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Office of Solid Waste and
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Remedial Design-Stage Optimization Review Report

Sandy Beach Ground Water Plume Superfund Site
Tarrant County, Texas
EPA Region 6

Prepared for United States Environmental Protection Agency

Prepared by Tetra Tech, Inc. and GSI Environmental, Inc.

EXECUTIVE SUMMARY

Optimization Background

U.S. Environmental Protection Agency defines optimization as the following:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply some other approaches to identify opportunities for greater efficiency and effectiveness. Contractors, states, tribes, the public, and PRPs are also encouraged to put forth opportunities for the Agency to consider."*[1]

An optimization review considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews.

An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent review, and represent the opinions of the optimization review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the EPA Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP).

[1] U.S. Environmental Protection Agency. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

Site-Specific Background

The Sandy Beach Road Ground Water Plume Superfund Site, CERCLIS ID No. TXN000605649, is located within incorporated areas of Pelican Bay and Azle, Texas and an unincorporated portion of Tarrant County, Texas. The site is the location of a former unpermitted landfill where existing ravines were used to deposit waste and later backfilled. Releases of trichloroethene (TCE) from the landfill migrated through shallow soil to the underlying Paluxy Aquifer, which is a local source of drinking water. The former landfill has since been converted to residential property with significant open space. The source area is currently owned by an innocent owner operator (IOO). The basis for taking action at the site is the exceedance of drinking water standards in private water wells and in Pelican Bay public water supply (PWS) wells screened in the Paluxy Aquifer.

In 2004, the Texas Commission on Environmental Quality (TCEQ) reported that PWS wells in Pelican Bay, as well as private residential wells, were contaminated by TCE at concentrations exceeding the Maximum Contaminant Level (MCL). TCEQ subsequently investigated area groundwater, with support from EPA. The affected PWS wells were shut down and filtration units were installed on the affected private water wells. The site was added to the National Priorities List (NPL) in 2005 and a remedial investigation (RI) and feasibility study (FS) were finalized in 2011. The Record of Decision (ROD) was published in 2011. Water supply connections from the City of Azle distribution system have replaced all of the filtration systems, except for the residences located along Liberty School Road and one residence located on Sandy Beach Road, to address exposure pathways associated with contaminated water supplies. In addition to providing clean water for residents, remedies proposed for the site include soil vapor extraction (SVE), *in situ* bioremediation (ISB) and groundwater extraction and treatment (pump and treat; or P&T) remedy components. The site is currently in the remedial design phase.

The optimization review team along with the site project managers and regional consultants conducted a site visit in April 2013. This site optimization review report includes recommendations based on review of site documents, finding of the site visit and meeting with EPA remedial project managers (RPM).

Summary of Conceptual Site Model and Key Findings

In site decision documents, the most likely source of contamination to soil and groundwater was identified as an unpermitted landfill that operated from 1958 to 1971 north of Sandy Beach Road and east of Mountain View Road. Source identification was accomplished through review of historic aerial photos and site investigations including a passive soil gas survey and geophysical surveys. Historic records on the type and quantity of material buried at the site are unavailable. Minimally invasive source characterization was performed to comply with the wishes of the current IOO.

The optimization review team has identified uncertainties about materials remaining in the source as a data gap in the CSM. The primary release mechanisms at the landfill is believed to be historic direct disposal of TCE into the ravines (RI, June 2011), however, the potential presence of intact drums of chlorinated solvents or other primary sources may be important to the design of the remedial response. The secondary sources of contamination include affected soils beneath and around the ravines, where TCE may volatilize or leach to groundwater. Shallow soils consist of a mixture of silty to sand clays, clayey sands and silty sand. Saturation occurs at a depth below 70-75 feet below ground surface (ft bgs) in the source area. The precise distribution of TCE in shallow and saturated soils, including its distribution in soils of varying porosity (for example clays versus sands), is another data gap affecting the design of the source remedies.

The Paluxy Aquifer is a shallow water table aquifer underlying the former landfill. The Paluxy Aquifer generally has no more than 25 ft of saturated thickness, eventually discharging to Walnut Creek approximately ½ mile downgradient. The Twin Mountains Aquifer is located at a depth over 400 ft bgs and is separated from the Paluxy Aquifer by the Glen Rose Formation. Unsaturated soil between the Glen Rose Formation and the Twin Mountains Aquifer indicates that the Paluxy Aquifer is perched on top of the Glen Rose Formation. Many private and some PWS wells have drawn or continue to draw water from the affected depths of the Paluxy Aquifer. The Twin Mountains Aquifer is an active source of drinking water. Groundwater analytical results also indicate that the Twin Mountains Aquifer has been impacted by TCE in one location through a private well (GW-39) that screens both aquifers; contamination in the impacted Paluxy Aquifer appears to migrated to the Twin Mountains Aquifer in the area of this well.

Additional data gaps relevant to the proposed remedies include questions surrounding the potential water quality impact from ISB treatments and the effect of back- or matrix-diffusion from low permeability deposits on the magnitude and persistence of the dissolved phase plume.

Summary of Recommendations

Recommendations are provided to improve remedy design in the areas of effectiveness and cost efficiency. The majority of recommendations address data gaps in the CSM. The recommendations in these areas are as follows:

Improving effectiveness –

Recommendations to improve the effectiveness of the proposed remedy include prioritizing and sequencing remedial activities. The optimization review team recommends plugging, abandoning and if necessary, replacing the remaining impacted private water supply wells that may provide human exposure and migration pathways to lower units.

Installation of the SVE in the source area should be prioritized both as a means of direct source treatment and control and to address data gaps. The potential for additional sources of TCE (such as buried drums) can be evaluated during the installation of the SVE system. Typically, extraction wells would be installed before trenching and piping, but in this case, the optimization review team suggests implementing trenching and piping in this area first, during which the site team can observe the nature of the debris to evaluate evidence of residual drums, tanks or other vessels that may contain TCE. If there is evidence of additional sources, then the site team should proceed with planning for excavation of these potential sources. The source remedy design process should be flexible and adaptive, in order to incorporate data gathered during installation of the SVE to optimize placement of remedial components.

The optimization review team recommends characterization of the source area saturated soils during installation of the SVE wells. The deeper interval SVE wells should be installed through the deep unsaturated zone and soil samples from various intervals in the saturated zone collected (using sonic drilling techniques) and analyzed for contaminants. Characterization data should be used to identify areas of contamination that may provide long-term sources of contaminants to groundwater.

To optimize the efficacy of ISB treatment and identify potential water quality impacts, the optimization review team recommends performing an additional site ISB pilot test.

After source treatment, plume migration control is the next highest priority. The hydraulic control system as presented in the Preliminary Design Report (EA 2013) should include a minimum number of wells to provide hydraulic control of the plume. The optimization review team also recommends appropriate scaling of the groundwater P&T system by reducing the initial number of extraction wells. However, the optimization review team recommends increasing the capacity of the groundwater treatment plant up to 150 gallons per minute (gpm), as a contingency in case the extraction system needs to be expanded. If full-scale P&T were required due to plume migration, the scaled-up treatment plant would be available to accommodate the increased treatment volumes. This report also provides recommendations to simplify the design of the treatment plant to include a liquid granular activated carbon (LGAC) treatment process.

This optimization review report also recommends a groundwater performance monitoring plan to confirm control of the plume and the performance of aggressive source remediation.

Reducing cost –

Recommendations to prioritize source area remediation and combine additional source area characterization with implementation of the currently planned SVE system are anticipated to reduce costs over the lifetime of the project. Additional costs associated with sampling in the source area are estimated at $100,000; however costs are anticipated to be offset by more efficient remedy design, contaminant mass removal and a shorter operation life time for the SVE remedy.

Recommendations for appropriate scaling and streamlining of the P&T system are also anticipated to reduce life-cycle costs. Remedy performance monitoring along with establishing remedy operation exit (or termination) criteria for each remedy component can help reduce the risk of operating a remedy past the point of effectiveness.

Technical improvement –

Technical improvements for the proposed remedy are anticipated to result from additional site characterization (to refine remedy component placement), pilot testing of ISB treatment and remedy performance monitoring accompanied by continued good data management practices. Prioritizing the source remedy is anticipated to provide the maximum reduction in residual contaminant mass, improving the long-term efficacy of the hydraulic control system. Recommendations on the scale and design of the P&T system should improve the efficacy of plume hydraulic control.

Site closure –

Recommendations that are anticipated to shorten the time to attain cleanup goals include additional source area characterization during installation of the SVE system, pilot testing the ISB amendments, prioritizing source area cleanup and implementing remedy performance monitoring.

Green remediation –

No specific recommendations have been provided for environmental footprint reduction. However, several of the above recommendations have the potential to reduce the remedy footprint by either streamlining the treatment process or reducing the likelihood of operating a remedy component past the point of measureable benefit in achieving the associated remedial action objective(s).

NOTICE AND DISCLAIMER

Work described herein was performed by Tetra Tech for the U.S. Environmental Protection Agency. GSI Environmental performed work under a subcontract to Tetra Tech. Work conducted by Tetra Tech, including preparation of this report, was performed under Work Assignment 2-58 of EPA contract EP-W-07-078 with Tetra Tech Inc., Chicago, Illinois. The report was approved for release as an EPA document, following the Agency's administrative and expert review process

This optimization review is an independent study funded by the EPA that focuses on protectiveness, cost-effectiveness, site closure, technical improvements and green remediation. Detailed consideration of EPA policy was not part of the scope of work for this review. This report does not impose legally binding requirements, confer legal rights, impose legal obligations, implement any statutory or regulatory provisions or change or substitute for any statutory or regulatory provisions. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Recommendations are based on an independent evaluation of existing site information, represent the technical views of the optimization review team and are intended to help the site team identify opportunities for improvements in the current site remediation strategy. These recommendations do not constitute requirements for future action; rather, they are provided for consideration by the EPA Region and other site stakeholders.

While certain recommendations may provide specific details to consider during implementation, these recommendations are not meant to supersede other, more comprehensive, planning documents such as work plans, sampling plans and quality assurance project plans (QAPP); nor are they intended to override applicable or relevant and appropriate requirements (ARARs). Further analysis of recommendations, including review of EPA policy may be needed prior to implementation.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization practices from site assessment to site completion implemented by the United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI)(2). The project contacts are as follows:

Organization	Key Contact	Contact Information
EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Kirby Biggs	EPA OSRTI Technology Innovation and Field Services Division (TIFSD) 2777 Crystal Drive Arlington, VA 22202 biggs.kirby@epa.gov phone: 703-823-3081
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The national optimization strategy includes a system for tracking consideration and implementation of the optimization recommendations and includes a provision for follow-up technical assistance from the optimization review team as mutually agreed upon by the site management team and EPA OSRTI.[2]

[2] U.S. Environmental Protection Agency. 2012. Memorandum: Transmittal of the National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28.

