Chloroform | 2.2 | 10.74 |
| | Dichlorodifluoromethane (Freon-12) | 4 | 19.78 |
| | Heptane | 0.68 J | 2.78 J |
| | Hexane | 0.66 J | 2.32 J |
| | Trichloroethene | 0.63 J | 3.38 J |
| TV-04 | Carbon disulfide | 1.6 | 4.98 |
| | Chloroform | 0.58 J | 2.83 J |
| | Dichlorodifluoromethane (Freon-12) | 1.9 | 9.39 |
| TV-05 | 1,2,4-Trimethylbenzene | 1 | 4.91 |
| | 4-Ethyltoluene | 0.52 J | 2.55 J |
| | Ethanol | 7.1 | 13.38 |
| | m,p-Xylene | 1 | 4.34 |
| | o-Xylene | 0.58 J | 2.51 J |
| TV-06 | 1,2-Dichlorotetrafluoroethane (Freon-114) | 1.8 | 12.58 |
| | Carbon disulfide | 21 | 65.37 |
| | Chloroform | 0.52 J | 2.53 J |
| | Ethanol | 7.1 | 13.38 |
| TV-07 | Acetone | 2.9 J | 6.88 J |
| | Carbon disulfide | 1.3 | 4.04 |
| | Ethanol | 4.7 | 8.85 |
| | m,p-Xylene | 0.66 J | 2.86 J |
| TV-08 | Carbon disulfide | 0.65 J | 2.02 J |
| | Chloroform | 1.1 | 5.37 |
| TV-09 | Tetrahydrofuran | 1 J+ | 2.94 J |
| TV-10 | Carbon disulfide | 0.78 J | 2.42 J |
| | Tetrahydrofuran | 0.94 J | 2.77 J |
| TV-12 | Carbon disulfide | 0.64 J | 1.99 J |

TABLE 1-6
VOCs Detected in Soil Gas (September 2006)
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Analyte | Result (ppbv) | Result (µg/m$^3$) |
|---|---|---|---|
| TV-14 | Chloroform | 4.7 | 22.94 |
| | Dichlorodifluoromethane (Freon-12) | 0.79 J | 3.9 J |
| | m,p-Xylene | 0.83 J | 3.6 J |
| | Tetrachloroethene | 0.52 J | 3.61 J |
| | Toluene | 2.1 | 7.91 |
| TV-15 | Bromodichloromethane | 0.62 J | 4.15 J |
| | Carbon disulfide | 0.55 J | 1.71 J |
| | Chloroform | 16 | 78.12 |
| | Tetrahydrofuran | 0.58 J | 1.71 J |
| TV-16 | Chloroform | 0.76 J | 3.71 J |

Notes:

VOCs were analyzed in an offsite laboratory using method TO-15.
“J” indicates an estimated value.

µg/m$^3$ = microgram per cubic meter
ppbv = parts per billion by volume

# Figures

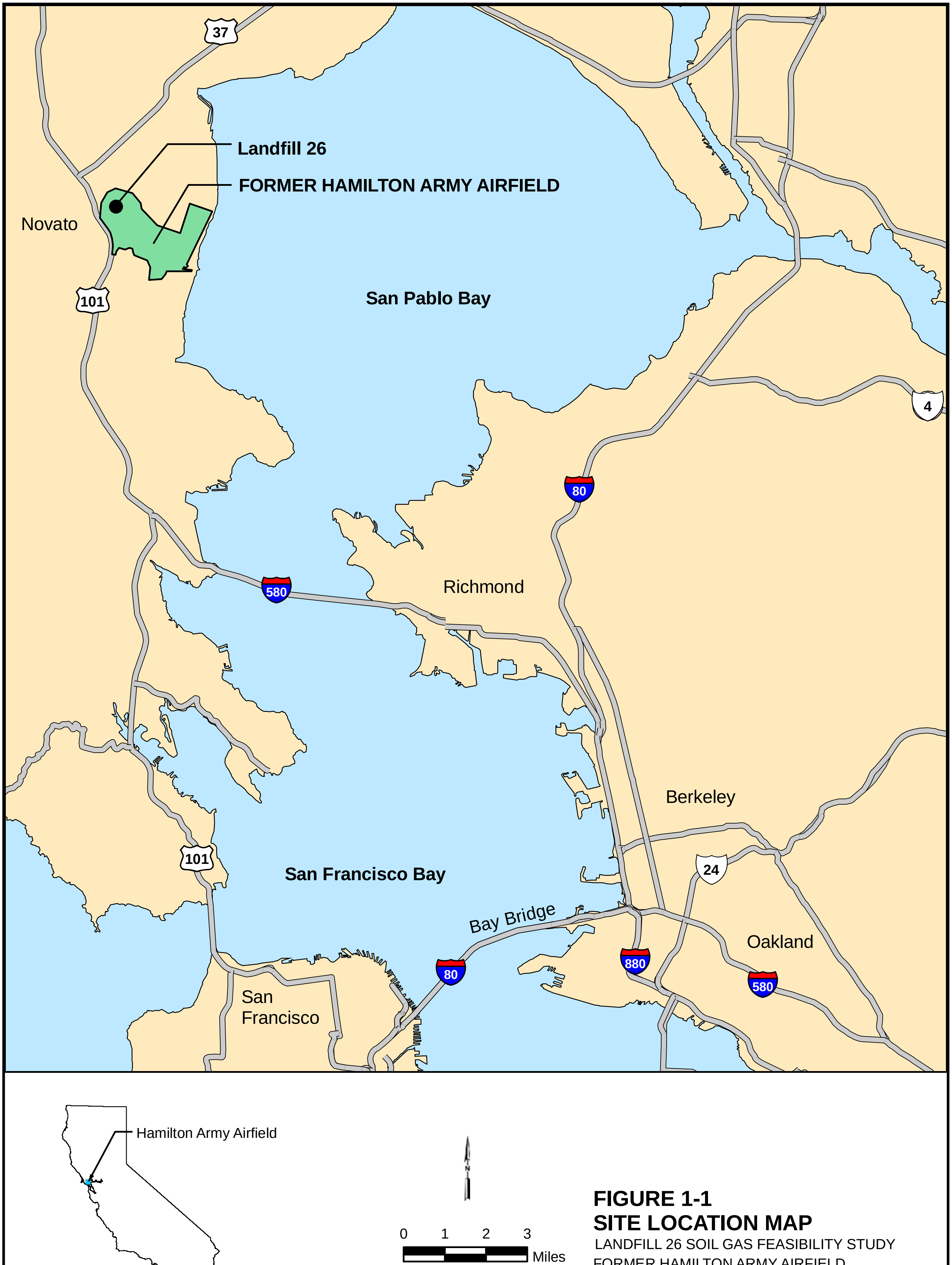


**FIGURE 1-1**
**SITE LOCATION MAP**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL

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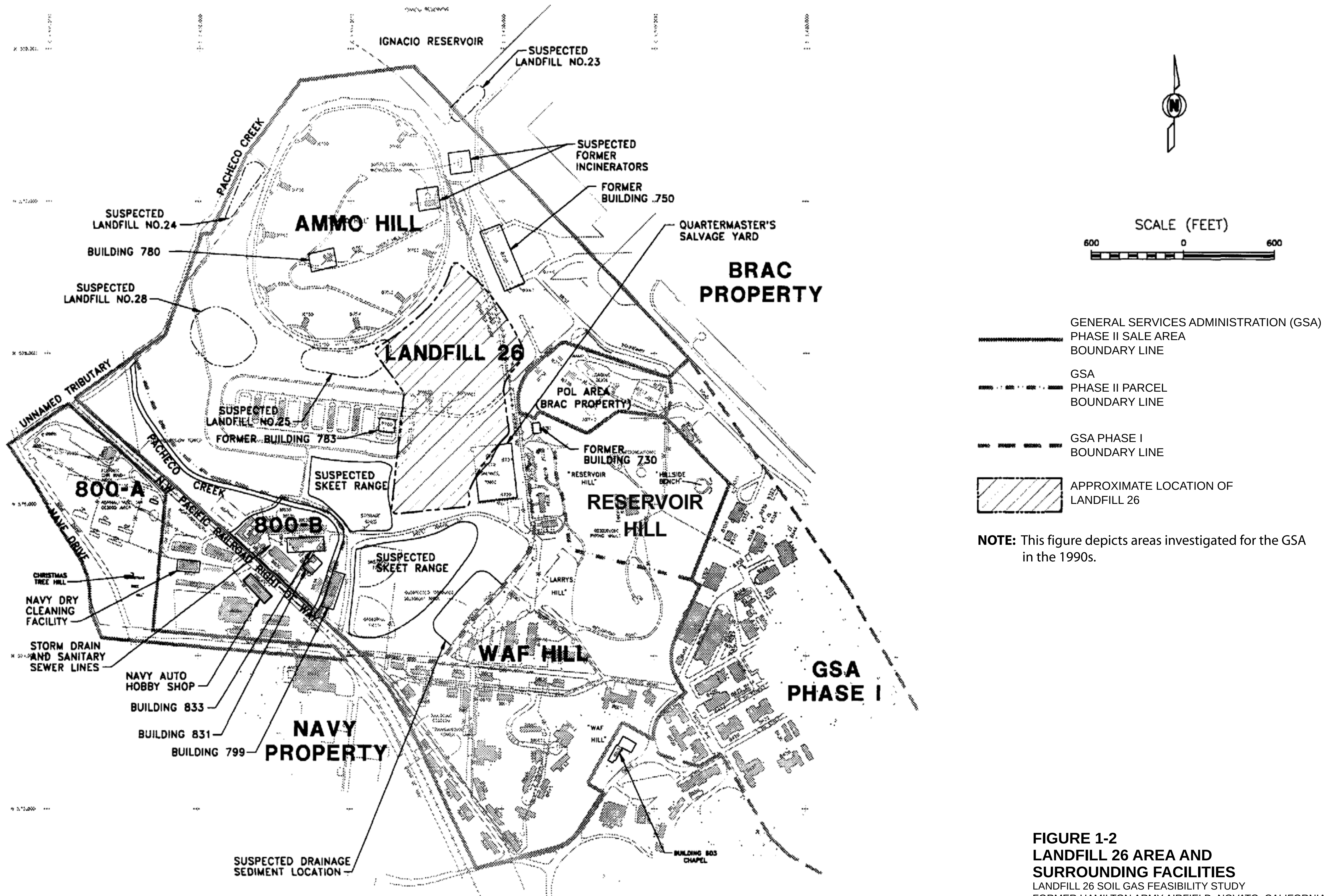


**FIGURE 1-2**
**LANDFILL 26 AREA AND SURROUNDING FACILITIES**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

**SOURCE:** Site Investigation Report 800-B and Ammo Hill Parcels, GSA Phase II Sale Area (IT, 1998a)

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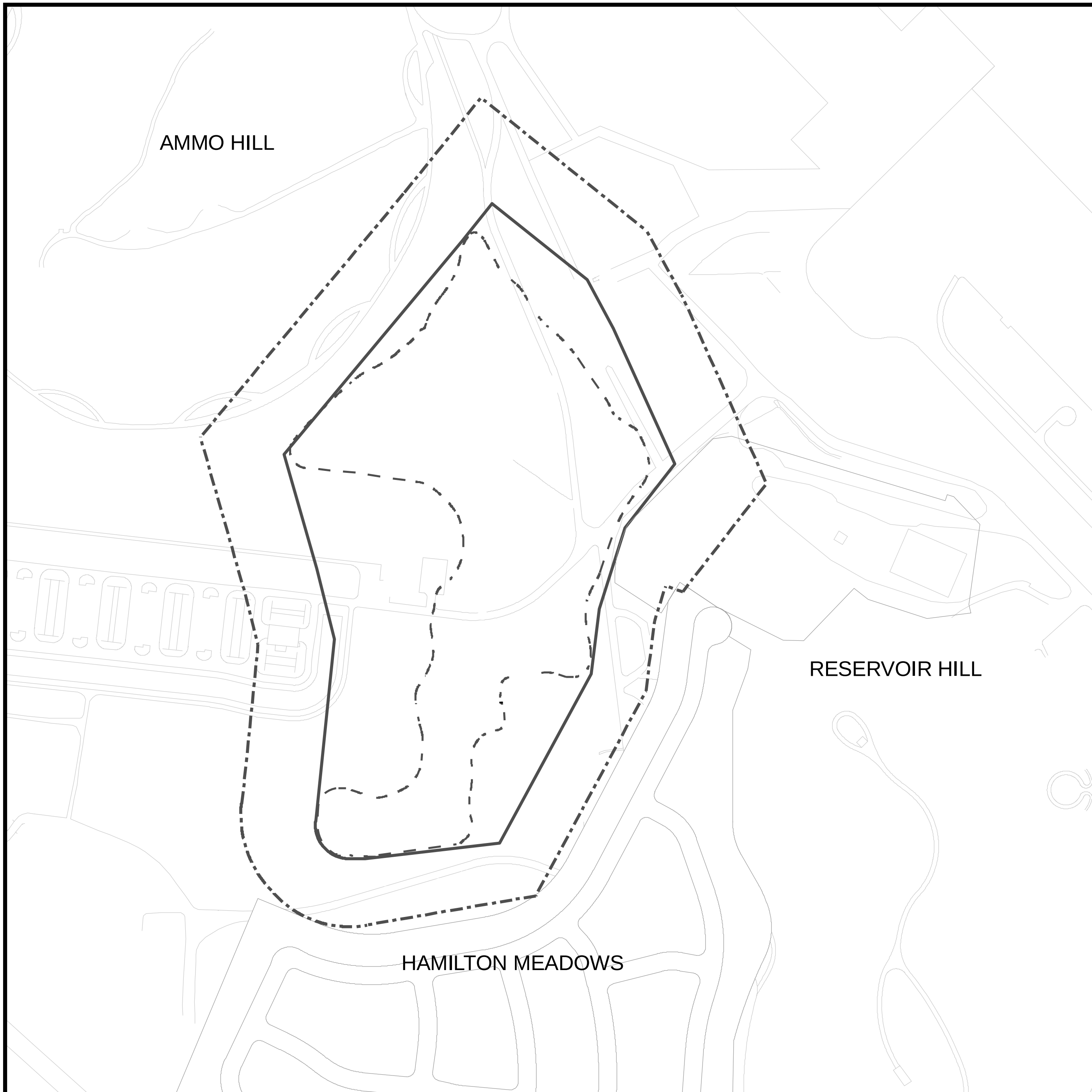


**LEGEND**

- EXTENT OF REFUSE
- RCRA-TYPE CAP BOUNDARY
- LANDFILL BUFFER ZONE BOUNDARY

SOURCE: MODIFIED FROM *SUMMARY TECHNICAL REPORT FOR LANDFILL 26 AT HAMILTON ARMY AIRFIELD* (WCC, 1997)

0 200 400
FEET

## FIGURE 1-3
## LANDFILL 26 SITE MAP

LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD,
NOVATO, CALIFORNIA

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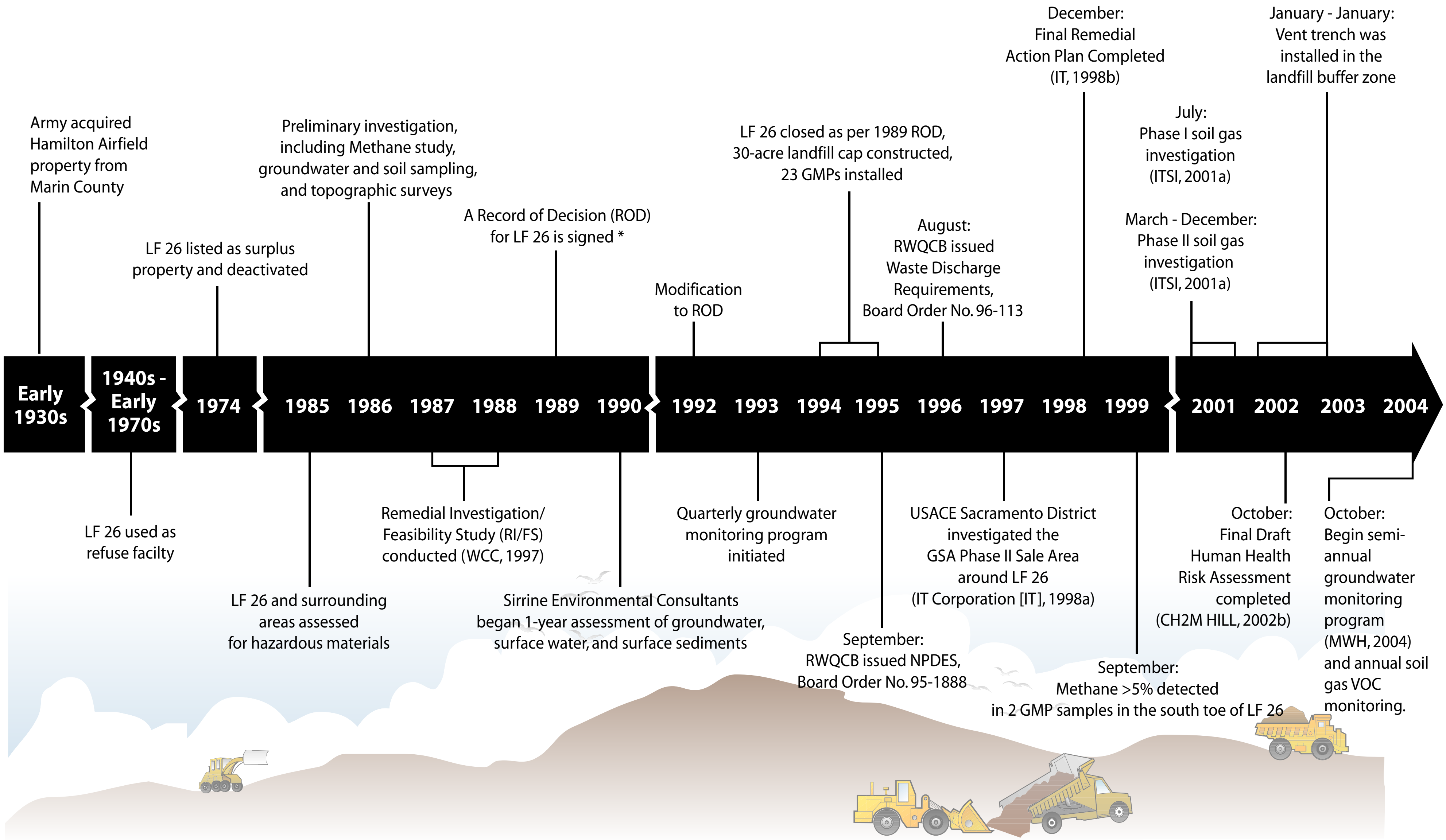


** On August 11, 1989, a Record of Decision (ROD) for LF 26 was signed that included eight remedial alternatives. The ROD described the selected remedial alternative, based on the Feasibility Study conducted in 1988. Chemical fixation and Class II closure with a variance was selected as the proposed remedy. This ROD was subsequently overturned in 1992.*

**FIGURE 1-4**
**TIMELINE OF LANDFILL 26 MILESTONE EVENTS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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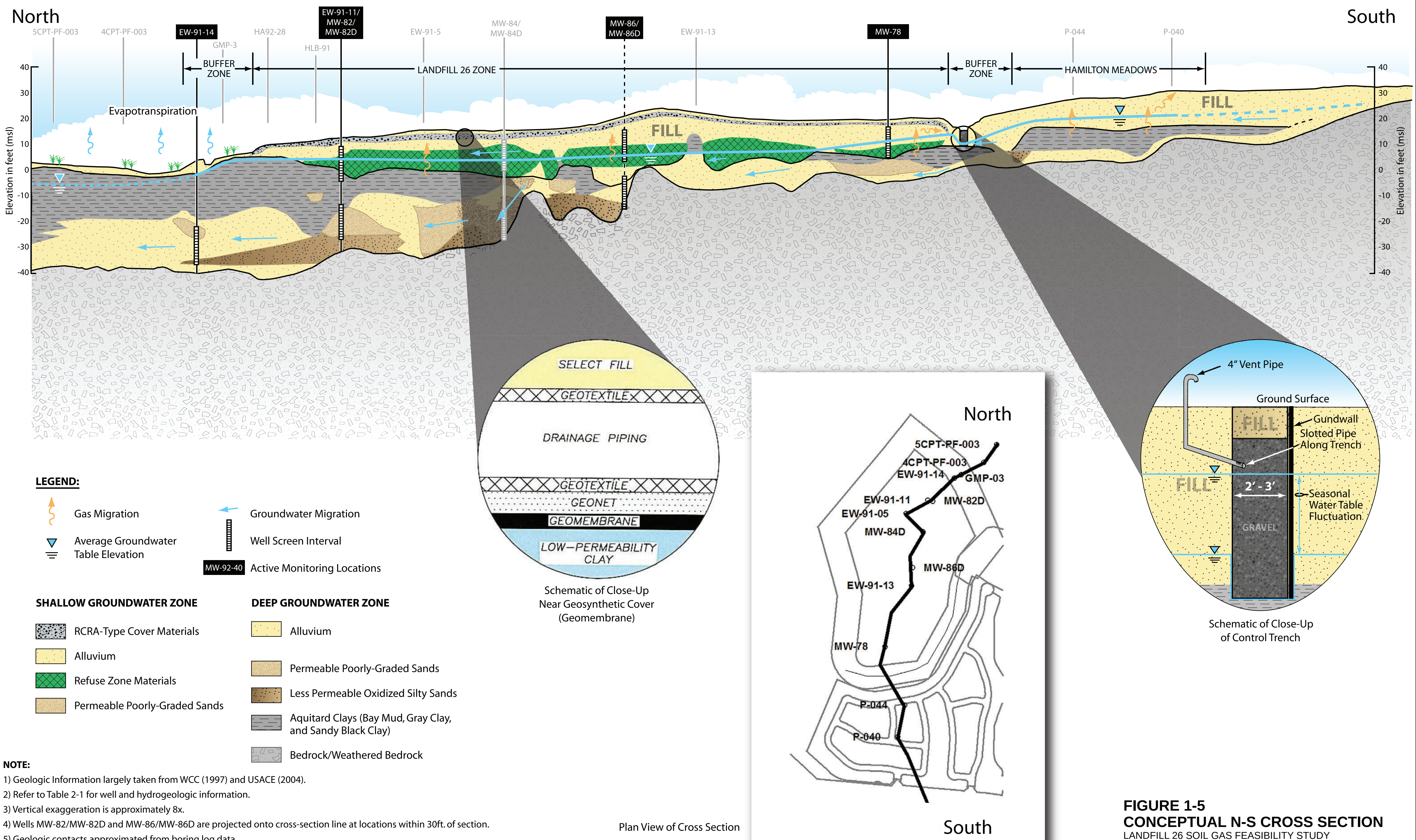


Plan View of Cross Section

**NOTE:**

1) Geologic Information largely taken from WCC (1997) and USACE (2004).
2) Refer to Table 2-1 for well and hydrogeologic information.
3) Vertical exaggeration is approximately 8x.
4) Wells MW-82/MW-82D and MW-86/MW-86D are projected onto cross-section line at locations within 30ft. of section.
5) Geologic contacts approximated from boring log data.
6) Bay Mud logged at MW-86 was not included in the section to the west as presented in WCC (1997).

**FIGURE 1-5**
**CONCEPTUAL N-S CROSS SECTION**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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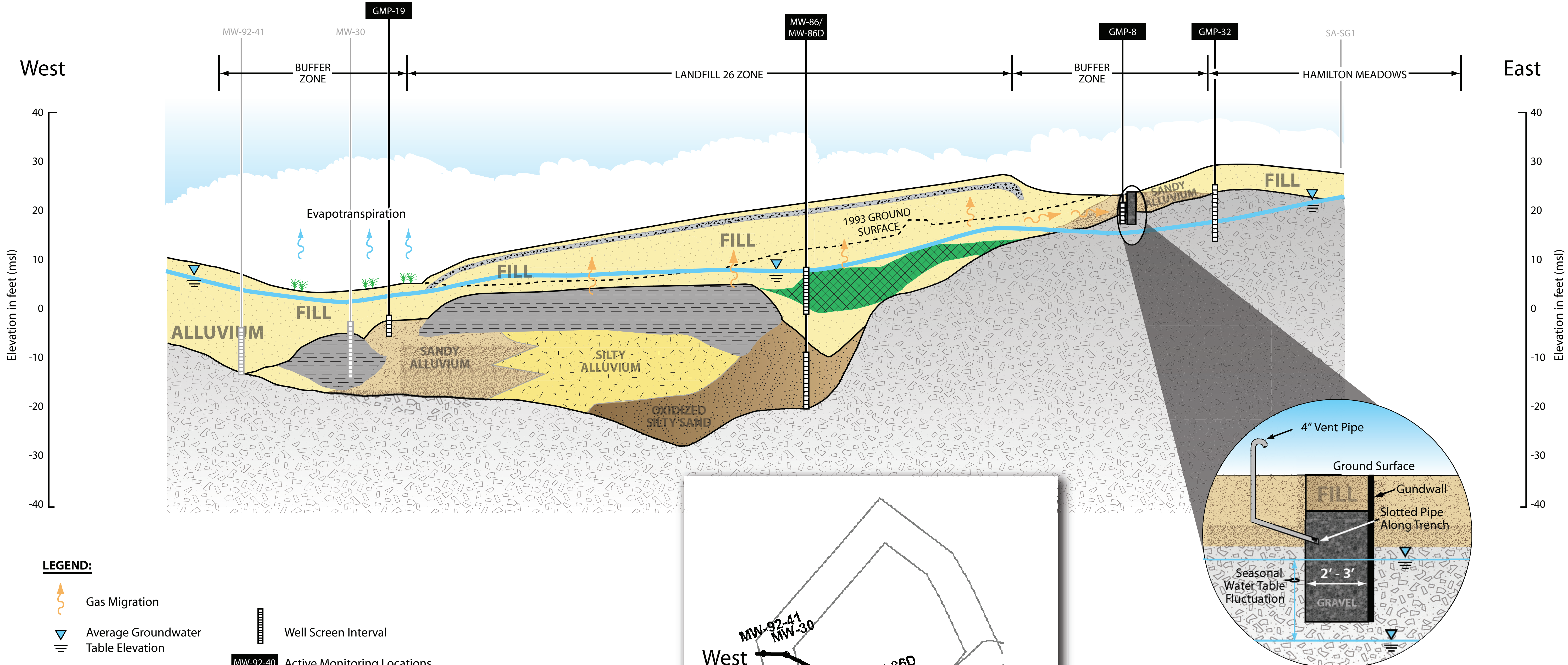
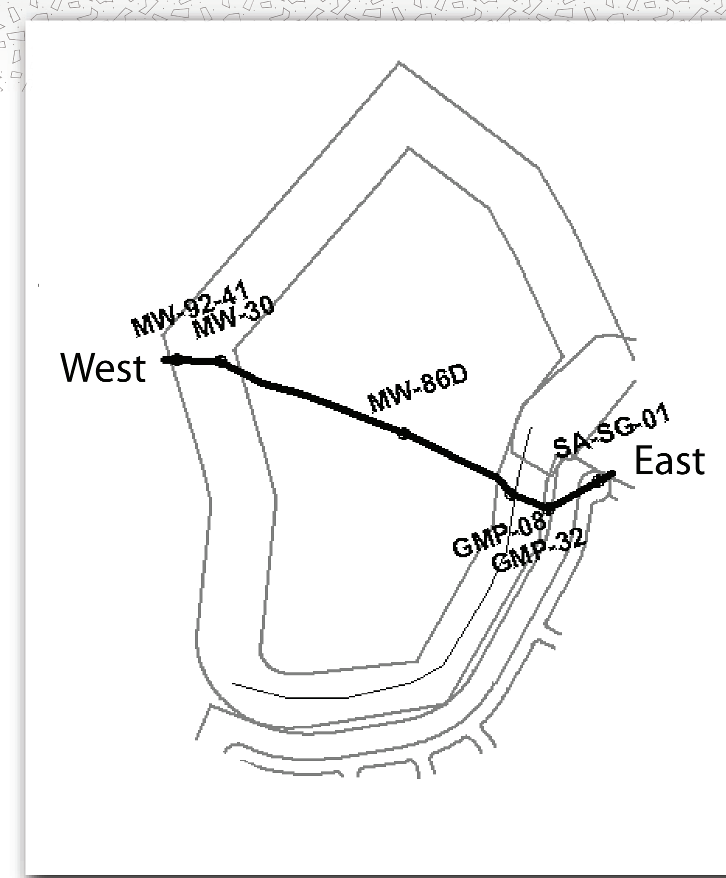



Schematic of Close-Up of Control Trench




Plan View of Cross Section

**LEGEND:**

Gas Migration

Average Groundwater Table Elevation

Well Screen Interval

MW-92-40 Active Monitoring Locations

**SHALLOW GROUNDWATER ZONE**

- RCRA-Type Cover Materials
- Alluvium
- Refuse Zone Materials
- Permeable Poorly-Graded Sands

**DEEP GROUNDWATER ZONE**

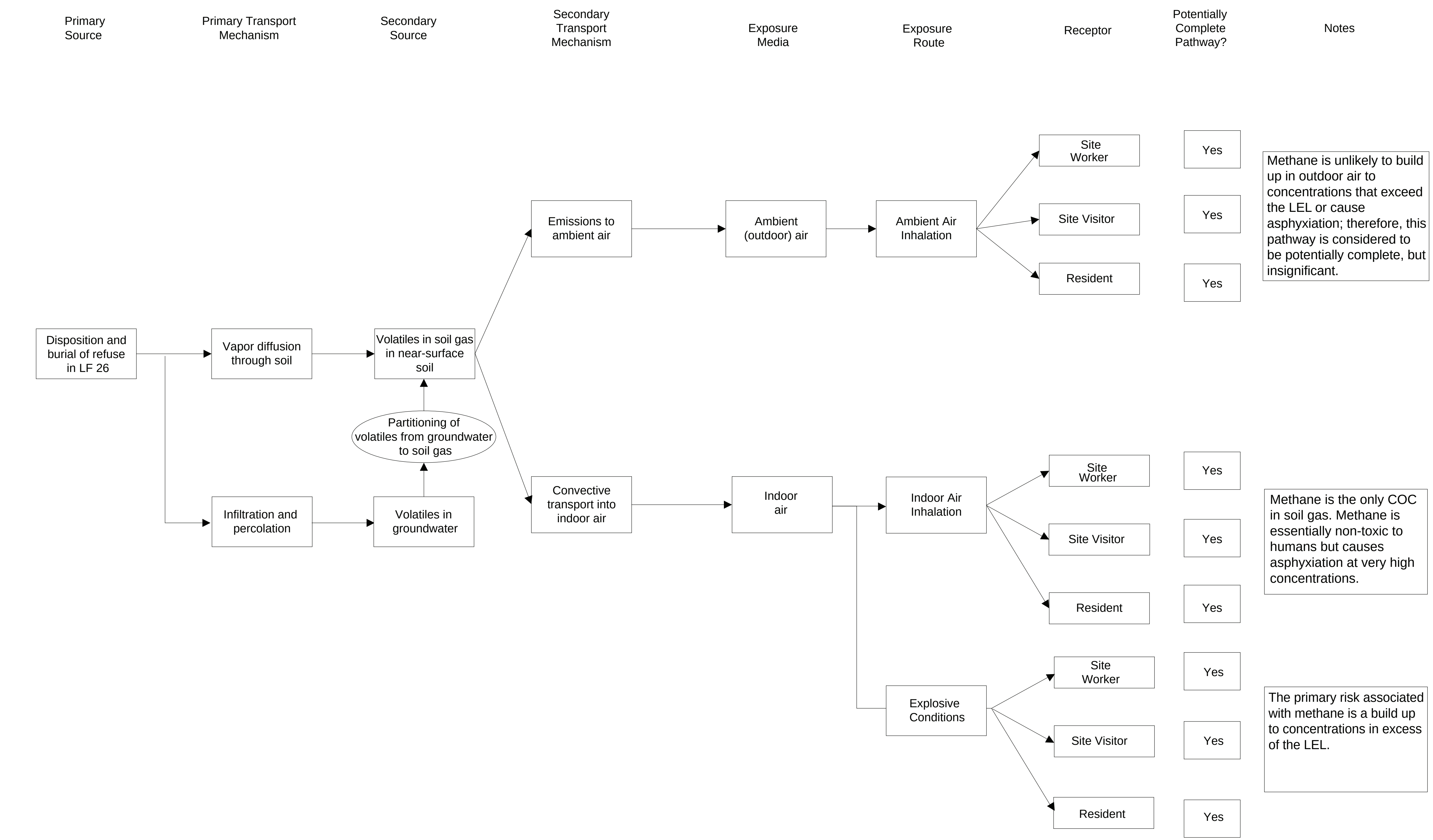
- Alluvium
- Permeable Poorly-Graded Sands
- Less Permeable Oxidized Silty Sands
- Aquitard Clays (Bay Mud, Gray Clay, and Sandy Black Clay)
- Bedrock/Weathered Bedrock

**NOTE:**

1) Geologic Information largely taken from WCC (1997) and USACE (2004).
2) Refer to Table 2-1 for well and hydrogeologic information.
3) Vertical exaggeration is approximately 8x.
4) Dominant groundwater flow direction is perpendicular to section towards the north.
5) Geologic contacts approximated from boring log data.

**FIGURE 1-6**
**CONCEPTUAL E-W CROSS SECTION**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

CH2MHILL




Notes:
LEL = lower explosive limit

**FIGURE 1-7**
**CONCEPTUAL SITE MODEL - IDENTIFICATION OF POTENTIALLY COMPLETE EXPOSURE PATHWAYS FOR SOIL GAS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

*Source: CH2M HILL 2002, Workplan for HHRA of VOCs in Soil Gas Near Hamilton Army Airfield, Landfill 26, Novato, California*

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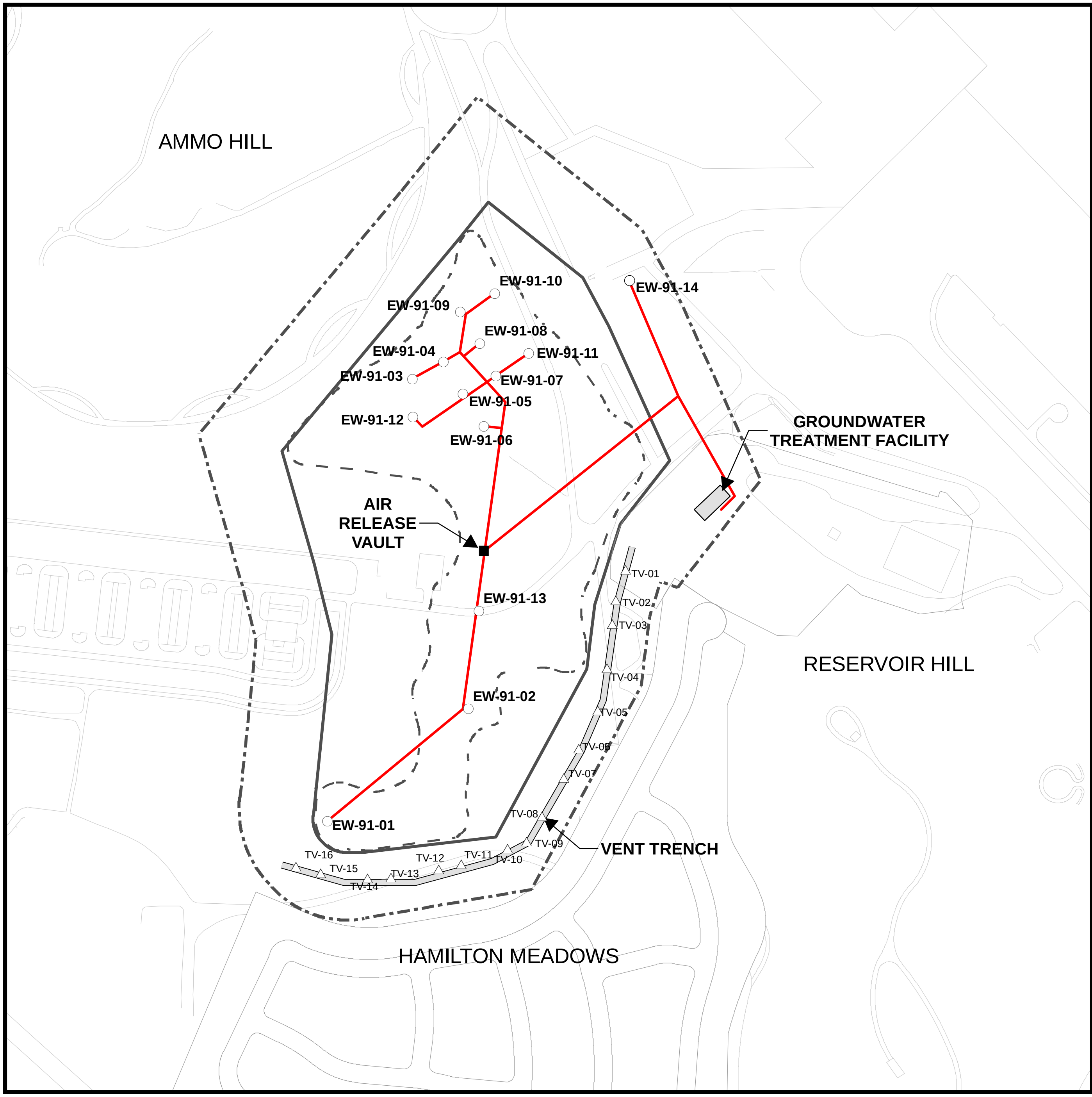



**LEGEND**

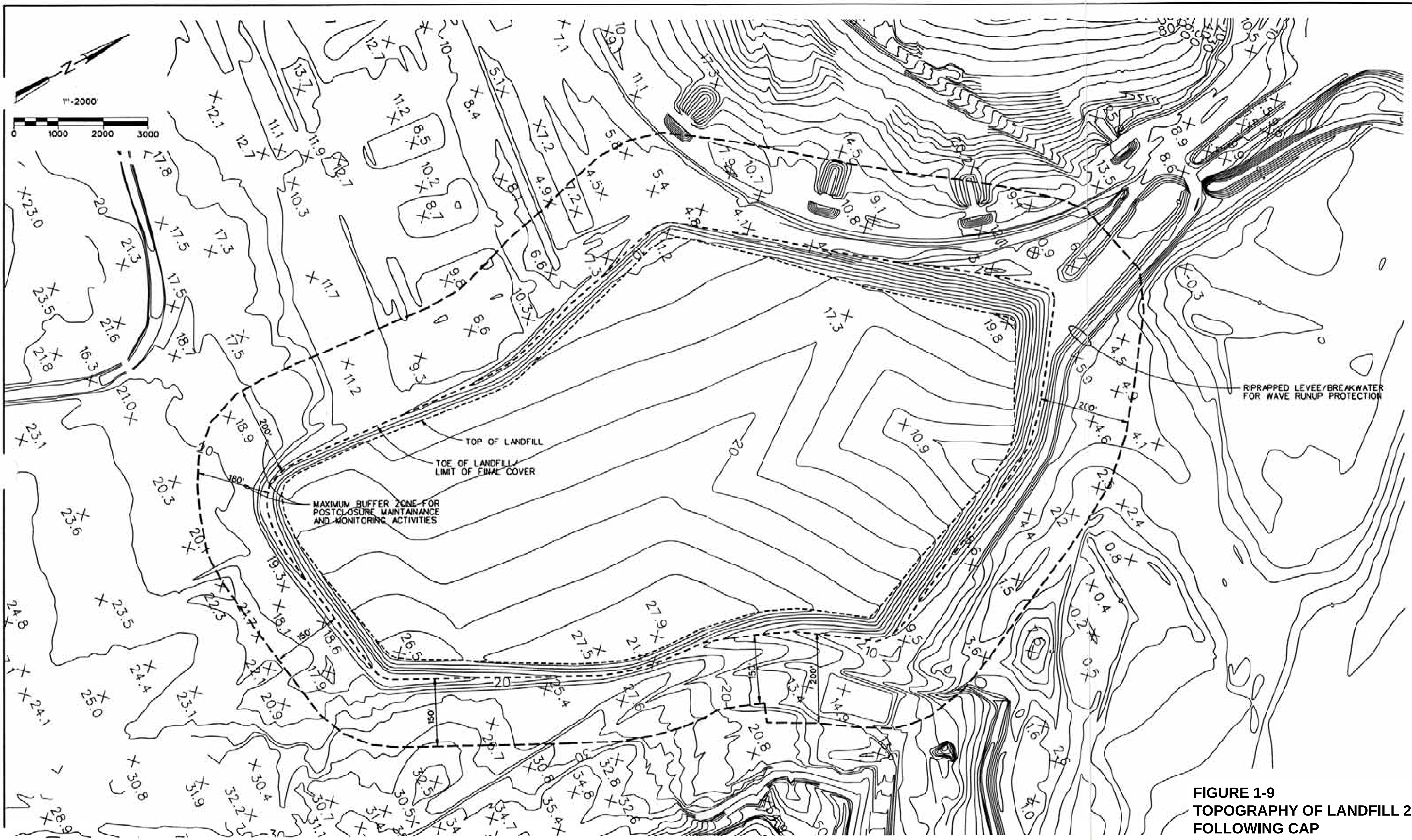
- ○ GROUNDWATER EXTRACTION WELL
- GROUNDWATER EXTRACTION SYSTEM
- PASSIVE VENTING TRENCH
- △ TRENCH VENT
- EXTENT OF REFUSE
- RCRA-TYPE CAP BOUNDARY
- LANDFILL BUFFER ZONE BOUNDARY

SOURCE: MODIFIED FROM *SUMMARY TECHNICAL REPORT FOR LANDFILL 26 AT HAMILTON ARMY AIRFIELD* (WCC, 1997)

**FIGURE 1-8**
**EXISTING REMEDIES AT LANDFILL 26**

LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD,
NOVATO, CALIFORNIA

CH2MHILL




OTE: EXISTING TOPOGRAPHY AND PLANIMETRIC FEATURES ARE TAKEN FROM GROUND SURVEYS AND PHOTOGRAMMETRIC MAPPING PREPARED BY: HUNTER SURVEYING INC., 6216 MAIN AVENUE, SUITE A, ORANGEVALE, CA 95662, TELEPHONE NUMBER (916) 988-5600.