LIST OF ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below ground surface
CERCLA	Comprehensive Environmental Restoration Compensation and Liability Act
CSM	Conceptual site model
COC	Contaminant of concern
Cis-1,2 DCE	*cis*-1,2-Dichloroethene
DPT	Direct-push technology
EA	EA Engineering, Science and Technology, Inc.
EPA	U.S. Environmental Protection Agency
ERT	Environmental Response Team
EW	Extraction well
FS	Feasibility study
ft	feet
GAC	Granular activated carbon
gpm	gallons per minute
GW	Groundwater
HASP	health and safety plan
HQ	Headquarters
IC	Institutional control
ISB	*In situ* bioremediation
IOO	Innocent owner operator
IW	Injection well
LGAC	Liquid phase granular activated carbon
MCL	Maximum Contaminant Level
MW	Monitoring well
NPL	National Priorities List
O&F	Operational and Functional
O&M	Operation and Maintenance
ORP	Oxidation reduction potential
OSRTI	Office of Superfund Remediation and Technology Innovation
PCL	Protective concentration levels
P&T	Pump and treat
PWS	Public water supply
QAPP	Quality assurance project plan
RA	Remedial Action
RAC	Remedial action contractor
RAO	Remedial action objective
RD	Remedial design
RI	Remedial investigation
ROD	Record of Decision
RPM	Remedial Project Manager
SAP	Sampling and analysis plan
SVE	Soil vapor extraction
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TIFSD	Technology Innovation and Field Services Division
TOC	Total organic carbon

TRRP	Texas Risk Reduction Program
µg/L	micrograms per liter
VC	Vinyl chloride
VOC	Volatile organic compound

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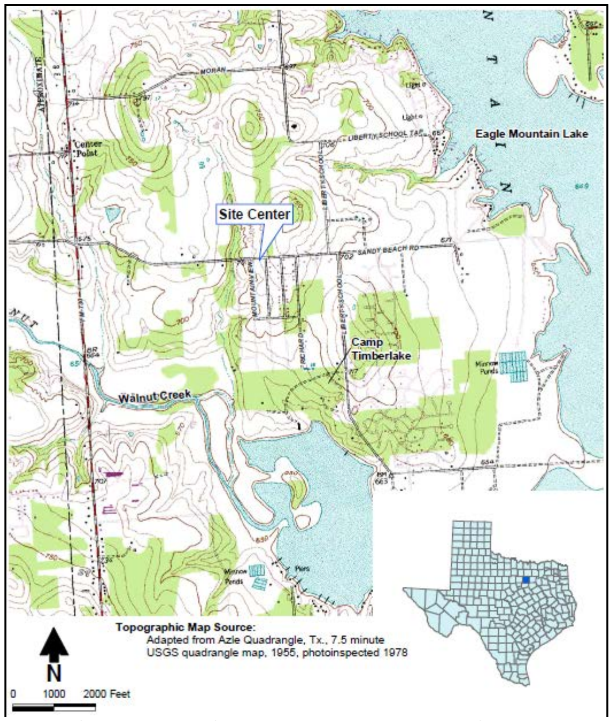
APPENDICES

1.0 OBJECTIVES OF OPTIMIZATION REVIEW

For more than a decade, the Office of Superfund Remediation and Technology Innovation (OSRTI) has provided technical support to the EPA regional offices through the use of independent (third party) optimization reviews at Superfund sites. The Sandy Beach Road Ground Water Plume Superfund Site (Sandy Beach Site) was nominated for an optimization review at the request of the Region 6 remedial project manager (RPM) in January 2013. The current optimization review of the site is intended to improve protectiveness, reduce cost and reduce the time required to attain cleanup goals.

The site is located within incorporated areas of Pelican Bay and Azle, Texas and an unincorporated portion of Tarrant County, Texas in EPA Region 6 (Figure 1). The site was added to the National Priorities List (NPL) on September 14, 2005, and activities under CERCLA have been on-going since this time. Site Remedial Investigation (RI) (EA 2010a) and Feasibility Study (FS) (EA 2010b) reports were finalized in June and September 2011, respectively, and a Record of Decision (ROD) (EPA 2011) was signed in September 2011. The site is currently in the Remedial Design (RD) phase.

Figure 1: Site location.



Excerpt from Figure 1 of the September 2011 ROD. A full size version of this figure is provided in Appendix B.

To this end, an optimization review team (described below) was assembled and met with regulatory stakeholders and consultants in Dallas, Texas and at the site to review site data, remediation goals, potential funding and time frames to implement the remedy. The optimization team also reviewed site documents. This report summarizes the findings and recommendations of the optimization review team.

Objectives of this RD-stage optimization review include:

- Review of conceptual site model (CSM)
- Review of Remedial Action Objectives (RAO)
- Review of proposed remedies and associated costs
- Provide recommendations for:
  - CSM improvements
  - Remedy improvements
  - Prioritization and sequencing of the remedy components
  - Performance monitoring metrics in support of exit criteria for each remedy component

Green remediation is not a primary objective for this optimization review and specific recommendations for green remediation are not provided. However, several of the remedy optimization recommendations have the potential to reduce the remedy footprint by either streamlining the treatment process or reducing the likelihood of operating a remedy component past the point of measureable benefit in achieving the associated RAO(s).

2.0 OPTIMIZATION REVIEW TEAM

The remedy design-stage optimization review team consisted of the independent, third-party participants listed in Table 1. The optimization review team collaborated with representatives of EPA Headquarters (HQ) (OSRTI and Environmental Response Team [ERT]) and EPA Region 6, the Texas Commission on Environmental Quality (TCEQ) and representatives of EA Engineering, Science and Technology, Inc. (EA), the Remedial Action Contractor (RAC) for EPA Region 6.

The independent, third-party optimization review team consisted of the following individuals:

Table 1: Optimization Review Team

Name	Organization	Phone	Email
Kirby Biggs	EPA HQ OSRTI	703-299-3438	biggs.kirby@epa.gov
Tom Kady	EPA HQ ERT	732-735-5822	kady.thomas@epa.gov
Doug Sutton	Tetra Tech	732-409-0344	doug.sutton@tetratech.com
Mindy Vanderford	GSI Environmental, Inc.	713-522-6300	mvanderford@gsi-net.com

The individuals listed in Table 2 also contributed to the optimization review process:

Table 2: Other Optimization Review Contributors

Name	Organization	Title/Party	Present for Site Visit/Site Meeting
Vincent Malott	EPA Region 6	RPM and Region 6 Optimization Liaison	Yes
Marilyn Czimer Long	TCEQ	Project Manager	Yes
Buddy Henderson	TCEQ	Project Technical Support	Yes
Jay Snyder	EA	RAC Consultant	Yes
Stan Wallace	EA	RAC Consultant	Yes

A site visit followed by a meeting at Region 6 HQ in Dallas, Texas occurred on April 24, 2013. Documents reviewed during the optimization review process are listed in Appendix A.

2.1 Quality Assurance

This optimization review used existing environmental data to interpret the CSM, evaluate potential future remedy performance and make recommendations to improve the remedy. The quality of the existing data was evaluated by the optimization review team before use. The evaluation for data quality included a brief review of how the data were collected and managed (where practical, the site QAPP was considered), the consistency of the data with other site data and the use of the data in the optimization review. Data that were of suspect quality were either not used as part of the optimization review or were used with the quality concerns noted. Where appropriate, this report provides recommendations to improve data quality.

3.0 REMEDIAL ACTION OBJECTIVES AND PROPOSED REMEDIES

The Sandy Beach site is the location of a former unpermitted landfill. Releases of trichloroethene (TCE) from the landfill migrated to the shallow Paluxy aquifer, which is a local source of drinking water. The current CSM is detailed in documents including the ROD (EPA 2011), RI (EA 2010a), FS (EA 2010b), data evaluation summaries and the Preliminary Remedial Design Report (EA 2013) listed in Appendix A. A summary of the CSM components relevant to remedial design (RD) and remedial action (RA) is provided below.

3.1 Remedial Action Objectives and Affected Media

RAOs for the site were developed to address contaminants of concern (COCs) associated with the release of TCE from a former unpermitted landfill that operated from 1958 to 1971 (Figure 2). The former landfill has since been converted to residential property with significant open space. The source area is currently owned by an innocent owner operator (IOO). The basis for taking action at the site is the exceedance of drinking water standards in private water wells and Pelican Bay water supply wells screened in the Paluxy Aquifer (Figure 3).

Figure 2: Location of source area as indicated by overlay of passive soil gas sampling and geophysics. Contamination is co-located with buried debris on former landfill site that is now a residence owned by an IOO

Figure is an excerpt of Figure 13 from the September 2011 ROD. A full size version of the figure is provided in Appendix B.

Figure 3: Distribution of TCE contamination in the Paluxy aquifer

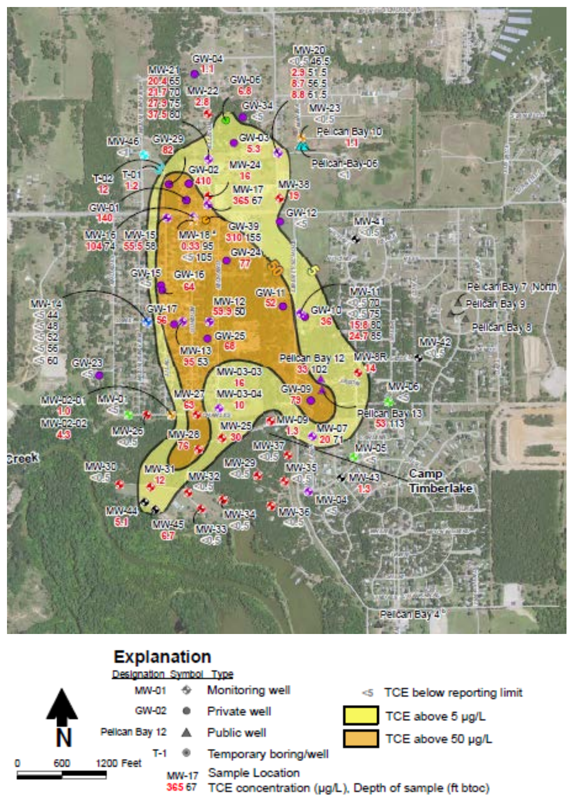


Figure is an excerpt of Figure 16 from the September 2011 ROD. A full size version of the figure is provided in Appendix B.

Figure 4: Geologic cross-section along primary groundwater flow direction showing Paluxy formation perched above the low permeability Glen Rose formation, and the underlying Twin Mountains Aquifer

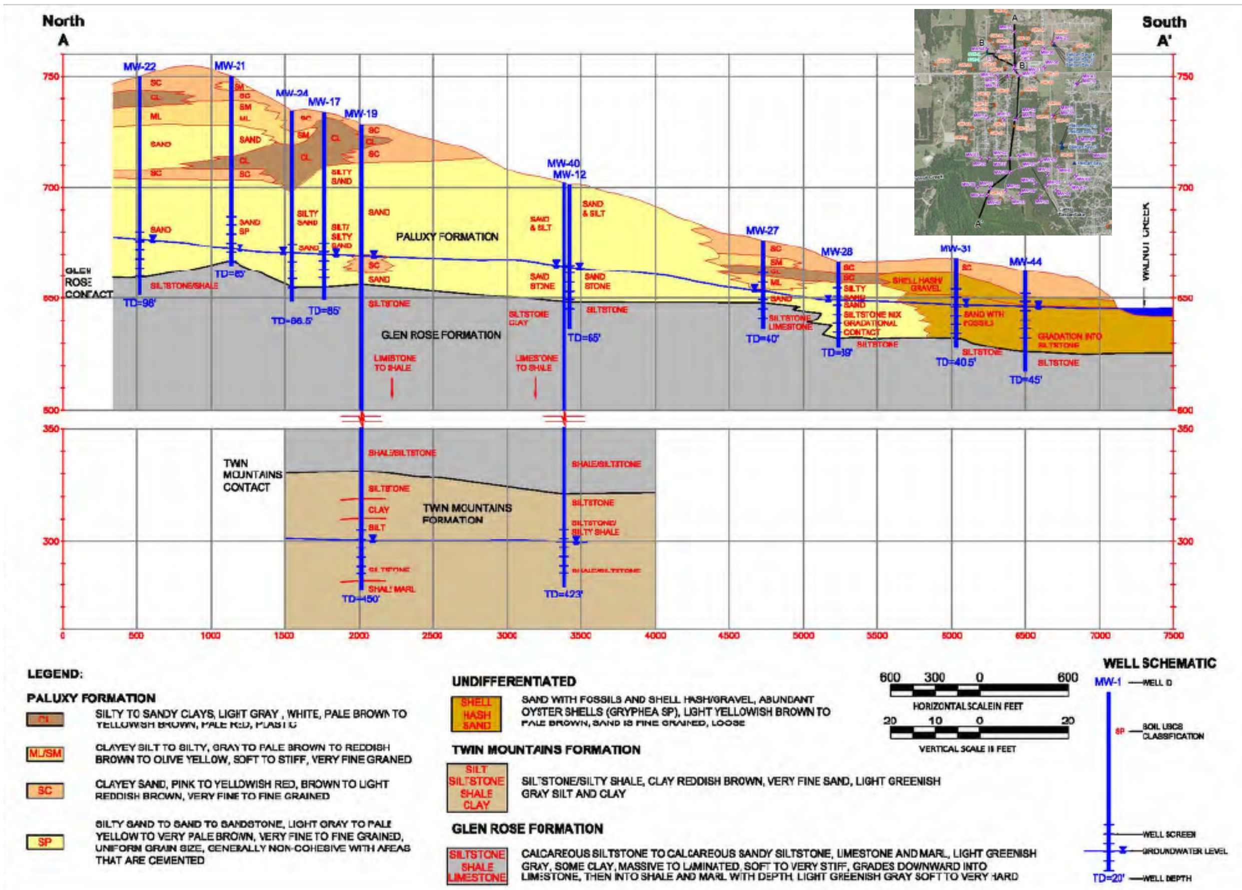


Figure is an excerpt of Figure 5 from the September 2011 ROD. A full size version of the figure is provided in Appendix B.

Area aquifers include the Paluxy Aquifer and the Twin Mountains Aquifer (Figure 4). The Paluxy Aquifer is a shallow water table aquifer that ranges from approximately 75 feet (ft) below ground surface (bgs) near the former unpermitted landfill to approximately 4 ft bgs near Walnut Creek. The Paluxy Aquifer generally has no more than 25 ft of saturated thickness. The Twin Mountains Aquifer is over 400 ft bgs and is separated from the Paluxy Aquifer by the Glen Rose Formation. Unsaturated soil between the Glen Rose Formation and the Twin Mountains Aquifer indicate that the Paluxy Aquifer is perched on top of the Glen Rose Formation. Many private and some municipal water supply wells draw water from the affected depths of the Paluxy Aquifer. The Twin Mountains Aquifer is another source of drinking water.

TCE has migrated to the Twin Mountains Aquifer in at least one location through a private well (GW-39), that screens both aquifers. The impacted Pelican Bay water supply wells have been shut down. A water supply line was installed in 2006 under a Removal Action to provide municipal water to all but four residences with impacted wells. Filtration systems were installed and maintained on private water supply wells. Filtration systems are still currently maintained on the remaining four residential supply wells. Paluxy Aquifer groundwater continues to be used by residents for irrigation purposes. The TCE plume continues to migrate with two primary lobes: (1) the western lobe discharges to Walnut Creek and (2) the eastern lobe migrates past the location of the impacted Pelican Bay water supply wells.

Table 3 shows Site COCs and cleanup goals based on federal Maximum Contaminant Levels (MCLs). Table 4 summarizes affected and potentially affected media along with potential exposure/migration pathways. Table 5 lists RAOs for the source area and downgradient groundwater.

Table 3: Contaminants of Concern and Cleanup Goals

Constituent Name	Affected Media	Cleanup Goal
TCE	Paluxy and Twin Mountains Aquifers	5 µg/L
cis-1,2-Dichlroethylene (cis-1,2 DCE)		70 µg/L

Notes: COC = Contaminant of Concern; TCE = trichloroethene; µg/L = micrograms per liter

Table 4: Affected or Potentially Affected Media on Site

Medium	Location	Composition	Potential Exposure / Migration Pathways
Unsaturated soil and buried debris	Ground surface to Paluxy Aquifer water table in approximate 200 feet by 200 feet source area	Clay, sandy clay and sand	• Discharge to shallow groundwater • Direct exposure by excavation
Paluxy Aquifer	25 feet or less of saturated thickness starting between 25 and 75 feet below ground surface	Sandstone, mudstone, limestone and sand	• Ingestion of water from Pelican Bay supply wells • Ingestion of water from private supply wells • Discharge to Twin Mountains Aquifer through improperly constructed wells • Discharge to Walnut Creek
Twin Mountains aquifer	400+ feet below ground surface	Sandstone	• Ingestion of water from Pelican Bay supply wells • Ingestion of water from Private water supply wells
Indoor air	Residences	No risk based on human health risk assessment described in Record of Decision (EPA 2011)	

Table 5: Remedial Action Objectives as Stated in the Record of Decision

Remedial Action Objective	
Exposure Prevention	Prevent human exposure to COCs from water supply wells at concentrations above MCLs or ARARs
Plume Containment	Prevent or minimize further migration of COCs in groundwater at concentrations exceeding the MCLs or ARARs
Aquifer Restoration	Restore the groundwater to its expected beneficial uses, wherever practicable, so that concentrations of COCs are less than the applicable MCLs or ARARs
Source Control	Prevent or minimize further migration of COCs in the vadose zone soils that would cause concentrations of COCs in groundwater to exceed MCLs or ARARs and mitigate potential vapor intrusion

Notes: COC = contaminant of concern; MCL = maximum contaminant level; ARAR = applicable and relevant or appropriate requirement

3.2 Proposed Remedies

Table 6 lists the remedies in the order presented in the ROD (EPA 2011) or Preliminary Design Report (EA 2013).

The ROD considered *in situ* bioremediation (ISB) as a potential source area groundwater remedy, but ISB was not included as a final recommendation in the ROD due to cost concerns. A preliminary ISB pilot test was performed prior to completion of the ROD with results indicating that ISB could be used to treat dissolved groundwater contamination. Accordingly, ISB was evaluated with equal consideration to other remedies as part of the optimization review.

Table 6: Remedies Documented in the Record of Decision and Preliminary Design Report

Remedy	Target Medium	Description
Water supply well replacement	Drinking water	Plug and abandon impacted private water supply wells and install new Twin Mountains Aquifer wells for residences that cannot be served by the municipal water line. This component would include plugging and abandoning water supply well GW-39 (the well that currently provides a connection between the Paluxy and Twin Mountains Aquifers).
Pump and treat system	Paluxy Aquifer	The Preliminary Design Report (EA 2013) describes treatment with filtration, air stripping with potential off-gas treatment and effluent polishing with liquid phase granular activated carbon. Two potential extraction schemes are provided to contain the TCE plume: 1. Vertical extraction wells • 23 extraction wells • 109 gpm extraction rate • 8 injection wells 2. Horizontal extraction wells • 21 horizontal wells • 1 vertical well • 139 gpm extraction rate • 8 injection wells
Soil vapor extraction	Source area soil	Extract contaminated soil vapors with horizontal or vertical wells and treat off-gas with GAC. Includes contingency to excavate and remove principal threat waste from the source area if discovered during the Remedial Design/Remedial Action data collection and construction activities.
Institutional controls	Residential properties and area groundwater	Restrictive covenants, deed notices and/or other area-wide restrictions of groundwater use.
Five-Year Reviews	All site media	Reports to document remedy performance and protectiveness.

Notes: GAC = granular activated carbon; gpm = gallons per minute; RD/RA= remedial design/remedial action; TCE = trichloroethene

3.3 Current Exit Strategy

The ROD (EPA 2011) sets forth short-term expectations that the exposure to contaminated groundwater will be prevented, that plume migration will be controlled and that source area soil will be remediated (including excavation and removal of any principal threat wastes). The ROD (EPA 2011) also sets the long-term expectation that the groundwater remedy will require approximately 30 years to restore the aquifers. This Fund-lead remedy would be transferred to the State in 10 years after the remedy becomes Operational and Functional (O&F).

4.0 FINDINGS

This section presents key findings based on discussions during the optimization review meeting and document review.

4.1 Data Gaps and Characterization

Several key data gaps and uncertainties in the CSM were identified for the site. Table 7 identifies data gaps that may influence remedy design.

Table 7: Identified Data Gaps

Medium	Data Gap	Potential Recommendation
Source material	Potential for additional sources of TCE (such as drums) in the buried debris	Evaluate presence of drums during SVE installation. See recommendations in Section 5.1.
Source area saturated soils	Unknown distribution and mass of TCE in source area saturated soils	Characterize source area saturated soils to determine if source area remediation is required for saturated soils. See recommendations in Section 5.2.
Groundwater	Extent and duration of water quality impacts from potential *in situ* bioremediation remedy	Consider potential water quality effects and mitigation approaches if bioremediation is used for source area saturated soil remediation. See recommendations in Section 5.2.
Groundwater	Impacts of matrix diffusion on time frame for aquifer restoration	Monitor groundwater concentrations following comprehensive source area remediation to determine effect on morphology and migration of downgradient plume. See recommendations in Section 5.3, 5.4, 5.5 and 5.7.

Notes: SVE = soil vapor extraction; TCE = trichloroethene

4.2 Remedial Strategy

The optimization review team and site team agreed on a revised strategy for the site that prioritizes activities as follows:

- Eliminate exposure/migration pathways by plugging, abandoning and replacing specific wells.
- Remediate the source area with SVE and potentially ISB, and further characterize and remove principal threat wastes identified during the SVE installation.
- Control plume migration through the installation of a streamlined P&T system.
- Restore the aquifers through a combination of source remediation, plume migration control and natural attenuation.
- Expand the P&T system for dissolved plume remediation and aquifer restoration only if multiple years of monitoring (5-year cycles suggested) suggest P&T is needed and capable of restoring the aquifer in a timely and cost-effective manner.

5.0 RECOMMENDATIONS

The recommendations provided by the optimization review team address the data gaps identified in Section 4.1 and are consistent with the remedial strategy outlined in Section 4.2. The presentation of the recommendations is consistent with the prioritization and sequencing presented in Section 4.2. Additional recommendations are provided for performance monitoring, data management and development of exit criteria for each remedy component.

Relative to the ROD (EPA 2011), the recommended strategy raises the priority of source remediation and emphasizes performance monitoring and timely shutdown of remedy components. Collectively, the recommendations help address key data gaps and satisfy the RAOs in a cost-efficient manner.

5.1 Recommendations to Eliminate Exposure Pathway and Vertical Migration by Replacing Specific Private Water Supply Wells

Currently, private water supply wells GW-9, GW-10 and GW-11 are supplying residents that are not being served by municipal water. These wells continue to have filtration systems that are operated by the State. In addition, the site team has identified private water supply well GW-39 as having a hydraulic connection between the contaminated Paluxy Aquifer and the Twin Mountains Aquifer. Well GW-39 is no longer used for potable purposes but is used for irrigation by the homeowner; it has not been plugged and abandoned. This connection is likely the primary preferential pathway for site-related contamination to reach the Twin Mountains Aquifer, and TCE has been observed in the Twin Mountains Aquifer monitoring well downgradient of GW-39.

Benefits of Implementing Section 5.1 Recommendations

- Eliminate exposure pathway over the long term for three residences not connected to public water supply.
- Prevent vertical migration of contamination to the Twin Mountains Aquifer.

Recommendation 5.1.1: Plug, Abandon and Replace Water Supply Wells GW-9, GW-10, GW-11 and GW-39

The optimization review team supports prioritizing option DW-3 from the ROD; plug, abandon and replace private water supply wells GW-9, GW-10, and GW-11to eliminate exposure and GW-39 to prevent plume migration. This remedial response will directly address the RAO to prevent human exposure to COCs above MCLs and prevent or minimize further migration of COCs to the Twin Mountains Aquifer. Based on discussions during the optimization review, the optimization review team estimates that plugging, abandoning and replacing these wells (with Twin Mountain Aquifer wells or public water supply) would cost approximately $600,000.

5.2 Recommendations for Source Characterization and Treatment

The source area includes contaminated unsaturated soils, and based on the results from the characterization recommended in Section 4.1, may include contaminated saturated soils. There is also the potential that as yet unidentified, but suspected, primary sources (such as buried drums) remain in the source area. Property access restrictions in the area of the former unpermitted landfill require that source investigations be minimally intrusive.