DATE OF PHOYOGRAPHY: NOVEMBER 25, 1996 AND FEBRUARY 13, 1997.

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**FIGURE 1-9**
**TOPOGRAPHY OF LANDFILL 26 FOLLOWING CAP INSTALLATION (1996)**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD,
NOVATO, CALIFORNIA

CH2MHILL

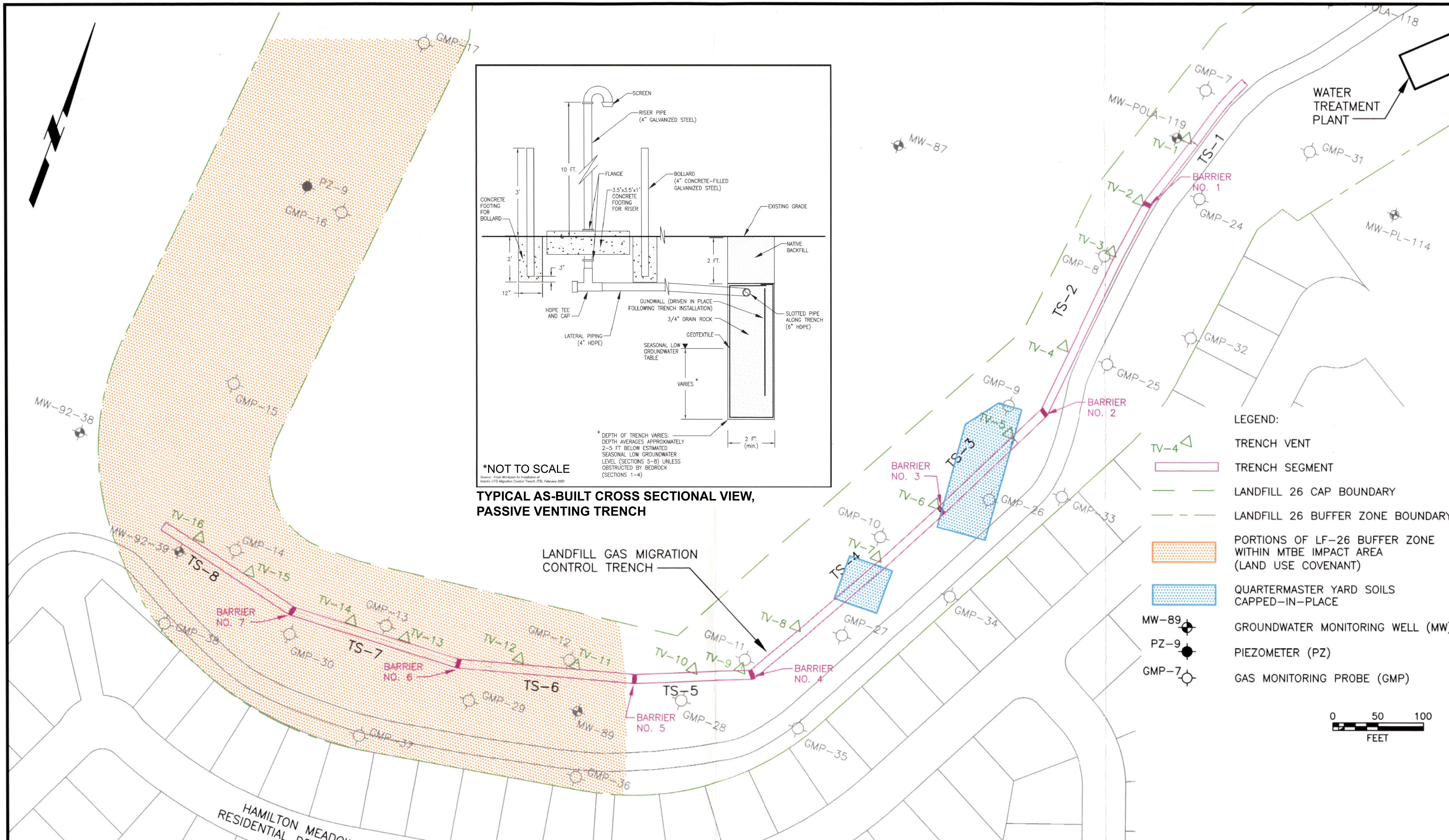


**FIGURE 1-10**
**PASSIVE VENTING TRENCH SCHEMATIC**
LANDFILL 26 FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD,
NOVATO, CALIFORNIA

*Source: Final Workplan for Installation of Interim LFG Migration Control Trench, ITSI, February 2002*

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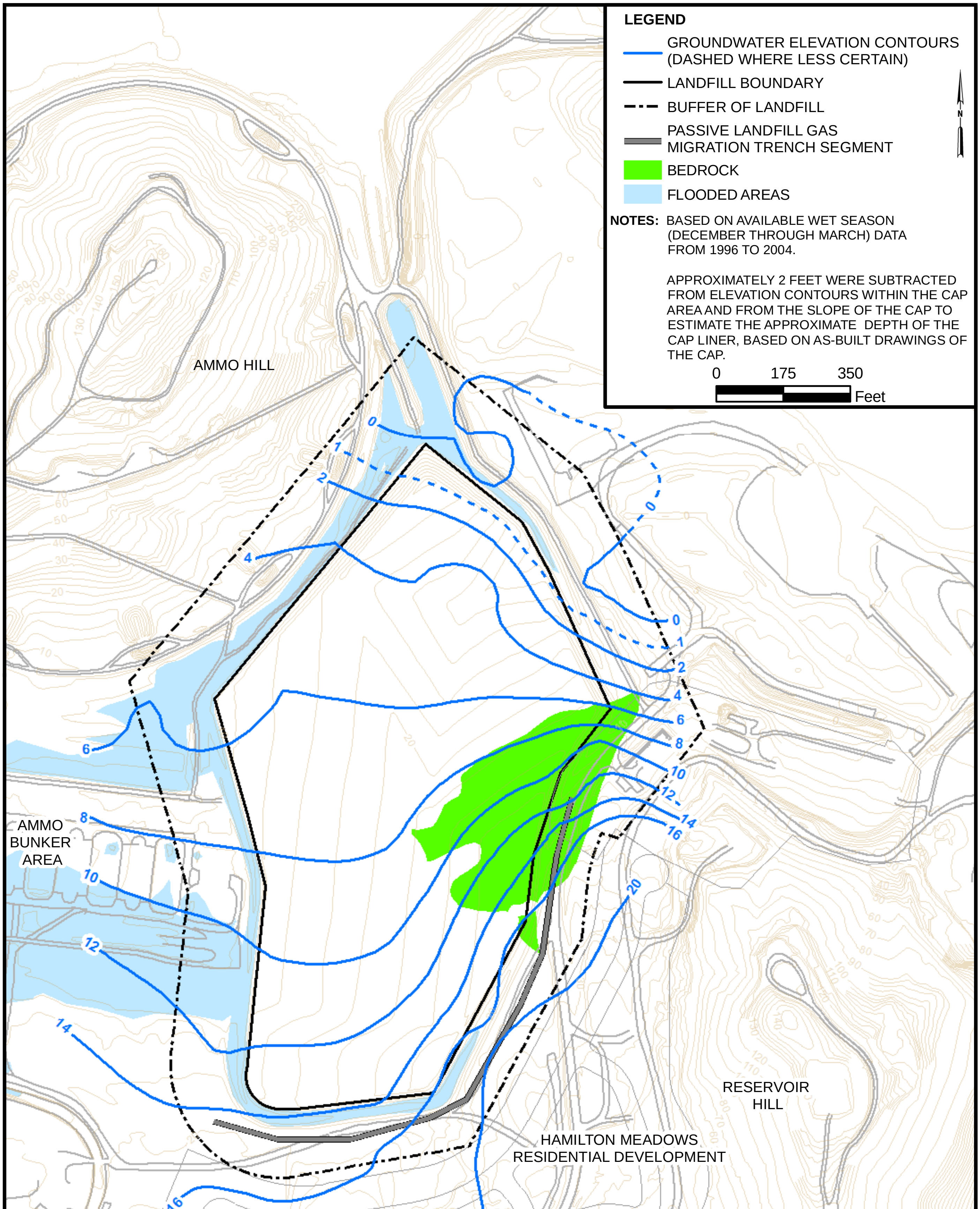


**FIGURE 1-11**
**APPROXIMATE LOCATION OF SHALLOW GROUNDWATER AND BEDROCK**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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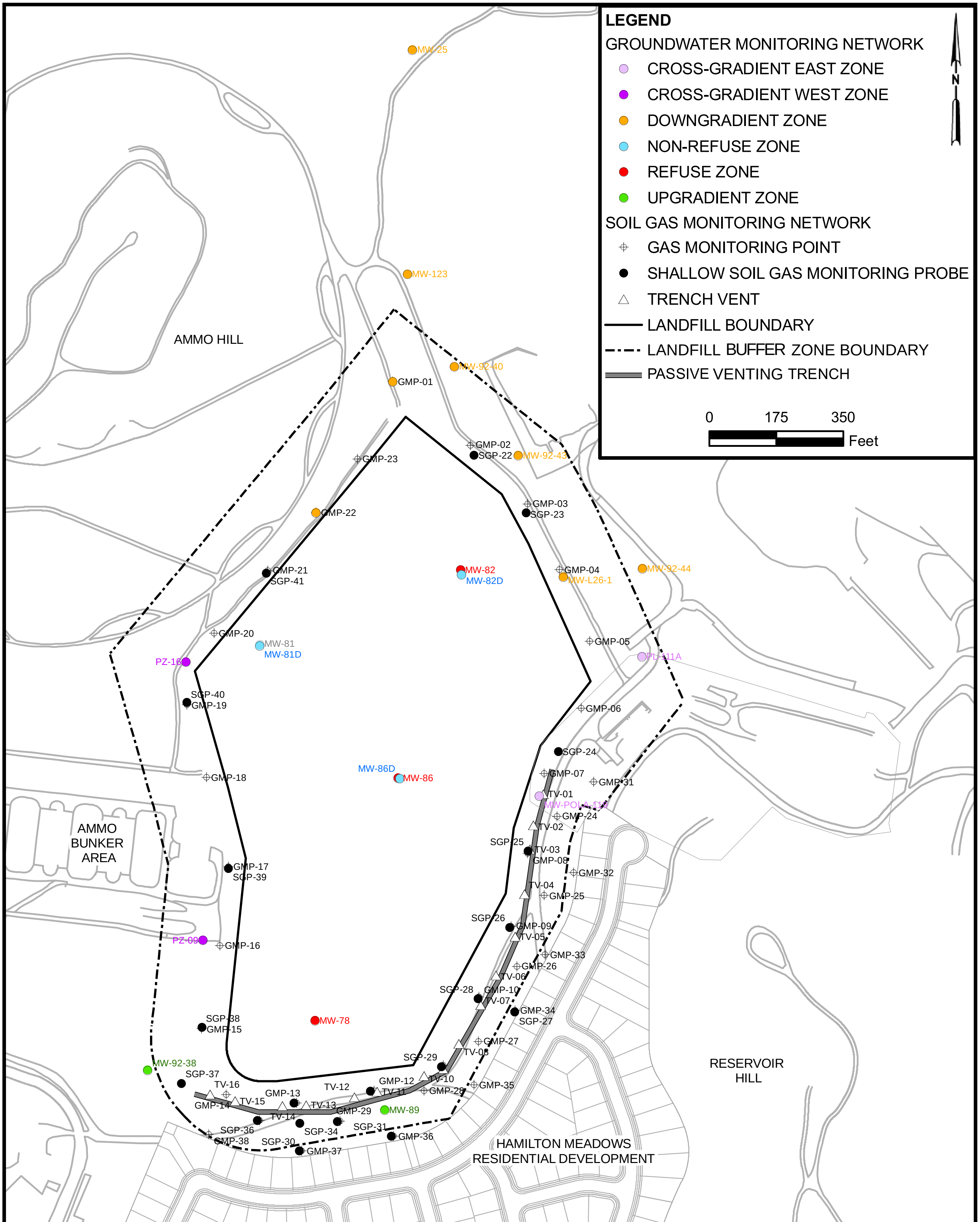


**FIGURE 1-12**
**CURRENT MONITORING NETWORK**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA
CH2MHILL

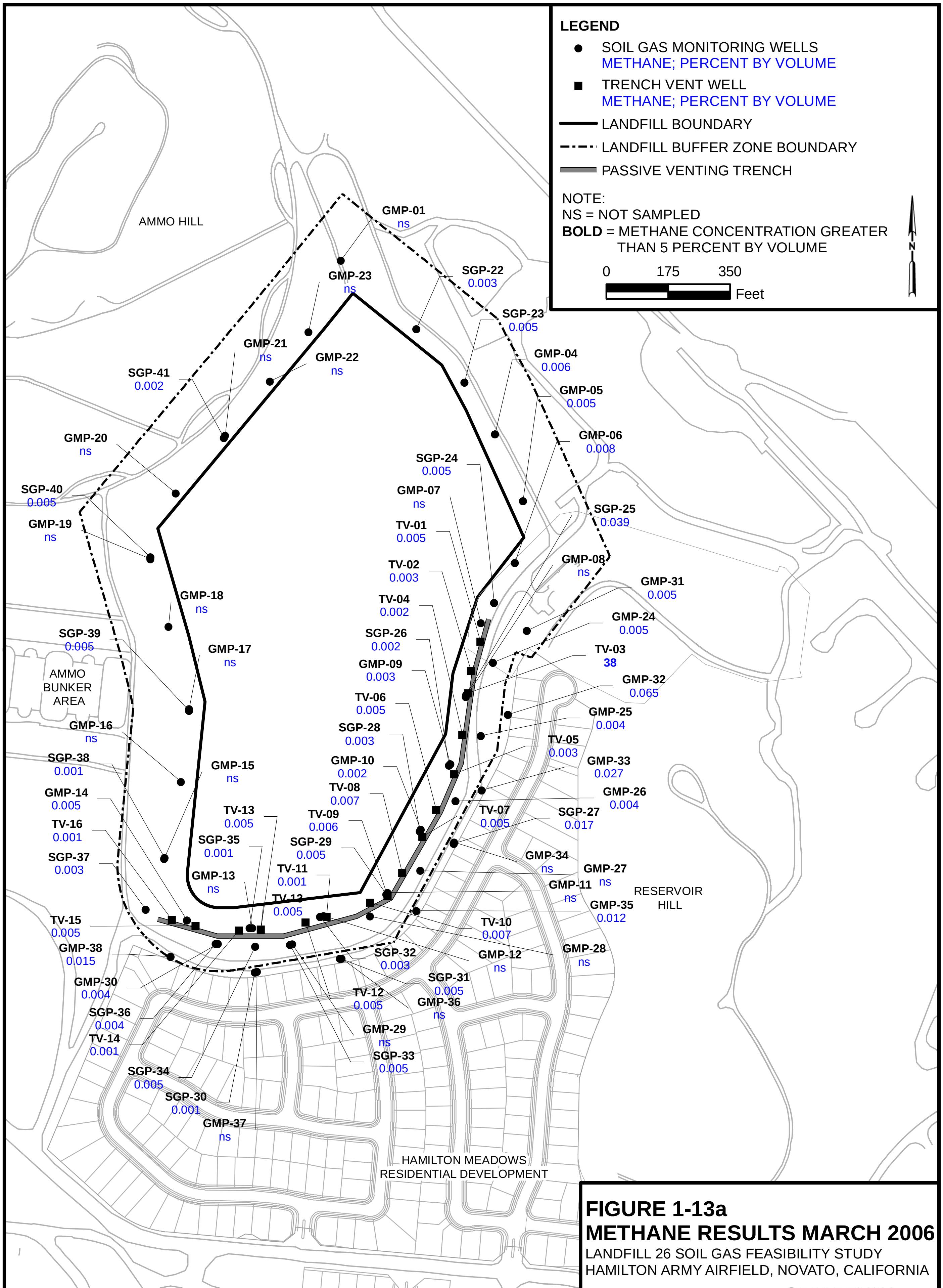


**FIGURE 1-13a**
**METHANE RESULTS MARCH 2006**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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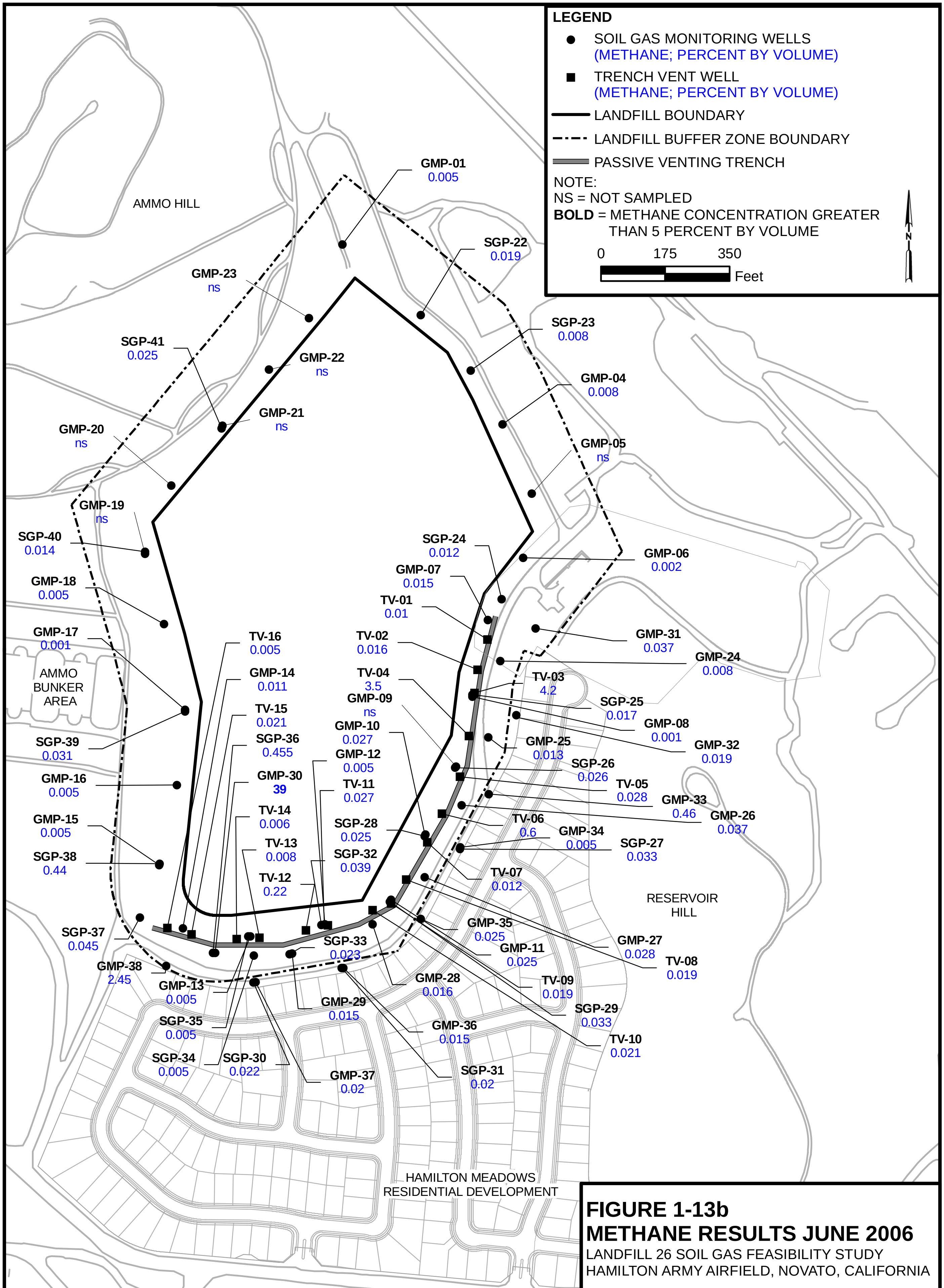


## FIGURE 1-13b
## METHANE RESULTS JUNE 2006

LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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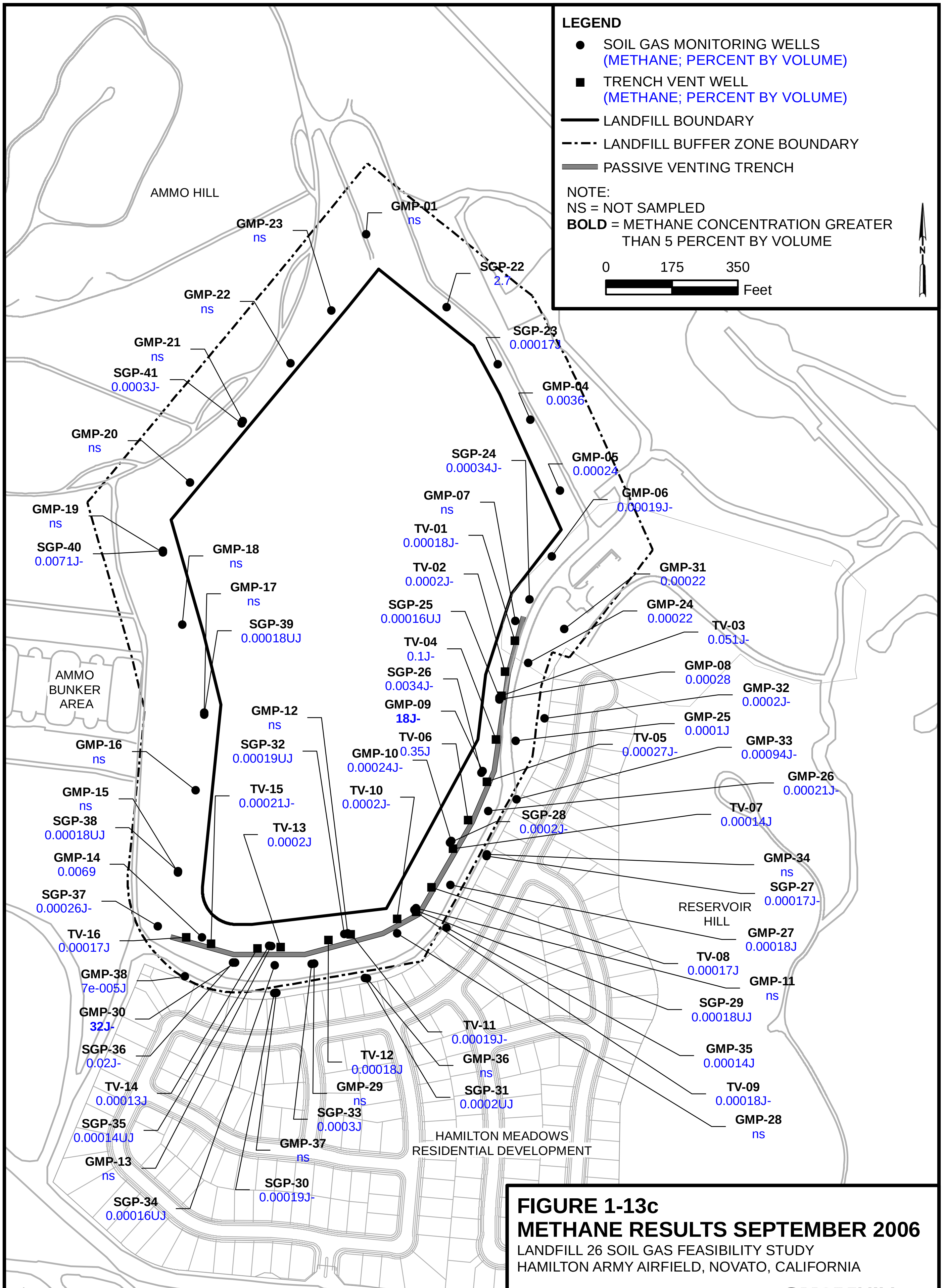
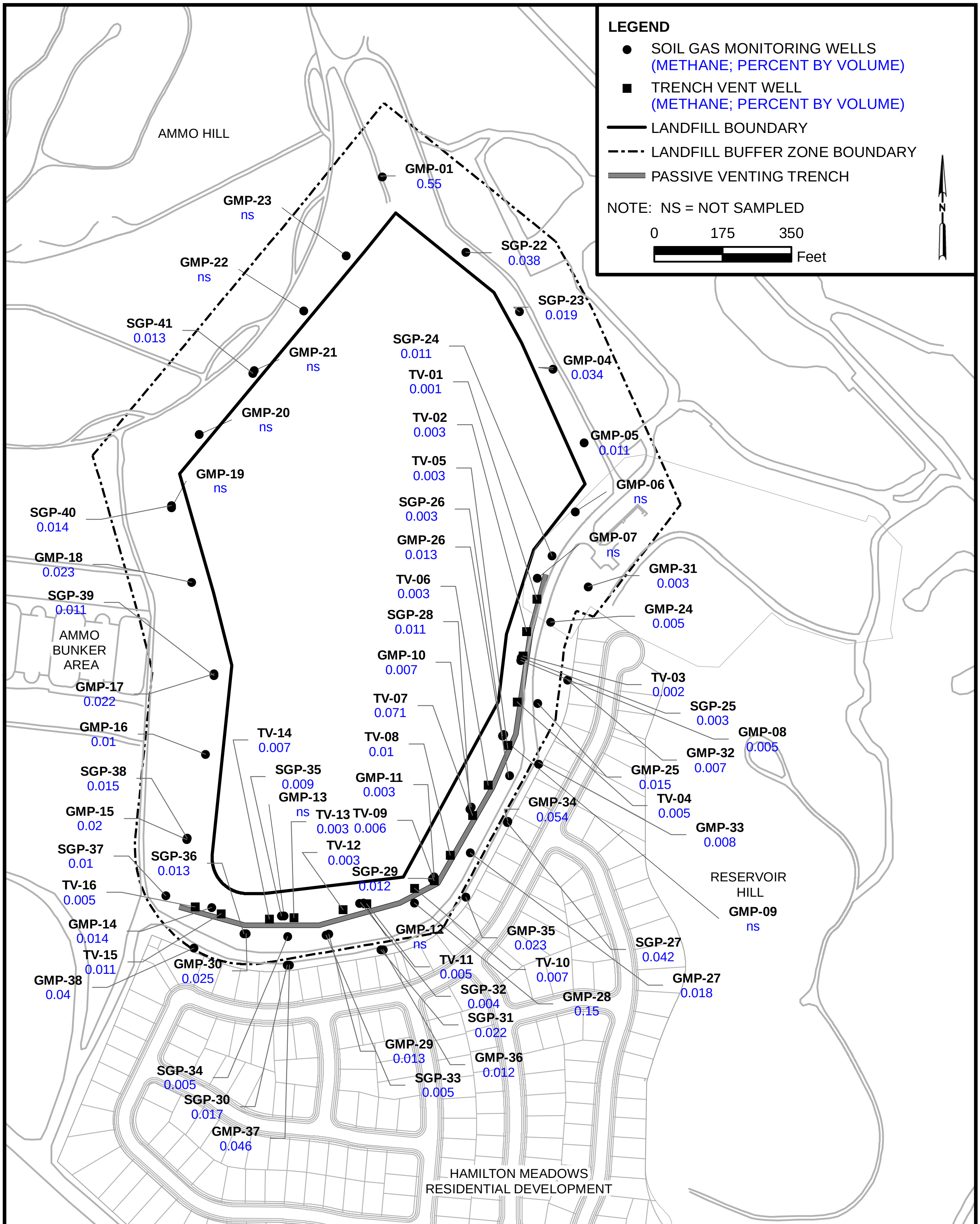



**FIGURE 1-13c**
**METHANE RESULTS SEPTEMBER 2006**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA




# FIGURE 1-13d
# METHANE RESULTS DECEMBER 2006

LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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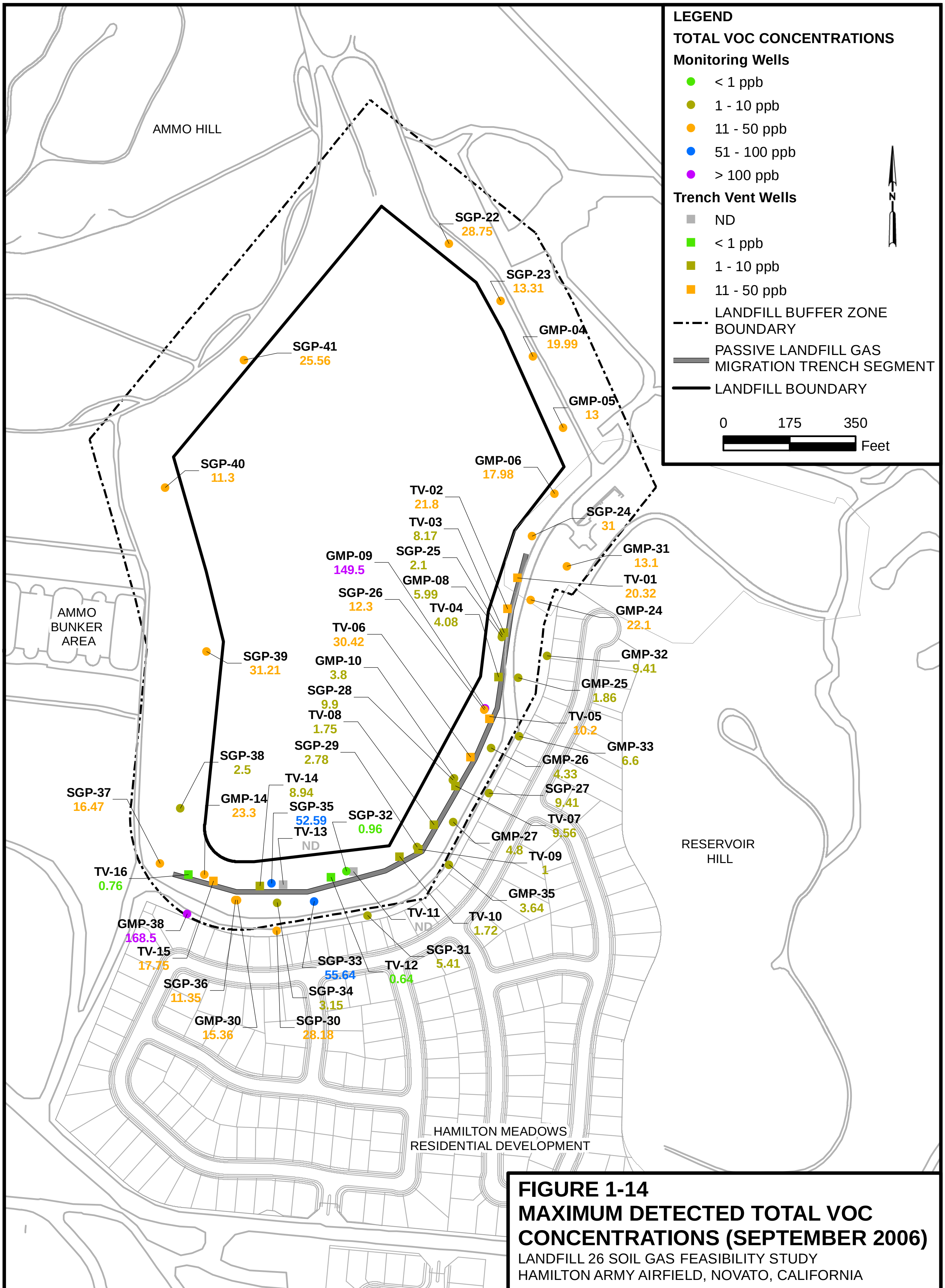


# FIGURE 1-14
# MAXIMUM DETECTED TOTAL VOC CONCENTRATIONS (SEPTEMBER 2006)

LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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SECTION 2

# Derivation of Remedial Requirements

This section presents the RAOs for soil gas, identified ARARs, and preliminary cleanup goals for soil gas at LF 26.

## 2.1 Remedial Action Objectives

RAOs define the extent to which a site will require a remedy to meet the objectives of protecting human health and the environment. For this FS, the medium of concern is limited to soil gas. The only COC in soil gas at LF 26 is methane associated with LF 26 refuse (not naturally occurring methane). The primary risk to human health associated with methane is related to potential explosive conditions that could result from a buildup of methane to concentrations at or above the LEL. The following RAO reflects this conceptual model.

The RAO for soil gas at LF 26 is the protection of human health from explosive conditions that could result from the migration and buildup of methane. The objective of the remedy will be met if:

1. The concentration of methane associated with LF 26 refuse (not naturally occurring methane) is at or below the LEL (5 percent by volume) at the facility property boundary (point of compliance)[1]; and

2. The concentration of methane is at or below 25 percent of the LEL (1.25 percent by volume) in structures within the landfill boundary.

## 2.2 Applicable or Relevant and Appropriate Requirements

Section 121(d) of the CERCLA states that remedial actions at CERCLA sites must attain (or justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be ARARs. Applicable requirements are those cleanup standards, criteria, or limitations promulgated under federal or state law that specifically extend to the situation at a CERCLA site. A requirement is applicable if the jurisdictional prerequisites of the environmental standard show a direct correspondence when objectively compared with the conditions at the site.

If a requirement is not applicable, the requirement may be relevant and appropriate. Relevant and appropriate requirements are those cleanup standards; standards of control; and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations sufficiently similar to the circumstances of the proposed response action and are

[1] California Code of Regulations (CCR) Title 27, Section 20921 indicates that methane must be at or below the LEL (5 percent by volume) at the "facility property boundary", or "point of compliance." For the purposes of this FS, the "point of compliance" is considered to be the outermost edge of the buffer zone.

well-suited to the conditions of the site. The criteria for determining relevance and appropriateness are listed in Title 40, Code of Federal Regulations (CFR), Section 300.400(g)(2).

ARARs are concerned only with substantive, not administrative, requirements of a statute or regulation. The substantive portions of the regulation are those requirements that pertain directly to actions or conditions in the environment. Examples of substantive requirements include quantitative health- or risk-based restrictions upon exposure to types of hazardous substances. Administrative requirements are the mechanisms that facilitate implementation of the substantive requirements. Administrative requirements include issuance of permits, documentation, reporting, recordkeeping, and enforcement. Thus, in determining the extent to which onsite CERCLA response actions must comply with environmental laws, a distinction should be made between substantive requirements, which may be ARARs, and administrative requirements, which are not.

Furthermore, the ARARs provision in CERCLA applies to onsite actions. "Onsite" is defined as the areal extent of contamination and areas in proximity to it necessary for the implementation of the remedy. According to CERCLA §121(e), a remedial response action that takes place entirely onsite is exempt from administrative portions of ARARs and may proceed without the obtaining of permits. This permit exemption applies to all administrative requirements, as well as to permits. Actions taken offsite must comply with all applicable laws and regulations.

Pursuant to EPA guidance, ARARs generally are classified into three categories: chemical-specific, location-specific, and action-specific requirements. These three categories of ARARs are defined below:

- **Chemical-specific ARARs** include those laws and requirements that regulate the release to the environment of materials possessing certain chemical or physical characteristics or containing specified chemical compounds. These requirements generally set health- or risk-based concentration limits or discharge limitations for specific hazardous substances. If, in a specific situation, a chemical is subject to more than one discharge or exposure limit, the more stringent of the requirements should generally be applied.
- **Location-specific ARARs** are those requirements that relate to the geographical or physical position of the site, rather than the nature of the contaminants or the proposed site remedial actions. These requirements may limit the placement of remedial action and may impose additional constraints on the cleanup action.
- **Action-specific ARARs** are requirements that define acceptable handling, treatment, and disposal procedures for hazardous substances. These ARARs generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Because a remedial site usually involves several alternative actions, very different action-specific requirements can apply.

A requirement may not meet the definition of ARAR as defined above, but may still be useful in determining whether or how to take action at a site or to what degree action is necessary. This can be particularly true when there are no ARARs for a site, action, or contaminant. Such requirements are called to-be-considered (TBC) criteria. TBC materials are non-promulgated advisories or guidance issued by federal or state government that are not legally binding, but that may provide useful information or recommended procedures for remedial action. Although TBCs do not have the status of ARARs, they may be considered together with ARARs to establish the cleanup levels or processes for protection of human health or the environment. The critical difference between a TBC criterion and an ARAR is that one is not required to comply with or meet a TBC criterion when deciding on a remedial action.

### 2.2.1 Chemical-specific ARARs

For this FS, the environmental medium of concern is soil gas and the sole COC is methane associated with LF 26 refuse (not naturally occurring methane). Potential chemical-specific ARARs for this FS that establish levels that are protective of human health in the event of exposure to soil gas are provided in Table 2-1.

### 2.2.2 Location-specific ARARs

No potential state and federal location-specific ARARs for the alternatives presented in this FS have been identified.

### 2.2.3 Action-specific ARARs

Action-specific ARARs related to cleanup of contamination at LF 26 depend on which remedial technologies and process options are selected. Action-specific ARARs determine how and where specific activities can be performed, not what cleanup goals need to be met. Additional detailed discussions of these ARARs are presented in Table 2-2.

## 2.3 Cleanup Goals for Methane

Cleanup goals for methane at LF 26 are dictated by the requirements of Title 27 of the CCR (27 CCR 20921) that specify that landfill owners must ensure that the concentration of methane gas does not exceed the LEL for methane (5 percent by volume) at the point of compliance, and 25 percent of the LEL (1.25 percent by volume) within structures inside the facility boundary. The RAOs presented in Section 2.1 incorporate these cleanup goals for methane. These goals will be used during the evaluation of the remedial alternatives to assess the remedy's ability to meet these goals. Ultimately, these goals will be used to demonstrate the effectiveness of the selected remedy.

# Tables

TABLE 2-1
Potential Chemical-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Source | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| California Hazardous Waste Control Law (HWCL) Hazardous Waste Determination | 22 CCR, Division 4.5, Chapter 11, 66261.21, 66261.22(a)(1), 66261.22(a)(2), 66261.23, and 66261.24 or Article 4, Chapter 11 | Applicable | A solid waste is considered a hazardous waste if it exhibits any of the characteristics of ignitability, corrosivity, reactivity, or toxicity, or if it is listed as a hazardous waste. | May be applicable if the selected remedy includes soil excavation and contamination is encountered during digging. Excavated soil may require testing to verify whether or not it is hazardous. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. Both actions will create excavated soil materials requiring disposal. |
| California Land Disposal Restrictions | 22 CCR 66268.48 | Applicable | This requirement establishes numeric universal treatment standards by chemical constituent that may not be exceeded under the land disposal restrictions. Following excavation, contaminated soil determined to be hazardous waste in accordance with state and federal regulations may be subject to land disposal restrictions (LDRs) if placed on land in a waste management unit outside of the Area of Contamination from which the waste was generated. Toxicity characteristic waste needs to be treated so that it (1) no longer exhibits the characteristic of toxicity, and (2) is treated to 10 times the Universal Treatment Standard (10 × UTS) or achieves 90 percent reduction, whichever is higher. | May be applicable if the selected remedy includes soil excavation and contamination is encountered during digging. Excavated soil may require testing to verify whether or not it is hazardous. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. Both actions will create excavated soil materials requiring disposal. |

TABLE 2-1
Potential Chemical-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Source | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| Landfill Gas Monitoring and Control | 27 CCR 20919 through 20937 (Article 6, Gas Monitoring and Control at Active and Closed Disposal Sites) | Applicable | Requires that methane gas generated by disposal sites not exceed 5 percent by volume in air at the property boundary or other approved monitoring point. Requires that concentrations of methane gas do not exceed 25 percent of the LEL or 1.25 percent by volume in air within onsite structures. Requires a gas monitoring program and specifies requirements of the program. Requires a gas control system if methane concentrations exceed compliance levels. | Establishes chemical-specific standards for allowable concentrations of methane gas in air in the vicinity of LF 26. Also an action-specific ARAR for landfill gas controls. | Alternatives 2 through 5 require a method of landfill gas control to meet this standard. |

TABLE 2-2
Potential Federal and State Action-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Action | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| Landfill Gas Monitoring and Control | 27 CCR 20919 through 20937 (Article 6, Gas Monitoring and Control at Active and Closed Disposal Sites) | Applicable | Requires that methane gas generated by disposal sites not exceed 5 percent by volume in air at the property boundary or other approved monitoring point. Requires that concentrations of methane gas do not exceed 25 percent of the LEL or 1.25 percent by volume in air within onsite structures. Requires a gas monitoring program and specifies requirements of the program. Requires a gas control system if methane concentrations exceed compliance levels. | Applies to LF 26. | Alternatives 2 through 5 involve a method of landfill gas control that is required to meet this standard. |
| Landfill Closure and Postclosure Maintenance | 27 CCR 21160 | Applicable | Requires landfill gas control pursuant to 27 CCR Sections 20917 through 20937. | This requirement is applicable to LF 26. | Alternatives 2 through 5 involve environmental control systems for landfill gas that must meet this standard. |
| Landfill Closure and Postclosure Maintenance | 27 CCR 21180 | Applicable | Requires landfill final cover and environmental control systems to be maintained and monitored for no less than 30 years following closure. | This requirement is applicable to LF 26. | Alternatives 2 through 5 involve environmental control systems for landfill gas that must meet this standard. |
| Landfill Closure and Postclosure Maintenance | 27 CCR 21190 | Applicable | Postclosure construction activities may be restricted and must maintain integrity of final cover, drainage controls, landfill gas controls, and other systems.<br><br>Buildings associated with postclosure land uses that are constructed within buffer zones must meet design requirements. | This requirement is applicable to LF 26. | Alternatives 2 through 5 involve environmental control systems for landfill gas that must be maintained. |

TABLE 2-2
Potential Federal and State Action-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Action | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| Waste Characterization and Disposal | 27 CCR 20200, 20210, 20220, and 20230<br><br>23 CCR 2520, 2521 | Applicable | Requires that wastes be characterized to determine whether they are hazardous, designated, nonhazardous, or inert waste. Hazardous waste must be managed in accordance with the requirements of 22 CCR. Discharge of designated, nonhazardous, and inert waste shall be in accordance with 27 CCR 20210, 20220, or 20230. | Applies to wastes (including soil) that are excavated during construction of the remedy. Wastes must be characterized properly and disposed of at an appropriate waste management facility that is authorized to receive the type of waste. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. Both actions will create excavated soil materials requiring disposal. |
| Control of Air Emissions | Bay Area Air Quality Management District (BAAQMD) Regulation 6, Particulate Matter and Visible Emissions | Applicable | Limits visible emissions, particulate emissions by weight, and emissions from sulfuric acid plants and sulfur recovery units. Applicable to any remedial action activity that may discharge air contaminants as defined by the rule. | Construction of the selected remedy may generate visible air emissions. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. Both actions can create air emissions from soil excavation and stockpiling activities. |
| Control of Air Emissions | BAAQMD Regulation 7, Odorous Substances | To be considered | Limits odorous emissions per complaints received from persons on properties where the emissions did not occur, and the regulation places maximum concentration limits on certain organic emissions. | Would need to be considered for soil gas if gas produces odorous emissions and if complaints are received. | Alternatives 2 through 5 involve landfill gas control measures which would be required to limit odorous emissions. |
| Treatment Standards for Hazardous Debris | 22 CCR 66268.45 | Applicable | Requires treatment of hazardous debris prior to land disposal to waste-specific treatment standards. | Applicable to any debris identified as hazardous during excavation if debris will be placed for disposal in an area outside of a corrective action management unit (CAMU), treatment unit, or staging pile. Also applicable to offsite disposal of debris. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. Either action could unearth debris requiring disposal. |

TABLE 2-2
Potential Federal and State Action-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Action | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| Alternative LDR Treatment Standards for Contaminated Soil | 22 CCR 66268.7 and 66268.40 through 66268.44 and 66268.49 | Applicable | Prohibits hazardous waste from land disposal unless waste meets one of three types of treatment standard requirements. Establishes alternative standards for treatment of contaminated soil prior to land disposal. | LDRs must be met for hazardous wastes excavated and then placed in an area outside of a CAMU, treatment unit, or staging pile. Also applicable to offsite disposal. If excavated soils are hazardous, then will have to meet these requirements. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. Both actions will create excavated soil materials requiring disposal. If materials are hazardous waste, they must meet LDRs. |
| Discharges of storm water from industrial areas | 40 CFR Parts 122, 123, 124, NPDES, implemented by California Storm Water Permit for Construction Activities, RWQCB Order 92-08-DWQ | Relevant and Appropriate | Regulates pollutants in discharge of storm water associated with construction activity (clearing, grading, or excavation) involving the disturbance of 1 acre or more. Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards. | The CERCLA permit exemption applies to all discharges that are related to response actions and are "onsite," as that term is defined in the NCP. Remedies should meet the substantive requirements of the NPDES Program. | Alternatives 3 through 5 require excavation of soil or boring into soil to construct wells. If the construction activities disturb more than an acre, the substantive requirements of the storm water pollution prevention program should be met. |
| National Oil and Hazardous Substances Pollution Contingency Plan – Procedures for planning and implementing offsite response actions | 40 CFR 300.440 | Applicable | Offsite transfer of CERCLA remediation waste for disposal must be to an EPA-approved facility. | This requirement applies to offsite disposal of wastes that could be generated during implementation of the remedy. | Alternatives 3 through 3 require excavation of soil or boring into soil to construct wells. Both actions will create excavated soil materials requiring disposal. |

TABLE 2-2
Potential Federal and State Action-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Action | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| Land Use Covenant | 22 CCR, Section 67391.1(a) | Relevant and Appropriate | Requires imposition of appropriate limitations on land use by recorded land use covenant when hazardous substances remain on the property at levels that are not suitable for unrestricted use of the land. | This requirement is applicable when hazardous substances are disposed of on site. It is relevant and appropriate in this situation, when the closed landfill may generate methane that may impact soil gas on adjacent sites. Land use restrictions are required to control land use in the vicinity of the landfill. | Alternatives 2 through 5 involve control of landfill gas migration from a closed landfill. |
| Land Use Covenant | 22 CCR, Section 67391.1(b) | Relevant and Appropriate | Requires that the cleanup decision document contain an implementation and enforcement plan for land use limitations. | This requirement implements Section 67391.1(a). | Alternatives 2 through 5 involve control of landfill gas migration from a closed landfill. |
| Land Use Covenant | 22 CCR, Section 67391.1(d) | Relevant and Appropriate | Requires that the land use covenant be recorded in the county where the land is located. | This requirement implements Section 67391.1(a). | Alternatives 2 through 5 involve control of landfill gas migration from a closed landfill. |

TABLE 2-2
Potential Federal and State Action-specific ARARs
*Landfill 26 Soil Gas Feasibility Study, Hamilton Army Airfield, Novato, California*

| Action | Standard, Requirement, Criterion, or Limitation | ARAR Status | Description | Comment | Applicability to Alternatives |
|---|---|---|---|---|---|
| Land Use Covenant | CA Civil Code Section 1471(a) | Relevant and Appropriate | Allows the state (as non-owners) to enter into restrictive land use covenants with land owners and their successors after determining that protection of present or future human health or safety or the environment is necessary. The covenants will run with the land if the affected land is described in the instrument of the covenant, the successive owners are expressly bound in the instrument of the covenant, each act in the covenant relates to use of the land and is reasonably necessary to protect present or future human health or safety or the environment, and the covenant is recorded with the county. | The state has determined the need for a land use covenant for protection of health, safety, and the environment. | Alternatives 2 through 5 involve control of landfill gas migration from a closed landfill. |

**SECTION 3**

# Identification and Screening of Technologies

This section describes the identification and screening of remedial technologies to satisfy the RAOs defined for landfill refuse-related methane control at LF 26. Because RAOs for this FS are limited to methane control, only those technologies that address the soil gas media are included in this evaluation. The approach taken is consistent with the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988). The organization and contents of this section are summarized as follows:

- **General Response Actions** – The broad range of actions that will satisfy LF 26 RAOs for soil gas methane control are identified.
- **Screening of Remedial Technologies and Process Options** – Under each GRA, the potentially applicable remedial technologies and the processes that could be used to implement those technologies are identified and screened against the criterion of technical implementability.
- **Evaluations of Process Options** – Remedial technologies and process options are evaluated against the criteria of effectiveness, institutional implementability, and relative cost.
- **Selection of Representative Process Options** – Individual process options are chosen to *represent* the range of process options under a remedial technology by considering those that are the best established, proven, and reliable over a range of site conditions.
- **Descriptions of Representative Process Options** – Summary descriptions of the representative process options are provided.

## 3.1 General Response Actions

GRAs describe the broad range of actions that will satisfy identified RAOs. For soil gas methane control at LF 26, the GRAs include No Action, Institutional Controls, Monitoring, Engineering Controls, Containment, and Treatment. Individual GRAs are seldom implemented in isolation but are typically implemented in combination with other GRAs to fully address RAOs. Typically, the No Action GRA cannot satisfy RAOs and is used solely for the purpose of comparison.

A summary of the GRAs for soil gas methane control at LF 26 is provided in the following list:

- **No Action** – No attempt is made to satisfy the RAOs, and no remedial measures are implemented. The No Action GRA is required for consideration by the NCP.
- **Institutional Controls** – Actions using non-engineering methods whereby potential exposure to soil gas methane is restricted or regulated.

- **Monitoring** – Collection and analysis of soil gas samples to evaluate methane concentrations. The data can be used to evaluate the extent of methane migration, distribution, remediation, or degradation.
- **Engineering Controls** – Physical methods or actions taken to control methane, thereby minimizing or eliminating the migration of soil gas methane and preventing direct exposure to methane or explosive conditions that could result from methane buildup.
- **Containment** – Physical methods or actions taken to contain soil gas methane, thereby minimizing or eliminating the migration of soil gas methane and preventing direct exposure to methane or explosive conditions that could result from methane buildup.
- **Treatment** – Methods or actions taken to physically or chemically treat soil gas methane to reduce its concentration and/or volume.

## 3.2 Screening of Remedial Technologies and Process Options

Following the development of the GRAs, potential remedial technologies and process options for implementing the GRAs are identified and screened for technical implementability as described in the following subsections.

### 3.2.1 Identification of Remedial Technologies and Process Options

Except for the No Action GRA, each GRA can be achieved by one or more remedial technologies and associated process options. In this context, the following definitions apply:

- **Remedial Technologies** – The general categories of remedies under a GRA. For example, vapor collection is one of the remedial technologies under the treatment GRA.
- **Process Options** – Specific categories of remedies within each remedial technology. The process options are used to implement each remedial technology. For example, the remedial technology of vapor collection could be implemented using a passive venting system, one of several process options under this technology.

Several technology types and process options are available to implement the GRAs for soil gas methane control at LF 26. Potentially applicable technologies and process options under each of the GRAs are provided on Figure 3-1. The technologies and process options for soil gas methane control listed on Figure 3-1 were identified through various sources, including references developed specifically for application to CERCLA sites or military installations, Internet searches, vendor-supplied information, standard engineering texts, and other sources. Identifying a comprehensive list of technologies and process options ensures that potentially viable remedies are not overlooked early in the FS process.

### 3.2.2 Technical Implementability Screening

After potentially applicable technologies and process options are identified, the options are screened for technical implementability. Technical implementability refers to the ability of the remedial technology or process option to meet RAOs and be implementable at the site under consideration. This initial screening eliminates those technologies and process options that are clearly not applicable or not workable for the contaminants or site characteristics at LF 26 and addressed by this FS.

The technical implementability screening of potential remediation technologies and process options is also provided on Figure 3-1. This figure provides brief descriptions of the technologies and process options associated with the GRAs. The figure also includes the rationale for either retaining or screening out a particular option. Technologies and process options that are screened out because they are not technically implementable are represented on Figure 3-1 with a crosshatched symbol.

## 3.3 Evaluation of Process Options

Following the technical implementability screening, the surviving technologies and process options are evaluated in greater detail using the criteria of effectiveness, implementability, and relative cost. For this evaluation, the implementability criterion focuses on administrative and institutional issues instead of technical issues (technical issues were addressed previously in the evaluation in Section 3.2). The evaluation of process options is summarized on Figure 3-2.

Descriptions of each evaluation criterion are provided in the following subsections.

### 3.3.1 Effectiveness

Specific process options are evaluated for effectiveness by considering the following factors:

- The ability of a process option to address the estimated areas or volumes of contaminated media and meet the goals identified in the RAOs.
- The potential impacts to human health and the environment during the construction and implementation phases.
- The reliability and proven success the process has shown with respect to the types of contamination and site conditions that will be encountered.

### 3.3.2 Institutional Implementability

For the evaluation of process options, implementability focuses on the administrative or institutional aspects of using a technology or process, as compared with the technical implementability screening described in Section 3.2.2. Factors considered under this criterion include the ability to obtain necessary permits; the availability and capacity of treatment, storage, and disposal services; and the availability of the equipment and workers to implement the technology.

### 3.3.3 Relative Cost

Cost plays a limited role in the screening of process options. At this stage of evaluation, relative capital plus Operations and Maintenance (O&M) costs are used rather than detailed estimates. The costs for each process option are evaluated according to engineering judgment as high, medium, or low relative to the other process options in the same technology type.

## 3.4 Selection of Process Options

Following evaluations for the criteria of effectiveness, implementability, and relative cost, process options are chosen for further analysis. Implementation of some process options, in isolation, may not completely satisfy RAOs. Therefore, process options are generally used in conjunction with other process options to assemble remedial alternatives that fully achieve RAOs. Representative process options for soil gas methane control at LF 26 are summarized in Table 3-1.

## 3.5 Descriptions of Representative Process Options

This subsection provides summary descriptions of the representative process options listed in Table 3-1.

### 3.5.1 No Action

The No Action process option represents a situation where no further administrative or physical actions would be taken at LF 26 to address soil gas methane. All previously installed remedies such as the RCRA-type cap and the passive venting system would remain in place; however, all further inspection, maintenance, and monitoring activities would be suspended. The No Action process option is intended primarily for comparison to other alternatives. No Action is required for consideration by the NCP, but typically will not be implemented because the option does not satisfy the RAOs.

### 3.5.2 Institutional Controls

Institutional controls are often included in remedies because, if properly implemented, monitored, and enforced, they can protect human health and the environment. In addition, the short-term cost of institutional controls is much less than that of other conventional remedies (e.g., soil gas collection, containment, or treatment). However, institutional controls have notable limitations. If implemented alone, they may not fully comply with ARARs and RAOs, and they do not reduce the toxicity or the volume of contamination. The long-term costs to monitor and enforce the institutional controls may be significant, and there are obstacles to successful monitoring and enforcement. See Figure 3-2 for a description of each institutional control process option.

The intent of the institutional control is to limit or eliminate exposure pathways to receptors. Because HAAF has closed and areas immediately adjacent to LF 26 have been developed for residential use, land use restrictions will be essential to protect ongoing remedial activities, ensure the viability of the remedies, and protect human health. The following general types of institutional controls may be implemented:

- Governmental
- Proprietary
- Informational

The LF 26 area is currently owned by the Army; however, at some point in the future the property will likely be transferred to the City of Novato. Institutional controls will be necessary before, at, and following property transfer. The specific types of institutional controls to be implemented during each stage are discussed below.

#### 3.5.2.1 Institutional Controls under Army Ownership

Prior to property transfer, the Army would implement institutional controls for LF 26. The primary mechanism for institutional controls will be the landfill postclosure maintenance requirements (a governmental control). State regulations for postclosure maintenance and land use are detailed in 27 CCR, Sections 21180 and 21190, respectively. These regulations call for a minimum of 30 years of postclosure monitoring, reporting, and site maintenance activities. Postclosure land uses are limited to those activities that will not affect the integrity or performance of the final cover system. This regulation sets forth the performance standards and the minimum substantive requirement for proper reuse of solid waste disposal sites to ensure protection of human health and the environment. Some of the site use-related postclosure requirements include the following:

- All proposed construction improvements and changes to end use on closed sites (other than non-irrigated open space) shall be submitted to the LEA (i.e., the Environmental Health Services Division of the Marin County Community Development Agency), RWQCB, the CIWMB, the local air district (i.e., the Bay Area Air Quality Management District), and the local planning agency (i.e., the City of Novato Planning Department) for review, comment, and approval regarding possible construction problems, hazards to health and safety, and concerns about the integrity of the landfill's final closure cover and environmental monitoring and control networks (e.g., groundwater monitoring network, soil gas monitoring network, and drainage control system).
- Construction improvements on the site shall maintain the integrity of the final cover and liner(s), all components of the containment system(s), and the functions of the monitoring system(s).
- Construction of structural improvements on top of the landfill area during the postclosure period shall include (but not be limited to) the following components in accordance with the abovementioned regulatory requirements:
  - Automatic methane gas sensors designed to trigger an audible alarm when methane concentrations are detected shall be installed in all buildings.
  - Any utility connections shall be designed with flexible connections and utility collars and shall not be installed in or below the barrier layer of the final cover or any liner.
  - The LEA or CIWMB may require that an additional soil layer or building pad be placed on the final cover prior to construction to protect the integrity and function of the various layers of the final cover.

The postclosure requirements may also stipulate the need for all structures constructed on the land owner's property within 1,000 feet of the boundary of the disposal area and on the landfill cap to be designed and constructed to minimize the potential for methane migration into the structures in accordance with the following:

- A permeable layer of open-graded material of clean aggregate with a minimum thickness of 12 inches shall be between the geomembrane and the subgrade or slab.

- A geotextile filter layer shall be utilized to prevent the introduction of fines into the permeable layer.
- Perforated venting pipes shall be installed within the permeable layer and shall be designed to operate without clogging; automatic gas sensors that trigger an audible alarm when methane is detected shall be installed within the piping/permeable layer and inside the building.

#### 3.5.2.2 Institutional Controls at Property Transfer

Pursuant to 27 CCR, Section 21200, the following actions must be taken if there is a property transfer during the postclosure maintenance period (minimum of 30 years):

1. Before the title to a disposal site is transferred to another person during closure or postclosure maintenance, the new owner shall be notified by the previous owner or his agent of the existence of these standards and of the conditions and agreements assigned to ensure compliance; and
2. The previous owner shall notify the LEA of the change in title within thirty (30) days and shall provide the name, firm, mailing address, and telephone number of the new owner.

#### 3.5.2.3 Institutional Controls Following Property Transfer

The postclosure requirements will remain in effect after property transfer. However, because the Army will not fully control the property following transfer, the Army (or the State) may elect to impose further institutional controls on the property to ensure the safety of human health and the environment through the use of propriety controls. Proprietary controls are an aspect of private property law that can be used to restrict or affect the use of property. Common examples include covenants or easements restricting future land use or prohibiting activities that may compromise the remedy. Proprietary controls can be implemented as a possessory interest (e.g., a landlord-tenant relationship) or as a non-possessory interest by which one party could control another's use of its own property. Deed covenants (beyond the 27 CCR requirements) are a non-possessory interest that the Army can implement on property transfer. The State can also implement land use covenant (SLUC) with the property owner (e.g., the City of Novato after property transfer) to control land use. The state has authority to place land use restrictions under the Health and Safety Code Section 25355.5 for remediated sites (Toxic Substances Control Program Official Policy/Procedure No. 87-14) and under Title 22, Division 4.5, Chapter 39, Section 67391.1(e)(1). As an alternative, DTSC and the property owner may enter into a mutual agreement regarding land use restrictions (Health and Safety Code Section 25222.1). By applying mutually reinforcing mechanisms (i.e., layering) (U.S. Department of Defense, 2001), the overall effectiveness of land use restrictions can be strengthened.

Advisories do not have any legal effect but can be used to provide notice to potential land users of residual contamination and the existence of the institutional control. Local public health agencies, the State, and/or the Army can implement the advisories through the existing community relations program.

The identification and screening of the institutional control process options is presented on Figures 3-1 and 3-2, respectively. The representative process options under the institutional control GRA to be specifically evaluated in this FS are as follows:

- Implemented by LEA:
  - Landfill postclosure requirement monitoring
  - 27 CCR deed notification
- Implemented by the State:
  - SLUC
- Implemented by the Army:
  - Landfill postclosure requirements
  - Deed covenants
  - Deed notices
  - Advisories

The representative process options listed above are included as components of the alternatives described in Section 4. While the other process options (i.e., administrative orders and consent decrees) are not retained as representative process options and are not specifically included in an alternative, under CERCLA these may be implemented in the future with the proper documentation.

### 3.5.3 Monitoring

Under monitoring, the applicable process option is vadose zone monitoring. Vadose zone monitoring consists of the collection and analysis (whether in the field or laboratory) of soil gas samples for methane, and it would be implemented in conjunction with remediation technologies such as gas collection and containment. In general, monitoring is not implemented as a stand-alone response action; rather, it is combined with other GRAs to meet RAOs and ARARs (i.e., 27 CCR). Monitoring includes vadose zone monitoring, remedy monitoring (e.g., monitoring of passive trench vents), and structure monitoring (e.g., monitoring of buildings and/or utility vaults).

### 3.5.4 Engineering Controls

Under the engineering controls GRA, three process options were chosen. The remedial technologies and process options include the following:

- **Surface controls** – Vapor barrier
- **Vapor collection** – Perimeter passive venting system (trench)
- **Vapor collection** – Perimeter active collection system (wells or trench)

Summary descriptions of the representative process options are provided in the following subsections.

#### 3.5.4.1 Vapor Barrier

This section discusses both structure vapor barriers and utility trench vapor barriers.

**Structure Vapor Barriers.** Structure vapor barriers are impermeable membranes (also called geomembranes) placed such that they obstruct the flow of soil gas from one side of the vapor barrier to the other, thereby limiting exposure pathways to human and ecological receptors. Vapor barriers are made from various materials, including HDPE, low-density polyethylene (LDPE), polypropylene, polyvinyl chloride (PVC), chlorosulphonated polyethylene, neoprene, butyl rubber, and elasticized polyolefin. Vapor barriers can be applied as solid liners or sprayed on in liquid form. Spray-on vapor barriers are composed of a rubberized asphalt emulsion that solidifies when exposed to ambient air. New building construction often requires the installation of a vapor barrier when the threat of soil gas infiltration exists. For new construction, the vapor barriers are applied beneath the building foundation. For retrofit of existing buildings with a slab-on-grade foundation, either the slab may be removed to allow for installation of the barrier and then reinstalled, or the vapor barrier may be applied directly to the slab, with the addition of a shallow slab cover for protection. Land use restrictions will be necessary at each site containing a vapor barrier to prevent damage to the barrier and the creation of exposure pathways.

Advantages of a structure vapor barrier are as follows:

- Reduces contaminant mobility
- Cost effective
- Low O&M costs (if installed with new construction)
- Relatively easy to install for new construction
- Non-invasive
- Low-profile

Limitations of a structure vapor barrier are as follows:

- Does not remove or treat contaminant
- Does not reduce toxicity or volume of contaminant
- Damage to the integrity of the membrane could compromise effectiveness

**Underground Utility Vapor Barriers.** Underground utility vapor barriers typically consist of clay dams or other "plugs" of low permeability material (such as concrete with bentonite added) at periodic intervals within the backfill along an underground utility trench corridor. The dams can be accompanied by vents in the trench backfill between the dams or plugs. Utility vapor barriers can be incorporated into new utility trench construction or existing utility trenches by excavating and retrofitting them or by adding the vapor barriers when utility trenches are extended.

Advantages of an underground utility vapor barrier are as follows:

- Reduces contaminant mobility within utility trench
- Cost effective
- Low O&M costs
- Relatively easy to install for new construction
- Non-invasive (does not require construction within a contaminated soil gas area or under a structure but only construction within existing or planned utility trenches)
- Low-profile (does not add above-grade features that would significantly impact land use, but could possibly have some above-grade monitoring locations or vents)

Limitations are as follows:

- Does not remove or treat contaminant
- Does not reduce toxicity or volume of contaminant
- Damage to the vapor barrier material could compromise effectiveness

#### 3.5.4.2 Perimeter Passive Venting System

Perimeter passive venting systems use existing variations in atmospheric pressure, soil gas pressure, and gas concentrations to collect and vent landfill gas to the atmosphere. Perimeter passive venting systems generally use trenches equipped with vertical and/or horizontal piping for gas collection and removal. The trenches are filled with a permeable material such as gravel that allows gas to collect and move within the trench. Typically, slotted, large-diameter vertical and/or horizontal pipes are also located in the permeable backfill to collect the soil gas and route it to vertical risers that typically vent the collected gas directly to the atmosphere. Because the rate of removal and/or mass of contaminants removed is generally low, treatment of effluent gas is generally not required with passive venting systems. Passive venting systems are generally located outside of the landfill fill material to intercept, collect, and remove any soil gas from the subsurface before the gas migrates offsite. These systems are designed and located to mitigate potential soil gas migration concerns in the immediate area.

Advantages of a perimeter passive venting system are as follows:

- Highly effective at collecting and removing soil gas in the immediate area or from intercepted preferential soil gas migration pathways; reduces contaminant mobility
- Promotes aeration of soils within and adjacent to the trench, which supports methanotophic bacteria that may reduce methane concentrations
- Relatively easy to install
- Can be designed for conversion to an active system without adding significant cost
- No moving parts, self performing remedy
- Permanent and effective over the long term with minimal O&M requirements
- Minimal (if any) operation costs and low maintenance costs (repairs for vandalism or catastrophic events only)

Limitations of a perimeter passive venting system are as follows:

- Does not affect existing soil gas that has already migrated from the source to beyond the trench location
- 27 CCR, Section 20937(c)(3) requires that passive system use an impermeable membrane barrier resulting in more complex and costly construction
- Requires long-term inspection and maintenance

#### 3.5.4.3 Perimeter Active Collection System

Active collection systems use vacuum pumps to collect and remove landfill gas from the landfill or surrounding area and discharge the gas. Active collection systems also use trenches or wells to serve as conduits for gas collection and removal. As with a passive system, the trench or wells are typically placed at the perimeter of the landfill to intercept, collect, and remove any landfill gas from the subsurface before it migrates offsite. Because the rate of removal and/or mass of contaminants collected is generally higher than with passive systems, active collection systems generally require treatment of the effluent prior to discharging it to the atmosphere.

Advantages of an active venting system are as follows:

- Highly effective at collecting and removing soil gas in the immediate area, or from intercepted preferential soil gas migration pathways; reduces contaminant mobility
- Provides a pressure gradient within the trench to enhance gas removal
- Promotes aeration of soils within and adjacent to the trench, which supports methanotophic bacteria that may reduce methane concentrations
- Could be used to draw back soil gas that has migrated beyond the trench
- Relatively easy to install if done as part of landfill development or closure

Limitations of an active venting system are as follows:

- Higher construction cost than a passive system
- Greater potential for mechanical failure than a passive system
- Requires long-term inspection and O&M
- Higher O&M costs (relative to passive systems)

### 3.5.5 Containment

For this GRA, the remedial technology selected was a vertical barrier and the process option selected is a trench lining system. A trench lining system consists of an impermeable barrier material on the "outboard" (furthest from landfill) side of the trench, extending from 2 feet below the low groundwater elevation to the ground surface. Because it is an impermeable barrier, the trench lining system provides containment and does not allow landfill gas to migrate beyond the barrier location. An impermeable barrier such as a trench lining system is necessary for compliance with 27 CCR, Section 20937(c)(3) when a passive collection system is used for methane control. For the purposes of this FS, the following trench lining system was assumed:

- GSE GundWall® interlocking rigid HDPE panels
  - Panels are driven in place using a vibratory hammer method following completion of the gravel lined trench.
  - Panels will be 80 to 120 mil (2.0 to 3.0 mm) thick with excellent resistance to chemicals and rodent attack; panels should not exhibit environmental stress cracking.

  – Panels interlock using an extruded hydrophilic gasket that swells when exposed to water to ensure leak-free panel connections.

Advantages of a trench lining system are as follows:

- Eliminates contaminant mobility of methane across the liner
- Provides additional protection over a non-lined passive venting trench or active collection trench that rely upon air exchange alone for methane removal

Limitations of a trench lining system are as follows:

- When used independently, does not facilitate venting for removal of methane from soil gas; the system only blocks soil gas flow
- Does not reduce the volume of contamination

### 3.5.6 Treatment

Treatment may be required to remove methane from soil gas collected within the perimeter active collection system prior to the gas being discharged to the atmosphere. Under the Treatment GRA, three potential ex situ treatment process options were evaluated. The biofilter treatment process option was selected as representative.

Biofilters primarily consist of an air flow system and filter media. Within a biofilter, air is forced through the biofilter media. A biofilter can be enclosed in a modular container or be located outdoors on the ground or on a roof. Biofilters convert gaseous compounds into carbon dioxide, water, energy, and organic matter. The air stream is typically passed through a blend of organic matter and mineral components. The airborne compounds impinge upon a film of water surrounding each particle of these media (adsorption). Once the compounds are trapped in this film, they become food source for the micro-organisms living on the wet surfaces of the particles. The digestive process of the organisms breaks down the soil gas constituents into odorless decomposition by-products (i.e., carbon dioxide).

Advantages of a biofilter are as follows:

- Relatively low cost
- Reduces the volume and toxicity of contamination
- Effective for most low soil gas concentrations
- Less costly than most other gas treatment options

Disadvantages of a biofilter treatment system area are as follows:

- Requires moving parts (blower)
- Ongoing operating costs for blower system and maintenance for biofilter media replacement
- Destruction of methane is usually only partial
- Requires long-term inspection and maintenance

# Table

TABLE 3-1
Summary of Representative Process Options
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| General Response Action | Remedial Technology | Process Option |
|---|---|---|
| No Action | None | None |
| Institutional Controls | Governmental controls | Postclosure maintenance requirements |
| | Proprietary controls | Deed covenants<br>State Land Use Covenant (SLUC) |
| | Informational devices | Deed notice<br>Advisories |
| Engineering Controls | Surface controls | Vapor barrier (for buildings and utility structures) |
| | Gas collection | Passive venting system (perimeter trench)<br>Active collection system (perimeter wells or trench) |
| Containment | Vertical barrier | Geomembrane trench liner |
| Treatment | Ex situ treatment | Biofilter |
| Monitoring | Monitoring | Vadose zone monitoring<br>Selected remedy monitoring (e.g., trench vent monitoring)<br>Structure monitoring |

See Figure 3-2 for a description of each Process Option.

# Figures

| SOIL GAS GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|---|
| No Action | None | None | No action is taken. | Required for consideration by NCP. Does not satisfy RAOs or ARARs. |
| Institutional Controls | Governmental controls | Zoning and other ordinances | A common land use restriction specifying allowed land uses for certain areas. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | Local permits | Permits outlining specific requirements before an activity can be authorized. Permits may be required for grading, construction, well installation, demolition, or right-of-way encroachment. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | Post-Closure Requirements | Regulatory requirements for post-closure end use, monitoring, and maintenance that must be followed and amended with regulatory approval for changes in site use, ownership, monitoring, and maintenance. | Applicable to LF 26 and required under current regulations. |
| | Proprietary controls | Easements | A property right conveyed by a land owner to another party that gives the second party rights with regard to the first party's land. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | Deed covenants | A covenant is an agreement between one landowner and another made in connection with a conveyance of property to use or refrain from using the property in a certain manner. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | State Land Use Covenant (SLUC) | Convenant, implemented by the state, that can specify requirements or limit the use of real property and affect the title to property. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | Enforcement and permit tools | Administrative Order | An order directly restricting the use of property by a named party. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | Consent Decree | A Consent Decree is signed by a judge and documents the settlement of an enforcement case. Similar to an administrative order, it is used to specify restrictions on land use by the settling party. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | Federal Facilities Agreement | Contract with a federal facility determining the strategy, priority, and schedule of a remedial response program. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | Informational devices | Deed notice | Commonly refers to non-enforceable, purely informational documents filed in public land records that alert anyone searching the records to important information about the property. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| | | Advisories | Warnings that provide notice to potential users of land, surface water, or groundwater of some existing or impending risk associated with its use. | Potentially applicable to LF 26 if used in conjunction with other technologies. |
| Monitoring | Monitoring | Vadose zone monitoring | Short- and/or long-term monitoring of soil gas to evaluate methane levels, and potential degradation and/or migration. | Applicable to LF 26. |
| | | Selected remedy monitoring | Short- and/or long-term monitoring of the selected remedy to assess operational parameters and/or effectiveness. | Applicable to LF 26. |
| | | Structure monitoring | Short- and/or long-term monitoring of methane in buildings and/or utility structures. | Applicable to LF 26. |

**LEGEND**

- [plain box] Technology or process option considered technically implementable.
- [hatched box] Technology and/or process option screened out on the basis of technical implementability.