Recommendation 5.2.1: Evaluate Potential Additional Sources During SVE System Installation

Installation of the SVE in the source area should be prioritized (after recommendations in 5.1.1) to (1) provide direct source treatment and control and (2) address data gaps. Current access restrictions prevent intrusive investigation for additional sources; however, the potential for additional sources of TCE (such as buried drums) can be evaluated during the installation of the SVE system. The debris where additional sources may be present is also the optimal location for several of the SVE wells. Therefore, drilling and trenching (for extraction piping) will be required in the debris. Typically, extraction wells would be installed before trenching and piping, but in this particular case, the optimization review team suggests that the trenching and piping in this area occur first. During trenching and piping, the site team can observe the nature of the debris for evidence of residual drums, tanks or other vessels that may contain TCE. Potential worker health and safety risks and risks to machinery associated with buried debris should be included in the project-specific health and safety plan.

Benefits of Implementing Section 5.2 Recommendations

- Identify if additional sources are present.
- Determine need for remediation of source area saturated soils while installing remedy for unsaturated zone.
- Reduce time to closure by raising priority of source area remediation.
- Provide a means for source area saturated zone remediation without affecting water quality for nearby residences using groundwater.

If there is no evidence of such potential sources, the site team can proceed with drilling the extraction wells in this area. The drill cuttings can be evaluated to determine the likelihood of an additional source and/or long-term matrix diffusion from contaminated fine-grained material. Evaluation of source area soils should include an estimate of residual contaminant mass to assess long-term source strength and performance of the SVE remedy. If there is evidence of extensive residual or remaining sources, then the site team should plan for excavation of these potential sources.

Recommendation 5.2.2: Characterize Source Area Saturated Soils

The optimization review team recommends characterization of the source area saturated soils. The site team states that direct-push technology (DPT) is not an appropriate drilling technique for the Paluxy Aquifer. Therefore, the optimization review team recommends characterization of the source area saturated soils during installation of the SVE wells. The deeper interval SVE wells should be installed through the deep unsaturated zone and soil samples from various intervals in the saturated zone collected and analyzed for volatile organic compounds (VOCs). Groundwater should also be sampled from these wells and analyzed for VOCs.

Air rotary drilling, which the site team has historically used at this site will not be appropriate for the soil VOC investigation. Sonic drilling would be more appropriate for collecting these soil samples and installing the wells. Sonic drilling would also provide useful soil cores for interpreting the Paluxy Aquifer stratigraphy. If the site team has concerns about the use of sonic drilling, then the wells can be installed with air rotary drilling with no soil sampling and analysis. The investigation would then be limited to groundwater sampling and analysis.

Additional costs above the currently scoped installation of SVE wells, including mobilization of rigs for sonic drilling and soil and groundwater sampling are anticipated to be in the range of $50,000. The cost will include modification of sampling and analysis plan (SAP), the health and safety plan (HASP), and interpretation of sampling results through the creation of detailed cross-sections and maps.

Recommendation 5.2.3: Prioritize Source Area Treatment Above Plume Containment and Aquifer Restoration

The optimization review team assigns a high priority to source area characterization and treatment, because aquifer restoration cannot begin until the source is removed or controlled. The optimization review team supports the SVE remedy for unsaturated soil and recommends that vertical wells be used for remediation. Unless otherwise informed by findings during drilling of the SVE wells, shallow SVE wells should be installed to extract vapors from 5 ft bgs to 15 ft bgs and deeper SVE wells should be installed to extract vapors from 15 ft bgs to the water table (approximately 75 ft bgs). As described above, the screen intervals of the deeper wells should be installed to fully screen the Paluxy Aquifer to provide a means of sampling or injecting reagents into it. The horizontal arrangement of vertical SVE wells and associated piping depicted in the Preliminary Design Report (EA 2013) is appropriate. One row of the SVE wells should be installed through the center of the suspected debris field at the center of the source area as defined by the existing passive soil gas sampling results and the proposed confirmation of no buried drums in the debris.

Recommendations to combine source area characterization with the currently planned SVE system do not impose significant additional costs.

Recommendation 5.2.4: Conduct Additional ISB Pilot Test to Evaluate Effectiveness as a Source Area Remedy and Secondary Impacts to Water Quality

The ISB pilot test conducted by the site team was discontinued too early to determine (1) the extent of secondary metals impacts such as mobilization of manganese, arsenic, and iron; and (2) TCE degradation resulting from the reducing conditions imparted by the microbial activity. As a result, the appropriateness of ISB for source area remediation remains unknown. If the source area saturated zone investigation suggests the need for targeted remediation of the saturated soils, the potential use of ISB in addition to SVE can be further evaluated with another pilot test including a longer follow-up monitoring period. If there are concerns about water quality effects imparted by ISB or other source area remedies from the pilot test, it may be appropriate to replace private Paluxy Aquifer wells (in addition to those discussed in Recommendation 5.1.1) near the source area with Twin Mountains Aquifer wells (beyond the range of municipal water supply lines) so that the supply wells are not adversely affected by an ISB remedy.

The cost of the ISB pilot test using the installed well network described above and testing with a recirculation cell (pumping groundwater and reinjecting upgradient with ISB amendments added) would be approximately $50,000.

5.3 Recommendations for Phased P&T for Plume Migration Control and Aquifer Restoration, If Needed

The plume continues to migrate to Walnut Creek and past the Pelican Bay supply wells where contamination was first discovered. This section provides recommendations for phased P&T for plume migration control and aquifer restoration (as needed).

Recommendation 5.3.1: Install P&T System for Focused Hydraulic Containment Only; Include Treatment Capacity for Full-Scale System for Potential Future Needs as Contingency

After well replacement and source area treatment and characterization, the optimization review team assigns the next highest priority to plume migration control. The optimization review team concurs with the approach to use P&T to provide hydraulic control of the plume. A hydraulic control system could be similar in nature to the system with horizontal extraction wells presented in the Preliminary Design Report (EA 2013) but would need to include the following extraction locations: EW-13 through EW-15, and EW-17 through EW-21. Reinjection could occur at location IW-2, as presented in the Preliminary Design Report (EA 2013).

Based on extraction rates from previous simulations, the total extraction rate for this system would be approximately 48 gpm. Revisiting the groundwater model with this extraction and injection scenario could help refine the extraction locations, injection locations and extraction rates. To accommodate future potential flow contributions, the groundwater treatment plant should be designed for up to 150 gpm.

Benefits of Implementing Section 5.3 Recommendations

- Decrease operating time frame of P&T system by addressing source area before installing P&T system.
- Reduce capital costs for P&T system by focusing on plume migration control.
- Allow opportunity for aquifer restoration through source remediation and plume control and potentially eliminate the need for the full-scale P&T system.

Capital costs associated with scale-up of the groundwater treatment plant are in the range of $50,000 assuming the need for a larger air stripper model, GAC units, pumps and piping. Extra volume impacts on operation and maintenance (O&M) costs for VOC treatment systems are typically relatively low.

Recommendation 5.3.2: Monitor and Evaluate Aquifer Restoration and Only Implement Full-Scale P&T if Monitoring Suggests P&T is Needed and Capable of Timely and Cost-Effective Aquifer Restoration

With aggressive source removal and plume migration control, the next remedial priority would be aquifer restoration. Progress toward aquifer restoration will begin as soon as the source area is treated because the contaminant mass input to the plume will be reduced or eliminated. After a successful source area remedy and several years of monitoring (five year review cycle is recommended – monitoring recommendations are provided in Appendix C) are completed, the site team should assess if short-term aquifer restoration has been achieved. If aquifer restoration does not meet anticipated mass reduction goals or the plume appears to be migrating, the P&T system can be expanded to include additional capacity as described in the Preliminary Design Report (EA 2013) (a contingency response). The groundwater treatment system would already be designed to accommodate this additional potential flow. Therefore, only the extraction and injection systems would need to be expanded. If aquifer restoration occurs in a sufficient time frame following source area remediation, the extraction and injection systems do not need to be expanded, and the P&T system can continue to operate as a containment system until plume concentrations have attained cleanup goals. Remedy performance monitoring recommendations are described in Section 5.5 below.

5.4 Recommendations for Streamlined Groundwater Treatment Plant

Recommendation 5.4.1: Streamline Groundwater Treatment Plant to Include One Treatment Process for VOCs

The Preliminary Design Report (EA 2013) calls for treatment of the extracted water with filtration, chemical addition (biocide, defoamer and scale inhibitor), air stripping with off-gas treatment and polishing with liquid phase granular activated carbon (LGAC). The optimization review team believes this system is overly redundant and recommends simplifying the treatment system to reduce long-term operation and maintenance (O&M) costs.

Benefits of Implementing Section 5.4 Recommendations

- Reduce operating costs by streamlining groundwater treatment system.

The optimization review team presents two options:

Air stripping only: At an extraction rate of 48 gpm or 150 gpm, the four or six tray air stripper rated for 500 gpm in the Preliminary Design Report (EA 2013) would be able to provide treated water with undetectable TCE and cis-1,2 DCE concentrations with a conservative safety factor. Eliminating the LGAC would save some construction costs. More importantly, it would reduce O&M costs and issues associated with potential LGAC fouling from scaling caused by aeration and costs associated with addition of the scale inhibitor. Based on the cost estimates provided in the Preliminary Design Report (EA 2013), this approach would save approximately $20,000 per year, but savings may actually be higher if this approach avoids problems with scaling that would otherwise have occurred.

LGAC only: Another, more cost-effective option, which is favored by the optimization review team, would be to provide treatment with LGAC only and eliminate the chemical addition and air stripping. Because the water is not aerated, scaling of treatment plant equipment and the injection well would be avoided. In addition, vapors from air stripping are not emitted, so off-gas treatment would not be needed. The optimization review team estimates that an LGAC-only system should operate for less than $150,000 per year (including project management) if treating 48 gpm and less than $260,000 per year if treating 150 gpm. These estimated annual O&M costs would represent savings of more than $250,000 per year relative to the costs identified in the Preliminary Design Report (EA 2013). Additional cost savings could be realized if breakthrough of cis-1,2 DCE below 70 µg/L is acceptable to EPA and LGAC can be changed out based on TCE breakthrough. The optimization review team would not suggest providing the treated water to others for direct use if the cis-1,2 DCE (or TCE) is detected in the effluent below MCLs.

Currently, vinyl chloride (VC) is not present at concentrations of concern in the downgradient plume lobes. The MCL for VC (2 µg/L) is well below that for cis-1,2 DCE (70 µg/L), so there may be a concern that VC above protective concentrations could be generated from cis-1,2 DCE present below the cleanup goal. Based on current data, however, the geochemical environment of the aquifer does not favor the formation of VC from cis-1,2 DCE. If VC is generated as a result of ISB treatment and transported downgradient, then the LGAC only option may not be sufficiently protective. Releases of cis-1,2 DCE to aerobic surface water and sediments or reinjection in the largely aerobic aquifer are unlikely to generate VC above MCLs. The optimization review team does not consider residual cis-1,2 DCE below 70 µg/L as a potential risk driver in effluent.

5.5 Recommendations for Remedy Performance Monitoring

Recommendation 5.5.1: Implement Remedy Performance Monitoring

Benefits of Implementing Section 5.5 Recommendations

- Cost-effective monitoring program and performance metrics to optimize remedy operation and shutdown remedy components in a timely manner.

The performance monitoring recommendations for each of the remedies discussed above are provided in Appendix B. Monitoring and Remediation Optimization System (MAROS) Analysis Reports supporting remedy performance recommendations are provided in Appendix C.

Recommended remedy performance metrics by remedy are presented below. More detailed remedy performance criteria, including specific data collection and analytical methods, target concentration reductions and capture zones should be developed during remedy design. Monitoring results can be compared to exit criteria (Section 5.6) to evaluate the shutdown of particular remedy components and to help operate or optimize remedy components.