**FIGURE 3-1 (Page 1 of 3)**
**TECHNICAL IMPLEMENTABILITY SCREENING OF LANDFILL GAS CONTROL TECHNOLOGIES AND PROCESS OPTIONS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL

| SOIL GAS GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|---|
| Engineering Controls | Surface controls | Vapor barrier | Impermeable membrane placed beneath a building or utility structure (e.g., trench or vault) to prevent vapor intrusion. | Potentially applicable if used in conjunction with other technologies to satisfy RAOs. Reduces contaminant mobility by minimizing vapor intrusion and eliminates vapor intrusion pathway. Does not reduce toxicity or volume of contaminants. Most suitable for new building construction with raised or slab foundations. Retrofit of existing structures is also possible. |
| | Vapor collection | Passive collection system with perimeter wells | Installation of collection wells along the perimeter of a landfill or other contaminated area to collect and remove soil gas. Passive gas collection systems use existing variations in landfill pressure and gas concentration gradients to collect the soil gas and remove it from the landfill by venting. | Not applicable. Passive vent wells are only effective at venting small, localized areas or hotspots. Venting wells are not effective or reliable at preventing the migration of soil gas methane over large areas. Due to variations in lithology, there may be some areas between the wells where soil gas is not affected (i.e., captured and vented) and where methane may migrate beyond the venting system and point of compliance. |
| | | Passive collection system with perimeter trench | Installation of collection trench around the perimeter of a landfill or other contaminated area to collect and remove soil gas. Passive gas collection systems use existing variations in landfill pressure and gas concentration gradients to collect the soil gas and remove it from the landfill by venting. | Potentially applicable if used in conjunction with other technologies to satisfy RAOs. |
| | | Passive collection system with internal wells | Installation of collection pipes and/or wells within the interior of a landfill or other contaminated area. Passive gas collection systems use existing variations in landfill pressure and gas concentration gradients to collect soil gas and remove it from the landfill. | Not applicable. Internal collection systems may not fully prevent landfill gas from migrating beyond the point of compliance at the perimeter of the landfill. In addition, the installation of internal piping or wells into a landfill with an existing cap requires perforation of the cap liner that could affect integrity and performance of the liner. Multiple surface exposure of pipe would affect future site use. |
| | | Active collection system with perimeter wells | Installation of collection wells around the perimeter of a landfill or other contaminated area to collect and remove soil gas. An active gas collection system uses vacuum pumps to actively draw soil gas out of the landfill area. | Potentially applicable if used in conjunction with other technologies to satisfy RAOs. |
| | | Active collection system with perimeter trench | Installation of collection trenches around the perimeter of a landfill or other contaminated area to collect and remove soil gas. An active gas collection system uses vacuum pumps to actively draw soil gas out of the landfill area. | Potentially applicable if used in conjunction with other technologies to satisfy RAOs. |
| | | Active collection system with internal wells | Installation of collection pipes and/or wells within the interior of a landfill or other contaminated area. An active gas collection system uses vacuum pumps to actively draw soil gas out of the landfill. | Not applicable. Internal collection systems may not fully prevent landfill gas from migrating beyond the point of compliance at the perimeter of the landfill. In addition, the installation of internal piping or wells into a landfill with an existing cap requires perforation of the cap liner that could affect integrity and performance of the liner. Multiple surface exposure of pipe would affect future site use. |
| Containment | Vertical barrier | Slurry wall | Trench is excavated around landfill and backfilled with a soil-bentonite slurry or other low permeable material. | Potentially applicable if used in conjunction with other technologies. When used alone, an impermeable trench that extends to groundwater could impede groundwater flow and result in drainage problems. The trench could cause methane to migrate in unintended directions. |
| | | Trench lining membrane | Vibrator force is used to advance a steel beam into the ground. Bentonite or cement slurry is injected as the beam is withdrawn. | Potentially applicable if used in conjunction with other technologies. When used alone impermeable trench that extends to groundwater could impede groundwater flow and result in drainage problems. The trench could cause methane to migrate in unintended directions. |

**LEGEND**

| | |
|---|---|
| (open box) | Technology or process option considered technically implementable. |
| (hatched box) | Technology and/or process option screened out on the basis of technical implementability. |

**FIGURE 3-1 (Page 2 of 3)**
**TECHNICAL IMPLEMENTABILITY SCREENING OF LANDFILL GAS CONTROL TECHNOLOGIES AND PROCESS OPTIONS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL

| SOIL GAS GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTION | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|---|
| Treatment | Ex situ treatment | Combustion | Collected soil gas is destroyed using flares, incinerators, boilers, gas turbines, or internal combustion engines. | Potentially applicable. |
| | | Gas recovery | Includes conversion of high quality landfill gas to hydrogen fuel or liquid natural gas (LNG). | Not applicable. Methane concentrations are not sufficiently high at Landfill 26 to utilize these technologies. |
| | | Biofilter | Gas is pumped into a biofilter with appropriate filter media to bioremediate soil gas constituents. Exhaust from biofilter is vented to the atmosphere. | Potentially applicable if used in conjunction with other technologies to satisfy RAOs. |
| | In situ treatment | Aeration | Create an aerobic soil media within a trench that promotes methane degradation prior to venting. | Potentially applicable if used in conjunction with other technologies to satisfy RAOs. |

**LEGEND**

- (blank box) Technology or process option considered technically implementable.
- (hatched box) Technology and/or process option screened out on the basis of technical implementability.

**FIGURE 3-1 (Page 3 of 3)**
**TECHNICAL IMPLEMENTABILITY SCREENING OF LANDFILL GAS CONTROL TECHNOLOGIES AND PROCESS OPTIONS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL

| SOIL GAS GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTION | EFFECTIVENESS | INSTITUTIONAL IMPLEMENTABILITY | RELATIVE COST |
|---|---|---|---|---|---|
| No Action | None | None | Low effectiveness. Contaminant loss from natural processes only. | May be implemented at sites with regulatory agency acceptance. | None. No actions are implemented. |
| Institutional Controls | Governmental controls | Zoning and other ordinances | Effectiveness depends on continued future implementation. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | | Local permits | Effectiveness depends on continued future implementation. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | | Post-Closure Requirements | Effectiveness depends on continued future implementation and enforcement. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | Proprietary controls | Easements | Effectiveness depends on the willingness of party to hold the easement. | Implementable. | Low capital, low maintenance. |
| | | Deed covenants | Effectiveness depends on the agreements made with the subsequent owner. | Implementable. | Low capital, low maintenance. |
| | | State Land Use Covenant (SLUC) | Effectiveness depends on continued future implementation. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | Enforcement and permit tools | Administrative Order | Effective for initial owners. Does not bind subsequent owners or parties not named in the order. | Implementable. | Low capital, low maintenance. |
| | | Consent Decree | Effectiveness depends on continued future implementation. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | | Federal Facilities Agreement | Effectiveness depends on continued future implementation. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | Informational devices | Deed notice | Moderately effective. A deed notice is not an interest in real property, so recording a notice has little or no effect on a property owner's legal rights regarding the future use of the property. | Implementable. | Low capital, low maintenance. |
| | | Advisories | Effectiveness depends on continued future implementation. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| Monitoring | Monitoring | Vadose zone monitoring | Effective for assessing methane concentrations in soil vapor, but does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | | Selected remedy monitoring | Effective for assessing operation and effectiveness of the selected remedy. Does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |
| | | Structure monitoring | Effective for co-monitoring of building and utility structures, but does not remediate contamination by itself. | Implementable. | Low capital, low maintenance. |

LEGEND

[box] Technology or process option considered technically implementable.

**FIGURE 3-2 (PAGE 1 OF 2)**
**EVALUATION OF SOIL GAS REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

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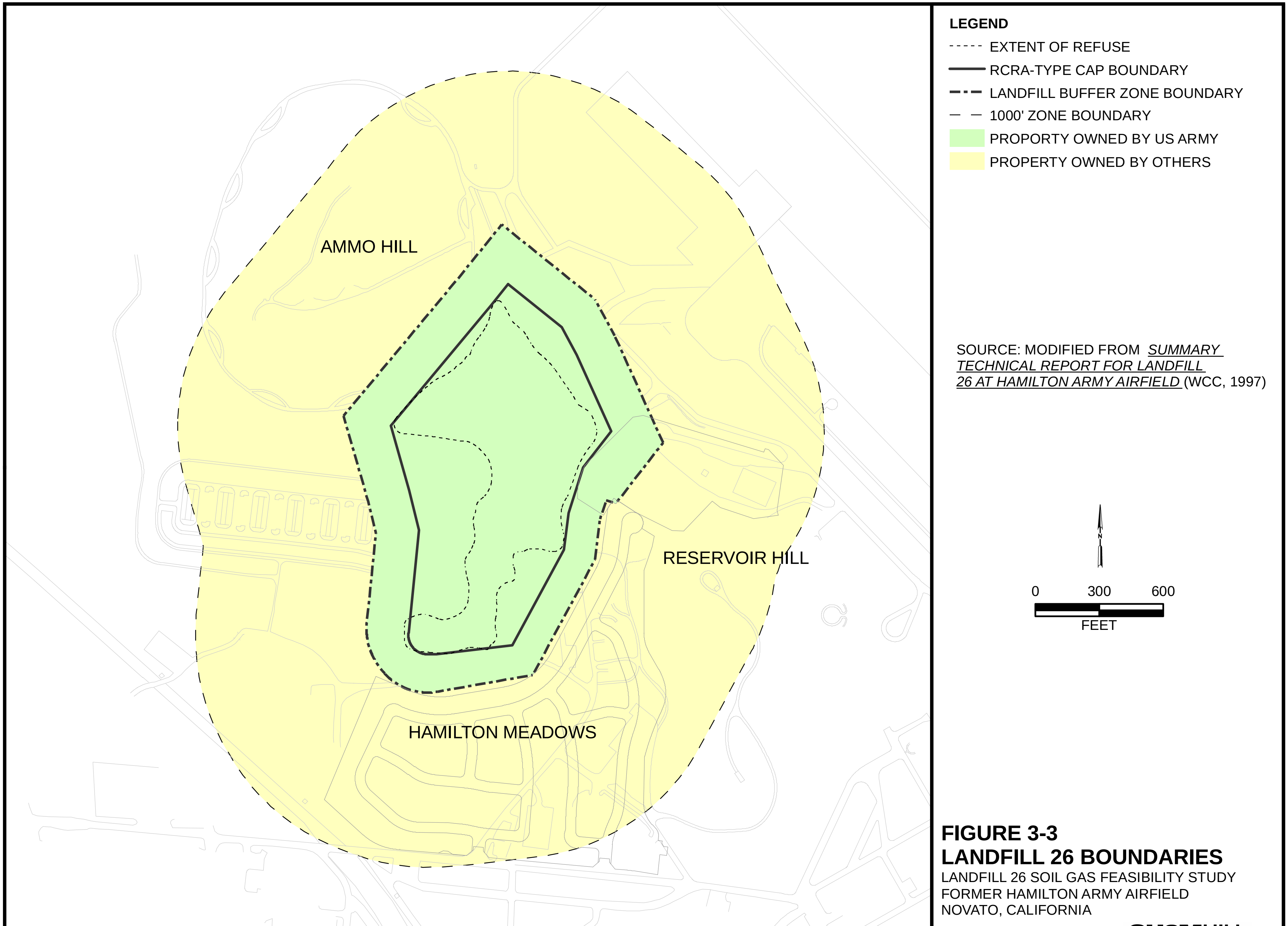
| SOIL GAS GENERAL RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTION | EFFECTIVENESS | INSTITUTIONAL IMPLEMENTABILITY | RELATIVE COST |
|---|---|---|---|---|---|
| Engineering Controls | Surface controls | Vapor barrier | Effective for mitigating methane intrusion into buildings or utility structures (e.g., trenches and vaults) if membrane integrity is maintained. Methane may collect beneath the membrane and slowly vent into the building. | Implementable. More easily implementable for new construction. Retrofit of existing buildings and utility systems is possible. | Low capital, low maintenance. |
| | Vapor collection | Passive collection system with perimeter trench | Effective for collecting and removing methane and minimizing mitration of methane. Increases oxygenation within the subsurface that removes methane degradations. | Implementable. | Low to moderate capital, low maintenance. |
| | | Active collection system with perimeter wells | Effective for collecting and removing methane and minimizing mitration of methane. Increases oxygenation within the subsurface that removes methane degradations. | Implementable. | Moderate capital, moderate maintenance. |
| | | Active collection system with perimeter trench | Effective for collecting and removing methane and minimizing mitration of methane. Increases oxygenation within the subsurface that removes methane degradations. | Implementable. | Moderate to high capital, moderate maintenance. |
| Containment | Vertical barrier | Slurry wall | Effective at minimizing migration of methane. Does not remediate contamination. | Implementable. | Moderate to high capital, low maintenance. |
| | | Trench lining membrane | Effective at minimizing migration of methane. Does not remediate contamination. | Implementable. | Moderate capital, low maintenance. |
| Treatment | Ex situ treatment | Combustion | Effective at destroying methane in effluent air stream. | Implementable. | Moderate to high capital, moderate maintenance. |
| | | Biofilter | Effective at destroying methane in effluent air stream. | Implementable. | Moderate capital, moderate maintenance. |

**LEGEND**

[box] Technology or process option considered technically implementable.

**FIGURE 3-2 (PAGE 2 OF 2)**
**EVALUATION OF SOIL GAS REMEDIATION TECHNOLOGIES AND PROCESS OPTIONS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL




SOURCE: MODIFIED FROM *SUMMARY TECHNICAL REPORT FOR LANDFILL 26 AT HAMILTON ARMY AIRFIELD* (WCC, 1997)

**FIGURE 3-3**
**LANDFILL 26 BOUNDARIES**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
FORMER HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

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SECTION 4
# Assembly and Screening of Alternatives

In this section, the representative process options identified in Section 3 are assembled into remedial alternatives to address landfill refuse–related methane in soil gas at LF 26. The assembled alternatives are then evaluated against the criteria of effectiveness, implementability, and cost. Alternatives with the most favorable composite evaluation of all factors are retained for more detailed evaluation against additional CERCLA criteria, as described in Section 5. This process of alternative development is depicted graphically on Figure 4-1.

## 4.1 Assembly of Alternatives

The assembly of representative process options into soil gas remediation alternatives is shown in Table 4-1. The assembled alternatives consist of the following:

- Alternative 1 – No Action
- Alternative 2 – Passive Venting System (Perimeter Trench)
- Alternative 3 – Active Collection System (Perimeter Wells)
- Alternative 4 – Active Collection System (Perimeter Trench)
- Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

Except for Alternative 1 (No Action), each alternative consists of several combined GRAs and corresponding process options (see Table 4-1). For example, Alternative 2 (Passive Collection System with Perimeter Trench) includes 11 representative process options. One of the process options, the Passive Collection System, is the primary component of Alternative 2. The additional process options included to achieve RAOs and meet ARARs consist of institutional controls, surface controls (vapor barriers), and a vertical barrier (geomembrane trench liner). Each of the remedial alternatives is described in greater detail in the following subsections.

### 4.1.1 Alternative 1 – No Action

The No Action Alternative provides a baseline for comparing other alternatives. No remedial activities are implemented under Alternative 1. Evaluation of the No Action Alternative is required by the NCP to serve as a baseline for comparison to other alternatives. Therefore, the No Action alternative is evaluated for soil gas at LF 26. No cost is associated with this alternative.

### 4.1.2 Alternative 2 – Passive Venting System (Perimeter Trench)

Under Alternative 2, a passive venting system incorporating a perimeter trench would be utilized at LF 26 to control soil gas methane. In addition to the passive venting system, this alternative also includes institutional controls, vapor barriers, a vertical barrier, and monitoring as discussed below.

#### 4.1.2.1 Passive Venting System with Perimeter Trench

The primary component of Alternative 2 is a passive venting system utilizing a continuous perimeter trench. For the purposes of this FS, it is assumed that the passive venting system with a perimeter trench would match the design of the existing trench system. The existing passive venting trench is located along the southeastern perimeter of LF 26 (Figure 4-2). Based on soil gas data, and lithologic and hydrogeologic information, the southeastern boundary is the only portion of the perimeter of LF 26 where landfill refuse-related methane has the potential to migrate beyond the landfill boundary. The existing trench extends from an area of high seasonal groundwater at the southwest corner of the landfill to an area of shallow bedrock along the northeastern side of the landfill, a distance of approximately 1,560 feet. Along the western and northwestern boundaries of the landfill, shallow groundwater and bedrock prevent migration of soil gas contamination beyond the limit of the cap. Historical soil gas data support the conclusion that soil gas migration has only occurred along the southeastern boundary of LF 26. Additional details on the existing passive venting trench, including justification for the trench location, are presented in Section 1.6.3.

#### 4.1.2.2 Institutional Controls

Institutional controls would be implemented under this alternative to eliminate or limit exposure pathways to human receptors and the environment using non-engineered methods. The institutional control aspect of this alternative has three distinct parts based on the responsible party for implementation. For this alternative, the Army, Marin County (i.e., the LEA), and the State (e.g., DTSC, RWQCB, and/or CIWMB) each have responsibilities for implementing and monitoring specific institutional control process options. Prior to property transfer, the Army implements the institutional controls. Subsequent to property transfer, the State or the new property owner takes the lead on implementing the institutional controls. In addition, Alternative 2 includes monitoring of the institutional controls by each of these parties. Institutional controls will be limited to the area currently owned by the Army and defined by the outer boundary of the buffer zone (Figure 4-2).

Prior to property transfer, the Army and the LEA or CIWMB would have the primary responsibility for implementing and monitoring institutional controls. The Army would implement the postclosure maintenance requirements required by 27 CCR and the LEA or CIWMB would monitor the implementation. During this time period, the Army would also establish and maintain any necessary site security features such as signage or fencing to restrict access and minimize the potential for impacts to the landfill cap and other remedy components.

At property transfer, the Army would impose further institutional controls on the property in the form of a deed restriction. The Federal deed for the LF 26 site will include a description of the residual contamination on the property, consistent with the Army's obligations under CERCLA Section 120(h). The institutional control, in the form of a deed restriction, is an "environmental restriction" under California Civil Code Section 1471. The deed will contain appropriate provisions to ensure that the restrictions continue to run with the land, as provided in California Civil Code Section 1471 and will include a legal description of the restricted portion of the sites. The deed will also contain a reservation of access to the property for the Army and the regulatory agencies, and their respective officials, agents, employees, contractors, and subcontractors for purposes consistent with continued monitoring of the remedy.

Following property transfer, the new property owner would implement the postclosure requirements of 27 CCR, and the LEA or CIWMB would continue to monitor the implementation of these requirements. The State may also elect to establish a SLUC to further outline land use restrictions for the property.

#### 4.1.2.3 Vapor Barriers

For this alternative, it is assumed that vapor barriers would be installed within buildings or subsurface structures (e.g., utility trenches or vaults) within the boundary of the buffer zone to limit migration of methane gas into indoor air. Vapor barriers would be installed during new construction or retrofitted to existing buildings (there is only one existing building within the landfill and buffer zone: the existing groundwater treatment plant building). As discussed in Section 3, several types of vapor barriers are commercially available. At the time of implementation, an engineer would determine the specific design of the vapor barrier, which would be based on the structure type, location, and use. For the purposes of the cost estimate, it is assumed that future buildings constructed within the site boundary would use a vapor barrier under this alternative. In addition, the existing groundwater treatment plant building would be retrofitted with a vapor barrier.

#### 4.1.2.4 Vertical Barrier

To comply with 27 CCR Section 20937(c)(3), a vertical barrier in the form of a trench lining system is included as a component of this alternative. The trench lining system would consists of GSE GundWall® interlocking rigid HDPE panels installed on the "outboard" (furthest from landfill) side of the passive venting trench. The lining system would be installed along the entire outboard side of the trench, and would extend from 2 feet below the low groundwater elevation to the ground surface.

#### 4.1.2.5 Monitoring

Monitoring under this alternative would include vadose zone monitoring, monitoring of the passive venting wells, and building/structure monitoring.

Vadose zone monitoring would consist of the collection and analysis of soil gas samples from the point of compliance and remedy monitoring wells established for LF 26. For the purposes of the cost estimate, sampling is limited to the point of compliance and remedy monitoring wells identified in Appendix C and analysis is limited to methane. The frequency of sampling will also occur according to the requirements outlined in Appendix C.

Passive venting well monitoring would consist of the collection and analysis of gas samples from each vent well (a total of 16 wells). Sampling would be performed on a quarterly basis and the samples would be analyzed for methane.

Building and structure monitoring would conform to the requirements of 27 CCR Section 20931, and would utilize continuous monitoring systems for methane.

### 4.1.3 Alternative 3 – Active Collection System (Perimeter Wells)

An active collection system utilizing a perimeter well network would be installed at LF 26 to control soil gas methane under Alternative 3. In addition to the active collection system, this alternative also includes institutional controls, vapor barriers, and monitoring as discussed below.

#### 4.1.3.1 Active Collection System with Perimeter Wells

The primary component of Alternative 3 is an active collection system utilizing a perimeter well network. Based on comprehensive landfill gas migration studies (ITSI, 2001, 2002a), the southern and southeastern portions of the perimeter of LF 26 are the only areas where the potential for methane migration exists. This portion of the landfill perimeter extends from an area of high seasonal groundwater at the southwest corner of the landfill to an area of shallow bedrock along the northeastern side of the landfill, a distance of approximately 1,560 feet.

Subsurface lithology in the vadose zone within the southern and southeastern portions of the perimeter of LF 26 is highly heterogeneous and is composed predominately of fill materials and some alluvium. The fill materials range from sandy, clayey gravel to sandy, gravelly clay. The alluvium is predominantly sandy clay. Given the heterogeneous lithology and the presence of fine-grained soils (e.g., silts and clays), a relatively close spacing (e.g., 25 feet) of the collection wells is assumed for the purposes of this FS (a detailed engineering evaluation would need to be performed to establish the predicted radius of influence for the collection wells). Using this assumption, a line of approximately 64 collection wells would be required to span the 1,560 foot distance of vadose zone along the southeastern portion of LF 26.

A manifold system would be installed to connect all of the collection wells together and a vacuum pump would be added to withdraw air from the system. Under this alternative, effluent air would be discharged directly to the atmosphere without treatment.

#### 4.1.3.2 Institutional Controls

Institutional controls would be required under this alternative and would be the same as discussed in Section 4.1.2.2.

#### 4.1.3.3 Vapor Barriers

Vapor barriers are a component of this alternative and would be implemented as discussed in Section 4.1.2.3.

#### 4.1.3.4 Monitoring

Monitoring under this alternative would include vadose zone monitoring, monitoring of the active collection system, and building/structure monitoring. Vadose zone monitoring and building/structure monitoring would be implemented under this alternative and would be performed as discussed in Section 4.1.2.4. Monitoring of the active collection system would consist of the collection of a gas sample on a quarterly basis from the effluent of the system (it is assumed that there is just one effluent point) and analysis of the sample for methane.

## 4.1.4 Alternative 4 – Active Collection System (Perimeter Trench)

An active collection system utilizing a perimeter trench would be installed at LF 26 to control soil gas methane under Alternative 4. In addition to the active collection system, this alternative also includes institutional controls, vapor barriers, and monitoring as discussed below.

### 4.1.4.1 Active Collection System with Perimeter Trench

The primary component of Alternative 4 is an active collection system utilizing a perimeter trench. For the purposes of this FS, it is assumed that the below grade portion of the active collection system including the trench, piping, and gravel pack would match the design of those components of the existing passive venting trench. The existing passive venting trench was designed and installed with the ability to be converted to an active collection system if necessary. Additional details on the existing passive venting trench are presented in Section 1.6.3. Above grade, a manifold system would be installed to connect all of the vertical risers together, and a vacuum pump would be added to withdraw air from the system. Under this alternative, effluent air would be discharged directly to the atmosphere without treatment.

### 4.1.4.2 Institutional Controls

Institutional controls would be required under this alternative and would be the same as discussed in Section 4.1.2.2.

### 4.1.4.3 Vapor Barriers

Vapor barriers are a component of this alternative and would be implemented as discussed in Section 4.1.2.3.

### 4.1.4.4 Monitoring

Monitoring under this alternative would include vadose zone monitoring, monitoring of the active collection system, and building/structure monitoring. Vadose zone monitoring and building/structure monitoring would be implemented under this alternative and would be performed as discussed in Section 4.1.2.4. Monitoring of the active collection system would consist of the collection of a gas sample on a quarterly basis from the effluent of the system (it is assumed that there is just one effluent point) and analysis of the sample for methane.

## 4.1.5 Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

Alternative 5 consists of an active collection system utilizing a perimeter trench as presented under Alternative 4. However, Alternative 5 also includes treatment of the effluent soil gas prior to its discharge to the atmosphere. In addition to the active collection system with effluent treatment, this alternative also includes institutional controls, vapor barriers, and monitoring as discussed below.

### 4.1.5.1 Active Collection System with Perimeter Trench and Effluent Treatment

The active collection system under this alternative would be the same as for Alternative 4 as discussed in Section 4.1.4.1. However, a treatment system consisting of a biofilter would be added to treat effluent air prior to its being released to the atmosphere.

#### 4.1.5.2 Institutional Controls

Institutional controls would be required under this alternative and would be the same as discussed in Section 4.1.2.2.

#### 4.1.5.3 Vapor Barriers

Vapor barriers are a component of this alternative and would be implemented as discussed in Section 4.1.2.3.

#### 4.1.5.4 Monitoring

Monitoring under this alternative would include vadose zone monitoring, monitoring of the active collection system, and building/structure monitoring. Vadose zone monitoring and building/structure monitoring would be implemented under this alternative and would be performed as discussed in Section 4.1.2.4. Monitoring of the active collection system would consist of the collection of a gas sample on a quarterly basis from the effluent of the system (downstream of the biofilter) and analysis of the sample for methane.

## 4.2 Screening of Alternatives

In this section, the five assembled remedial alternatives are screened against the criteria of effectiveness, implementability, and cost. Following are summary descriptions of the three criteria:

- **Effectiveness** – Refers to the effectiveness of each alternative at protecting human health and the environment. Each alternative is evaluated in terms of its effectiveness in providing protection and the reductions in toxicity, mobility, or volume that it will achieve. Short- and long-term effectiveness are evaluated. In this context, short-term refers to the construction and implementation period for the alternative. Long-term refers to the period after remedial action is completed.
- **Implementability** – Implementability is evaluated in terms of the technical and administrative feasibility of constructing, operating, and maintaining a remedial alternative.
  - Technical feasibility refers to the ability to construct, reliably operate, and comply with regulatory requirements during implementation of an alternative. Technical feasibility also refers to the future operation, maintenance, and monitoring of an alternative after the remedial action has been completed.
  - Administrative feasibility refers to the ability to obtain approvals and permits from regulatory agencies; the availability and capacity of treatment, storage, and disposal services; and the requirements for and availability of specialized equipment and technicians.
- **Cost** – The cost screening criterion permits comparative estimates between alternatives. Cost information is presented in Appendix D. Although these estimates do not present cradle-to-grave costs, they are used in the alternatives screening as a measure of relative costs between different process options.

The results of the screening process are summarized in Table 4-2. Four of the five alternatives survived the screening process and are retained for more detailed evaluation in Section 5:

- Alternative 1 – No Action
- Alternative 2 – Passive Venting System (Perimeter Trench)
- Alternative 4 – Active Collection System (Perimeter Trench)
- Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

Alternative 3 (Active Collection System with Perimeter Wells) was screened out because it was not likely to be effective at attaining RAOs. Lithology in the vadose zone within the LF 26 area is very heterogeneous and contains varying amounts of fine-grained soils (e.g., silts and clays). Collection wells are not effective at uniformly affecting and withdrawing soil gas from all areas in this type of lithology; therefore, it is possible that methane could migrate beyond the collection wells and point of compliance. A continuous trench system that bisects the entire vadose zone within the area of concern (as utilized for Alternatives 2, 4, and 5) is more effective at preventing the migration of methane.

With the exception of Alternative 1 (No Action), the retaining alternatives (Alternatives 2, 4, and 5) are considered to be effective at attaining RAOs and are implementable. Although Alternative 1 (No Action) is not considered to be effective, it is retained as required by the NCP, along with Alternatives 2, 4, and 5 for further evaluation in the detailed and comparatives analyses described in Sections 5 and 6, respectively.

# Tables

TABLE 4-1
Remedial Alternatives Assembled from Representative Process Options
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| GRAs | Remedial Technology | Representative Process Option | Alternative 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| No Action | None | None | ● | | | | |
| Institutional Controls | Governmental controls | Postclosure maintenance requirements | | ● | ● | ● | ● |
| | Proprietary controls | Deed covenants | | ● | ● | ● | ● |
| | | State Land Use Covenant | | ● | ● | ● | ● |
| | Informational devices | Deed notices | | ● | ● | ● | ● |
| | | Advisories | | ● | ● | ● | ● |
| Engineering Controls | Surface controls | Vapor barrier | | ● | ● | ● | ● |
| | Gas collection | Passive venting system (perimeter trench) | | ● | | | |
| | Gas collection | Active collection system (perimeter wells or trench) | | | ● | ● | ● |
| Containment | Vertical barrier | Geomembrane trench liner | | ● | | | |
| Treatment | Ex situ treatment | Biofilter | | | | | ● |
| Monitoring | Monitoring | Vadose zone monitoring | | ● | ● | ● | ● |
| | | Selected remedy monitoring | | ● | ● | ● | ● |
| | | Structure monitoring | | ● | ● | ● | ● |

TABLE 4-2
Initial Screening of Remedial Alternatives
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | Remedial Alternative | Effectiveness | Implementability | Relative Cost | Comments |
|---|---|---|---|---|---|
| 1 | No Action | Ineffective. Would not be protective of human health and the environment. Would not implement any actions to reduce the toxicity, mobility, and volume of methane. Would not meet the RAOs of protecting human health and the environment by reducing exposure or risks. Would not use permanent solutions, consider innovative technologies, nor remediate landfill refuse-related methane. Would not expedite site cleanup. Natural attenuation of methane might result in reduced concentrations. | Not applicable. | Capital: none<br>O&M: none | Retained for detailed analysis, as required by the NCP. |
| 2 | Passive Venting System (Perimeter Trench) | Effective. When combined with vapor barriers and a geomembrane trench liner, the passive venting trench system would provide short-term and potential long-term protection of human health by significantly reducing or eliminating the migration of methane beyond the point of compliance and/or into structures situated within the boundary of the landfill. Aeration of soil in the vicinity of the trench would promote biodegradation of methane and reduce the volume of contamination. | Implementable. Would be technically feasible. Construction contractors and equipment would be readily available. | Capital: low to moderate<br>O&M: low | Alternative 2 is retained for more detailed evaluation. |
| 3 | Active Collection System (Perimeter Wells) | Not effective. Perimeter collection wells may not be effective at withdrawing soil gas from all areas of concern given heterogeneous and fine-grained soils in the southern and southeastern portions of the LF 26 area. Methane could migrate through areas of the vadose zone not influenced by the collection wells and move beyond the point of compliance. | Implementable. Would be technically feasible. Construction contractors and equipment would be readily available. | Capital: moderate<br>O&M: moderate | Alternative 3 is screened out on the criterion of effectiveness. |
| 4 | Active Collection System (Perimeter Trench) | Effective. When combined with vapor barriers, the active collection trench system would provide short-term and potential long-term protection of human health by significantly reducing or eliminating the migration of methane beyond the point of compliance and/or into structures situated within the boundary of the landfill. Aeration of soil in the vicinity of the trench would promote biodegradation of methane and reduce the volume of contamination. | Implementable. Would be technically feasible. Construction contractors and equipment would be readily available. | Capital: moderate to high<br>O&M: moderate | Alternative 4 is retained for more detailed evaluation. |

TABLE 4-2
Initial Screening of Remedial Alternatives
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Remedial Alternative | | Effectiveness | Implementability | Relative Cost | Comments |
|---|---|---|---|---|---|
| 5 | Active Collection System (Perimeter Trench) with Effluent Treatment | Effective. When combined with vapor barriers, the active collection trench system would provide short-term and potential long-term protection of human health by significantly reducing or eliminating the migration of methane beyond the point of compliance and/or into structures situated within the boundary of the landfill. Aeration of soil in the vicinity of the trench would promote biodegradation of methane and reduce the volume of contamination in soil gas. Treatment of the effluent would also reduce the concentration of methane. | Implementable. Would be technically feasible. Construction contractors and equipment would be readily available. | Capital: high<br>O&M: moderate to high | Alternative 5 is retained for more detailed evaluation. |

# Figures

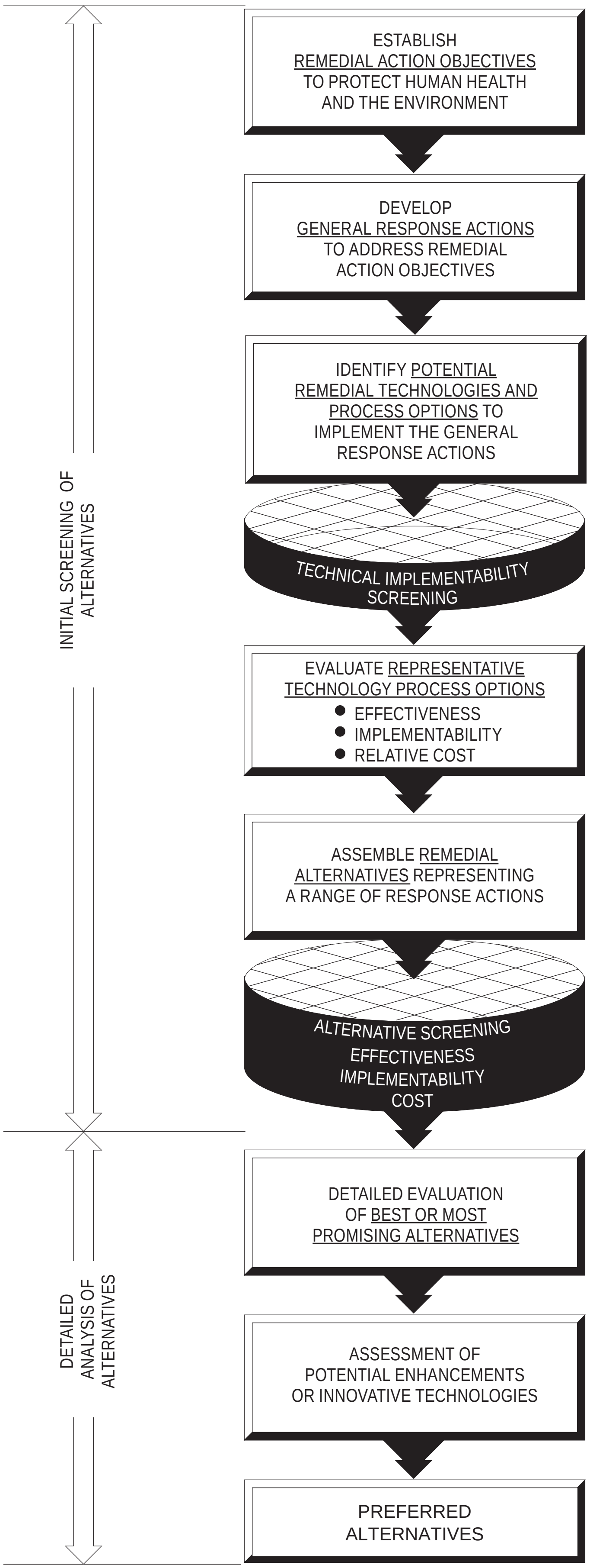


**FIGURE 4-1**
**REMEDIAL ALTERNATIVE DEVELOPMENT PROCESS**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL

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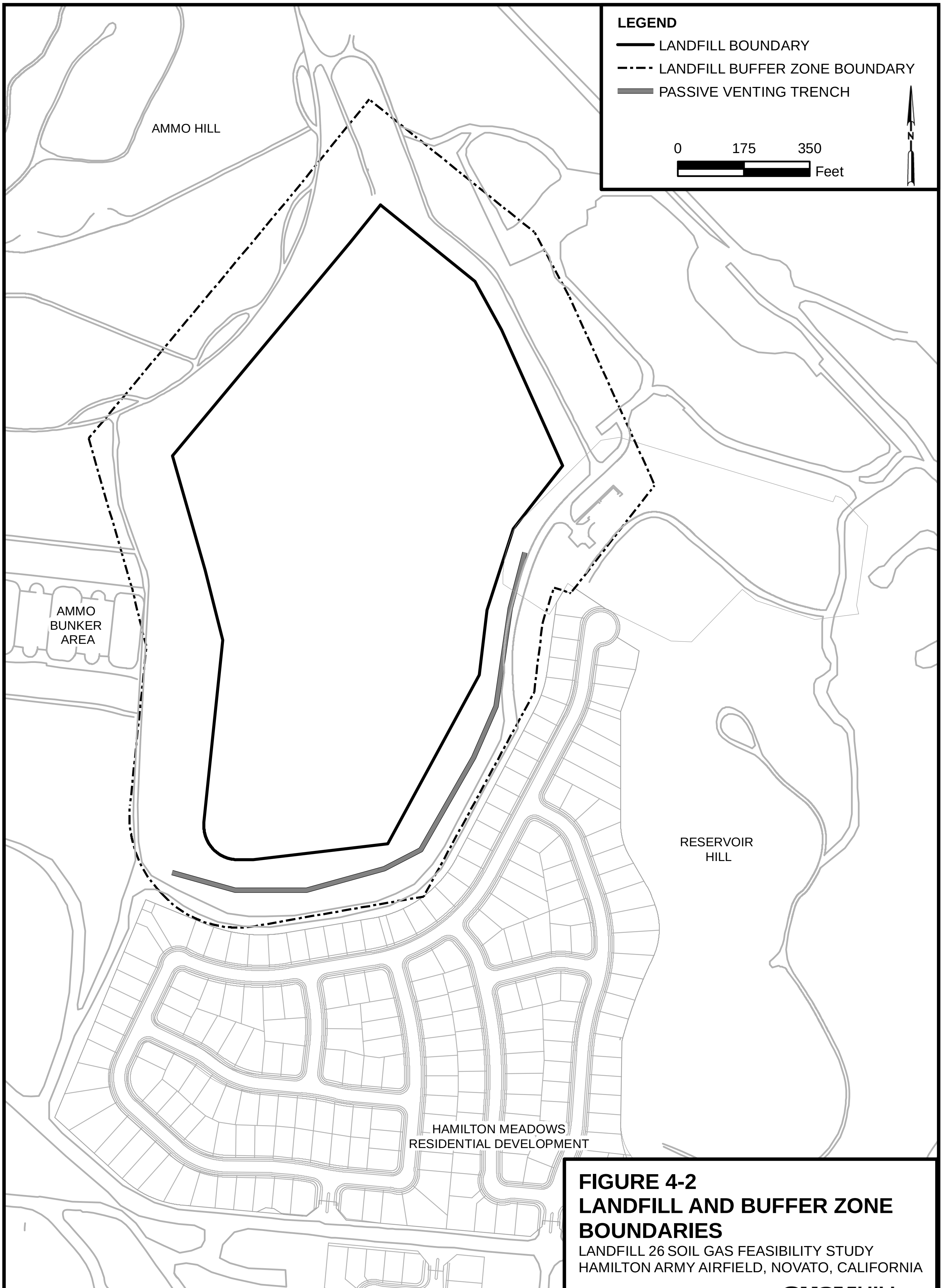


**FIGURE 4-2**
**LANDFILL AND BUFFER ZONE BOUNDARIES**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

CH2MHILL

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**SECTION 5**

# Detailed Analysis of Alternatives

In this section, the remedial alternatives that were retained after the screening process in Section 4 are subjected to detailed analysis. These alternatives include the following:

- Alternative 1 – No Action
- Alternative 2 – Passive Venting System (Perimeter Trench)
- Alternative 4 – Active Collection System (Perimeter Trench)
- Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

The detailed analysis provides sufficient information to allow for comparisons among the different alternatives based on the criteria specified in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988).

The nine CERCLA evaluation criteria included the following:

1. Overall Protection of Human Health and the Environment
2. Compliance with ARARs
3. Long-term Effectiveness and Permanence
4. Reduction of Toxicity, Mobility, or Volume through Treatment
5. Short-term Effectiveness
6. Implementability
7. Cost
8. State Acceptance
9. Community Acceptance

The NCP (40 CFR Section 300.430(e)(9)(iii)) categorizes these nine criteria into the following three groups:

- **Threshold criteria.** Threshold criteria are requirements that each alternative must meet to be eligible for selection as a preferred alternative, and consist of Criterion 1, Overall Protection of Human Health and the Environment and Criterion 2, Compliance with ARARs (unless a waiver is obtained).

- **Primary balancing criteria.** Primary balancing criteria are used to weigh effectiveness and cost tradeoffs among alternatives. The primary balancing criteria consist of Criterion 3, Long-term Effectiveness and Permanence; Criterion 4, Reduction of Toxicity, Mobility, or Volume through Treatment; Criterion 5, Short-term Effectiveness; Criterion 6, Implementability; and Criterion 7, Cost. The primary balancing criteria represent the main technical criteria that the alternative evaluation is based on.

- **Modifying criteria.** Modifying criteria consist of Criterion 8, State Acceptance and Criterion 9, Community Acceptance. Modifying criteria are generally evaluated after public comment on the FS and the Proposed Plan, and could be used to modify aspects of the preferred alternative when preparing the ROD Amendment for LF 26.

Accordingly, only the seven threshold and primary balancing criteria are in the detailed analysis phase. The following sections provide descriptions of the first seven evaluation criteria.

## 5.1 Description of Evaluation Criteria

### 5.1.1 Criterion 1 – Overall Protection of Human Health and the Environment

This evaluation criterion assesses how each alternative provides and maintains adequate protection of human health and the environment. The alternatives are assessed to determine whether they can adequately protect human health and the environment from unacceptable risks posed by methane. This criterion is also used to evaluate how risks would be eliminated, reduced, or controlled through treatment, engineering, institutional controls, or other remedial activities.

### 5.1.2 Criterion 2 – Compliance with ARARs

This evaluation criterion is used to determine if each alternative would attain compliance with federal and state ARARs. Other information, such as advisories, criteria, or guidance, is considered where appropriate during the ARARs analysis. The considerations evaluated during the analysis of the ARARs applicable to each alternative are presented in Table 5-1. Potential action-, location-, and chemical-specific ARARs for the alternatives presented in this FS are identified in Section 2.3.

### 5.1.3 Criterion 3 – Long-term Effectiveness and Permanence

This evaluation criterion addresses the long-term effectiveness and permanence of maintaining the protection of human health and the environment after implementing the remedial action imposed by the alternative. The primary components of this criterion are the magnitude of residual risk remaining at the site after remedial objectives have been met and the extent and effectiveness of controls that might be required to manage the residual risk. The considerations evaluated during the analysis of each alternative for long-term effectiveness and permanence are presented in Table 5-2. The components addressed for each alternative are described in more detail in the following subsections.

#### 5.1.3.1 Magnitude of Residual Risk

The magnitude of residual risk at the end of remedial activities is measured by numerical standards, such as the concentration of landfill refuse-related methane at the point of compliance or methane concentrations within nearby structures.

#### 5.1.3.2 Adequacy and Reliability of Controls

The adequacy and reliability of controls that are used to manage residual contaminants is evaluated. This criterion includes an assessment of the remedial systems and institutional controls to evaluate the degree of confidence that they adequately handle potential problems and provide sufficient protection. The criterion also addresses long-term reliability and the need for long-term management and monitoring of the site.

### 5.1.4 Criterion 4 – Reduction of Toxicity, Mobility, or Volume through Treatment

This evaluation criterion addresses the anticipated performance of the treatment technologies included in the alternatives to permanently and significantly reduce toxicity, mobility, and/or volume of hazardous materials at the site. The NCP prefers remedial actions where treatment is used to reduce the principal threats at a site through destruction of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media. The considerations evaluated during the analysis of each alternative for reduction of toxicity, mobility, or volume of methane are presented in Table 5-3.

### 5.1.5 Criterion 5 – Short-term Effectiveness

This evaluation criterion considers the effect of each alternative on the protection of human health and the environment during the construction and implementation process. The short-term effectiveness evaluation only addresses protection prior to meeting the RAO. The considerations evaluated during the analysis of each alternative for short-term effectiveness are presented in Table 5-4. This criterion includes consideration of the time required to achieve RAOs.

### 5.1.6 Criterion 6 – Implementability

This criterion evaluates the technical and administrative feasibility (i.e., the ease or difficulty) of implementing each alternative. This includes the availability of required services and materials during its implementation; ability to obtain approvals and permits from regulatory agencies; availability and capacity of treatment, storage, and disposal services; and requirements for and availability of specialized equipment and technicians. The considerations typically evaluated during the analysis of each alternative for implementability are presented in Table 5-5.

### 5.1.7 Criterion 7 – Cost

This criterion evaluates the cost of implementing each alternative. The cost of an alternative encompasses all engineering, construction, administrative, and O&M (including institutional controls and administration of any SLUCs) costs incurred over the life of the project. Per EPA guidance (EPA, 2000), the assessment against this criterion is based on the estimated present value of the costs for each alternative. Present value is defined as the amount of money, which, if invested in the current year, would be sufficient to cover all costs over time associated with a project (EPA, 2000). Because remedial action projects typically involve varying proportions of upfront construction costs (e.g., capital costs) and costs in subsequent years to maintain the remedy (e.g., long-term costs), the present value methodology is used to evaluate expenditures, either capital or long-term, which occur over different time periods, and to allow for comparisons of different remedial alternatives on the basis of a single cost figure.

## 5.2 CERCLA Criteria Evaluation

In this subsection, the remedial alternatives to address landfill refuse-related methane in soil gas at LF 26 are evaluated against the seven CERCLA criteria. The previously developed alternatives consist of the following:

- Alternative 1 – No Action
- Alternative 2 – Passive Venting System (Perimeter Trench)
- Alternative 4 – Active Collection System (Perimeter Trench)
- Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

The detailed analyses of these alternatives are provided below.

### 5.2.1 Alternative 1 – No Action

Under Alternative 1, no action would be taken at LF 26. The "No Action" alternative, does not meet EPA's national program goal identified in the NCP (40 CFR 300.430(a)(1)(i)) for the remedy selection process, which is to "select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste." However, as required by the NCP, LF 26 was evaluated for the No Action Alternative. The results for Alternative 1 provide a baseline for comparison of the other alternatives. For the purposes of this FS, the No Action Alternative would entail the discontinuation of all current monitoring and maintenance programs in place at LF 26.

#### 5.2.1.1 Overall Protection of Human Health and the Environment

Under Alternative 1, there would be no reduction in risk to human health, because landfill refuse-related methane would be allowed to migrate away from the landfill, and possibly into structures on top of and around the landfill. There would be unlimited access to the LF 26 site, and future activities at LF 26 (such as excavation and construction) would not be monitored or restricted.

#### 5.2.1.2 Compliance with ARARs

Alternative 1 is not in compliance with ARARs. For example, ARARs intended to be protective of the environment by preventing migration of methane would not be met. In addition, this alternative would not be in compliance with ARARs designed to protect the public from the hazards (e.g., explosive conditions) associated with methane.

#### 5.2.1.3 Long-term Effectiveness and Permanence

All current and future risks remain under Alternative 1; therefore, the alternative is not effective. For LF 26, landfill refuse-related methane in soil gas may continue to migrate away from the landfill to pose a potential risk to human health.

#### 5.2.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

With the exception of the natural degradation of methane, there would be no reduction of toxicity, mobility, or volume through treatment because no treatment technologies would be employed. Permanent or significant reduction in toxicity and volume would occur only gradually as natural biological degradation occurs. These processes would be inherently irreversible.

#### 5.2.1.5 Short-term Effectiveness

No remedial action would be taken under Alternative 1; therefore, there would be no short-term risks to the community or to workers as a result of remedial activity. Similarly, there would be no environmental impact from construction activities.

#### 5.2.1.6 Implementability

No technology factors are evaluated (i.e., ability to construct or operate the technology, availability, and reliability of the technology or specialists) under Alternative 1. There would be no impediments to implementing future remedial actions.

#### 5.2.1.7 Cost

No costs are associated with Alternative 1.

### 5.2.2 Alternative 2 – Passive Venting System (Perimeter Trench)

Under this alternative, a passive venting system employing a perimeter trench would be constructed along the southeastern portion of the perimeter of LF 26 to prevent the migration of landfill refuse-related methane away from the landfill. The passive venting system also incorporates a vertical barrier in the form of a trench lining system installed on the "outboard" (farthest from landfill) side of the venting trench. For the purposes of this FS, it is assumed that the passive venting system and vertical barrier would match the designs of the existing systems at LF 26. This alternative also includes institutional controls, vapor barriers, and monitoring.

#### 5.2.2.1 Overall Protection of Human Health and the Environment

Protection of human health would be achieved and maintained by preventing the migration of methane away from the landfill, or migration of methane into structures on top of or adjacent to the landfill. Under Alternative 2, the passive venting trench would provide protection of human health by facilitating the removal of landfill refuse-related methane from the vadose zone and venting it to the atmosphere where it would readily dissipate. The passive venting trench and vertical barrier would provide protection of human health by eliminating the migration of landfill refuse-related methane in the vadose zone beyond the point of compliance. Soil gas monitoring data collected since the existing passive venting trench was installed (the trench was completed in August 2002) indicate that the trench has been effective at reducing concentrations of landfill refuse-related methane to levels below 5 percent by volume in the area between the trench and the property line.[1] These data demonstrate the protectiveness of the existing passive venting trench (i.e., Alternative 2).

Alternative 2 also includes vapor barriers for structures within the footprint of the landfill. The vapor barriers would eliminate the potential for the migration of methane into structures both on top of and adjacent to the landfill. The monitoring and institutional controls included in the alternate would ensure continued protection of human health under Alternative 2.

[1] Although the passive venting trench has been effective at reducing landfill refuse-related methane, some naturally-occurring methane may be present in the area between the trench and the property line at concentrations exceeding 5 percent by volume.

#### 5.2.2.2 Compliance with ARARs

Overall, Alternative 2 meets the requirements of 27 CCR 20921 through 20937. Specifically, the existing passive venting trench and vertical barrier trench were designed and installed in accordance with the requirements outlined in 27 CCR 20937(c)(3), and the vapor barriers included in Alternative 2 meet the requirements of 27 CCR 20937(d). Overall, the alternative meets the explosive gas control requirements of 27 CCR 20919.5. In addition, the monitoring component of Alternative 2 meets the design requirements of 27 CCR 20923 and 20925. Maintenance of the system will be performed in compliance with the closure and postclosure requirements of 27 CCR 21180 and 21190, which require environmental control systems to be maintained. Therefore, Alternative 2 is consistent with identified ARARs.

#### 5.2.2.3 Long-term Effectiveness and Permanence

Alternative 2 would meet RAOs and provide continued effective protection of human health as long as the integrity and performance of the passive venting system and vertical barrier are monitored and institutional controls are enforced.

Alternative 2 would provide an additional degree of permanence and long-term effectiveness because of the incorporation of vapor barriers. Vapor barriers would be installed under buildings and other enclosed structures adjacent to or on the LF 26 site. Vapor barriers would minimize the potential for methane intrusion and would continue to be effective as long as the barriers are not disturbed.

Long-term monitoring would be required to verify continued effectiveness of the passive venting system and vertical barrier at containing the methane and the effectiveness of the vapor barriers. Long-term monitoring for methane would include vadose zone monitoring (e.g., point of compliance wells), system monitoring (e.g., vent and remedy monitoring), and structure monitoring.

#### 5.2.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 does not necessarily meet the statutory preference for treatment because Alternative 2 does not incorporate treatment as a principal element. However, Alternative 2 does provide for some reduction in the volume of methane in the subsurface, because the venting trench facilitates aeration of soils within and adjacent to the trench that supports biodegradation of methane.

#### 5.2.2.5 Short-term Effectiveness

Construction of a passive venting system and vertical barrier can be completed in a relatively short time period (the existing trench and barrier system was installed within approximately a 12 month time period); therefore, this alternative provides adequate short-term protectiveness. Typical site work necessary for construction of a passive venting system includes excavation of the trench; therefore, workers may come into direct contact with methane in soil gas or potentially contaminated soils. Engineering controls (e.g., personal protective equipment and dust control) are typically used to minimize worker and nearby community exposure. However, because a passive venting system has already been installed at LF 26, no further construction is required to complete this alternative.

#### 5.2.2.6 Implementability

A passive venting system is readily implementable from both the technical and administrative standpoints. For example, the existing passive venting system, including the vertical barrier, was designed and constructed without significant delays or problems. Administratively, the regulatory agencies concurred with the design and installation of the existing system.

Vapor barriers are also implementable, especially for new construction. Vapor barriers could also be retrofitted to existing structures; however, implementability would be more difficult. Contractors and materials would be readily available for these activities.

Institutional controls would be readily implementable technically. Materials, legal mechanisms, and services to implement the alternative would be available. Because the parties would have a right of access in the deed covenant, they would be able to conduct inspections and implement monitoring. From an administrative standpoint, implementation of institutional controls would require coordination between the Army, State, and local agencies (e.g., County of Marin and City of Novato).

#### 5.2.2.7 Cost

As previously indicated, it was assumed that the passive venting system with a perimeter trench and vertical barrier would match the designs of the existing systems at LF 26. Therefore, the cost information included for these components of the alternative were taken from the actual construction costs incurred. The estimated present value cost (30 years) for Alternative 2 is $1,897,000. This includes a capital cost of approximately $1,296,000 (for installation of the trench, impermeable barrier, etc.) and estimated annual costs of about $30,700. Assumptions and details regarding the cost estimation can be found in Appendix D.

### 5.2.3 Alternative 4 – Active Collection System (Perimeter Trench)

For Alternative 4, an active collection system employing a perimeter trench would be constructed along the southeastern portion of the perimeter of LF 26 to prevent the migration of landfill refuse-related methane away from the landfill. This alternative also includes institutional controls, vapor barriers, and monitoring.

#### 5.2.3.1 Overall Protection of Human Health and the Environment

Protection of human health would be achieved and maintained by preventing the migration of methane away from the landfill or migration of methane into structures on top of or adjacent to the landfill. Under Alternative 4, the active collection trench would provide protection of human health by actively collecting landfill refuse-related methane and discharging it to the atmosphere where it would readily dissipate. Active collection of methane from the vadose zone would eliminate the migration of landfill refuse-related methane beyond the point of compliance. In addition, vapor barriers would eliminate the potential for the migration of methane into structures both on top of and adjacent to the landfill. The monitoring and institutional controls included in the alternate would ensure continued protection of human health under Alternative 4.

#### 5.2.3.2 Compliance with ARARs

Overall, Alternative 4 meets the requirements of 27 CCR 20921 through 20937. Specifically, the existing active venting trench would be designed and installed in accordance with the requirements outlined in 27 CCR 20937(c)(1), and the vapor barriers included in Alternative 4 meet the requirements of 27 CCR 20937(d). Overall, the alternative meets the explosive gas control requirements of 27 CCR 20919.5. In addition, the monitoring component of Alternative 4 meets the design requirements of 27 CCR 20923 and 20925. Maintenance of the system will be performed in compliance with the closure and postclosure requirements of 27 CCR 21180 and 21190, which require environmental control systems to be maintained. Therefore, Alternative 4 is consistent with identified ARARs.

#### 5.2.3.3 Long-term Effectiveness and Permanence

Alternative 4 would meet RAOs and provide continued effective protection of human health as long as the integrity and performance of the active collection system is monitored and institutional controls are enforced.

Alternative 4 would also provide an additional degree of permanence and long-term effectiveness because of the incorporation of vapor barriers. Vapor barriers would be installed under buildings and other enclosed structures adjacent to or on the LF 26 site. Vapor barriers would minimize the potential for methane intrusion and would continue to be effective as long as the barriers are not disturbed.

Long-term monitoring would be required to verify continued effectiveness of the active collection system at containing the methane and the effectiveness of the vapor barriers. Long-term monitoring for methane would include vadose zone monitoring (e.g., point of compliance wells), system monitoring (e.g., effluent monitoring), and structure monitoring.

#### 5.2.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 4 does not necessarily meet the statutory preference for treatment because Alternative 4 does not incorporate treatment as a principal element. However, Alternative 4 does provide for some reduction in the volume of methane in the subsurface, because the collection trench facilitates aeration of soils within and adjacent to the trench that supports biodegradation of methane.

#### 5.2.3.5 Short-term Effectiveness

Construction of an active collection system can be completed in a relatively short time period; therefore, this alternative provides adequate short-term protectiveness. Typical site work necessary for construction of an active collection system includes excavation of the trench; therefore, workers may come into direct contact with methane in soil gas or potentially contaminated soils. Engineering controls (e.g., personal protective equipment and dust control) are typically used to minimize worker and nearby community exposure. Because the existing passive venting trench was designed to be converted to an active system, no further subsurface work would be required under this alternative. The remainder of the work (e.g., header construction and vacuum pump installation) is above ground and therefore the potential for contact with contamination is minimal. Upon completion of implementation, Alternative 4 is immediately protective of human health, and RAOs would be achieved.

#### 5.2.3.6 Implementability

An active collection system would be readily implementable from a technical standpoint. The existing passive venting trench was designed and constructed to allow it to be converted into an active collection system if necessary. Implementation would therefore focus on the conversion process that would involve constructing the collection headers and installation of the vacuum pump. Contractors and materials would be available for these activities. An active collection system is also considered to be readily implementable from an administrative standpoint (difficulties associated with regulatory agency concurrence and/or permitting are not envisioned).

Implementability of the vapor barriers and institutional controls would be the same as for Alternative 2 (see Section 5.2.2.6).

#### 5.2.3.7 Cost

As previously indicated, it was assumed that the passive venting system with a perimeter trench would match the designs of the existing systems at LF 26. Therefore, the cost information included for this component of the alternative was taken from the actual construction costs incurred. The estimated present value cost (30 years) for Alternative 4 is $1,917,000. This includes a capital cost of approximately $1,103,000 (for installation of the trench, pump systems, etc.) and estimated annual costs of about $41,500. Assumptions and details regarding the cost estimation can be found in Appendix D.

### 5.2.4 Alternative 5 – Active Collection System (Perimeter Trench) with Effluent Treatment

Alternative 5 consists of an active collection system employing a perimeter trench that would be constructed along the southeastern portion of the perimeter of LF 26 to prevent the migration of landfill refuse-related methane away from the landfill. Treatment of the effluent air from the collection system in the form of a biofilter is also a component of this alternative (the treatment component of Alternative 5 differentiates it from Alternative 4). This alternative also includes institutional controls, vapor barriers, and monitoring.

#### 5.2.4.1 Overall Protection of Human Health and the Environment

Protection of human health would be achieved and maintained by preventing the migration of methane away from the landfill, or migration of methane into structures on top of or adjacent to the landfill. Under Alternative 5, the active collection trench would provide protection of human health by actively collecting landfill refuse-related methane and treating (i.e., removing the methane) the effluent air prior to discharging it to the atmosphere. Active collection of methane from the vadose zone would eliminate the migration of landfill refuse-related methane beyond the point of compliance, and treatment of the effluent air to remove the methane would enhance the overall protection of human health. In addition, vapor barriers would eliminate the potential for the migration of methane into structures both on top of and adjacent to the landfill. The monitoring and institutional controls included in the alternative would ensure continued protection of human health under Alternative 5.

#### 5.2.4.2 Compliance with ARARs

Alternative 5 would comply with ARARs for protection of human health. The primary ARARs are the same as for Alternatives 2 and 4 (i.e., 27 CCR).

#### 5.2.4.3 Long-term Effectiveness and Permanence

Alternative 5 would meet RAOs and provide continued effective protection of human health as long as the integrity and performance of the active collection and treatment systems are monitored and institutional controls are enforced.

Alternative 5 would also provide an additional degree of permanence and long-term effectiveness because of the incorporation of vapor barriers. Vapor barriers would be installed under buildings and other enclosed structures adjacent to or on the LF 26 site. Vapor barriers would minimize the potential for methane intrusion and would continue to be effective as long as the barriers are not disturbed.

Long-term monitoring would be required to verify continued effectiveness of the active collection system at containing the methane and the effectiveness of the vapor barriers. Long-term monitoring for methane would include vadose zone monitoring (e.g., point of compliance wells), system monitoring (e.g., effluent monitoring), and structure monitoring.

#### 5.2.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

The effluent treatment component of Alternative 5 would provide for a reduction in the volume of methane, thereby meeting the statutory preference for treatment as a principal element. In addition, Alternative 5 provides for some in situ reduction in the volume of methane because the collection trench facilitates aeration of soils within and adjacent to the trench that supports biodegradation of methane.

#### 5.2.4.5 Short-term Effectiveness

The short-term effectiveness for Alternative 5 would be similar to that for Alternative 4.

#### 5.2.4.6 Implementability

An active collection system with effluent treatment would be readily implementable from a technical standpoint. The existing passive venting trench was designed and constructed to allow it to be converted into an active collection system if necessary. Implementation of Alternative 5 would therefore focus on the conversion process, including constructing the collection headers, installation of the vacuum pump, and installation of the biofilter. Contractors and materials would be available for these activities. An active collection system with effluent treatment is also considered to be readily implementable from an administrative standpoint (difficulties associated with regulatory agency concurrence and/or permitting are not envisioned).

Implementability of the vapor barriers and institutional controls would be the same as for Alternative 2 (see Section 5.2.2.6).

#### 5.2.4.7 Cost

As previously indicated, it was assumed that the passive venting system with a perimeter trench would match the designs of the existing systems at LF 26. Therefore, the cost information included for this component of the alternative was taken from the actual construction costs incurred. The estimated present value cost (30 years) for Alternative 5 is $2,047,000. This includes a capital cost of approximately $1,113,000 (for installation of the trench, pump, biofilter, etc.) and estimated annual costs of about $47,600. Assumptions and details regarding the cost estimation can be found in Appendix D.

# Tables

TABLE 5-1
Criterion 2 – Compliance with ARARs
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Analysis Factor | Considerations |
|---|---|
| Chemical-specific ARARs | Likelihood that the alternative would achieve compliance with chemical-specific ARARs within a reasonable period of time. |
| Location-specific ARARs | Determination of whether any location-specific ARARs would apply to the alternative (no location-specific ARARs have been identified for the remedies addressed in this FS) and whether the alternative would achieve compliance with the location-specific ARAR. |
| Action-specific ARARs | Likelihood that the alternative would achieve compliance with action-specific ARARs (e.g., hazardous waste treatment regulations). |
| Other criteria and guidance | Likelihood that the alternative would achieve compliance with other criteria such as risk-based criteria. |

TABLE 5-2
Criterion 3 – Long-term Effectiveness and Permanence
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Analysis Factor | Considerations |
|---|---|
| Magnitude of residual risks | Magnitude of the remaining risks. |
| Adequacy and reliability of controls | Likelihood that the technologies would meet required process efficiencies or performance specifications.<br><br>Type and degree of long-term management that would be required.<br><br>Long-term monitoring requirements.<br><br>O&M functions that would need to be performed.<br><br>Difficulties and uncertainties that would be associated with long-term O&M functions.<br><br>Potential need for technical components replacement.<br><br>Degree of confidence that controls could adequately handle potential problems. |

TABLE 5-3
Criterion 4 – Reduction of Toxicity, Mobility, or Volume through Treatment
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Analysis Factor | Considerations |
|---|---|
| Treatment process and remedy | Likelihood that the treatment process would address the principal threat (i.e., methane).<br><br>Special requirements for the treatment process. |
| Amount of contaminants destroyed or treated | Portion (mass) of methane that would be destroyed.<br><br>Portion (mass) of methane that would be treated. |
| Reduction in toxicity, mobility, or volume | Extent that the total mass of methane would be reduced.<br><br>Extent that the mobility of methane would be reduced.<br><br>Extent that the volume of methane would be reduced. |
| Irreversibility of treatment | Extent that the effects of the treatment would be irreversible. |
| Type and quantity of treatment residual | Residuals that would remain.<br><br>Quantities and characteristics of the residuals.<br><br>Risk posed by the treatment residuals (if present). |
| Statutory preference for treatment as a principal element | Extent to which the scope of the action would cover the principal threat (i.e., methane).<br><br>Extent to which the scope of the action would reduce the inherent hazards posed by the methane at the site. |

TABLE 5-4
Criterion 5 – Short-term Effectiveness
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Analysis Factors | Considerations |
|---|---|
| Protection of the community during the remedial action | Risks to the community that would need to be addressed.<br>How the risks would be addressed and mitigated.<br>Remaining risks that could not be readily controlled. |
| Protection of workers during remedial actions | Risks to the workers that would need to be addressed.<br>How the risks would be addressed and mitigated.<br>Remaining risks that could not be readily controlled. |
| Environmental Impacts | Environmental impacts that would be expected with the construction and implementation of the alternative.<br>Mitigation measures that would be available and their reliability to minimize potential impacts.<br>Impacts that could not be avoided, should the alternative be implemented. |
| Time until remedial action objectives are achieved | Time to achieve protection against the threats being addressed.<br>Time until any remaining threats would be addressed.<br>Time until RAOs would be achieved. |

TABLE 5-5
Criterion 6 – Implementability
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Analysis Factors | Considerations |
|---|---|
| **Technical Feasibility** | |
| Ability to construct and operate the technology | Difficulties that would be associated with the construction. |
| | Uncertainties that would be associated with the construction. |
| Reliability of the technology | Likelihood that technical problems would lead to schedule delays. |
| Monitoring considerations | Migration or exposure pathways that could not be monitored adequately. |
| | Risks of exposure, should the monitoring be insufficient to detect failure. |
| **Administrative Feasibility** | |
| Need for land use restrictions | Requirement for institutional controls and implementation of land use restrictions. |
| Coordination with other agencies | Steps that would be required to coordinate with regulatory agencies. |
| | Steps that would be required to establish long-term or future coordination among agencies. |
| | Ease of obtaining permits for offsite activities, if required. |
| **Availability of Services and Materials** | |
| Availability of treatment, storage capacity, and disposal services | Availability of adequate treatment, storage capacity, and disposal services. |
| | Additional capacity that would be necessary. |
| | Whether lack of capacity would prevent implementation. |
| | Additional provisions that would be required to ensure that additional capacity would be available. |
| Availability of necessary equipment and specialists | Availability of adequate equipment and specialists. |
| | Additional equipment or specialists that would be required. |
| | Whether there would be a lack of equipment or specialists. |
| | Additional provisions that would be required to ensure that equipment and specialists would be available. |
| Availability of prospective technologies | Whether technologies under consideration would be generally available and sufficiently demonstrated. |
| | Further field applications that would be needed to demonstrate that the technologies might be used full-scale to treat the waste at the site. |
| | When technology should be available for full-scale use. |
| | Whether more than one vendor would be available to provide a competitive bid. |

**SECTION 6**

# Comparative Analysis of Alternatives

This section provides a comparative analysis of the relative performance of each alternative in relation to the seven CERCLA evaluation criteria. A comparative ranking of the alternatives with respect to the CERCLA evaluation criteria is presented in Figure 6-1. The comparative analysis of the alternatives is also summarized in Table 6-1.

## 6.1 Overall Protection of Human Health and the Environment

Alternative 1 (No Action) would not reduce the risk to human health because exposure to contaminants would be possible. The risk of impacting the environment remains because the migration of contamination to groundwater, soil, and surface water is not eliminated.

Alternative 2 (Passive Venting System with Perimeter Trench) and Alternative 4 (Active Collection System with Perimeter Trench) would provide similar levels of protection of human health by facilitating the removal of landfill refuse-related methane from the vadose zone, and by eliminating the migration of landfill refuse-related methane in the vadose zone beyond the point of compliance.

Because the venting trench (Alternative 2) works passively, does not require electrical power to operate, and requires only limited maintenance, it is likely to facilitate the control and removal of methane on a continuous basis into the foreseeable future with minimal, if any, operational issues (e.g., downtime). In addition, the passive venting system incorporates an impermeable barrier into the design that provides further protection against potential methane migration. Soil gas monitoring data collected since the existing passive venting trench and associated impermeable barrier were installed (the trench and barrier were completed in August 2002) indicate that concentrations of landfill refuse-related methane in monitoring wells along the entire perimeter of the landfill have been at concentrations well below 5 percent by volume.[1] These data demonstrate the protectiveness of the existing passive venting trench system (i.e., Alternative 2). The vapor barriers included in Alternative 2 would eliminate the potential for the migration of methane into structures both on top of and adjacent to the landfill. Monitoring and institutional controls would ensure the continued protectiveness of Alternative 2.

Alternative 4 would also facilitate the removal of landfill refuse-related methane from the vadose zone and would eliminate the migration of landfill refuse-related methane in the vadose zone beyond the point of compliance. As specified in 27 CCR 20937(c)(2), active collection systems must be operated at a rate that is sufficient for methane control, but does not result in higher than necessary production rates (i.e., overpulling) as specified in 27 CCR 20937(c)(2). Therefore, active collection systems are not necessarily more effective at

[1] Although the passive venting trench has been effective at reducing landfill refuse-related methane, some naturally-occurring methane may be present to the south of the landfill in the area between the trench and the property line at concentrations exceeding 5 percent by volume.

methane removal when compared with passive venting systems, especially at landfills such as LF 26 where methane production rates and concentrations in soil gas are relatively low. The vapor barriers, monitoring, and institutional controls included in Alternative 4 would provide the same level of protectiveness as in Alternative 2.

Alternative 5 (Active Collection System with Perimeter Trench and Effluent Treatment) provides a slightly higher level of protectiveness than Alternatives 2 and 4. Because Alternative 5 includes effluent air treatment, and methane within the effluent air would be destroyed during treatment rather than being released to the atmosphere, it would result in a slight increase in protectiveness compared with Alternative 4. The vapor barriers, monitoring, and institutional controls included in Alternative 4 would provide the same level of protectiveness as in Alternatives 2 and 4.

## 6.2 Compliance with ARARs

With the exception of Alternative 1 (No Action), all alternatives would comply with potential ARARs (primarily 27 CCR ). Alternative 1 does not meet EPA's national program goal identified in the NCP (40 CFR 300.430(a)(1)(i)) for the remedy selection process, which is to "select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste."

## 6.3 Long-term Effectiveness and Permanence

There are no controls implemented to manage methane at LF 26 for Alternative 1. Therefore, under Alternative 1, the criterion for long-term effectiveness and permanence is not met.

A passive venting system (Alternative 2) is a conventional method used for methane control at landfills, and these systems typically have a track record of providing a high degree of long-term effectiveness and permanence. The long-term effectiveness and permanence of Alternative 2 with respect to methane control and removal is slightly higher relative to Alternatives 4 and 5. As previously discussed, the venting trench works passively, does not require electrical power to operate, and requires only limited maintenance. Therefore, the passive venting trench is likely to facilitate the control and removal of methane on a continuous basis into the foreseeable future with minimal if any operational issues (e.g., downtime). In addition, the passive venting system incorporates an impermeable barrier into the design that provides further protection against potential methane migration. The vapor barrier component of Alternative 2 also provides very good long-term effectiveness and permanence with respect to methane intrusion. The long-term protectiveness and permanence of Alternative 2 is, however, dependent on proper and sustained implementation of monitoring and institutional controls.

An active collection system (Alternatives 4 and 5) is also the conventional method used for methane control at landfills, and these systems also typically have a track record of providing a high degree of long-term effectiveness and permanence. The long-term effectiveness and permanence of Alternatives 4 and 5 are similar to one another, but slightly lower relative to Alternative 2. Because both active collection systems require electrical power to operate and for continued maintenance, the control and removal of methane is more dependent on proper and sustained O&M procedures. The active collection systems also do not include an impermeable barrier. The vapor barrier component of Alternatives 4 and 5 also provides very good long-term effectiveness and permanence with respect to methane intrusion. The long-term protectiveness and permanence of Alternatives 4 and 5 is, however, dependent on proper and sustained implementation of monitoring and institutional controls.

## 6.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 would not reduce contaminant toxicity, mobility, and volume through treatment because no treatment technologies are employed.

Alternatives 2 and 4 do not actively incorporate treatment as a principal element. However, Alternatives 2 and 4 do provide for some reduction in the volume of methane in the subsurface, because the venting trench facilitates aeration of soils within and adjacent to the trench that supports biodegradation of methane.

Alternative 5 includes treatment of the effluent air from the active collection system (a biofilter). The treatment component of this alternative would reduce the volume of methane, and therefore ranks higher in this criterion compared with Alternatives 2 and 4.

## 6.5 Short-term Effectiveness

No remedial action will be taken under Alternative 1. Therefore, no environmental impacts will occur, and no short-term risks to the community or to workers as a result of implementing the action will occur.

Under Alternatives 2, 4, and 5, the RAOs for protection of human health could be achieved in a relatively short period of time with construction of the trench (passive or active), installation of vapor barriers, and implementation of institutional controls. The short-term effectiveness is similar for all three alternatives. No significant potential short-term exposures to the community or workers would be anticipated during the construction required for Alternatives 2, 4, or 5. Because a passive venting system has already been installed at LF 26, no further construction at the site would be required for Alternative 2. For Alternatives 4 and 5, some additional aboveground construction would be required for the manifold, pumps, and treatment systems.

## 6.6 Implementability

There are no actions associated with Alternative 1. Therefore, there are no technical impediments to implementing Alternative 1.

Alternatives 2, 4, and 5 are all readily implementable from both a technical and administrative standpoint. However, the implementability of Alternative 2 is slightly higher compared with Alternatives 4 and 5 because the passive venting system does not require any utilities to operate. Because Alternative 2 does not require any utilities, the design and construction of the system is simpler.

## 6.7 Cost

The estimated costs for implementing the alternatives evaluated in this FS are presented in Table 6-1. Detailed cost calculations are presented in Appendix D. The costs presented in Table 6-1 reflect the total cost of each alternative in 2007 dollars (i.e., present value costs), and reflect what it would cost to implement each alternative starting in 2007. The cost for Alternative 2 includes all of the costs associated with this alternative, including those that have already been incurred (e.g., costs for construction of the passive venting trench and impermeable barrier). This approach provides for a direct comparison of the total costs for each alternative.

Alternative 2 ($1,897,000) has the lowest overall cost. Although the capital costs associated with construction of the passive venting system are slightly higher when compared with the active collection systems (mainly due to the cost of the impermeable barrier), the lower long-term O&M costs associated with the passive system result in a lower overall cost for Alternative 2.

The overall cost for Alternative 4 ($1,917,000) is higher compared with Alternative 2, but lower compared with Alternative 5 ($2,047,000). The capital costs for construction of the active collection system are lower than those for the passive venting system (Alternative 2); however, the costs for long-term O&M associated with the active system result in a higher overall cost compared with Alternative 2.

Alternative 5 ($2,047,000) has the highest overall cost. Costs for construction under Alternative 5 are higher compared with Alternative 4 due to the inclusion of the treatment unit. The long-term O&M costs associated with Alternative 5 are also greater compared with Alternative 4 because additional O&M is required for the treatment unit.

It should be noted that the difference between the estimated total present value costs (30 years) for the three alternatives is less than 10 percent. This difference falls within the range of accuracy for an order-of-magnitude estimate of this type (plus 50 percent to minus 30 percent).

As previously indicated, the costs discussed above reflect the total overall costs for each alternative, even though some components of the alternatives have already been installed. To support additional evaluation of all three alternatives, Table 6-2 presents the costs associated with implementing each alternative and takes into account those capital costs that have already been incurred (i.e., costs for installation of the existing passive venting system and impermeable barrier). Therefore, the costs in Table 6-2 represent the additional costs that would be required to implement each alternative beyond what has been incurred to date (e.g., conversion of the existing passive venting system to an active collection system per Alternatives 4 and 5).

When evaluated in this manner, Alternative 2 still has the lowest overall cost. Capital costs associated with this alternative are limited to installation of vapor barriers and methane monitoring systems in existing and future buildings. Alternative 2 also has the lowest long-term O&M costs.

The overall cost for Alternative 4 is higher compared with Alternative 2, but lower compared with Alternative 5. The capital costs associated with Alternative 4 include retrofitting the existing venting trench for active collection, including installation of the manifold system and pumps. The O&M costs for Alternative 4 are also higher compared with Alternative 2 because additional O&M is required for the active system.

Alternative 5 still has the highest overall cost. Costs for construction under Alternative 5 are higher compared with Alternative 4 due to the inclusion of the treatment unit. The long-term O&M costs associated with Alternative 5 are also greater compared with Alternatives 2 and 4 because additional O&M is required for the treatment unit.

# Tables

TABLE 6-1
Comparative Analysis Summary for Alternatives
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Criteria | Alternative 1: No Action | Alternative 2: Passive Venting System (Perimeter Trench) | Alternative 4: Active Collection System (Perimeter Trench) | Alternative 5: Active Collection System (Perimeter Trench) with Effluent Treatment |
|---|---|---|---|---|
| **Protection of Human Health and Environment** | Would not reduce risk to human health or the environment. | A passive venting trench provides a similar level of protection relative to Alternative 4, but slightly lower than Alternative 5. A passive venting of methane is not subject to interruptions in operation due to equipment and/or power failure. In addition, the impermeable barrier provides additional protection against the possible migration of methane beyond the trench. Vapor barriers, monitoring, and institutional controls also contribute to the overall protection of human health. | Alternative 4 is protective and it provides a similar level of protection relative to Alternative 2. The active collection system actively collects and removes methane from the area, but it does not include an impermeable barrier. Vapor barriers, monitoring, and institutional controls also contribute to the overall protection of human health. | Alternative 5 is protective. It provides a slightly higher level of protection compared with Alternatives 2 and 4 because Alternative 5 includes effluent treatment. Vapor barriers, monitoring, and institutional controls also contribute to the overall protection of human health. |
| **Compliance with ARARs** | Does not comply with ARARs. | Compliant with identified ARARs. | Compliant with identified ARARs. | Compliant with identified ARARs. |
| **Long-term Effectiveness and Permanence** | Does not provide long-term effectiveness or permanence. | A passive venting system provides a slightly higher degree of long-term protectiveness relative to Alternatives 4 and 5 because it relies on passive venting of methane that is not subject to interruptions due to equipment and/or power failures. The impermeable barrier provides additional protection against the possible migration of methane. Permanence is dependent on proper maintenance and monitoring of the passive venting system and the vertical barrier. Vapor barriers provide very good long-term protectiveness and permanence with respect to methane intrusion. | Alternative 4 provides a slightly lower overall level of long-term protectiveness relative to Alternative 2. The active collection system is subject to interruptions in operation due to equipment and/or power failures. Permanence is dependent on proper maintenance and monitoring of the passive venting system and the vertical barrier. Vapor barriers provide very good long-term protectiveness and permanence with respect to methane intrusion. | Alternative 5 provides a slightly lower overall level of long-term protectiveness relative to Alternative 2, but provides a similar level as Alternative 4. The active collection system is subject to interruptions in operation due to equipment and/or power failures. Permanence is dependent on proper maintenance and monitoring of the passive venting system and the vertical barrier. Vapor barriers provide very good long-term protectiveness and permanence with respect to methane intrusion. |
| **Reduction in Toxicity, Mobility, and Volume through Treatment** | Would not actively reduce toxicity, mobility, or volume. Reduction by natural degradation processes only. | Treatment is not a principle component of this alternative; however, some reduction in the volume of methane occurs because the venting trench facilitates aeration of surrounding soil and promotes biodegradation of methane. | Treatment is not a principle component of this alternative; however, some reduction in the volume of methane occurs because the collection trench facilitates aeration of surrounding soil and promotes biodegradation of methane. | Effluent treatment (the biofilter) will reduce the volume of methane. In addition, some in situ reduction in the volume of methane occurs because the collection trench facilitates aeration of surrounding soil and promotes biodegradation of methane. |
| **Short-term Effectiveness** | Not applicable for no action. | Passive venting systems and vertical barriers can be constructed relatively rapidly to provide protection of human health. Temporary engineered controls can be used to protect workers and the nearby community during construction. | Active collection systems can be constructed relatively rapidly to provide protection of human health. Temporary engineered controls can be used to protect workers and the nearby community during construction. | Active collection systems can be constructed relatively rapidly to provide protection of human health. Temporary engineered controls can be used to protect workers and the nearby community during construction. |
| **Implementability (Technical)** | Not applicable for no action. | Readily implementable; technical services and equipment readily available to construct passive venting system, vertical barrier, and vapor barriers. | Readily implementable; technical services and equipment readily available to construct active collection system and vapor barriers. | Readily implementable; technical services and equipment readily available to construct active collection system, treatment system, and vapor barriers. |
| **Implementability (Administrative)** | Not applicable for no action. | Implementable; would require coordination between the Army and regulatory agencies. | Implementable; would require coordination between the Army and regulatory agencies. | Implementable; would require coordination between the Army and regulatory agencies. |
| **Cost ($PV_{30}$)** | $0 | $1,897,000. Lowest overall cost. | $1,917,000. Overall cost is greater than Alternative 2, but lower than Alternative 5. | $2,047,000. Highest overall cost. |

TABLE 6-2
Additional Costs by Alternative
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| | Alternative 2 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| Total capital cost | $82,000 | $268,000 | $278,000 |
| Total annual cost | $30,700 | $41,500 | $47,600 |
| Present value (30 years) | $683,000 | $1,081,000 | $1,211,000 |

# Figure


Notes:

Alternative 2 – Passive Venting System with Perimeter Trench
Alternative 4 – Active Collection System with Perimeter Trench
Alternative 5 – Active Collection System with Perimeter Trench and Effluent Treatment

Criterion 4: Reductions in toxicity, mobility, and/or volume for methane under Alternatives 2 and 4 are due primarily to engineering controls or physical removal rather than treatment.
Criterion 2: Criterion 2 is not included on this table because all alternatives comply with ARARs.
Criterion 7: Ranked by Total Cost ($PV_{30}$)

**FIGURE 6-1**
**RELATIVE RANKING OF ALTERNATIVES**
LANDFILL 26 SOIL GAS FEASIBILITY STUDY
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

**SECTION 7**

# Identification of the Preferred Alternative

Alternative 2 (Passive Venting System with Perimeter Trench) has been identified by the USACE as the preferred alternative for addressing landfill refuse-related methane in soil gas at LF 26. Alternative 2 achieves identified RAOs. When compared with CERCLA remedy evaluation criteria and the other alternatives considered in this FS, Alternative 2 was identified as protective of human health and it provided the highest level of long-term effectiveness and permanence. In addition, Alternative 2 is also compliant with identified ARARs, and it is the most cost effective of the alternatives considered in this FS.