- SVE – The SVE system should remove source area residual mass and decrease mass discharge to the Paluxy Aquifer over time. Potential performance metrics should include the following:
    - Mass removed by individual extraction wells and the combined system over time based on measurements of vapor extraction rate and vapor concentrations. Total mass removed should be compared to energy and maintenance costs to determine a cost per unit mass value.
    - Groundwater concentrations in source area monitoring wells over time relative to baseline groundwater concentrations at the same wells. Statistical concentration trends should be evaluated relative to baseline monitoring results. To this end, a comprehensive groundwater monitoring event including private supply and monitoring wells is recommended prior to initiation of source remediation to establish the baseline.
    - Groundwater concentrations of VOCs (and metals after ISB treatments ([if implemented]) in source area monitoring wells over time relative to cleanup goals.
    - Mass discharge in groundwater from the source area based on interpreted groundwater flow and contaminant concentrations in source area monitoring wells.

- ISB (if implemented as a remedy amendment) – The ISB remedy, if implemented, should significantly reduce the TCE concentrations in the source area and reduce mass discharge to the downgradient dissolved plume to allow aquifer restoration over time without causing unacceptable secondary water quality issues. Secondary water quality issues may include mobilization of metals such as manganese, arsenic, and iron; or production of odors or colors that may have health or aesthetic impacts at downgradient water supply wells. Potential performance metrics should include the following:
    - Groundwater concentrations of VOCs in source area monitoring wells over time relative to baseline groundwater concentrations at the same wells. (See recommendation for baseline groundwater monitoring above).
    - Mass discharge in groundwater downgradient from the source area based on interpreted groundwater flow and contaminant concentrations in monitoring wells.
    - Total organic carbon (TOC) concentrations and geochemical indicators such as oxidation reduction potential (ORP), pH and sulfide relative to target values for attainment of anaerobic conditions.
    - Manganese, iron, arsenic and odor relative to target values for human health and aesthetic impacts to maintain adequate water quality.

- P&T system for hydraulic control – The P&T system for hydraulic control should provide effective plume capture relative to the target capture zone to prevent continued plume migration. A lack of capture would suggest the potential need for system upgrades. A decrease in mass removal rates below target levels at specific locations could help evaluate shutdown of that extraction component of the system. Potential performance metrics could include the following:
    - Water levels and interpreted hydraulic capture zone relative to target capture zone.
    - Statistical concentration trends and concentrations relative to cleanup goals in downgradient performance monitoring wells to evaluate plume capture.
    - Mass removal rate relative to mass discharge that would result in unacceptable plume migration.
    - Estimates of total dissolved mass in the plume and statistical trends of dissolved mass.

- Aquifer restoration – TCE concentrations throughout the dissolved plume should decrease once source remediation is implemented. Consequently, the plume area relative to specific target concentrations should decrease over time. Potential performance metrics could include the following:

- Concentration trends and concentrations relative to cleanup goals.
- Plume area that is above cleanup goals.
- Plume area that is above four times the cleanup goals.

Where concentration trends are monitored, visual analysis (concentration versus time graphs) and statistical trend tests can be performed for groundwater data and included in Five-Year Reviews. Visual analysis and trend tests can be performed for relevant monitoring locations with datasets with four or more sample events. Visual analysis and a non-parametric test for trend, such as the Mann-Kendall test can be used to track both individual well concentrations and estimates of total dissolved mass and plume footprint for groundwater response to RAs. Semi-annual to annual sampling will generate datasets of sufficient size to develop statistically significant trends.

Mass discharge calculations refer to estimates of the mass passing through a plane perpendicular to groundwater flow. Estimates of mass discharge indicate the mass moving downgradient that may cause plumes to migrate or persist for extended periods of time. Source treatment should significantly reduce mass discharge through pre-determined cross-sectional planes perpendicular to groundwater flow. It is recommended that mass discharge be estimated prior to source treatment, and annually after source treatment. Significant reductions (>25 percent) in mass discharge should be apparent after source treatment.

5.6 Recommendations for Data Management

Recommendation 5.6.1: Continue With Current Data Management Practices

Site data have been collected from over 135 sampling locations since 2007. The optimization review team recommends continuing to maintain the site database with particular attention to accuracy of X and Y (horizontal) and Z (elevation) locational coordinates of sampling locations, boring logs and well construction details. Site characterization activities coinciding with installation of the SVE system will generate data essential to characterizing the concentration and morphology of the source of TCE. Sustained data management will enable cumulative data to be used to support future decisions on source treatment and assess how the plume will behave over the long term.

Benefits of Implementing Section 5.6 Recommendations
• Maintenance of data in a readily accessible and easy to use form.

5.7 Recommendations for Establishing Remedy Operation Exit Criteria

Establishing remedy operation exit criteria, or performance metrics, for each remedy component can help reduce the risk of operating a remedy past the point of effectiveness. The exit criteria are not related to the programmatic transition from Long-Term Remedial Action to Operation and Maintenance at a Superfund financed RA or to a decision to delete a site from the NPL, but rather are remedy-specific recommendations developed to evaluate the cost/benefit of continued operation of each remedy component.

Recommendation 5.7.1: Establish Exit Criteria for Each Remedy Component

Exit criteria for each remedy should be developed by the site team. The optimization review team provides the following suggestions by remedy for consideration by the site team. The performance monitoring recommended in Section 5.4 provides the necessary information to compare with the exit criteria.

Benefits of Implementing Section 5.7 Recommendations

- Criteria to help avoid operating long-term remedies longer than necessary.

- SVE
  - One potential exit criterion for the SVE system (or individual wells within the SVE system) is a TCE mass removal rate that is small relative to the initial TCE mass removal rate of the SVE system, such that continued operation of the system will result in negligible mass removal relative to mass removal at startup.
  - Another potential exit criterion for the SVE system can be based on a mass removal rate relative to the current mass flux from the source area to the dissolved plume. For example, there is a given flux of TCE mass from the source area to the dissolved plume that could be represented by the estimated groundwater volume flow rate through the cross-sectional area from MW-15 to MW-16 and to MW-17 multiplied by the average TCE concentration from these three wells. A similar cross-sectional area could be developed from the recommended monitoring wells during system installation. The exit criterion could be to shut down the SVE system when the mass removal rate from the SVE system is some multiple of the current mass flux rate through specified cross-sectional area.
  - TCE vapor concentrations may rebound at particular locations after a SVE well is shut down due to diffusion of mass out of tighter subsurface material. SVE extraction wells can be operated in pulse mode or on a rotating basis to extract the accumulated vapors.
  - Relevant criteria for terminating the SVE system are discussed in the ROD (EPA 2011) (Section 12.4) and are supported by the optimization review team.

- ISB (if implemented as a remedy amendment)
  - An exit criterion for a source area saturated zone remedy could be based on TCE concentrations and mass discharge at MW-15, MW-16 and MW-17 or mass discharge directly from source area monitoring wells.
  - Another potential exit criterion could be a determination that continued source area remediation is providing no measurable benefit or is causing unacceptable secondary water quality issues such as exceedance of primary MCLs for arsenic in drinking water (10 µg/L) and secondary MCLs for manganese (50 µg/L) for aesthetic impacts or Texas Protective Concentration Levels (PCLs) (1.1 mg/L) for protection of human health. Other aesthetic effects such as color or odor may also trigger reduction or elimination of ISB treatments. Further action may be warranted to address the scope and longevity of potential secondary water quality issues.

- P&T system for plume control
  - The exit criterion for a specific extraction zone within the P&T hydraulic control remedy could be based on the TCE concentration and mass discharge at that extraction zone relative to a predetermined threshold below which unacceptable plume migration will not occur.

- P&T system for aquifer restoration
    - The exit criterion or the criterion for not building the full-scale aquifer restoration P&T system can be based on observable decreasing concentration trends within the plume and a decreasing plume footprint over time relative to the expected decreases that would result from P&T system installation and operation.

Additional study by the site team would be needed to help define reasonable exit criteria for the various remedy components to help avoid unnecessary operation of these remedies.

5.8 Recommendations for Environmental Footprint Reduction

No specific recommendations have been provided for environmental footprint reduction. However, several of the above recommendations have the potential to reduce the remedy footprint by either streamlining the treatment process or reducing the likelihood of operating a remedy component past the point of measureable benefit in achieving the RAOs.

Table 8: Recommendation Summary

Recommendation	Effectiveness	Cost Reduction	Technical Improvement	Site Closure	Environmental Footprint Reduction	Capital Cost	Change in Annual Cost
5.1.1 Plug, abandon and replace water supply wells GW-9, GW-10, GW-11 and GW-39	■					$600,000	
5.2.1 Evaluate potential additional sources during SVE system installation	■	■		■		N/A	
5.2.2 Characterize source area saturated soils	■			■		$50,000	
5.2.3 Prioritize source area remediation above plume containment and aquifer restoration	■	■		■		N/A	
5.2.4 Conduct additional ISB pilot test to evaluate effectiveness as a source area remedy and secondary impacts to water quality	■		■	■		$50,000	
5.3.1 Install P&T system for focused hydraulic containment only but include treatment capacity for full-scale system for potential future needs	■	■		■	■	$50,000 (additional cost associated with scale up or treatment system)	
5.3.2 Monitor and evaluate aquifer restoration and only implement full-scale P&T if monitoring suggests P&T is needed and capable of timely and cost-effective aquifer restoration		■		■	■	N/A	(See 5.5.1 Remedy Performance Monitoring)
5.4.1 Streamline groundwater treatment plant to include one treatment process for VOCs		■			■	N/A	(-$20,000)
5.5.1 Implement remedy performance monitoring	■	■	■	■		$100,000	
5.6.1 Continue with current data management practices			■			N/A	
5.7.1 Establish exit criteria for operation of each remedy component				■	■	N/A	

APPENDIX A

REFERENCES

APPENDIX A

REFERENCES

EA (2010a). *Remedial Investigation, Sandy Beach Road Ground Water Plume Superfund Site. Lewisville, Texas*, EA Engineering for US Environmental Protection Agency Region 6.

EA (2010b). *Feasibility Study Report, Sandy Beach Road Ground Water Plume Ground Water Plume Superfund Site. Lewisville, Texas*, EA Engineering for US Environmental Protection Agency Region 6.

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USEPA (2011). *Record of Decision Sandy Beach Road Ground Water Plume Superfund Site. Dallas, TX*, U.S. Environmental Protection Agency Region 6.