The primary components of Alternative 2 are the passive venting trench and impermeable barrier. These components of Alternative 2 already have been installed at LF 26 and are effectively operating. The remaining components of Alternative 2, consisting of vapor barriers (for new construction and retrofit of the existing groundwater treatment plant building), institutional controls, and monitoring, would be implemented as appropriate.

**SECTION 8**

# Works Cited


CH2M HILL. 1998a. *Construction Quality Assurance (CQA) Report, Hamilton Army Airfield, Landfill 26, Final Cover System*. February. Prepared for the U.S. Army Corps of Engineers, Sacramento District.

CH2M HILL. 1998b. *HAAF Landfill 26, Perimeter Grading and Drainage Modifications Alternatives*. April. Prepared for the U.S. Army Corps of Engineers/Sutter Remediation, Inc.

CH2M HILL. 1998c. *Construction Quality Assurance (CQA) Report, Hamilton Army Airfield, Landfill 26, Grading and Drainage Adjustments*. September.

CH2M HILL. 1999. *Final Closure and Post-Closure Maintenance Plan, Hamilton Army Airfield, Landfill 26, Novato, California*. June.

CH2M HILL. 2002. *Methane Remedial Measures Study, Landfill 26, Novato, California*. February.

CH2M HILL. 2005. *Landfill 26 Corrective Action Investigation Work Plan, Hamilton Army Airfield, Novato, California.* Final Report. December.

CH2M HILL. 2006. *Landfill 26 Conceptual Site Model Update, Hamilton Army Airfield, Novato, California.* Final Report. September.

Harding Lawson Associates (HLA). 1999. Preliminary Methane Sampling Results at Landfill 26, memorandum. October.

International Technology Corporation (IT). 1998a. *Site Investigation Report, 800-B and Ammo Hill Parcels, GSA Phase II Sale Area*. March.

International Technology Corporation (IT). 1998b. *Final Remedial Action Plan, 800-B and Ammo Hill Parcels, GSA Phase II Sale Area*. December.

Innovative Technology Solutions (ITSI). 1999. *Final Workplan for Landfill Monitoring Program, Landfill 26, Hamilton Army Airfield, Novato, California*. August.

Innovative Technology Solutions (ITSI). 2000a. *December 1999, Landfill Gas Monitoring Report, LF 26, HAAF*. May.

Innovative Technology Solutions (ITSI). 2000b. Draft Workplan Update Memorandum for Landfill Monitoring Program, Landfill 26, Hamilton Army Airfield, Novato, California. August.

Innovative Technology Solutions (ITSI). 2001. *Landfill Gas Migration Study: An Evaluation of the Presence and Distribution of Landfill Gas along the Eastern Margin of Landfill 26, Hamilton Army Airfield, Novato, California*.

Innovative Technology Solutions (ITSI). 2002a. *Comprehensive Report on Gas Migration near Landfill 26, An Evaluation of the Distribution and Origins of Soil Gases near Landfill 26, Hamilton Army Airfield, Novato, California.*

Innovative Technology Solutions (ITSI). 2002b. *Final Workplan for Installation of Interim Landfill Gas (LFG) Migration Control Trench, Hamilton Army Airfield, Novato, California.* February.

Innovative Technology Solutions (ITSI). 2003. *Completion Report, Interim Landfill Gas Migration Control Trench, Hamilton Army Airfield, Novato, California.* October.

Montgomery Watson Harza (MWH). 2004. *April 2004 Report, Landfill 26 Monitoring Program, Hamilton Army Airfield Novato, California*. Draft Final. September.

Montgomery-Watson Harza (MWH). 2005. *October/November 2003 Report, Landfill 26 Monitoring Program, Hamilton Army Airfield Novato, California*. Final. January.

Sirrine Environmental Consultants (Sirrine). 1991. *Long-Term Assessment of Ground Water, Surface Water, and Surface Sediment at Hamilton Air Force Base, Novato, California*. Draft. June.

United States Army Corps of Engineers (USACE). 1989. *Record of Decision, Remedial Alternative Selection (Hamilton AFB, Landfill No. 26).* Omaha District. August 11.

United States Army Corps of Engineers (USACE). 1992. *Explanation of Significant Differences (Hamilton AFB, Landfill No. 26).* Omaha District.

United States Army Corps of Engineers (USACE). 1993. *Final Design Analysis, Hamilton AFB, Remedial Action, Landfill #26, Phase II.* Omaha District. July.

United States Army Corps of Engineers (USACE). 2004. *Investigation of Methane and Volatile Organic Compounds at Landfill 26 and Hamilton Meadows*. Final Report. Hamilton Army Airfield, Novato, California. Sacramento District. September.

United States Department of Defense. 2001. *Policy on Land Use Controls Associated with Environmental Restoration Activities.* January.

United States Environmental Protection Agency (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.* OSWR Directive 9355.3-01. Office of Solid Waste and Emergency Response. October.

United States Environmental Protection Agency (EPA). 1997. *Rules of Thumb for Superfund Remedy Selection.* August.

United States Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates during the Feasibility Study*. Office of Solid Waste and Emergency Response. 9355.0-75. July.

Woodward-Clyde Consultants (WCC). 1987. *Remedial Investigation of Landfill No. 26 and Landfill Sites No. 23, 24, 25, and 28, GSA Sale Property, Hamilton Air Force Base, Novato, California*. August 15.

Woodward-Clyde Consultants (WCC). 1997. *Summary Technical Report for Landfill 26 at Hamilton Army Airfield: Geologic and Chemical Data Analysis*. February 21.

APPENDIX A

# Assessments of Risk Associated with VOCs in Soil Gas at LF 26

CESPK-ED-GD 2 October 2007

MEMORANDUM FOR CESPK-PM-C (Ray Zimny)

Potential risks/hazards due to exposure to VOCs via the indoor air vapor intrusion pathway for a hypothetical future structure on Landfill-26 at Former Hamilton Army Airfield (HAAF) have been assessed. While land use controls will likely prevent such construction, it is presented here to represent a "worst-case" exposure scenario. The assessment below is based on DTSC's "Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air."

**Assumptions:**

1. The maximum detections of soil gas data collected since 2003 were used. This time period is assumed to best represent current conditions. It is assumed that these concentrations remain constant over time.
2. All of the maximum soil gas detections are assumed to be located in the same location even though these maximum soil gas detections were detected at various locations throughout the landfill.
3. It is assumed that any future building would be constructed directly over these maximum soil gas detections.
4. A residential exposure scenario is assumed.

All soil gas data was obtained from the HAAF Landfill 26 database, version dated Sep 2007.

Using an attenuation factor of 0.0009 for a future residential slab-on-grade building (DTSC 2005; Table 2) potential VOC concentrations in indoor air were estimated by multiplying the maximum soil gas detections times this attenuation factor.

Using these estimated indoor air VOC concentrations and USEPA Region 9 ambient air PRGs (CAL-modified PRGs used when available), potential risk for carcinogenic constituents and potential hazards for non-carcinogenic constituents were estimated as follows. At the request of DTSC, both the carcinogenic toxicity endpoint (risk) and non-carcinogenic toxicity endpoint (hazard) were assessed for carcinogenic constituents.

**<u>Carcinogenic Effects</u>**

Potential carcinogenic risks were estimated using the following equation that incorporates the Region 9 ambient air PRGs, the EPCs, and the target risk of 1 x $10^{-6}$.

$$\text{Risk} = \text{TR} \times \text{EPC}_i/\text{PRG}_i \qquad (1)$$

where:

- TR = Target lifetime excess cancer risk (1 x $10^{-6}$)
- $EPC_i$ = Exposure Point Concentration of chemical "i." The EPC is the estimated indoor air concentration using the maximum detected soil gas values times the 0.0009 Attenuation Factor.
- $PRG_i$ = USEPA Region 9 ambient air PRG (or CAL-modified PRG) for chemical "i".

Assuming that the effects posed by multiple chemicals are additive (no synergistic or antagonistic interactions) and that the chemical concentrations and exposure parameters remain constant throughout the exposure duration, the cumulative cancer risk was calculated as follows:

$$\text{Cumulative Cancer Risk} = \Sigma\ \text{Chemical-Specific Cancer Risk} \qquad (2)$$

The specific EPCs, PRGs and resulting potential risk estimates are presented in Table 1.

**Non-carcinogenic Effects**
Potential non-cancer hazard was assessed by calculating a hazard quotient (HQ) using the EPC and the Region 9 ambient air PRG for those chemical having a toxicity endpoint other than cancer.

$$\text{Chemical-Specific Non-carcinogenic Hazard Quotient (HQ)} = EPC_i/PRG_i \quad (3)$$

where:

$EPC_i$ = Exposure Point Concentration of chemical "i." The EPC is the estimated indoor air concentration using the maximum detected soil gas values times the 0.0009 Attenuation Factor.

$PRG_i$ = USEPA Region 9 ambient air PRG for chemical "i" for non-cancer endpoint.

Assuming effects posed by multiple chemicals are additive (no synergistic or antagonistic interactions) and that chemical concentrations and exposure parameters remain constant throughout the exposure duration, the cumulative non-carcinogenic hazard index (HI), was calculated as follows:

$$\text{Hazard Index (HI)} = \Sigma \text{ Chemical-Specific HQs} \quad (4)$$

The specific EPCs, PRGs and resulting hazards are presented in Table 2.

**Results**

The estimate potential cancer risk for a future residential receptor is $7 \times 10^{-7}$ (Table 1). This estimated cancer risk is compared to the risk range of $1 \times 10^{-6}$ to $1 \times 10^{-4}$. In assessing cancer risk, DTSC and USEPA usually consider risk of less than $1 \times 10^{-6}$ as being "de minimis" and requiring no further action. Sites with estimated risks greater than $1 \times 10^{-4}$ are generally identified as being unacceptable and requiring further actions. Those sites that have estimated risks between $1 \times 10^{-6}$ and $1 \times 10^{-4}$ are generally considered to be within the risk management range, and decisions about further action or no further action are made on a site-specific basis. The estimated potential residential risk via the indoor air vapor intrusion pathway is less than the "de minimis" risk of $1 \times 10^{-6}$.

The estimated potential non-cancer hazard for a potential residential receptor (Table 2), as represented by a total Hazard Index (HI), is 0.01. In assessing non-cancer hazard DTSC and USEPA usually consider an HI of less than one to indicate no potential for adverse non-cancer effects. The estimated potential residential hazard via the indoor air vapor intrusion pathway is below the value of one, indicating no potential for adverse non-cancer hazards.

**Conclusions**

A hypothetical residential receptor was assessed as a worst case scenario. No adverse effects are expected for this hypothetical residential receptor via the indoor air inhalation pathway. Therefore, adverse effects are not expected for other less exposed receptors (e.g. recreational receptor, commercial worker).

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References

DTSC, 2005, Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air, Department of Toxic Substances Control, California Environmental Protection Agency, December 15, 2004 (Revised February 7, 2005)

HAAF Landfill 26 database, version dated Sep 2006.

USEPA Region IX Preliminary Remediation Goals, online:
http://www.epa.gov/region09/waste/sfund/prg/index.html

**Table 1. Potential Inhalation Risk using Maximum Detections of LF-26 Soil Gas**

| Chemical | Soil Gas Probe | Date | Maximum Detection (ug/M$^3$) | Potential Indoor Air Concentration (ug/M$^3$)[1] | USEPA Region 9 Ambient Air PRG (ug/M$^3$)[2] | Potential Inhalation Risk |
|---|---|---|---|---|---|---|
| Tetrachloroethene | SGP-41 | 10/29/2003 | 61.46 | 0.055314 | 0.32 | 1.7E-07 |
| Carbon tetrachloride | GMP-38 | 9/20/06 | 6.4 | 0.00576 | 0.13 | 4.4E-08 |
| Chloroform | SGP-29 | 4/9/2004 | 25.82 | 0.023238 | 0.35 | 6.6E-08 |
| Benzene | SGP-37 | 4/6/2005 | 7.15 | 0.006435 | 0.25 | 2.6E-08 |
| Chloroethane | GMP-36 | 9/22/2004 | 1.61 | 0.001449 | 2.3 | 6.3E-10 |
| Trichloroethene | GMP-32/SGP-27 | 9/19&20/06 | 22.9 | 0.02061 | 0.96 | 2.1E-08 |
| 1,4-Dichlorobenzene | GMP-37 | 9/22/2004 | 8.56 | 0.007704 | 0.31 | 2.5E-08 |
| 1,3-Butadiene | SGP-41 | 10/29/2003 | 1.418 | 0.0012762 | 0.011 | 1.2E-07 |
| 1,2-Dichloroethane | SGP-38 | 10/29/2003 | 0.2964 | 0.00026676 | 0.074 | 3.6E-09 |
| Tetrahydrofuran | SGP-31 | 4/8/2004 | 36 | 0.0324 | 0.99 | 3.3E-08 |
| 1,4-Dioxane | GMP-30 | 10/27/2003 | 2.053 | 0.0018477 | 0.61 | 3.0E-09 |
| Methyl tert-butyl ether (MTBE) | SGP-24 | 10/28/2003 | 586.7 | 0.52803 | 7.4 | 7.1E-08 |
| Vinyl chloride | SGP-38 | 10/29/2003 | 0.676 | 0.0006084 | 0.11 | 5.5E-09 |
| Methylene Chloride | SGP-30 | 9/20/06 | 24.38 | 0.021942 | 4.1 | 5.4E-09 |
| Bromodichloromethane | SGP-39 | 9/20/06 | 6.8 | 0.00612 | 0.11 | 5.6E-08 |
| 1,1-Dichloroethane | GMP-30 | 9/22/2004 | 0.459 | 0.0004131 | 1.2 | 3.4E-10 |
| | | | | | **Total Risk** | **7 E-07** |

1 Calculated using 0.0009 DTSC Attenuation Factor for Future Slab-on-Grade Residential Building (Max Soil Gas Concentration ug/M$^3$ x 0.0009).
2 USEPA Region 9 Ambient Air PRG using CA-Modified PRG when available.

## Table 2. Potential Inhalation Hazard using Maximum Detections of LF-26 Soil Gas

| Chemical | Soil Gas Probe | Date | Maximum Detection (ug/M$^3$) | Potential Indoor Air Concentration (ug/M$^3$)[1] | USEPA Region 9 Ambient Air PRG (ug/M$^3$)[2] | Potential Inhalation Hazard |
|---|---|---|---|---|---|---|
| Ethylbenzene | GMP-09 | 9/21/2004 | 6.18 | 0.005562 | 1100 | 5.1E-06 |
| Styrene | SGP-35 | 9/20/06 | 2.6 | 0.00234 | 1100 | 2.1E-06 |
| alpha-Chlorotoluene | GMP-04 | 4/5/2005 | 0.1896 | 0.00017064 | 73 | 2.3E-06 |
| 4-Methyl-2-pentanone | GMP-36 | 9/22/2004 | 2.625 | 0.0023625 | 3100 | 7.6E-07 |
| m,p-Xylene | GMP-36 | 9/22/2004 | 40.63 | 0.036567 | 110 | 3.3E-04 |
| 1,3,5-Trimethylbenzene | SGP-24 | 10/28/2003 | 14.5 | 0.01305 | 6.2 | 2.1E-03 |
| Toluene | SGP-33 | 9-20-06 | 99.7 | 0.08973 | 400 | 2.2E-04 |
| Chlorobenzene | GMP-35 | 4/6/2005 | 0.515 | 0.0004635 | 62 | 7.5E-06 |
| Cyclohexane | SGP-24 | 10/28/2003 | 56 | 0.0504 | 6200 | 8.1E-06 |
| cis-1,2-Dichloroethene | SGP-34 | 10/27/2003 | 3.589 | 0.0032301 | 37 | 8.7E-05 |
| 1,3-Dichlorobenzene | GMP-04 | 10/28/2003 | 24.5 | 0.02205 | 110 | 2.0E-04 |
| 2-Hexanone | SGP-32 | 4/6/2005 | 9.58 | 0.008622 | 3100 | 2.8E-06 |
| 4-Ethyltoluene | SGP-32 | 4/6/2005 | 41 | 0.0369 | 1100[3] | 3.3E-05 |
| Acetone | GMP-36 | 9/22/2004 | 113.6 | 0.10224 | 3300 | 3.1E-05 |
| 1,1,1-Trichloroethane | GMP-32 | 9/19/06 | 4.05 | 0.003645 | 2300 | 1.6E-06 |
| Bromomethane | GMP-25 | 9/23/2004 | 1.501 | 0.0013509 | 5.2 | 2.6E-04 |
| Chloromethane | SGP-32 | 4/8/2004 | 3.15 | 0.002835 | 95 | 3.0E-05 |
| Carbon disulfide | TV-06 | 9/19/06 | 66.5 | 0.05985 | 730 | 8.2E-05 |
| 1,1-Dichloroethene | SGP-27 | 9-20-06 | 2.86 | 0.002574 | 210 | 1.2E-05 |
| Freon 11 | SGP-30 | 9/20/06 | 3.314 | 0.0029826 | 730 | 4.1E-06 |
| Freon 12 | GMP-09 | 9/19/06 | 125.7 | 0.11313 | 210 | 5.4E-04 |
| Freon 113 | GMP-29 | 4/12/2004 | 8.57 | 0.007713 | 31000 | 2.5E-07 |
| Freon 114 | GMP-09 | 9/19/06 | 78.2 | 0.07038 | 31000[4] | 2.3E-06 |
| Methyl Ethyl Ketone | SGP-31 | 4/8/2004 | 168 | 0.1512 | 5100 | 3.0E-05 |
| o-Xylene | SGP-24 | 10/28/2003 | 16.78 | 0.015102 | 110 | 1.4E-04 |
| 1,2-Dichlorobenzene | GMP-28 | 4/12/2004 | 3.914 | 0.0035226 | 210 | 1.7E-05 |
| 1,2,4-Trimethylbenzene | GMP-36 | 9/22/2004 | 17.5 | 0.01575 | 6.2 | 2.5E-03 |
| Tetrachloroethene | SGP-41 | 10/29/2003 | 61.46 | 0.055314 | 37 | 1.5E-03 |
| Carbon tetrachloride | GMP-38 | 9/20/06 | 6.4 | 0.00576 | 2.6 | 2.2E-03 |
| Chloroform | SGP-29 | 4/9/2004 | 25.82 | 0.023238 | 51 | 4.6E-04 |
| Benzene | SGP-37 | 4/6/2005 | 7.15 | 0.006435 | 31 | 2.1E-04 |

## Table 2 (cont.). Potential Inhalation Hazard using Maximum Detections of LF-26 Soil Gas

| Chemical | Soil Gas Probe | Date | Maximum Detection (ug/M$^3$) | Potential Indoor Air Concentration (ug/M$^3$)[1] | USEPA Region 9 Ambient Air PRG (ug/M$^3$)[2] | Potential Inhalation Risk |
|---|---|---|---|---|---|---|
| Chloroethane | GMP-36 | 9/22/2004 | 1.61 | 0.001449 | 10000 | 1.4E-07 |
| Trichloroethene | GMP-32/SGP-27 | 9/19&20/06 | 22.9 | 0.02061 | 620 | 3.3E-05 |
| 1,4-Dichlorobenzene | GMP-37 | 9/22/2004 | 8.56 | 0.007704 | 840 | 9.2E-06 |
| 1,3-Butadiene | SGP-41 | 10/29/2003 | 1.418 | 0.0012762 | 21 | 6.1E-05 |
| 1,2-Dichloroethane | SGP-38 | 10/29/2003 | 0.2964 | 0.00026676 | 5.1 | 5.2E-05 |
| Tetrahydrofuran | SGP-31 | 4/8/2004 | 36 | 0.0324 | 310 | 1.0E-04 |
| 1,4-Dioxane | GMP-30 | 10/27/2003 | 2.053 | 0.0018477 | N/A[5] | N/A[5] |
| Methyl tert-butyl ether (MTBE) | SGP-24 | 10/28/2003 | 586.7 | 0.52803 | 3100 | 1.7E-04 |
| Vinyl chloride | SGP-38 | 10/29/2003 | 0.676 | 0.0006084 | 100 | 6.1E-06 |
| Methylene Chloride | SGP-30 | 9/20/06 | 24.38 | 0.021942 | 3100 | 7.1E-06 |
| Bromodichloromethane | SGP-39 | 9/20/06 | 6.8 | 0.00612 | 73 | 8.4E-05 |
| 1,1-Dichloroethane | GMP-30 | 9/22/2004 | 0.459 | 0.0004131 | 520 | 7.9E-07 |
| | | | | | **Total Hazard Index** | **0.01** |

1 Calculated using 0.0009 DTSC Attenuation Factor for Future Slab-on-Grade Residential Building (Max Soil Gas Concentration ug/M$^3$ x 0.0009).
2 USEPA Region 9 Ambient Air PRG using CA-Modified PRG when available.
3 PRG for ethylbenzene used.
4 PRG for Freon 113 used.
5 N/A – Not Available

APPENDIX B

# Landfill 26 Analytical Data (1985-2006)

**APPENDIX B**

# Landfill 26 Analytical Data (1985-2006)

The accompanying CD contains all of the air, soil, surface water, groundwater, and soil gas sample analytical data collected at LF 26 for the period from 1985 through 2006. To keep the data files to manageable sizes, the files have been segregated by sample matrix. The following analytical data files are provided in electronic format on the accompanying CD:

- LF26_Database_Air_Soil_SW.xls
- LF26_Database_GW_only.xls
- LF26_Database_Soilgas_only.xls

APPENDIX C

# Compliance Monitoring Technical Memorandum

# Former Hamilton Army Airfield Landfill 26 Postclosure Landfill Gas Monitoring Program Requirements

PREPARED FOR: U.S. Army Corps of Engineers, Sacramento District

PREPARED BY: CH2M HILL

DATE: May 2007

## Introduction

This memorandum summarizes the proposed postclosure "landfill gas" perimeter soil gas monitoring program (also termed point of compliance monitoring program) currently recommended by CH2M HILL for Hamilton Army Airfield (HAAF) Landfill 26 (LF 26). It also presents a proposed short-term monitoring program to monitor the current landfill gas migration control remedy, the passive venting trench. Currently numerous locations are sampled for various soil gas parameters on a wide range of frequencies. The current sampling program was established during the investigation/characterization phase of the project, a phase that typically requires the collection of relatively large amounts of data. However, once the nature and extent of contamination has been established and potential migration routes and rates are understood, significantly less data are needed to monitor the plume. The currently sampling program greatly exceeds minimum standards contained in the State of California regulatory requirements for closed landfill perimeter landfill gas monitoring.

It is our understanding that this memorandum will be used to work with the regulators to develop a reasonable and appropriate LF 26 postclosure point of compliance monitoring program. Recommendations included in this memorandum are appropriate at this time based on information available to CH2M HILL, and may differ in future years. Based on continued observations of the performance effectiveness of the passive venting trench, it is possible that in the future the US Army Corps of Engineers (USACE) may desire to further reduce both the point of compliance and remedy specific monitoring locations and frequencies below the details listed in this memorandum.

## Regulatory Perimeter Landfill Gas Monitoring Requirements

LF 26 is subject to State of California Code of Regulations (CCR) Title 27 for landfill postclosure perimeter soil gas monitoring. CCR Title 27, Sections 20917 through 20937 specify the requirements for landfill gas monitoring and control at active and closed disposal sites. A gas monitoring program is required to demonstrate compliance with CCR Title 27 Section 20919.5 that requires that the concentration of methane gas not exceed the lower explosive limit (LEL) for methane (5 percent by volume) at the facility property boundary (i.e., the point of compliance). The requirements of CCR Title 27 Section 20925 include the following for landfill gas compliance monitoring:

*(a) Location*

1) *Perimeter subsurface monitoring wells shall be installed around the waste deposit perimeter but not within refuse. The entire perimeter of the disposal site may not warrant the installation of monitoring wells. In this case, the operator shall demonstrate to the satisfaction of the EA that gas migration could not occur due to geologic barriers and that no inhabitable structure or other property such as agricultural lands within 1,000 feet of the property boundary are threatened by gas migration.*

2) *Perimeter monitoring wells shall be located at or near the disposal site property boundary. The operator may establish an alternate boundary closer to the waste deposit area based on a knowledge of the site factors in Section 20923(a)(2). When compliance levels are exceeded at the alternate boundary, the operator shall install additional monitoring wells closer to the property boundary, pursuant to Section 20937.*

*(b) Spacing*

1) *The lateral spacing between adjacent monitoring wells shall not exceed 1,000 feet, unless it can be established to the satisfaction of the LEA, in Section 20923(a)(2).*

2) *The spacing of monitoring wells shall be determined based upon, but not limited to: the nature of the structure to be protected and its proximity to the refuse. Wells shall be spaced to align with gas permeable structural or stratigraphic features, such as dry sand or gravel, off-site or on-site structures, and areas of dead or stressed vegetation that might be due to gas migration.*

3) *Probe spacing shall be reduced as necessary to protect persons and structures threatened by landfill gas migration.*

For LF 26, in addition to compliance monitoring, additional remedy monitoring is prudent to confirm the protectiveness of the landfill refuse-related gas control system and ensure the safety of nearby sensitive (i.e., residential) receptors.

At LF 26, there are a total of 58 existing vadose zone monitoring wells (GMP-1 through GMP-38 and SGP-22 through SGP-41) are currently being sampled on a routine basis as part of ongoing landfill investigation and monitoring activities. This existing sampling program was reviewed and evaluated in the context of the requirements of CCR Title 27 for landfill postclosure gas compliance monitoring and the need for remedy monitoring. Older soil gas monitoring wells (the GMP series wells) were not considered for compliance monitoring purposes because these well are screened across the water table and may therefore not yield samples representative of vadose zone conditions. Wells selected to be included in the compliance monitoring program are identified in Table 1, while well selected to be included in the remedy monitoring program are identified in Table 2. Table 3 identifies those wells that will not be included in either the compliance or remedy monitoring programs, and it provides detailed rationale for the deletion of each of these wells from further sampling. The results of the evaluation and the proposed compliance and remedy monitoring programs are presented in more detail below.

# Recommended Monitoring Program

The following recommended monitoring programs are separated into compliance monitoring to meet the requirements of CCR Title 27 and remedy monitoring as recommended previously.

## Compliance Monitoring

As required by CCR Title 27, compliance monitoring must be performed to demonstrate that landfill related gas is being controlled and that methane does not exceed a concentration of 5 percent by volume at the property boundary. This monitoring must be performed in the designated point of compliance perimeter monitoring network. Additionally, compliance monitoring must be performed in any on site structures within 1,000 feet of the landfill limit (CCR Title 27 Section 20931). The only structure that meets this requirement currently is the inactive groundwater treatment plant, and that structure is being addressed separately as part of the LF 26 5-Year Review also being performed by CH2M HILL.

The following text presents the details of the proposed compliance monitoring program including the monitoring well network, sampling frequency, and the analytical program.

### Point of Compliance Monitoring Well Network

Eight existing vadose zone monitoring wells (SGP-22, SGP-24, SGP-27, SGP-30, SGP-31, SGP-37, SGP-39, and SGP-41) were selected as point of compliance monitoring wells for both the closure and postclosure periods for LF 26 (see Table 1 and Figure 1). The criteria using for the selection of these eight wells included the requirements of CCR Title 27, site specific geology and hydrogeology, the location and depth of the existing wells, and the location of sensitive receptors. Table 1 presents the specific rationale for the selection of each well to be included in the compliance monitoring well network.

### Point of Compliance Monitoring Frequency

Currently, all of the vadose zone wells at LF 26 are scheduled to be sampled on a quarterly basis.[1] A review of historic data indicates that methane concentrations in the wells have been relatively stable, particularly for those wells located on the western and northern sides of LF 26. Figures 2 and 3 graphically present methane concentrations over time for selected monitoring wells located on the western and northern sides of LF 26, respectively.
As shown on Figures 2 and 3, historic methane concentrations in these wells are all below the 5 percent by volume compliance limit, and with the exception of GMP-01, there has been very little variation in methane concentrations over time (some of the wells have been continuously samples since 1994). Although GMP-01 displays a temporary increase in methane (to a concentration of 1.15 percent by volume) during the December 2003 sampling event, this concentration is an anomaly because all other methane concentrations reported over the 12 year sampling history for this well have been 0.55 percent or lower.

Based on historical methane data that indicates very low concentrations of methane in these areas, and little variation in methane concentrations overtime, it is proposed that for compliance monitoring wells located on the western and northern sides of LF 26 (SGP-22,

[1] Though all wells are scheduled for quarterly sampling, some wells cannot be sampled every quarter due to the presence of high groundwater.

SGP-39, and SGP-41), sampling would be conducted on an annual basis. Because of relatively high groundwater conditions in these areas over most of the year, sampling in the late fall (i.e., September or October) is proposed. During the fall time period groundwater levels are the lowest and a thicker portion of the soil column is unsaturated; therefore, the potential for methane migration is the greatest at this time. The collection of compliance samples during the fall time period would provide a conservative assessment of potential methane concentrations in the western and northeastern portions of LF 26.

Due to the presence of the existing Hamilton Meadows residential area in close proximity to the southern and southeastern portions of LF 26, quarterly sampling of the compliance wells located in this area (SGP-24, SGP-27, SGP-30, SGP-31, and SGP-37) is proposed. More frequent sampling warranted for these wells to ensure compliance in this area. If future compliance monitoring results indicate only continued low concentrations of methane in these wells, the sampling frequency could be revised to a semi-annual or annual basis. Any changes to the sampling frequency would need to be discussed with and approved by the regulatory agencies including the Local Enforcement Agency (LEA) (i.e., Marin County Marin County Department of Health Services) acting for the California Integrated Waste Management Board (CIWMB).

In addition to the routine annual or quarterly sampling intervals specified above, if methane gas levels are detected in a point of compliance monitoring location exceeding the above mentioned limits, the following provisions apply (per CCR Title 27 Section 20919.5):

(c) *If methane gas levels exceeding the limits specified in ¶(a)* [i.e., 5 percent by volume at the property line] *are detected, the owner or operator must:*

1) *The owner must immediately take all necessary steps to ensure protection of human health and notify the LEA.*

2) *Within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and*

3) *Within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record, and notify the EA that the plan has been implemented. The plan shall describe the nature and extent of the problem and the proposed remedy.*

4) *The LEA with concurrence by the CIWMB pursuant to 40 CFR 258.23(c)(4) may establish alternative schedules for demonstrating compliance with (c)(2) and (c)(3).*

### Compliance Monitoring Analytical Program

Methane and VOCs are the only contaminants detected in the soil gas medium at LF 26. Landfill refuse related methane has been detected within soil gas in the landfill area at concentrations exceeding the LEL of 5 percent by volume. Potential explosive conditions could result from the presence of methane at concentrations at or above the LEL. Therefore, all compliance well samples should be analyzed for methane using appropriate field instruments (e.g., a GEM 2000). Additionally, field sampling should include static pressure and oxygen levels (these measurements should be possible from the same GEM 2000 field instrument).

CCR Title 27 compliance monitoring programs do not typically require VOC sampling and analysis. VOCs have also been detected in soil gas samples from the LF 26 area. However, conservative assessments of potential risks to human health associated with current VOC concentrations in soil gas were recently performed for both the outdoor air and indoor air exposure pathways. The conclusions of these assessments indicate that risks associated with current VOC concentrations detected in soil gas within the landfill are well below the CERCLA point of departure of $1 \times 10^{-6}$ or a hazard quotient of 1. Therefore, because VOC concentrations in soil gas at LF 26 do not pose a significant risk to human health, ongoing regular analysis of compliance samples for VOCs is not warranted for a compliance monitoring program.

## Remedy Monitoring

The objectives of remedy monitoring will be to assess the continued protectiveness of the landfill refuse related gas control system with respect to nearby sensitive (i.e., residential) receptors. Remedy monitoring should be performed in conjunction with compliance monitoring; however, the results of the remedy monitoring will be used by the USACE solely to assess methane concentrations adjacent to the Hamilton Meadows residential development. Remedy monitoring results will not be used for compliance purposes, nor sampled or reported as part of the LF 26 postclosure monitoring program.

### Remedy Monitoring Well Network

Because of the location of the current remedy and sensitive receptors, remedy monitoring will be limited to the southern and southeastern areas of LF 26 near the Hamilton Meadows residential development. Nine existing vadose zone monitoring wells (GMP-25, GMP-26, GMP-27, GMP-32, GMP-35, SGP-26, SGP-32, SGP-35, and SGP-36) are proposed as remedy monitoring wells for both the postclosure period for LF 26 (see Table 2 and Figure 1). The criteria using for the selection of these nine wells included previous detections of methane, the location and depth of the existing wells, and the location of sensitive receptors. Table 2 presents the specific rationale for the selection of each well to be included in the remedy monitoring well network. In addition to the nine vadose zone monitoring wells, all 16 of the trench vent wells (TV-1 through TV-16) will be sampled under the remedy monitoring program.

### Remedy Monitoring Frequency

Due to the location of the existing Hamilton Meadows residential development in close proximity to the southern and southeastern portions of LF 26, quarterly sampling of the remedy wells located in this area is proposed. More frequent sampling is this area for at least the short term may be warranted to assess the protectiveness of the landfill gas control system (i.e., the passive venting trench). If future remedy monitoring results indicate only continued low concentrations of methane in these wells, the sampling frequency should be revised to a semi-annual or annual basis. Any changes to the sampling frequency would need to be approved by the regulatory agencies including the LEA.

### Remedy Monitoring Analytical Program

The recommended analytical program for remedy monitoring should be limited to field measurement of methane (see rationale for the exclusion of VOCs under *Compliance Monitoring Analytical Program*). Static pressure and oxygen level should also be recorded with each methane measurement.