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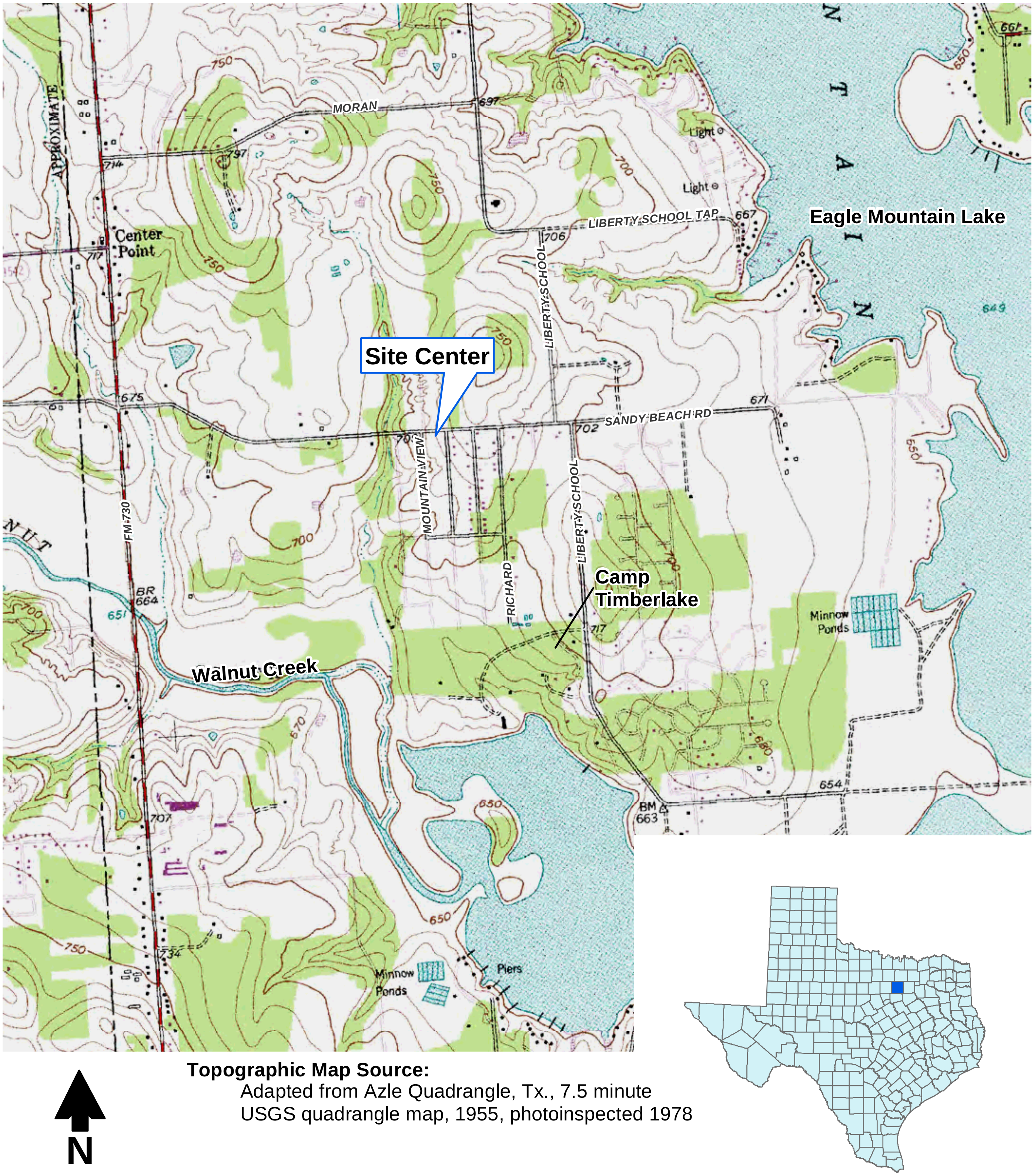
APPENDIX B

SUPPORTING FIGURES FROM EXISTING DOCUMENTS



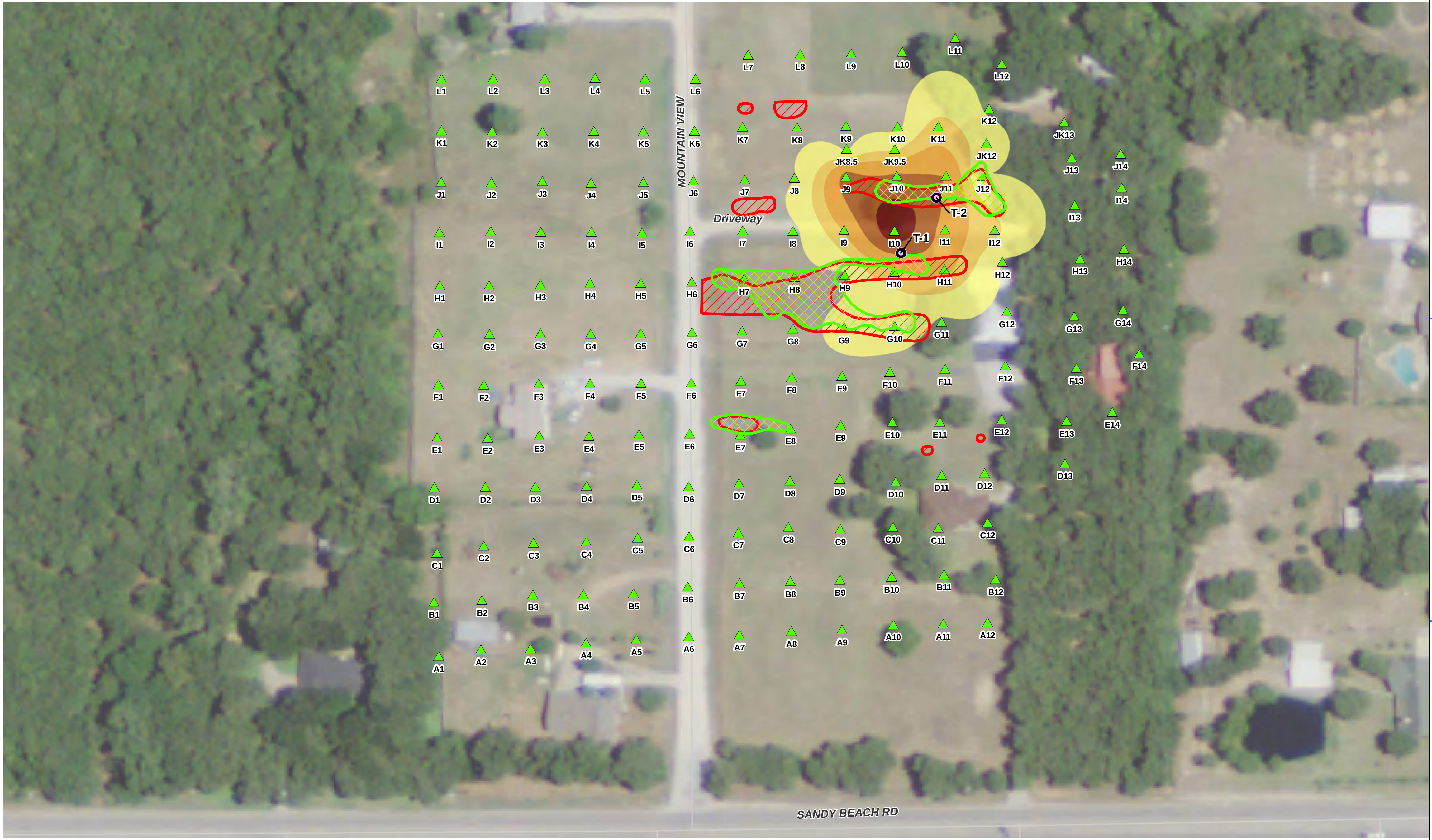
Topographic Map Source:
Adapted from Azle Quadrangle, Tx., 7.5 minute
USGS quadrangle map, 1955, photoinspected 1978

N

0 1000 2000 Feet

EA ENGINEERING, SCIENCE, AND TECHNOLOGY		SANDY BEACH ROAD GROUND WATER PLUME SUPERFUND SITE			**Site Location Map**	
DESIGNED BY TM	DRAWN BY CRS	CHECKED BY DWR	SCALE 1:12,000	DATE 09/13/2011	TASK ORDER 14342.13	FIGURE 1

Path: M:\Projects\EPA_RAC\EPA6.09_Sandy Beach\GIS\MXDs\Report Figures 2011\ROD\Fig01_Site_location.mxd



Explanation

Designation	Symbol	Type
D1	▲	Soil gas survey point
T1	○	Temporary boring/well

N

0 50 100 Feet

TCE mass from passive soil gas survey (nanograms)

- 2,500 - 10,000
- 10,000 - 20,000
- 20,000 - 35,000
- 35,000 - 50,000
- Above 50,000

Geophysical subsurface survey

- Possible buried ferrous and non-ferrous material
- Low conductivity EM-31 quadrature mode

Base Map Source:

Aerial photograph provided by Texas orthoimagery program 2008-2009

Notes:

EM - Electromagnetic
TCE = Trichloroethylene

TCE in Soil Gas and Geophysical Interpretation Near Mountain View and Sandy Beach Road

SANDY BEACH ROAD GROUND WATER PLUME SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

FIGURE	13
TASK ORDER	14342.13
DATE	08/04/2011
SCALE	1:1,200
CHECKED BY	DWR
DRAWN BY	CRS
DESIGNED BY	TM

UNITED STATES • ENVIRONMENTAL PROTECTION AGENCY

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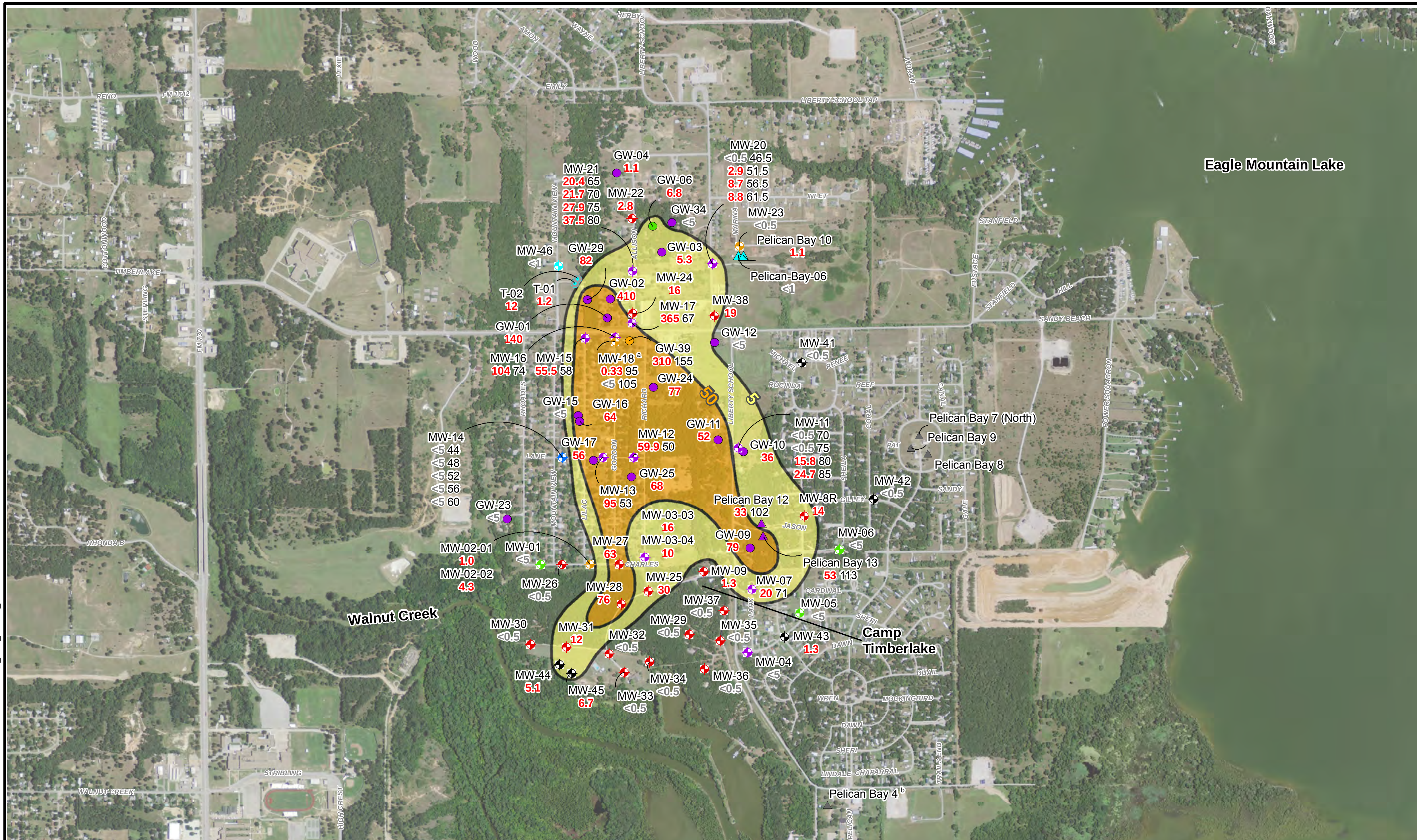

Explanation

Designation	Symbol	Type
MW-01		Monitoring well
GW-02		Private well
Pelican Bay 12		Public well
T-1		Temporary boring/well
MW-17 / 365 67		Sample Location / TCE concentration (µg/L), Depth of sample (ft btoc)