# Tables

TABLE 1
Proposed Point of Compliance Wells
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Rationale for Inclusion as a Point of Compliance Monitoring Well |
|---|---|
| SGP-22 | Provides soil gas data at northeastern corner of landfill. |
| SGP-24 | Provides soil gas data at the end of the passive vent trench on east side of landfill. |
| SGP-27 | Provides soil gas data outboard of passive vent trench near property boundary on east side of landfill. |
| SGP-30 | Provides soil gas data outboard of passive vent trench near property boundary on south side of landfill. |
| SGP-31 | Provides soil gas data outboard of passive vent trench near property boundary at southeast corner of landfill. |
| SGP-37 | Provides soil gas data outboard of passive vent trench near property boundary at southwest corner of landfill. |
| SGP-39 | Provides soil gas data on west side of landfill. |
| SGP-41 | Provides soil gas data on west side of landfill. |

TABLE 2
Proposed Remedy Monitoring Wells
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Rationale for Inclusion as a Remedy Monitoring Well |
|---|---|
| GMP-25 | Well previously contained up to 4.7 percent methane by volume and is located in proximity to residential properties. |
| GMP-26 | Well previously contained up to 10 percent methane by volume and is located in proximity to residential properties. |
| GMP-27 | Well is located near property boundary in proximity to residential properties. |
| GMP-32 | Well is located at property boundary in proximity to residential properties. |
| GMP-35 | Well is located at property boundary in proximity to residential properties. |
| SGP-26 | Well is located just inboard of the vent trench; well contained methane up to 5 percent by volume. |
| SGP-32 | Well is located just inboard of the vent trench. |
| SGP-35 | Well is located just inboard of the vent trench. |
| SGP-36 | Well previously contained up to 5 percent methane by volume and is located in proximity to residential properties. |

TABLE 3
Vadose Zone Monitoring Wells to be Deleted from Further Sampling Programs
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Rationale for Deletion of Well from Further Sampling |
|---|---|
| GMP-01 | Well is screened across the water table. Historic concentrations of methane at or below 1.15 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-02 | This well was inadvertently destroyed. However, historic concentrations of methane at or below 0.2 percent and it was directly adjacent to another vadose zone well (SGP-22) that will be sampled under the compliance monitoring program. |
| GMP-03 | This well was inadvertently destroyed. However, historic concentrations of methane at or below 1.5 percent and it was located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-04 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-05 | Well is screened across the water table. Recent concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-06 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-07 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-08 | Well is screened across the water table. Recent concentrations of methane at or below 0.01 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-09 | Well is screened across the water table. With the exception of December 2006, recent concentrations of methane at or below 0.005 percent; well is located inboard of passive venting system; and well is in close proximity to other vadose zone wells (e.g., SGP-26) that will be sampled under the compliance or remedy monitoring programs. |
| GMP-10 | Well is screened across the water table. Historic concentrations of methane at or below 0.6 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-11 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-12 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-13 | Well is screened across the water table. Recent concentrations of methane at or below 0.004 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-14 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |

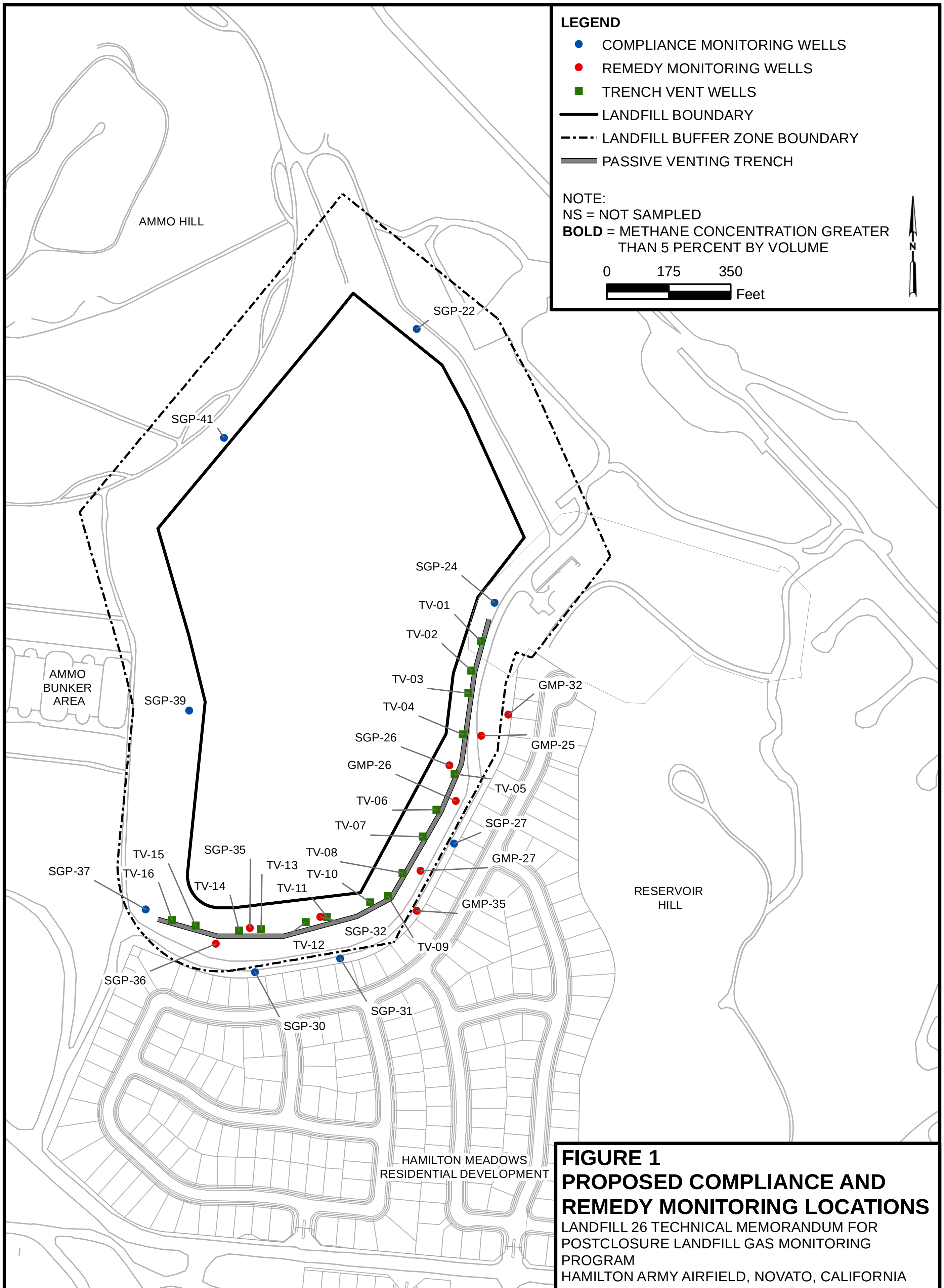
TABLE 3
Vadose Zone Monitoring Wells to be Deleted from Further Sampling Programs
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Rationale for Deletion of Well from Further Sampling |
|---|---|
| GMP-15 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater;well is not located in proximity to sensitive receptors; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-16 | Well is screened across the water table. Historic concentrations of methane at or below 0.09 percent; well is not located in proximity to sensitive receptors; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-17 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is directly adjacent to another vadose zone well (SGP-39) that will be sampled under the compliance monitoring program. |
| GMP-18 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-19 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-20 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-21 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is directly adjacent to another vadose zone well (SGP-41) that will be sampled under the compliance monitoring program. |
| GMP-22 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-23 | Well is screened across the water table. Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| GMP-24 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located in area of shallow bedrock; and well is located in close proximity to another vadose zone well (SGP-24) that will be sampled under the compliance monitoring program. |
| GMP-28 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; well is located in area of shallow bedrock; and well is located in close proximity to another vadose zone well (SGP-31) that will be sampled under the compliance monitoring program. |
| GMP-29 | Well is screened across the water table. Recent concentrations of methane at or below 0.02 percent; and well is located in close proximity to other vadose zone wells (SGP-30 and SGP-31) that will be sampled under the compliance or remedy monitoring programs. |
| GMP-30 | Well is screened across the water table. Methane results in this well are likely due to naturally occuring methane, not landfill related methane; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance or remedy monitoring programs. |

TABLE 3
Vadose Zone Monitoring Wells to be Deleted from Further Sampling Programs
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Location | Rationale for Deletion of Well from Further Sampling |
|---|---|
| GMP-31 | Well is screened across the water table. Recent concentrations of methane below 0.04 percent; and well is located in close proximity to other vadose zone wells that will be sampled under the compliance or remedy monitoring programs. |
| GMP-33 | Well is screened across the water table. Historic concentrations of methane at or below 0.3 percent; and well is located directly adjacent to an other vadose zone well (SGP-27) that will be sampled under the remedy monitoring program. |
| GMP-34 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; and well is located in close proximity to other vadose zone wells that will be sampled under the compliance or remedy monitoring programs. |
| GMP-35 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; and well is located in proximity to other vadose zone wells (SGP-27 and SGP-31) that will be sampled under the compliance monitoring program. |
| GMP-36 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; and well is located directly adjacent to an other vadose zone well (SGP-31) that will be sampled under the remedy monitoring program. |
| GMP-37 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; and well is located directly adjacent to an other vadose zone well (SGP-30) that will be sampled under the compliance monitoring program. |
| GMP-38 | Well is screened across the water table. Historic concentrations of methane at or below 0.1 percent; and well is located in close proximity to other vadose zone wells (SGP-36 and SGP-30) that will be sampled under the compliance or remedy monitoring programs. |
| SGP-23 | Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| SGP-25 | Historic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance or remedy monitoring programs. |
| SGP-28 | Histroic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance or remdy monitoring programs. |
| SGP-29 | Historic concentrations of methane at or below 0.1 percent; well is located inboard of passive venting system; and well is in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance or remedy monitoring programs. |
| SGP-33 | Recent concentrations of methane at or below 0.1 percent; and well is located in close proximity to other vadose zone wells (SGP-30 and SGP-31) that will be sampled under the compliance or remedy monitoring programs. |
| SGP-34 | Historic concentrations of methane at or below 0.1 percent; and well is located adjacent to an other vadose zone well (SGP-30) that will be sampled under the compliance monitoring program. |
| SGP-38 | Historic concentrations of methane at or below 0.1 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |
| SGP-40 | Historic concentrations of methane at or below 0.05 percent; well is located in area of high groundwater; well is not located in proximity to sensitive receptors; and well is located in proximity to (within 1,000 feet) other vadose zone wells that will be sampled under the compliance monitoring program. |

# Figures




# FIGURE 1
# PROPOSED COMPLIANCE AND REMEDY MONITORING LOCATIONS

LANDFILL 26 TECHNICAL MEMORANDUM FOR POSTCLOSURE LANDFILL GAS MONITORING PROGRAM
HAMILTON ARMY AIRFIELD, NOVATO, CALIFORNIA

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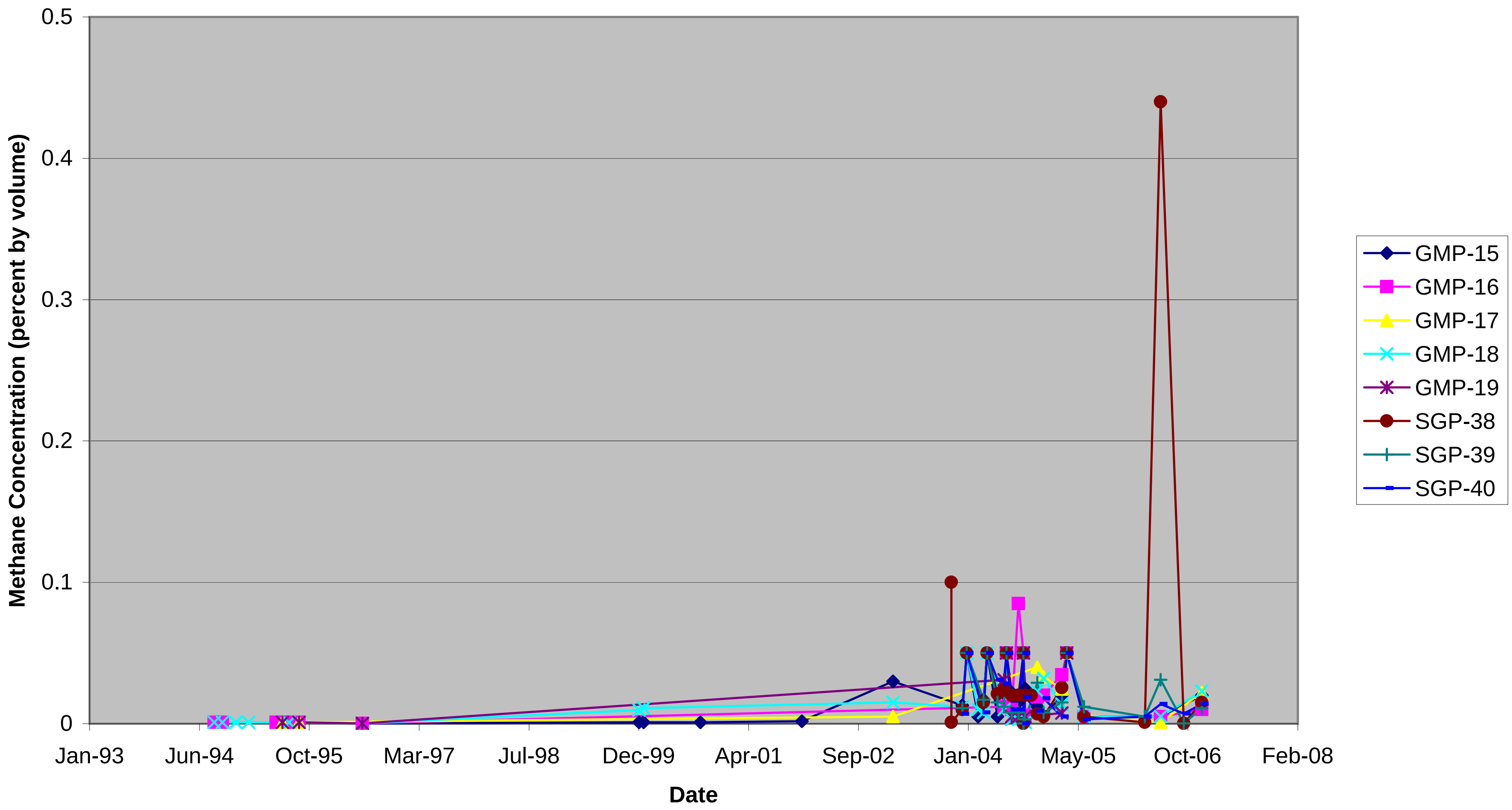


**FIGURE 2**
**LANDFILL 26 HISTORICAL METHANE CONCENTRATIONS WESTERN PERIMETER MONITORING WELLS**

LANDFILL 26 TECHNICAL MEMORANDUM FOR POSTCLOSURE LANDFILL GAS MONITORING PROGRAM
HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

CH2MHILL

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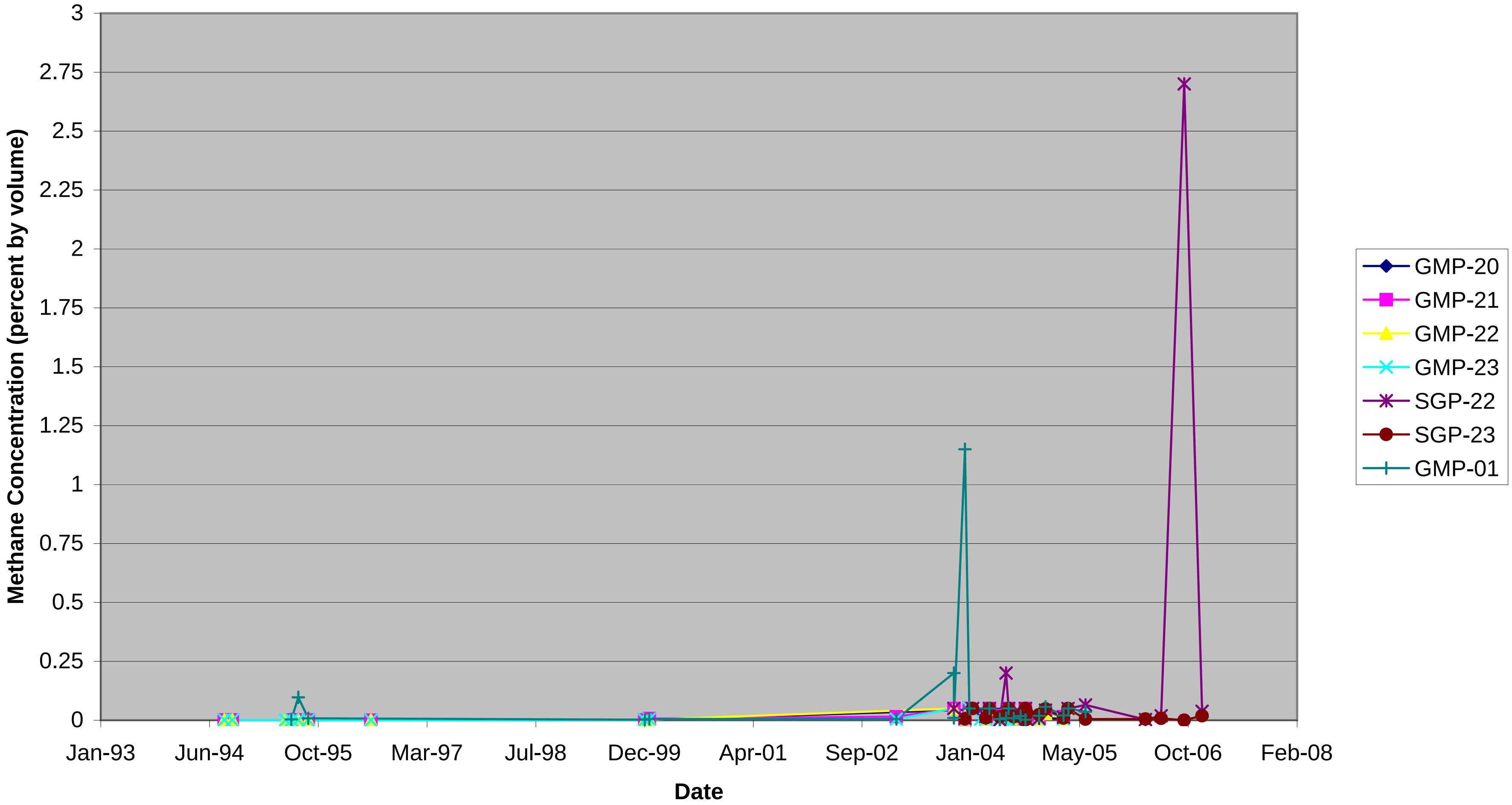


**FIGURE 3**
**LANDFILL 26 HISTORICAL METHANE CONCENTRATIONS NORTHERN PERIMETER MONITORING WELLS**

LANDFILL 26 TECHNICAL MEMORANDUM FOR POSTCLOSURE LANDFILL GAS MONITORING PROGRAM
HAMILTON ARMY AIRFIELD
NOVATO, CALIFORNIA

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APPENDIX D

# Cost Estimates for Alternatives

APPENDIX D

# Cost Estimates for Alternatives

## D.1 Introduction

Costs for Alternatives 2, 4, and 5 are presented in this appendix. (Alternative 1 has no associated costs, and Alternative 3 was removed from further consideration because it was not likely to be effective at attaining remedial action objectives [RAOs].) The costs include both capital and operation and maintenance (O&M) costs.

In accordance with U.S. Environmental Protection Agency (EPA) guidelines (EPA, 2000), the cost estimates for each alternative are order-of-magnitude estimates. Estimates of this type are generally accurate within plus 50 percent to minus 30 percent. The extent of this range implies that there is a high probability that the final projected cost will fall within this range. However, the accuracy of the estimates is subject to substantial variation because details of the specific design will not be known until the remedy is implemented. For example, project scope and schedule, design details, competitive market conditions, changes during construction, labor and equipment rates, and other variables are not known.

Furthermore, the selection of technologies or process options to estimate costs is not intended to limit flexibility during remedial design. Remedial design efforts might reveal possible cost savings as a result of value engineering studies and reduce the cost of implementing the remedy.

According to the guidelines (EPA, 2000), the discount rate used for the calculations was 3.0 percent and was taken from Appendix C of the Office of Management and Budget Circular A-94 (January 2007) for real discount rates over a 30-year period.

The formula used to calculate the present value is as follows:

$$PV_{30}=F(1/(1+i)^{n})+A[((1+i)^{n}-1)/(i(1+i)^{n})]$$

Where:

i = The discount rate
n = The number of years from 2007
F = A future cost
A = An annual cost

The methodology and information used to develop the cost estimates and the costs for each alternative by site are presented in the sections that follow. Section D.2 presents the unit costs and assumptions for each cost component (e.g., vapor barrier).

# D.2 Components of Costs

The alternatives evaluated in Section 5 of the Feasibility Study (FS) comprise a mix of several components: no action, institutional controls, vapor barriers, a perimeter venting trench, a vertical barrier, an active collection system, and monitoring. For example, institutional controls are a component of Alternatives 2, 4, and 5, and an active collection system is a component of Alternatives 4 and 5. These components were priced for LF 26 and the component costs are assembled into the cost estimates for each alternative. To support the evaluation of all three alternatives, the costs presented in this appendix assume that no remedial actions have been implemented at LF 26. An evaluation of the costs that takes into account the components that have already been installed is presented in Section 6 of the FS.

Cost estimates for the various components described in this section are presented in Table D-1. Table D-2 presents a summary of the costs by alternative. All tables are located at the end of this appendix.

## D.2.1 Institutional Controls

Costs for maintaining, monitoring, and enforcing land use restrictions and other institutional controls are included in the costs to implement Alternatives 2, 4, and 5. Minimal capital costs are included because the institutional controls will be implemented through existing processes (e.g., local permits) or processes that are required, regardless of the environmental contamination (e.g., recording deeds). Prior to property transfer, the Army implements the institutional controls. The Army would implement the postclosure maintenance requirements required by Title 27 of the California Code of Regulations (27 CCR) and the local enforcement agency (LEA) or California Integrated Waste Management Board (CIWMB) would monitor the implementation. At property transfer, the Army would impose further institutional controls on the property in the form of a deed restriction. Following property transfer, the new property owner would implement the postclosure requirements of 27 CCR, and the LEA or CIWMB would continue to monitor the implementation of these requirements. The State may also elect to establish a State Land Use Covenant (SLUC) to further outline land use restrictions for the property.
The components of the institutional controls are as follows:

- Implemented by LEA:
  - Landfill postclosure requirement monitoring
  - 27 CCR deed notification
- Implemented by the Army:
  - Landfill postclosure requirements
  - Advisories
  - Deed covenants
  - Deed notices
- Implemented by the State:
  - SLUC

Unit costs for institutional controls are presented in Table D-1, with total costs presented in Table D-2 by alternative. For Alternatives 2, 4, and 5, institutional controls continue to be implemented after the remedial action is constructed because residual levels of contamination are left in place.

The individual activities are described below with assumptions regarding the frequency and level of effort. Average costs per year were estimated. Actual costs may vary significantly by year depending on the level of activity (e.g., property transactions, breaches and enforcement actions, and construction activities). As shown in Table D-1, the institutional controls are implemented by technicians/institutional control specialists, attorneys, and regulators/program managers. The category of technician/institutional control specialist includes individuals with professional degrees in engineering, sciences, or public relations.

#### D.2.1.1 Part 2A—Institutional Controls Implemented by the Army

Costs are included for the following Army activities:

- **Advisories**—These warnings provide notice to potential property users of risks associated with the environmental contamination. The advisories remind key stakeholders of their role in maintaining the institution's control. The advisories will be issued by the Army as part of the community relations program, and costs to issue the advisories are included in the alternative costs. It is assumed that issuing the advisories and updating the list of stakeholders would require an average of 1 hour per year of a technician/institutional control specialist's time. Costs are also included to maintain a geographic information system database to track the status of the property with environmental contamination at a cost of 5 hours per year of a technician/institutional control specialist's time. The approximate cost for the advisories is $400 per year.
- **Deed covenants**—Deed covenants are implemented upon conveyance of the property. Costs for establishing the deed covenants are not included in the alternative costs because these costs will be incurred to transfer the property regardless of the environmental condition.
- **Deed notices**—These are information notices filed in public records to inform stakeholders of the presence of hazardous substances on the property. Costs for establishing the deed notices are not included in the alternative costs because these costs must be incurred to transfer the property regardless of the environmental condition.

#### D.2.1.2 Institutional Controls Implemented by the State

The State will enforce the SLUC. The SLUC can be used to achieve many of the same objectives as the deed covenants described previously. Costs include the following assumptions:

- Reviewing county reports, making telephone calls, writing letters, and attending meetings—2 hours per year of a regulator's time.
- Making periodic inspection—2 hours per year for a technician/institutional control specialist.

- Enforcing a major violation—10 hours each for an attorney and a regulator once every 30 years.
- Enforcing a minor violation—2 hours each for an attorney and a regulator once every 5 years.
- Renegotiating the SLUC (assumed to occur once every 5 years)—10 hours each for an attorney and a regulator.

The average cost for the State to implement the SLUC is approximately $980 per year.

#### D.2.1.3 Institutional Controls Implemented by LEA

Costs are included for the LEA to implement the following activities:

- **Landfill postclosure requirement monitoring**—The LEA will monitor the implementation of the postclosure requirements. Costs include the following assumptions:
  - Making periodic inspections—quarterly inspections, 3 hours per inspection for a technician/institutional control specialist.
  - Reviewing monitoring reports—quarterly reports, 2 hours per report of a regulator's time.
  - Reporting—one letter report per year

  The approximate cost for the LEA to monitor the implementation of the postclosure requirements is approximately $2,200 per year.
- **27 CCR deed notification**—These are information notices filed in public records to inform stakeholders of the presence of hazardous substances on the property. Costs for establishing the deed notices are not included in the alternative costs because these costs must be incurred to transfer the property regardless of the environmental condition.

### D.2.2 Vapor Barriers

Unit costs for the components of vapor barriers are provided in Table D-1. Alternatives 2, 4, and 5 include the installation of vapor barriers in future construction within the boundary of the buffer zone.

For the purposes of cost estimation, future land use is assumed to be open space with only two small buildings (e.g., restrooms or storage) constructed within the buffer zone. The buildings are estimated to be 500 square feet. Vapor barriers will be installed in each building. A vapor barrier will also be installed in the one existing building. On the basis of these assumptions, the cost for vapor barriers is estimated to be $23,500 (not including mobilization, demobilization, engineering design, construction oversight, and contingency).

Costs for mobilization, demobilization (5 percent of construction cost), engineering design and construction oversight (15 percent of construction cost), and contingency (15 percent of construction cost) are also included in the capital cost estimate.

### D.2.3 Perimeter Trench

Unit costs for the construction of a passive venting system using a perimeter trench are presented in Table D-1. Alternatives 2, 4, and 5 include the installation of a perimeter trench.

A perimeter passive venting trench was installed within the landfill buffer zone on the east and southeast sides of the landfill in 2002 to 2003. Details regarding the construction of the perimeter trench can be found in Section 1 of the main FS.

The estimated costs for the perimeter trench included as part of each alternative are based on the actual costs for the existing perimeter trench at LF 26, escalated to 2007. The capital cost associated with the perimeter trench is estimated to be $835,400. Costs for O&M, mobilization, demobilization, engineering design, construction oversight, and investigation-derived waste (IDW) disposal are included in the cost estimate.

### D.2.4 Vertical Barrier

Unit costs for the construction of a vertical barrier are presented in Table D-1. Alternative 2 includes the installation of a vertical barrier.

For the purposes of this FS, the following vertical barrier in the form of a trench lining system is assumed:

- GSE GundWall® interlocking rigid high-density polyethylene (HDPE) panels.
- Panels are driven in place using a vibratory hammer method following completion of the gravel lined trench.
- A panel thickness of 80 to 120 mil (2.0 to 3.0 mm) with excellent resistance to chemicals and rodent attack, does not exhibit environmental stress cracking.
- Panels interlock using an extruded hydrophilic gasket that swells when exposed to water to ensure leak-free panel connections.

The estimated costs for the vertical barrier are based on the actual costs for the GundWall® installed at LF 26, escalated to 2007. The capital cost associated with the perimeter trench is estimated to be $378,900. Costs for mobilization, demobilization, engineering design, and construction oversight are included in the cost estimate.

### D.2.5 Active Collection System

Unit costs for the construction and operation of an active collection system are presented in Table D-1. Alternatives 4 and 5 include the installation of an active collection system.

For the purposes of this FS, the following active collection system design was assumed:

- 3-inch HPDE abovegrade collection manifold terminating at the north-east end of venting trench.
- Manifold connections to one trench vent per trench segment; other vent is sealed.

- Pore-gas velocities within recommendations of United States Army Corps of Engineers (USACE) guidance (USACE, 2002).
- 10 cubic feet per minute collection system.
- 1.0-horsepower (hp) blower skid.

On the basis of these assumptions, the capital cost for the active collection system is estimated to be $137,900 (not including mobilization, demobilization, engineering design, construction oversight, and contingency).

Costs for O&M, mobilization, demobilization, engineering design, and construction, as well as a 15 percent contingency, are included in the cost estimate.

## D.2.6 Effluent Treatment

Unit costs for the installation and operation of an effluent treatment system are presented in Table D-1. Alternative 5 includes effluent treatment.

For the purposes of this FS, the following effluent treatment design was assumed:

- Active biofilter for removal of methane and volatile organic compounds (VOCs).
- Biofilter bed consisting of gravel base for gas distribution, geotextile separation layer, and approximately 3 cubic yards of media.
- Drip irrigation to hydrate bed during dry seasons.

On the basis of these assumptions, the capital cost for the effluent treatment system is estimated to be $7,400 (not including mobilization, demobilization, engineering design, construction oversight, and contingency).

Costs for O&M, mobilization, demobilization, engineering design, and construction, as well as a 15 percent contingency, are included in the cost estimate.

## D.2.7 Monitoring

### Vadose Zone Compliance Monitoring

Unit costs for the equipment, sampling, and reporting associated with vadose zone compliance monitoring are presented in Table D-1. Alternatives 2, 4, and 5 include compliance monitoring.

Compliance monitoring consists of the collection and analysis of soil gas samples from the point of compliance wells established for Landfill 26 (LF 26). For the purposes of the cost estimate, sampling is assumed to be conducted according the sampling program described in Appendix C. Three wells (SGP-22, SGP-39, and SGP-41) will be sampled annually and five wells (GMP-31, GMP-33, GMP-35, SGP-30, and SGP-37) will be sampled quarterly. The samples will be analyzed for methane using a field instrument (e.g., a GEM 2000). It is assumed that the sampling will require 2 hours per well with quarterly reports, each requiring 8 hours to prepare, for an estimated annual cost of $7,800. A total capital cost of $9,000 is estimated for the GEM 2000. An annual cost of approximately $900 is assumed for calibration, maintenance, and repair of the instrument.

### Remedy Monitoring

Unit costs for the sampling associated with remedy monitoring are presented in Table D-1. Alternatives 2, 4, and 5 include some form of remedy monitoring.

Remedy monitoring will be performed to assess the continued protectiveness of the landfill refuse-related gas control system with respect to nearby sensitive (i.e., residential) receptors. Under Alternative 2, remedy monitoring is assumed to be conducted according the sampling program described in Appendix C. Nine remedy monitoring wells (GMP-25, GMP-26, GMP-27, GMP-32, GMP-35, SGP-26, SGP-32, SGP-35, and SGP-36) will be sampled quarterly. In addition, all of the trench vent wells (TV-1 to TV-16) will be sampled under the remedy monitoring program for Alternative 2. Under Alternatives 4 and 5, quarterly samples will be collected from the nine remedy monitoring wells and the active collection system. An additional sample will be collected after the effluent treatment under Alternative 5.

It is assumed that the equipment used for the compliance monitoring will also be used for the remedy monitoring. The compliance monitoring report will include data collected under the remedy monitoring program.

### Structure Monitoring

Unit costs for the sampling associated with structure monitoring are presented in Table D-1. Alternatives 2, 4, and 5 include structure monitoring.

For the purposes of cost estimation, future land use is assumed to be open space with only two small buildings (e.g., restrooms or storage) constructed within the buffer zone. It is assumed that one continuous methane monitor/alarm (e.g., Guardian Plus $CH_4$ Monitor) will be installed in each building. Assuming that the monitors must be replaced every 10 years, the estimated capital cost for structure monitoring is $16,100. Costs for O&M are also included in the cost estimate.

## D.3 References

United States Army Corps of Engineers (USACE). 2002. *Engineering and Design: Soil Vapor Extraction and Bioventing.* EM 1110-1-4001. June.

United States Environmental Protection Agency (EPA). 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. Office of Solid Waste and Emergency Response. 9355.0-75. July.

# Tables

TABLE D-1
Unit Costs and Assumptions
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Task | Quantity | Unit Cost | Unit | Estimated Cost | Assumptions |
|---|---|---|---|---|---|
| **Component: Institutional Controls** | | | | | |
| Technician/IC Specialist | 1 | $67 | hour | $67 | Assumed to be $58/hour per US EPA - escalated to 2007 |
| Attorney | 1 | $116 | hour | $116 | Assumed to be $100/hour per DTSC - escalated to 2007 |
| Regulator/Program Manager | 1 | $111 | hour | $111 | Assumed to be $96/hour per US EPA - escalated to 2007 |
| **Implemented by the Army** | | | | | |
| Advisories - Technician | 1 | $67 | hours | $67 | Assumption, 1 hour per year for each site |
| Advisories (GIS Database) - Technician | 5 | $67 | hours | $336 | Annual update at 5 hours per site |
| **Annual Cost** | **-** | **-** | **-** | **$403** | **Annual** |
| **Implemented by the State** | | | | | |
| Oversight (Review Reports/Contacts) - Regulator | 2 | $111 | hours | $223 | Assumption |
| Oversight (Inspections) - IC Specialist | 2 | $67 | hours | $134 | Assumption |
| Enforcement - Attorney | 0.33 | $116 | hours | $39 | Assumption, one major violation every 30 years at 10 hours for each violation |
| Enforcement - Regulator | 0.33 | $111 | hours | $37 | Assumption, one major violation every 30 years at 10 hours for each violation |
| Enforcement - Attorney | 0.4 | $116 | hours | $46 | Assumption, one minor violation every 5 years at 2 hours for each violation |
| Enforcement - Regulator | 0.4 | $111 | hours | $45 | Assumption, one minor violation every 5 years at 2 hours for each violation |
| SLUC (Property Transaction) - Attorney | 2 | $116 | hours | $232 | Assumption, one transaction every 5 years at 10 hours for each transaction |
| SLUC (Property Transaction) -Regulator | 2 | $111 | hours | $223 | Assumption, one transaction every 5 years at 10 hours for each transaction |
| **Annual Cost** | **-** | **-** | **-** | **$978** | |
| **Implemented by the LEA** | | | | | |
| Postclosure Monitoring (Inspections) - Technician | 12 | $67 | hours | $807 | Assumption, quarterly inspections at 3 hours for each inspection |
| Postclosure Monitoring (Review Monitoring Reports) - Regulator | 8 | $111 | hours | $890 | Assumption, quarterly reports at 2 hours for each report |
| Postclosure Monitoring (Reporting) | 1 | 500 | lump sum | $500 | Assumes one letter report per year |
| **Annual Cost** | **-** | **-** | **-** | **$2,197** | **Annual** |
| **Component: Vapor Barrier** | | | | | |
| Vapor Barrier (new construction) | 1 | $2,459 | lump sum | $2,459 | 7/04 estimate from LBI of $2.25/ft$^2$, assume 2 small building within the buffer zone, 500 ft$^2$ per building, escalated to 2007 |
| Vapor Barrier (existing building) | 1 | $21,000 | lump sum | $21,000 | 3/07 estimate from LBI of $6/ft$^2$ for general retrofit, existing building is 3,500 ft$^2$ |
| Mobilization and Demobilization | 1 | $1,173 | lump sum | $1,173 | 5% of total construction cost |
| Engineering/Construction Oversight | 1 | $3,519 | lump sum | $3,519 | 15% of total construction cost |
| Contingency | 1 | $3,519 | lump sum | $3,519 | 15% of total construction cost |
| **Total Vapor Barrier Cost** | - | **-** | **-** | **$31,669** | **Initial capital cost** |
| **Component: Perimeter Trench** | | | | | |
| Construction | 1 | $510,330 | lump sum | $510,330 | Actual costs for existing trench, escalated to 2007 |
| IDW Disposal | 1 | $147,319 | lump sum | $147,319 | Actual costs for existing trench, escalated to 2007 |
| Engineering | 1 | $177,761 | lump sum | $177,761 | Actual costs for existing trench, escalated to 2007 |
| **Total Perimeter Trench Cost** | **-** | **-** | **-** | **$835,410** | |
| **Annual Operation and Maintenance** | **36** | **$100** | **hour** | **$3,600** | **Assumes 3 hours per month monthly inspections and riser repairs** |

TABLE D-1
Unit Costs and Assumptions
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Task | Quantity | Unit Cost | Unit | Estimated Cost | Assumptions |
|---|---|---|---|---|---|
| **Component: Vertical Barrier** | | | | | |
| Installation of GundWall® | 1 | $378,899 | lump sum | $378,899 | Actual costs for existing vertical barrier, escalated to 2007 |
| **Component: Active Collection System** | | | | | |
| SVE Skid, 1.0 hp | 1 | $4,635 | lump sum | $4,635 | Vendor quote |
| Electrical connection | 1 | $4,300 | lump sum | $4,300 | Assumes near a power pole/source |
| 3-inch HDPE collection manifold | 8,063 | $16 | foot | $129,008 | |
| Mobilization and Demobilization | 1 | $6,897 | lump sum | $6,897 | 5% of total construction cost |
| Engineering/Construction Oversight | 1 | $20,691 | lump sum | $20,691 | 15% of total construction cost |
| Contingency | 1 | $20,691 | lump sum | $20,691 | 15% of total construction cost |
| **Total Active Collection System Cost** | - | **-** | - | **$186,223** | |
| Annual Electricity | 8,165 | $0.10 | kw-hr | $817 | Assumes $0.10/kw-hr |
| O&M | 160 | $100 | hour | $16,000 | Assumes 8 hours per month monthly inspections and quarterly 16 hours service and repairs |
| **Annual Operation and Maintenance** | - | **-** | - | **$16,817** | |
| **Component: Effluent Treatment** | | | | | |
| Biofilter | 1 | $7,396 | lump sum | $7,396 | |
| Mobilization and Demobilization | 1 | $370 | lump sum | $370 | 5% of total construction cost |
| Engineering/Construction Oversight | 1 | $1,109 | lump sum | $1,109 | 15% of total construction cost |
| Contingency | 1 | $1,109 | lump sum | $1,109 | 15% of total construction cost |
| **Total Effluent Treatment Cost** | - | - | - | **$9,984** | |
| O&M | 48 | $100 | hour | $4,800 | Assumes 4 hours monthly for filter inspections and moisture adjustments |
| Biofilter media exchanges | 1 | $924 | lump sum | $924 | Assumes 25% of the construction costs, every 2 years |
| **Annual Operation and Maintenance** | - | **-** | - | **$5,724** | |
| **Component: Monitoring** | | | | | |
| GEM 2000 | 1 | $8,995 | lump sum | $8,995 | Assumes 1 monitor, vendor quote |
| Guardian Plus $CH_4$ monitor (continuous monitor/alarm) | 6 | $2,675 | lump sum | $16,050 | Assumes 1 monitor for each of 2 buildings, includes total replacement every 10 years, vendor quote |
| Electrical connection for continuous methane monitor | 2 | $4,300 | lump sum | $8,600 | Assumes 1 connection per building, near a power pole/source |
| Vadose zone compliance monitoring | 1 | $8,700 | lump sum | $8,700 | Annual cost, assumes 2 hours per well and 8 hours per report at $100 per hour, 3 wells sampled annually and 5 wells sampled quarterly, includes $900 for annual instrument calibration, maintenance and repair |
| Remedy monitoring | 1 | $100 | per location | $100 | Assumes 1 hour at $100/hour per sample location, reporting included with compliance monitoring |
| Structure monitoring | 48 | $100 | hour | $4,800 | Annual cost, assumes 4 hours per month for inspection, testing, and calibration |
| **Component: Reports** | | | | | |
| Remedial Action Completion Report | 1 | $25,000 | lump sum | $25,000 | Assumption based on completion of similar reports |

TABLE D-2
Costs by Alternative
*Landfill 26 Soil Gas Feasibility Study, Former Hamilton Army Airfield, Novato, California*

| Component | Alternative 2 | Alternative 4 | Alternative 5 |
|---|---|---|---|
| **Institutional controls (annual)** | $3,579 | $3,579 | $3,579 |
| **Vapor barrier (capital)** | $31,669 | $31,669 | $31,669 |
| **Perimeter trench** | | | |
| Capital cost | $835,410 | $835,410 | $835,410 |
| Annual cost | $3,600 | $3,600 | $3,600 |
| **Vertical barrier (capital)** | $378,899 | | |
| **Active collection system** | | | |
| Capital cost | | $186,223 | $186,223 |
| Annual cost | | $16,817 | $16,817 |
| **Effluent treatment** | | | |
| Capital cost | | | $9,984 |
| Annual cost | | | $5,724 |
| **Reports** | $25,000 | $25,000 | $25,000 |
| **Monitoring** | | | |
| Capital cost | $25,045 | $25,045 | $25,045 |
| Annual cost | $23,500 | $17,500 | $17,900 |
| **Total capital cost** | **$1,296,024** | **$1,103,347** | **$1,113,331** |
| **Total annual cost** | **$30,679** | **$41,495** | **$47,620** |
| **Total cost** | **$2,216,400** | **$2,348,200** | **$2,541,900** |
| **$PV_{30}$** | **$1,897,340** | **$1,916,673** | **$2,046,699** |

Note: All costs in 2007 dollars.

APPENDIX E

# Responses to Comments

**RESPONSE TO REVIEW COMMENTS**

**DATE:** 7 August 2007

**DOCUMENT REVIEWED:** Draft Final Landfill 26 Feasibility Study; Hamilton Army Airfield; Novato, CA by CH2M HILL

**REVIEWER:** Theresa McGarry, Project Manager, State of California, Department of Toxic Substances Control, Office of Military Affairs

| GENERAL COMMENTS | RESPONSE |
|---|---|
| 1. Please summarize all previous investigative studies and conclusions in FS report to support the reason for completing a FS for soil gas only. Please ensure sufficient rationale is in the FS to justify why the preferred remedy, (perimeter passive venting trench), is only necessary for the southern and southeastern portion of the landfill. | To the extent practicable, additional information from previous studies has been included in the FS to support the reason for addressing only soil gas in the document. A new subsection (Section 1.3) has been included that better the describes the environmental restoration process at LF 26, the current regulatory status of LF 26, and the anticipated future process required to achieve site closure and postclosure status for LF 26.<br><br>Additional information from previous studies has also been added to Section 1.6.3 (Perimeter Passive Venting System) to justify the location and extent of the existing venting system as the final remedy for soil gas. |
| 2. The previous major document approved by regulatory agencies was the Corrective Action Investigation Workplan. Please ensure that this document is cited in the FS and include an explanation of how recommendations from the workplan have been addressed. | A reference to the *Corrective Action Investigation Workplan* has been added to Section 1.7.3. This includes an explanation of how recommendations from the work plan have been addressed at LF 26. The workplan is also summarized in Table 1-2. |
| 3. The department of Health Services is referenced throughout the FS as the oversight agency instead of DTSC, (a separate state agency). Please correct. | References to the Department of Health Services have been changed to DTSC. |
| 4. Please discuss the public participation process for the FS. | A summary of the public participation process for environmental restoration activities at LF 26 has been added at the end of Section 1.3 |

| SPECIFIC COMMENTS | RESPONSE |
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| Table 2.1. Applicable or Relevant and appropriate Requirement (ARARs) Although the FS is focused on selection of a remedy and institutional controls for control of soil gas. The anticipated Land use Covenant (LUC) prepared for the landfill would also include prohibiting any activities that adversely impact the landfill cap, buffer and groundwater. | Comment noted. No response necessary. |
| Section 3.5.2.1 Institutional Controls (IC) under Army ownership. Please include a map showing the 1000 feet boundary from the edge of the landfill disposal area to show where California Code of Regulations (CCR) Title 27 protective measures would apply. While adjacent property not owned by the landfill operator/owner (Army) is not subject to the provisions of CCR Title 27, these measures are recommended for the health and safety of people who may occupy any structures build within 1000 feet of the landfill disposal area. Generally, these provisions can be made part of a locally issued “Conditional Use Permit,“ as appropriate. | A new figure (Figure 3-3) has been added to the document that shows the approximate extent of the landfill, the buffer zone, and the estimated 1000 foot boundary. Property owned by the Army’s verses property owned by others is also depicted in Figure 3-3. |
| Section 3.5.2.3 IC following Property Transfer. DTSC expects that the Army will enter in to a State Land use Covenant (prior to transfer) with DTSC and Regional Water Quality Control Board (RWQCB) to implement appropriate use restrictions. Persons, with adequate justification, may request a variance from DTSC for any use restrictions identified in the LUC. | Comment noted. No response necessary. |
| Preferred Alternative: Please list all anticipated use restrictions for landfill and buffer, to include the following:<br>– Prohibit actions that might damage or otherwise reduce the effectiveness of installed cap.<br>– Prohibit any land use other then “closed landfill” or open space.<br>– Restrict excavation into landfill cap and buffer unless approved by DTSC, RWQCB, CIWMB and County of Marin Environmental Health Services<br>– Prohibit groundwater use. | Section 7 has been amended to add text stating that “Specific restrictions for landfill and buffer zone use during the postclosure care period will be addressed in the closure and postclosure maintenance plan. These restrictions will follow 27 CCR guidelines.” |

| SPECIFIC COMMENTS | RESPONSE |
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| Section 4.1.2.2 IC. The Army may contractually arrange for third parties to perform any and all of the actions associated with ICs, although the Army is ultimately responsible under Comprehensive Environmental Response, Compensation, & Liability Act and State Law for the successful implementations of ICs, including monitoring, maintenance and review of ICs. | Comment noted. No response necessary. |

## RESPONSE TO REVIEW COMMENTS

**DATE:** 23 July 2007

**DOCUMENT REVIEWED:** Draft Final Landfill 26 Feasibility Study; Hamilton Army Airfield; Novato, CA by CH2M HILL

**REVIEWER:** Michele Dalrymple PG, Engineering Geologist, State of California, Department of Toxic Substances Control, Geologic Services Unit

| GENERAL COMMENTS AND RECOMMENDATIONS | RESPONSE |
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| A. The USACE identifies Alternative 2 (Passive Venting with Perimeter Trench) as the preferred alternative for addressing landfill refuse-related methane in soil gas at Landfill 26. Alternative 2 includes a passive venting trench that "matches the design of the existing trench system" that was installed as an interim remedy in 2003. The FS report should clarify how it was determined that the design of the interim remedy is sufficient to be used as the final remedy for soil gas migration at Landfill 26. GSU understands that the USACE has performed several previous studies at Landfill 26 that evaluated the potential for landfill-generated soil gas migration, and that the interim remedy was designed based on the findings of these studies. However, these studies are not sufficiently summarized in the FS report and require further elaboration.<br><br>__Recommendation__<br><br>**The FS report should provide a summary of the findings and data from previous studies to support the proposed design of the USACE's preferred alternative. Specifically, it should be demonstrated whether or not the passive vent trench should be extended or installed in other locations along the perimeter of the landfill that have the potential for significant landfill gas migration. If it has been determined that significant landfill gas migration will not occur in other locations, additional data and information should be provided to support this determination. The FS report should also demonstrate the sufficiency of the proposed compliance monitoring well network in relation to this evaluation.** | Additional information on the basis for the location and extent of the existing interim passive vent trench has been incorporated into Section 1.6.3 (formerly Section 1.3.7.3). In addition, information supporting the determination that the design of the interim remedy is sufficient to be used as the final remedy for soil gas migration at LF 26 has been added to Section 4.1.2.1. |

| GENERAL COMMENTS AND RECOMMENDATIONS | RESPONSE |
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| B. The USACE determined that VOCs are not compounds of concern (COCs) for soil gas at Landfill 26 based on the results of a human health risk assessment that evaluated both the outdoor air and indoor air pathways. The report states that the conclusions of the risk assessment indicate that risks associated with the "current VOC concentrations" in soil gas within the landfill are well below 1 x $10^{-6}$ or hazard quotient of 1. However, the process of selecting data to represent "current VOC concentrations" for use in the risk assessments is unclear, as described below.<br><br>Assumptions listed in Appendix A – *Assessments of Risk Associated with VOCs in Soil Gas at LF 26* state that the maximum detection of soil gas data collected since 2003 was used and that all soil gas data was obtained from the HAAF Landfill 26 database, version dated September 2006. However, based on a comparison of data included on Tables 1 and 2 of Appendix A with data in Appendix B – *Landfill 26 Analytical Data*, it appears that the maximum concentrations for some VOCs may not have been used. For example, the maximum concentrations of TCE, 1,3-butadiene, toluene, Freon 11, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene, among others, reported in Tables 1 and 2 are lower than the maximum concentrations reported in Appendix B. GSU evaluated the data for probe locations with GMP- and SGP- prefixes and the time period from 2003 through September 2006.<br><br>**<u>Recommendation</u>**<br><br>**GSU requests that the process that was used to select data for use in the risk assessments be clarified and that discrepancies between the maximum concentrations reported in Appendix B and those used in the risk assessment be resolved.** | VOCs (other than methane) have been addressed at LF26 throughout the characterization and risk evaluation phases of the project. The risk assessment process allows for the identification of those chemical constituents that pose the primary risk to identified receptors (i.e., risk drivers) verses those constituents that do not pose a significant risk (generally those constituents with a risk less than 1X$10^{-6}$ or a hazard index [HI] less than 1). At the remedy evaluation and selection stage under CERCLA, it is typical to re-assess COCs and to only retain the risk drivers, thereby focusing the selection process on identifying a remedy that reduces the most significant amount of risk. For the purposes of this FS, VOCs (other than methane) are not considered risk drivers and will not be retained as COCs.<br><br>The *Assessments of Risk Associated with VOCs in Soil Gas at LF 26* contained in Appendix A has been updated and revised to include the most recent VOC data (September 2006). |

| SPECIFIC COMMENTS AND RECOMMENDATIONS | RESPONSE |
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| 1. Section 1.5.3 – Recent Monitoring Results. Please identify the analytical methods that were used for methane and VOC analyses during the 2006 sampling events. | The methods used for methane and VOCs analysis for the 2006 sampling events has been added to Tables 1-5 and 1-6, respectively. |
| 2. Section 1.5.3.1 – Methane. | |
| a. Four sampling events were performed for methane in 2006, but only the results from the December 2006 sampling event are discussed in the FS Report. GSU requests that the other rounds from 2006 be discussed to evaluate temporal changes. Also, the September 2006 round should be discussed because VOCs were also analyzed during this round. Potential correlations between methane concentrations and elevated VOCs should be evaluated (see Specific Comment 3). | The text in Section 1.7 (formerly Section 1.5) was been expanded to provide a discussion of temporal trends in the methane data and potential correlations between the occurrence of elevated methane and VOC concentrations. |
| b. There is a discrepancy between the data in Appendix B and the information on Table 1-5 for methane concentrations from well GMP-09 in September 2006. Appendix B reports a value of 18 percent by volume for methane in September 2006 and Table 1-5 reports a value of 8.2 percent by volume. Please resolve this discrepancy. | Discrepancies between Table 1-5 and Appendix B have been resolved. |
| c. GSU requests that the report provide an explanation regarding the many probe locations that were not sampled for methane as indicated on Table 1-5. | Samples were not collected at various wells listed on Table 1-5 because these probes were submerged in groundwater at the time that sample collection was attempted. A foot note has been added to Table 1-5 to include this information. |
| 3. Section 1.5.3.2 – VOCs. GSU requests that the report evaluate and discuss whether a correlation exists between methane and VOC concentrations. For example, at GMP-09, a methane spike was detected in September 2006 (18 percent by volume) and the highest total VOC concentration was also detected at this location (149.5 part per billion by volume [ppbv]). GSU further requests that any significant temporal trends in contaminant concentrations be evaluated and discussed. | A new section, Section 1.7.2.3, as been added to provide a discussion of potential correlations between the occurrence of elevated methane and VOC concentrations. |
| 4. Appendix A - Assessments of Risk Associated with VOCs in Soil Gas at LF 26. It is requested that the maximum detection values shown on Tables 1 and 2 are provided in both ppbv and microgram per cubic meter so that a comparison of concentrations can easily be made between the data used in the risk assessment and the analytical data tables in Appendix B. | Both Tables 1 and 2 in Appendix A have been revised to include the data in units of ppbv and ug/m$^3$. |

| SPECIFIC COMMENTS AND RECOMMENDATIONS | RESPONSE |
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| 5. Appendix C – Compliance Monitoring Technical Memorandum, Point of Compliance Monitoring Frequency. The report states that GMP-01 displayed a temporary increase in methane during the December 2003 sampling event but that all other detections from this well have been 0.2 percent or lower. However, it should be noted that in the most recent sampling event (December 2006), the methane concentration increased to 0.55 percent by volume at this location. Please correct this information in the FS Report. | The data for well GMP-01 has been corrected. |
| 6. Appendix C – Compliance Monitoring Technical Memorandum, Remedy Monitoring Analytical Program. Please specify the field instrument that will be used to measure methane, static pressure, and oxygen level, and the anticipated accuracy of the measurements. | The exact type of field instruments to be used for methane, static pressure, and oxygen measurements, their detection limits and accuracy will be specified in *Postclosure Maintenance Plan* to be developed for LF 26 (this document will be reviewed and approved by the regulatory agencies prior to implementation). |
| 7. Appendix C – Compliance Monitoring Technical Memorandum, Table 3. GSU disagrees with the discontinuation of well GMP-09 from the sampling program. Table 3 incorrectly reports that the recent concentrations of methane have been at or below 0.005 percent in this well. According to Appendix B, this well had a methane concentration of 18 percent in September 2006 and it has historically had elevated levels of methane up to 57 percent. GSU requests that the USACE consider including this well in the remedy monitoring well network. | The information for GMP-09 in Table 3 has been corrected. Well GMP-09 lies directly adjacent to well SGP-26, a well that is included in the remedy monitoring well network. GMP-09 is a deeper probe that extends into the water table. At certain times of the year (e.g., winter and spring) GMP-09 cannot be sampled because the screened interval is submerged due to high groundwater conditions. SGP-26 is a shallower probe that does not experience submergence and is believed to yield samples that are more representative of soil gas conditions in this area. Therefore, SGP-26 was included in the remedy monitoring well network instead of GMP-09. |

## RESPONSE TO REVIEW COMMENTS

**DATE:** 30 July 2007

**DOCUMENT REVIEWED:** Draft Final Landfill 26 Feasibility Study; Hamilton Army Airfield; Novato, CA by CH2M HILL

**REVIEWER:** Tracy Taras, Ph.D., Staff Toxicologist, State of California, Department of Toxic Substances Control, Human and Ecological Risk Division (HERD)

| GENERAL COMMENTS | RESPONSE |
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| 1. Explosive and Asphyxiation Hazards for Methane.<br>HERD did not review information related to potential explosive and asphyxiation hazards associated with methane. For OMF's reference, we note that methane is hazardous in that it is combustible and potentially explosive when present at concentrations in excess of 53,000 parts per million by volume (ppmv) in the presence of oxygen (DTSC 2005). DTSC's "Advisory on methane assessment and common remedies at school sites", states that a concentration of 10% of the LEL, or 5000 ppmv, is commonly used as an "action level" above which mitigative measures are recommended. Methane can also act as a simple asphyxiant by causing oxygen deprivation. The California Division of Occupational Safety and Health (Cal-OSHA) does not list specific exposure limits for methane. | Commented noted. Please note that RAOs for soil gas (including methane) at LF 26 are based on the requirements of California Code of Regulations, Title 27, which is a promulgated regulation used throughout the State for the monitoring and assessment of solid waste landfills. |
| 2. Source of Methane Generation and MTBE.<br>HERD defers to DTSC's OMF and GSU regarding discussion in the document indicating that a majority of the methane may be naturally generated and methane generated by natural processes located outside of the LF 26 boundary is not associated with the landfill and will not be considered in this FS not the remedy. The document also states that methyl tert butyl ether (MTBE) detected in soil gas at LF 26 is not related to the landfill but instead derived from a former gasoline service station plume hydraulically upgradient of the LF 26 site. We defer to OMF and GSU on this issue. | Comment noted. No response necessary. |

| GENERAL COMMENTS | RESPONSE |
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| 3. Chemicals of Concern.<br><br>HERD disagrees with Section 1.4.4.2 of the document which states that VOCs (other than methane) are not chemicals of concern (COCs) at LF 26 because the risk assessment for indoor and outdoor air exposures to VOCs did not exceed the 1E-6 point of departure or a hazard quotient of one. The document concludes that methane (present at concentrations associated with potential explosive conditions) is the sole COC. Consistent with the evaluation of VOCs in the indoor air evaluation, HERD is of the opinion that VOCs detected in soil gas are chemicals of potential concern (COPCs). We recommend that VOCs detected in soil gas be included in future documents for public transparency regardless of whether they are determined to pose a significant risk to human health and the environment which require further consideration during risk management and potential remedial action. | VOCs (other than methane) have been addressed at LF26 throughout the characterization and risk evaluation phases of the project. The risk assessment process allows for the identification of those chemical constituents that pose the primary risk to identified receptors (i.e., risk drivers) verses those constituents that do not pose a significant risk (generally those constituents with a risk less than $1X10^{-6}$ or a hazard index [HI] less than 1). At the remedy evaluation and selection stage under CERCLA, it is typical to re-assess COCs and to only retain the risk drivers, thereby focusing the selection process on identifying a remedy that reduces the most significant amount of risk. The FS acknowledges the presence of VOCs; however, for the purposes of remedy evaluation, VOCs (other than methane) are not considered risk drivers and will not be retained as COCs. However, the fact that low concentrations of VOCs (other than methane) are present within soil gas at LF26 will be stated in both the forthcoming Proposed Plan (PP) and Record of Decision (ROD) Amendment for LF26. |
| 4. Conceptual Site Model (CSM, Figure 1-9).<br><br>a. COPCs. Currently, only methane is discussed in the notes for the CSM. HERD recommends that VOCs (other than methane) also be listed. | Please see response to General Comment #3. |

| GENERAL COMMENTS | RESPONSE |
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| 4. <u>Conceptual Site Model (CSM, Figure 1-9).</u><br><br>b. <u>Environmental Media Considered in the Human Health Risk valuation.</u> This FS focuses *solely* on landfill refuse-related soil gas contamination at the LF 26 site. That is, the only medium evaluated for human exposure was soil gas. Pathways stated to have been considered in the FS consisted of impacts to human health via inhalation of volatile organic compounds (VOCs) in indoor and outdoor air, and explosive conditions caused by methane. We have the following comments:<br><br>i Other than potential volatilization of VOCs from groundwater and partitioning of VOCs from soil to soil gas, risk associated with exposure to potential groundwater and soil contaminants has not been addressed in this document. If media at the site other than soil gas are contaminated, the risk estimates included in this document would not be representative of the cumulative total risk at the site.<br><br>ii As HERD has noted for other sites in the vicinity of LF 26, depending on the sampling methodology and depth of soil gas sampling, evaluation of the indoor air pathway using soil gas data only may underestimate risk from this exposure pathway if VOCs are present in groundwater.<br><br>iii Typically, HERD requires that cumulative total risk across all media be reported. Because the FS addresses soil gas only, we will defer to OMF on this issue but recommend that OMF consider this during risk management decisions at the site. This issue may be a potential data gap. | 4bi: As indicated in the FS, the only media addressed in this document is soil gas. Potential risks associated with other media (e.g., soil and groundwater) have been addressed in other documents prepared for LF 26 and by remedial measures that have been implemented at the landfill (e.g., the RCRA-type cap to mitigate potential risks associated with exposure to soil). The assessment of overall risks associated with all media of concern and the remedies selected to mitigate the identified risks will be documented in the forthcoming Proposed Plan and Record of Decision (ROD) Amendment.<br><br>4bii: Potential risks associated with the indoor air pathway were evaluated using an extensive set of actual soil gas data. It is unclear to the Army how the use of actual soil gas data could result in underestimation of potential risks via the indoor air pathway (given that there are no structures currently located within the footprint of the landfill).<br><br>4biii: Please see the response provided above regarding the assessment of cumulative risk. |

| GENERAL COMMENTS | RESPONSE |
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| 4. Conceptual Site Model (CSM, Figure 1-9). | |
| c. Human Receptors and Exposure Pathways. The CSM lists site worker, site visitor, and residents as potential receptors. Appendix A includes the USACE's evaluation of vapor intrusion to indoor air for future residential receptors. Also included in Appendix A is a 2002 human health risk screening analysis for outdoor ambient air impacted by the trench vents from the prepared by the Bay Area Air Quality Management District (BAAQMD). HERD did not review the BAAQMD evaluation in detail as we do not have expertise in landfill emissions modeling (see General Comment 5 below). | |
| i. The CSM does not list construction / trench workers as potential future receptors at the site. Per discussions with OMF, HERD understands that a land use restriction will be place for the landfill and buffer zone against future uses other than landfill / open space as part of the Record of Decision (ROD). If it is determined that construction may occur at the site in the future, HERD recommends evaluating a construction / trench worker scenario in the HHRA. This is particularly important given the presence of VOCs and methane at the site. For example, while it may be unlikely that methane would be present in outdoor ambient air at concentrations exceeding the lower explosive limit (LEL) or a concentration needed for asphyxiation due to dispersion and dilution, it is unclear whether this would be true for trench workers. | 4ci: A State land use covenant (SLUC) will prevent construction at the site. Therefore, a construction/trench worker is not a potential receptor of concern. |
| ii In general, HERD finds it likely that if exposure to VOC in soil gas does not pose a significant risk to residents from the indoor air pathway, then exposure to VOCs in outdoor ambient air emitted from soil gas would also not pose a significant risk. However, in the absence of a quantitative evaluation using accepted risk assessment methodology, this cannot be confirmed. HERD also cannot comment on whether this would be true for construction/trench workers (should such activities be envisioned in the future). | 4cii: The USACE concurs that if VOC in soil gas do not pose the potential for significant risk to residents via the indoor air pathway, that the potential for significant risk to an outdoor ambient air receptor is not likely. The outdoor ambient air pathway has been quantitatively addressed by the risk assessment performed by the BAAQMD. This assessment indicated that unacceptable risk would not occur. See response 4ci regarding a construction trench worker. |

| GENERAL COMMENTS | RESPONSE |
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| 4. Conceptual Site Model (CSM, Figure 1-9).<br><br>To address this issue, the risk assessment should be updated to include an evaluation of the outdoor ambient air pathway for residential receptors (given that a residential scenario indoor air evaluation is currently included). In addition, since questions may arise from persons using the landfill area for recreation, HERD recommends that the recreational scenario be evaluated for the outdoor ambient air pathway if this pathway is shown to pose a significant risk/hazard to residential receptors. Finally, there are also other potential future exposure scenarios (e.g. industrial, construction) where the outdoor ambient air pathway may be complete if land use restrictions are not in place. If such restrictions are not currently in place or will not be in the future, those receptors need to be evaluated as appropriate. For the current scenario, HERD does not have knowledge of workers who may be present at the site for maintenance of the cap, trench, etc. This needs to be addressed to ensure a scenario protective of such workers will be evaluated. | As stated previously, the outdoor ambient air pathway has been quantitatively addressed by the risk assessment performed by the BAAQMD. This assessment indicated that unacceptable risk would not occur for residential receptors. Unacceptable risk would, therefore, not occur for lesser exposed receptors. |
| 5. Bay Area Air Quality Management District, Health Risk Screening Analysis (March 21, 2002).<br><br>Appendix A contains a 2002 human health risk screening analysis prepared by the Bay Area Air Quality Management District (BAAQMD). This evaluation involved using air emission estimates and dispersion modeling to estimate maximum ambient air concentrations of various toxic air contaminants (TACs) present in landfill gas (LFG). HERD did not conduct a detailed review of this modeling. As reported by the BAAQMD, it was concluded that the maximum acute health hazard and chronic hazard index were less than one. The estimated lifetime cancer risk was 1.5E-6 and the two TACs that contributed most significantly to cancer risk were acrylonitrile and vinyl chloride. Subsequently, the USACE compared the BAAQMD predicted VOC concentrations to maximum measured VOC concentrations in soil gas (from soil gas data up to July 2004) and concluded that the actual measured VOC concentrations were several orders of magnitude less than those predicted indicating that the BAAQMD risk estimates are "overly conservative." While HERD did not review this BAAQMD analysis in detail, we note that there are several VOCs such as 1,3-butadiene which have been detected in soil gas from the site which were not included in the ambient air health risk screening conducted by the BAAQMD. For this reason, HERD has concerns that this evaluation may not be predictive of the actual risk at the site. | The evidence provided supports the conclusion that the BAAQMD assessment was conservative. The BAAQMD assessment (Section 4, page 2) also pointed out that actual VOC concentrations were much less (10 to 1000 times) than default values. Since there have not been significant changes to the conditions at LF26, the BAAQMD assessment findings are still valid.<br><br>In addition, the 1,3-butadiene detections only occurred immediately after installation of the soil gas sampling probes and have not been repeated after many rounds of sampling. Therefore, the Army concludes that the anomalous 1,3-butadiene detections are not representative of the site conditions. |

| GENERAL COMMENTS | RESPONSE |
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| 6. <u>Ecological Receptors.</u><br>The document states that no ecological receptors were identified for LF 26 yet no supporting information appears to have been provided. HERD notes that given the current open space uses of the landfill, the site may provide habitat to ecological receptors. As such, a scoping level ecological risk assessment per DTSC guidance should be performed. As an example, potential exposure of burrowing animals to VOCs in soil gas is one potential exposure pathway. | No threatened or endangered species have been identified at LF 26. LF 26 is a highly disturbed area. The roadway and the rip-rap at the margins of the landfill are maintained, and the surface cover (grass and brush) is routinely mowed. As such, the landfill area does not represent significant ecological habitat. Therefore, there are no ecological receptors of concern at LF 26. Section 1.4.5 will be revised to include this information. |
| 7. <u>Soil Gas Data Discussion and Presentation.</u><br>The document indicates that the most recent soil gas data from the site is from September 2006. The document should include a discussion of contaminant concentration trends over time. It would also be helpful to include a table with contaminant concentrations across the various sampling rounds to allow for a review of trends and which contaminants have been detected. In addition, the appendix should include the raw analytical data sheets from the laboratory as well as any notes or comments supplied by the laboratory. Finally, please note the depth at which the soil gas samples were collected. | The text in section 1.5.3.1 was been expanded to provide a discussion of temporal trends in the methane data and potential correlations between the occurrence of elevated methane and VOC concentrations.<br>Due to the volume of laboratory reports, it is not viable to include these in the document.<br>The depths from which soil gas samples were collected have been added to Section 1.5.3. |

| GENERAL COMMENTS | RESPONSE |
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| 8. <u>Evaluation of Vapor Intrusion to Indoor Air Pathway.</u><br><br>Conservative assumptions were stated to have been used for the indoor air evaluation. For example, maximum contaminant concentrations detected in soil gas from 2003 to September 2006 were utilized, it was assumed all maximum detected concentrations were co-located, and a residential scenario was evaluated assuming the building is located above contaminant maximum detected concentrations. The DTSC recommended default attenuation factor of 0.0009 for future residential buildings was used. HERD notes however that there are several issues which must be addressed prior to finalizing the report:<br><br>a. <u>Indoor Air Modeling at Landfills.</u><br><br>i While it is our understanding that a deed restriction against any future building in the landfill and buffer zone will be put into place, the document needs to clearly address which area is being evaluated in the risk assessment. The Army's evaluation in Appendix A indicates that potential risks/hazards due to exposure to VOCs via the indoor air vapor intrusion pathway were evaluated for any future structure that might be constructed on Landfill 26. However, the soil gas data utilized in the indoor air evaluation were collected from the landfill buffer zone rather than on top of the landfill itself. For the southern portion of the buffer zone, the data were collected on both sides of the trench. HERD is unfamiliar with the details of the landfill cap construction and whether any intentional or unintentional venting occurs through the cap itself in areas other than the trench on the southern portion of the buffer zone. If sampling data is available from on top of the landfill itself, please provide a summary. If not, please clearly state the rationale for why samples have not been collected from this area.<br><br>ii Use of attenuation factors derived based on Johnson and Ettinger (J&E) modeling to evaluate the indoor air pathway is likely not valid for future construction on top of the landfill itself due to landfill gas pressure. Please address this issue. For example, is this indoor air evaluation intended to support a conclusion that the indoor air pathway would not be a significant issue for future buildings which may be located on top of the landfill itself or only the buffer zone? For the buffer zone, please address the available data on landfill gas pressure. HERD has concerns that the landfill gas pressure may be incompatible with J&E modeling assumptions. | 8ai: All available data from LF-26 was used. Maximum detected soil gas values were used. A hypothetical home was assumed to be located directly over a hypothetical location that had soil gas at levels equal to the maximum value detected any where from the landfill, regardless of the location of those detections (either within the landfill or at the perimeter). This assessment was not performed to represent actual conditions, but was performed to represent a "worst-case" scenario with the intention to be able to conclude that if this "worst-case" scenario does not indicate unacceptable risk, then unacceptable risk would not occur to lesser exposed receptors.<br><br>The barrier portion of the landfill cap includes 12 to 24 inches of clay overlain by an impermeable geomembrane. The cap prevents the vertical (i.e., upward) migration of landfill gas. No soil gas probes were incorporated into the cap. Furthermore the conceptual site model developed during the 1999 investigation did not suggest that there was a need to collect VOC data from this portion of the site. Therefore no soil gas data is available from the top of the landfill.<br><br>8aii: Elevated soil gas pressures are often noted at landfills and this possibility was evaluated at LF 26 during the 1999 investigation. Pressure readings were made at monthly intervals from the perimeter soil gas probes. Evaluation of these data indicated that there is no evidence of high relative soil gas pressure at LF 26. The average pressure differential was -0.19 millibars with minimum and maximum values or -24 and 3 millibars, respectively. This is consistent with other aspects of LF 26 (i.e., age, low quantity of decomposable refuse, etc). In addition, the SLUC and other ICs, including the postclosure requirements of 27 CCR will restrict or prevent future construction on top of LF26. |

| **GENERAL COMMENTS** | **RESPONSE** |
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| 8. Evaluation of Vapor Intrusion to Indoor Air Pathway.<br><br>b. Exposure Point Concentrations. Review of Appendix B relative to the Appendix A Tables 1 and 2 indicates that for some chemicals, maximum detected contaminant concentrations may not have been used in the risk calculations. As an example, Table 1-6 and Appendix B indicate that trichloroethylene (TCE) was detected in September 2006 at GMP-32 at 4.2 ppbv (equal to 22.57 ug/m$^3$). The TCE concentration used in the risk calculations was 14.21 ug/m$^3$. Also, without a complete review of the data included on the compact disc included in Appendix B, it is unclear whether higher concentrations of this compound were detected in sampling events prior to September 2006. (Please note that TCE is listed as an example only.) Because of this discrepancy, all chemical concentrations used in the risk evaluation should be checked to ensure the maximum detected concentration were utilized for consistency with the stated assumptions. Please also clarify the basis for using data from after 2003 only. | The *Assessments of Risk Associated with VOCs in Soil Gas at LF 26* contained in Appendix A has been updated and revised to include the most recent VOC data (September 2006). Data from the time period between 2003 and 2006 is considered to best reflect current soil gas conditions, and was therefore used in the risk evaluation. This rationale is has been added to the text of Appendix A. |
| 8. Evaluation of Vapor Intrusion to Indoor Air Pathway<br><br>c. The compact disc included in Appendix B needs to be updated. On HERD's copy, the CD lists a series of numbers rather than sample dates for much of the soil gas data. In addition, please explain whether all soil gas data included on the CD was considered in selecting exposure point concentrations for the indoor air evaluation. | The data on the compact disk in Appendix B has been corrected to include sample date information. |
| 8. Evaluation of Vapor Intrusion to Indoor Air Pathway<br><br>d. The USACE indoor air risk evaluation included in Appendix A concludes that future residential receptors evaluated assuming exposure from the indoor air pathway represents a worst case scenario which would be protective of less exposed receptors such as recreational receptors and commercial workers. As noted in General Comment 4C ii, HERD recommends that this pathway be evaluated using standard risk assessment methodology. | Please see response to General Comments #4, #5, and #8. |

| GENERAL COMMENTS | RESPONSE |
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| 8. <u>Evaluation of Vapor Intrusion to Indoor Air Pathway</u><br>e. USEPA Region 9 ambient air preliminary remediation goals (PRGs) were used as risk-based residential air concentrations in the indoor air risk evaluation. HERD notes that both risk and hazard must be addressed for all COPCs. Currently, only cancer risk was evaluated for those COPCs which are carcinogens. Please see the USEPA Region 9 PRG InterCal tables for ambient air PRGs based on both hazard and cancer endpoints for carcinogens and update Table 2 (potential inhalation hazard) accordingly. | The carcinogens (Table 1) have been included in Table 2. It should be noted that this has no effect on the overall HI since the combined HI of these carcinogens is 4.8E-09. |

| SPECIFIC COMMENTS | RESPONSE |
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| 1. <u>VOC Concentrations.</u><br>Table 1-6 and Appendix B list VOC concentrations detected in soil gas collected in September of 2006 in units of ppbv. Please update the tables to also include the detected concentrations in units of ug/m$^3$, as these are the units needed for human health risk assessment purposes. | Table 1-6 and Appendix B will be revised to include the data in units of ug/m$^3$. |
| 2. <u>PRGs Based On Noncancer Endpoints.</u><br>HERD checked a subset of the PRGs used in the risk and hazard calculations and has noted several discrepancies which should be corrected:<br>a. Freon 12 is also known as dichlorodifluoromethane. The USEPA ambient air PRG for dichlorodifluoromethane is 210 ug/m$^3$ whereas the PRG used in the hazard calculations was 31000 ug/m$^3$. Please correct.<br>b. For Freon 11 (trichlorofluoromethane), the 2004 PRG is 730 ug/m$^3$ (not 31,000 ug/m$^3$).<br>c. For 1,1-dichloroethane the 2004 Cal-modified PRG is 1.2 ug/m$^3$. This value should be used rather than the USEPA PRG of 520 ug/m$^3$.<br>d. For other compounds such as 4-ethyltoluene and Freon 114, HERD is unaware of currently available PRGs. Please clarify where a surrogate was used. If so, please identify the surrogate compound selected and provide a rationale for why it was selected. HERD should be contacted to discuss surrogate selection for compounds without USEPA or Cal/EPA toxicity criteria. | 2a: 210 ug/m$^3$ has been used.<br>2b: 730 ug/m$^3$ has been used.<br>2c: 1.2 ug/m$^3$ is used for the carcinogenic endpoint and 520 ug/m$^3$ is used for the hazard endpoint.<br>2d: When surrogates are used they are identified within the document. |

**RESPONSE TO REVIEW COMMENTS**

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| **DATE:** | 27 August 2007 (via e-mail) |
| **DOCUMENT REVIEWED:** | Draft Final Landfill 26 Feasibility Study; Hamilton Army Airfield; Novato, CA by CH2M HILL |
| **REVIEWER:** | Gina Yekta, Project Manager, California Integrated Waste Management Board |

| COMMENT | RESPONSE |
|---|---|
| 1. As far as our comment on the FS goes, we like to suggest that the site should continue to be monitored on a quarterly frequency and in accordance with 27 CCR. Also, if high concentrations of gas (greater than the regulatory threshold) are detected during the routine monitoring event, the EA can direct the Army to monitor the site at another more conservative frequency. | The compliance monitoring program described in the *Compliance Monitoring Technical Memorandum* (Appendix C) was developed to be consistent with the monitoring requirements prescribed in 27 CCR. Quarterly monitoring is specified for the five selected compliance wells located in the southern and southeastern portions of LF 26 adjacent to the Hamilton Meadows residential area per 27 CCR 20933. As allowed under 27 CCR 20921 (d), the Army proposes a reduced monitoring schedule for three wells located on the western and northern sides of LF 26, as these locations have been demonstrated to not be significant landfill gas migration pathways nor are there currently any structures or utility lines in this area that would pose public risk. See Sections 1.5.3, 1.5.5, 1.5.6, 1.5.7, 1.6.3 and Appendix C of this report, and the *Landfill 26 Conceptual Site Model Update* (CH2M HILL, 2006) for further discussion of the landfill gas and related migration pathways at LF 26. |

**RESPONSE TO REVIEW COMMENTS**

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| **DATE:** | 10 July 2007 |
| **DOCUMENT REVIEWED:** | Draft Final Landfill 26 Feasibility Study; Hamilton Army Airfield; Novato, CA by CH2M HILL |
| **REVIEWER:** | Mark Janofsky, REHS, County of Marin, Community Development Agency, Environmental Health Services |

| GENERAL COMMENTS | RESPONSE |
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| **Page 3.5.2.1 *Institutional Controls under Army Ownership*, second sentence:** "State regulations for post closure maintenance and land use are detailed in 27 CCR, Section 21190." Postclosure maintenance and land use are addressed in separate sections of 27 CCR: 21180 and 21190 respectively. | The sentence has been revised to read as follows: *"State regulations for post closure maintenance and land use are detailed in 27 CCR, Sections 21180 and 21190, respectively."* |
| **Page 3.5.2.1 *Institutional Controls under Army Ownership*, second paragraph: " All proposed construction improvements and changes to end use on closed sites shall be submitted to the local enforcement agency (LEA) (i.e. Marin County Department of Health Services), RWQCB, and the California Integrated Waste Management Board (CIWMB)…."** The LEA is contained within the Environmental Health Services Division of the Marin County Community Development Agency. In addition to the aforementioned agencies, Section 21190 (c) requires that all proposed postclosure land uses, other than non-irrigated open space, shall be submitted to the local air district and the local planning department. | The reference to "Marin County Department of Health Services" has been changed to the "Environmental Health Services Division of the Marin County Community Development Agency."<br><br>The local air district and the local planning department have been added to the list of agencies that require notification in the event of a proposed change in end use (other than non-irrigated open space). |
| **Page 3.5.2.1 *Institutional Controls under Army Ownership:* "Construction of structural improvements on top of the landfill during postclosure period shall include the following components:"** The list provided after the aforementioned sentence does not include all of the components required by 21190 (e). The complete list of required components should be provided, or the sentence should be changed to indicate that the list is incomplete. | The sentence has been revised to read as follows: *"Construction of structural improvements on top of the landfill during postclosure period shall include (but not be limited to) the following components:"* |

| GENERAL COMMENTS | RESPONSE |
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| **Page 3.5.2.1 *Institutional Controls under Army Ownership:*** The previous comment also applies to the requirements listed for structures on the land owner's property within 1000 feet of the disposal area (i.e. the list provided in the Feasibility Study is not complete). In addition, it should be stated that these components are also required for structural improvements on top of the landfill, as the wording in 21190 (g) can be somewhat confusing. | The text has been revised as stated for the previous comment response to refer to the complete list of 27 CCR requirements.<br><br>Additionally, the text has been reworded to say (added text in italics):<br><br>"Construction of structural improvements on top of the landfill area during the postclosure period shall include (but not be limited to) the following components *in accordance with the above referenced regulatory requirements*:"<br><br>Additional revision:<br><br>"The postclosure requirements may also stipulate the need for all structures constructed on the land owner's property within 1,000 feet of the boundary of the disposal area *and on the landfill cap*…" |