<5 TCE below reporting limit

TCE above 5 µg/L

TCE above 50 µg/L

N

0 600 1200 Feet

Symbol color

Green	Sampled November 2009
Purple	Sampled June 2010
Yellow	Sampled September 2010
Blue	Sampled October 25, 2010
Red	Sampled December 2010
Black	Sampled February 2011
Cyan	Sampled May 2011

Base Map Source:

Aerial photograph provided by Texas orthoimagery program 2008-2009

Notes:

[a] Well not used for contouring purposes

[b] Well may be screened in Paluxy as well as Twin Mountain

TCE = Trichloroethylene

Distribution of TCE in Ground Water in Paluxy Aquifer

SANDY BEACH ROAD GROUND WATER PLUME SUPERFUND SITE

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

FIGURE	16
TASK ORDER	14342.13
DATE	06/20/2011
SCALE	1:14,400
CHECKED BY	TM
DRAWN BY	CRS
DESIGNED BY	DWR

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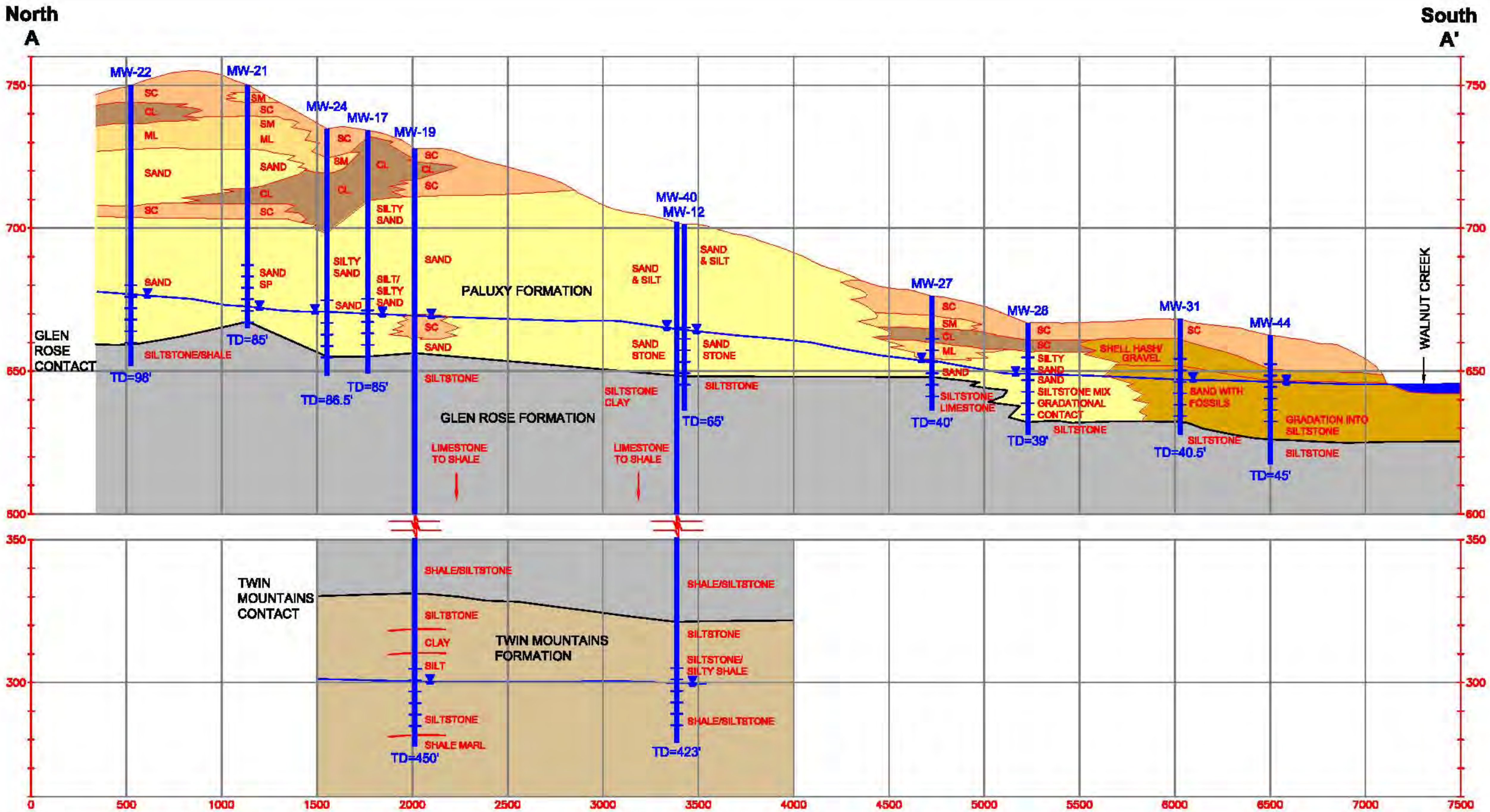


LEGEND:

PALUXY FORMATION

CL	SILTY TO SANDY CLAYS, LIGHT GRAY , WHITE, PALE BROWN TO YELLOWISH BROWN, PALE RED, PLASTIC
ML/SM	CLAYEY SILT TO SILTY, GRAY TO PALE BROWN TO REDDISH BROWN TO OLIVE YELLOW, SOFT TO STIFF, VERY FINE GRAINED
SC	CLAYEY SAND, PINK TO YELLOWISH RED, BROWN TO LIGHT REDDISH BROWN, VERY FINE TO FINE GRAINED
SP	SILTY SAND TO SAND TO SANDSTONE, LIGHT GRAY TO PALE YELLOW TO VERY PALE BROWN, VERY FINE TO FINE GRAINED, UNIFORM GRAIN SIZE, GENERALLY NON-COHESIVE WITH AREAS THAT ARE CEMENTED

UNDIFFERENTIATED

SHELL HASH SAND	SAND WITH FOSSILS AND SHELL HASH/GRAVEL, ABUNDANT OYSTER SHELLS (GRYPHEA SP), LIGHT YELLOWISH BROWN TO PALE BROWN, SAND IS FINE GRAINED, LOOSE

TWIN MOUNTAINS FORMATION

SILT SILTSTONE SHALE CLAY	SILTSTONE/SILTY SHALE, CLAY REDDISH BROWN, VERY FINE SAND, LIGHT GREENISH GRAY SILT AND CLAY

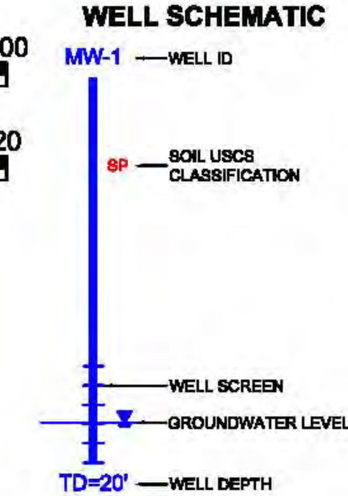
GLEN ROSE FORMATION

SILTSTONE SHALE LIMESTONE	CALCAREOUS SILTSTONE TO CALCAREOUS SANDY SILTSTONE, LIMESTONE AND MARL, LIGHT GREENISH GRAY, SOME CLAY, MASSIVE TO LAMINATED, SOFT TO VERY STIFF, GRADES DOWNWARD INTO LIMESTONE, THEN INTO SHALE AND MARL WITH DEPTH, LIGHT GREENISH GRAY SOFT TO VERY HARD

600 300 0 600
HORIZONTAL SCALE IN FEET

20 10 0 20
VERTICAL SCALE IN FEET

WELL SCHEMATIC



EA ENGINEERING, SCIENCE, AND TECHNOLOGY

SANDY BEACH ROAD GROUND WATER PLUME SUPERFUND SITE

Geologic Cross-Section A - A'

FIGURE	TASK ORDER	DATE	SCALE	CHECKED BY	DRAWN BY	DESIGNED BY
5	14342.13	09/13/2011	AS SHOWN	TM	JRM	TM

M:\Projects\EPA_RAC\EP48.09_Sandy Beach\VR Drawings\Fig05_Cross Section.dwg

APPENDIX C

RECOMMENDED GROUNDWATER PERFORMANCE MONITORING

APPENDIX C

RECOMMENDED GROUNDWATER PERFORMANCE MONITORING

Well Name	Unit	Objective	Parameters & Frequency*	Analyses
MW-15	Paluxy	Evaluate response to source area treatment	VOCs quarterly for 2 years during and after SVE installation, semi-annually after SVE treatment (Metals if ISB remedy is installed)	Statistical trend evaluation, mass discharge downgradient, mass removal versus cost of remedy
MW-16				
MW-17				
MW-18				
MW-24				
MW-38				
GW-39 Replacement				
GW-01				
GW-02				
GW-29A				
GW-24				
GW-12/36				
SVE Wells				
OB-1				
Suggested source area wells				
MW-45	Paluxy	Delineate source area north of treatment zone	VOCs semiannually while SVE is operational	Compare to cleanup standards
Replacement wells for GW-09, GW-10, GW-11	Paluxy	Evaluate plume migration and plume attenuation	VOCs semiannually after SVE is operational	Statistical trend evaluation, mass discharge downgradient
GW-16				
GW-19				
GW-25				
GW-33				
MW-11				
MW-12				
MW-13				
MW-14				
GW-03 thru GW-06	Paluxy	Delineate plume, monitor plume migration and remedial performance	VOCs annually	Compare to cleanup standards, evaluate trends where appropriate
MW-07				
MW-8R				
MW-09				
MW-10				
MW-20				
MW-21				
MW-22				
MW-23				
GW-33				
GW-34				

Well Name	Unit	Objective	Parameters & Frequency*	Analyses
GW-35	Paluxy	Delineate plume, monitor plume migration and remedial performance	VOCs annually	Compare to cleanup standards, evaluate trends where appropriate
GW-37				
MW-25 thru MW-39				
MW-41thru MW-45				
MW-01 thru MW-06 multiple levels				Mass discharge to tail of plume
MW-19	Twin Mountain	Evaluate plume migration in Twin Mountain aquifer	VOCs semiannually for 2 years after GW-39 is replaced	Statistical trend evaluation, comparison to cleanup standards
MW-10	Twin Mountain	Delineate plume in Twin Mountain aquifer	VOCs annually	Compare to cleanup standards
MW-39				
MW-40				
P&T extraction wells	Paluxy	Mass removal	VOCs quarterly	Mass removal rate
SVE extraction wells (vapor)	Paluxy vapor	Mass removal	Photoionization detector monthly and VOCs quarterly from key wells for comparison	Mass removal rate

A comprehensive, monitoring event is recommended prior to initiation of the source area remedies. The monitoring network can be reduced in both well number and frequency after the 2 year remedy performance monitoring period. If remedy installation/activation is delayed, annual monitoring is recommended until active remedies are initiated.

APPENDIX D

MONITORING AND REMEDIATION OPTIMIZATION SYSTEM ANALYSIS REPORTS

APPENDIX D

MAROS ANALYSIS REPORTS

MAROS Mann-Kendall Statistics Summary

Project: Sandy Beach **User Name:** MV

Location: Azel Texas **State:** Texas

Time Period: 10/29/2007 **to** 8/17/2011
Consolidation Period: Yearly
Consolidation Type: Median
Duplicate Consolidation: Average
ND Values: 1/2 Detection Limit
J Flag Values : Actual Value

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
TRICHLOROETHYLENE (TCE)								
GW-01	S	4	4	0.30	-6	95.8%	No	D
GW-02	S	4	4	0.33	0	37.5%	No	S
GW-03	S	4	3	0.58	-4	83.3%	No	S
GW-09A	T	4	4	0.17	0	37.5%	No	S
GW-10A	T	4	4	0.27	0	37.5%	No	S
GW-11A	T	4	4	0.30	-4	83.3%	No	S
GW-16	T	4	4	0.55	2	62.5%	No	NT
GW-24	T	4	4	0.27	2	62.5%	No	NT
GW-25	T	3	3	0.00	0	0.0%	No	N/A
GW-29A	S	4	4	0.41	0	37.5%	No	S
GW-33	T	1	1	0.00	0	0.0%	No	N/A
GW-34	T	4	2	0.21	-5	89.6%	No	S
GW-35	T	1	1	0.00	0	0.0%	No	N/A
GW-37	T	1	1	0.00	0	0.0%	No	N/A
GW-39	S	2	2	0.00	0	0.0%	No	N/A
MW-02-01	T	1	1	0.00	0	0.0%	No	N/A
MW-03-02	T	3	2	0.00	0	0.0%	No	N/A
MW-07	T	3	3	0.00	0	0.0%	No	N/A
MW-08R	T	2	2	0.00	0	0.0%	No	N/A
MW-09	T	3	2	0.00	0	0.0%	No	N/A
MW-11	T	2	2	0.00	0	0.0%	No	N/A
MW-12	T	3	3	0.00	0	0.0%	No	N/A
MW-13	T	3	3	0.00	0	0.0%	No	N/A
MW-15	S	3	3	0.00	0	0.0%	No	N/A
MW-16	S	3	3	0.00	0	0.0%	No	N/A
MW-17	S	3	3	0.00	0	0.0%	No	N/A

MAROS Mann-Kendall Statistics Summary

Project: Sandy Beach **User Name:** MV

Location: Azel Texas **State:** Texas

TRICHLOROETHYLENE (TCE)

Well	Source/ Tail	Number of Samples	Number of Detects	Coefficient of Variation	Mann-Kendall Statistic	Confidence in Trend	All Samples "ND" ?	Concentration Trend
MW-18	S	2	1	0.00	0	0.0%	No	N/A
MW-19	S	2	2	0.00	0	0.0%	No	N/A
MW-20	T	2	2	0.00	0	0.0%	No	N/A
MW-21	S	2	2	0.00	0	0.0%	No	N/A
MW-22	T	2	1	0.00	0	0.0%	No	N/A
MW-24	S	2	2	0.00	0	0.0%	No	N/A
MW-25	T	2	2	0.00	0	0.0%	No	N/A
MW-27	T	2	2	0.00	0	0.0%	No	N/A
MW-28	T	2	2	0.00	0	0.0%	No	N/A
MW-31	T	2	2	0.00	0	0.0%	No	N/A
MW-38	S	2	2	0.00	0	0.0%	No	N/A
MW-43	T	1	1	0.00	0	0.0%	No	N/A
MW-44	T	1	1	0.00	0	0.0%	No	N/A
MW-45	T	1	1	0.00	0	0.0%	No	N/A
OB-1	S	1	1	0.00	0	0.0%	No	N/A

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A)-Due to insufficient Data (< 4 sampling events); Source/Tail (S/T)

The Number of Samples and Number of Detects shown above are post-consolidation values.

MAROS Mann-Kendall Statistics Summary

Project: Sandy Beach | **User Name:** MV

Location: Azel Texas | **State:** Texas

Well: GW-01

Well Type: S

COC: TRICHLOROETHYLENE (TCE)

Time Period: 10/29/2007 **to** 8/17/2011

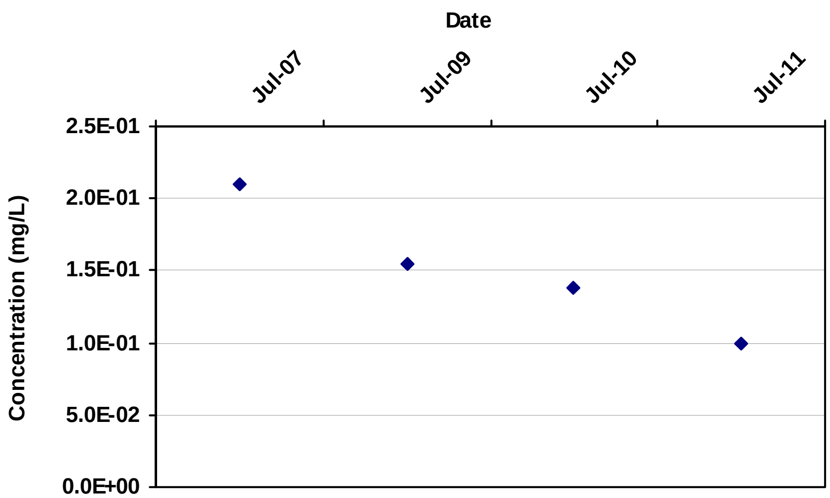
Consolidation Period: Yearly

Duplicate Consolidation: Median

Consolidation Type: Average

ND Values: 1/2 Detection Limit

J Flag Values : Actual Value



Mann Kendall S Statistic:

-6

Confidence in Trend:

95.8%

Coefficient of Variation:

0.30

Mann Kendall Concentration Trend: (See Note)

D

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
GW-01	S	7/1/2007	TRICHLOROETHYLEN	2.1E-01		1	1
GW-01	S	7/1/2009	TRICHLOROETHYLEN	1.6E-01		1	1
GW-01	S	7/1/2010	TRICHLOROETHYLEN	1.4E-01		1	1
GW-01	S	7/1/2011	TRICHLOROETHYLEN	1.0E-01		1	1

Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

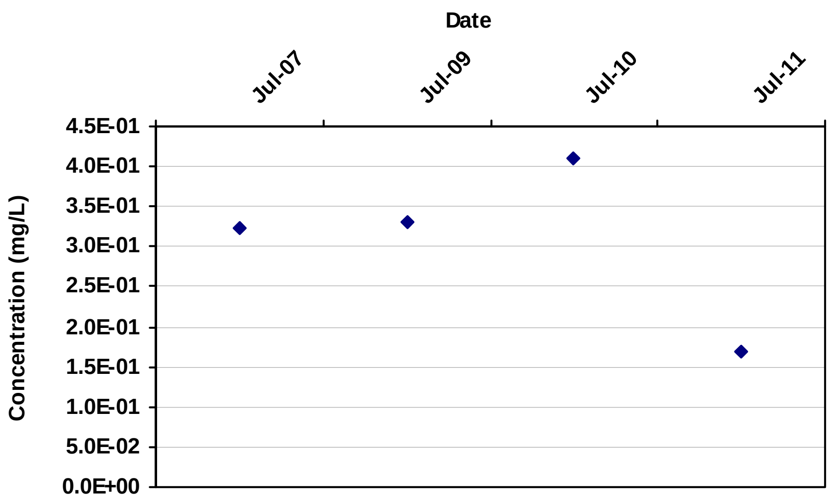
Project: Sandy Beach

User Name: MV

Location: Azel Texas

State: Texas

Well:	GW-02	**Time Period:**	10/29/2007 **to** 8/17/2011
Well Type:	S	**Consolidation Period:**	Yearly
COC:	TRICHLOROETHYLENE (TCE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Average
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

0

Confidence in Trend:

37.5%

Coefficient of Variation:

0.33

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
GW-02	S	7/1/2007	TRICHLOROETHYLEN	3.2E-01		1	1
GW-02	S	7/1/2009	TRICHLOROETHYLEN	3.3E-01		1	1
GW-02	S	7/1/2010	TRICHLOROETHYLEN	4.1E-01		1	1
GW-02	S	7/1/2011	TRICHLOROETHYLEN	1.7E-01		1	1

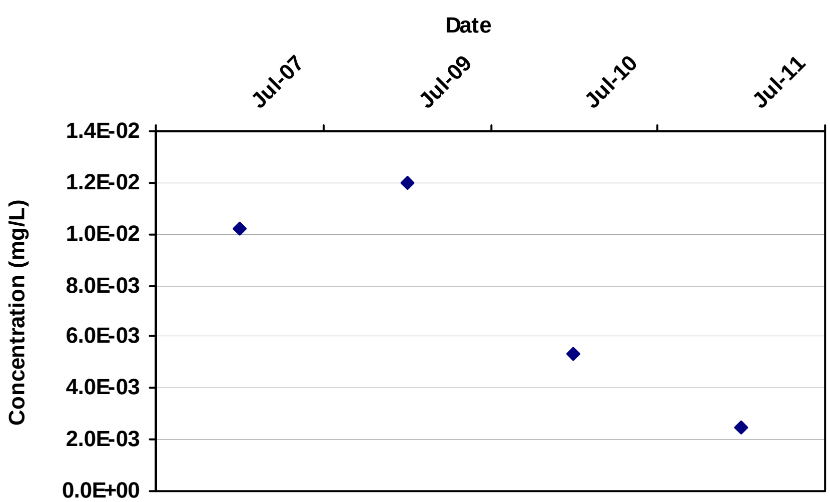
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: Sandy Beach **User Name:** MV

Location: Azel Texas **State:** Texas

Well:	GW-03	**Time Period:**	10/29/2007 **to** 8/17/2011
Well Type:	S	**Consolidation Period:**	Yearly
COC:	TRICHLOROETHYLENE (TCE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Average
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

-4

Confidence in Trend:

83.3%

Coefficient of Variation:

0.58

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
GW-03	S	7/1/2007	TRICHLOROETHYLEN	1.0E-02		1	1
GW-03	S	7/1/2009	TRICHLOROETHYLEN	1.2E-02		1	1
GW-03	S	7/1/2010	TRICHLOROETHYLEN	5.3E-03		1	1
GW-03	S	7/1/2011	TRICHLOROETHYLEN	2.5E-03	ND	1	0

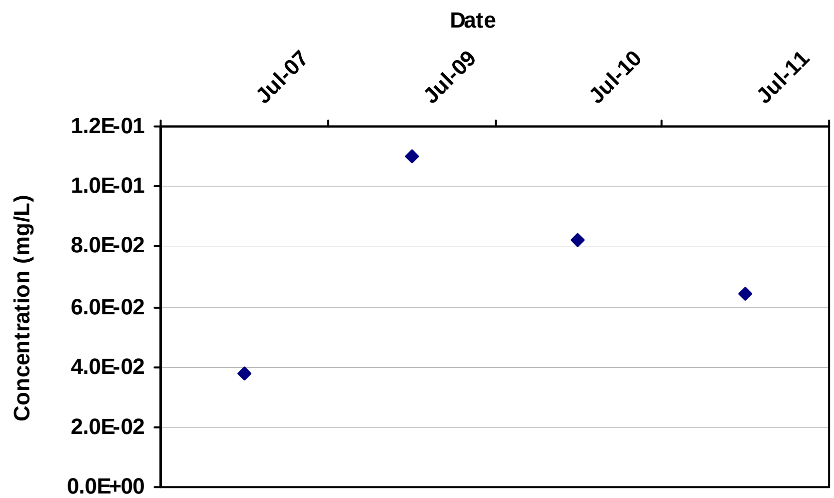
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Mann-Kendall Statistics Summary

Project: Sandy Beach **User Name:** MV

Location: Azel Texas **State:** Texas

Well:	GW-29A	**Time Period:**	10/29/2007 **to** 8/17/2011
Well Type:	S	**Consolidation Period:**	Yearly
COC:	TRICHLOROETHYLENE (TCE)	**Duplicate Consolidation:**	Median
		Consolidation Type:	Average
		ND Values:	1/2 Detection Limit
		J Flag Values :	Actual Value



Mann Kendall S Statistic:

0

Confidence in Trend:

37.5%

Coefficient of Variation:

0.41

Mann Kendall Concentration Trend: (See Note)

S

Data Table:

Well	Well Type	Effective Date	Constituent	Result (mg/L)	Flag	Number of Samples	Number of Detects
GW-29A	S	7/1/2007	TRICHLOROETHYLEN	3.8E-02		1	1
GW-29A	S	7/1/2009	TRICHLOROETHYLEN	1.1E-01		1	1
GW-29A	S	7/1/2010	TRICHLOROETHYLEN	8.2E-02		1	1
GW-29A	S	7/1/2011	TRICHLOROETHYLEN	6.4E-02		1	1

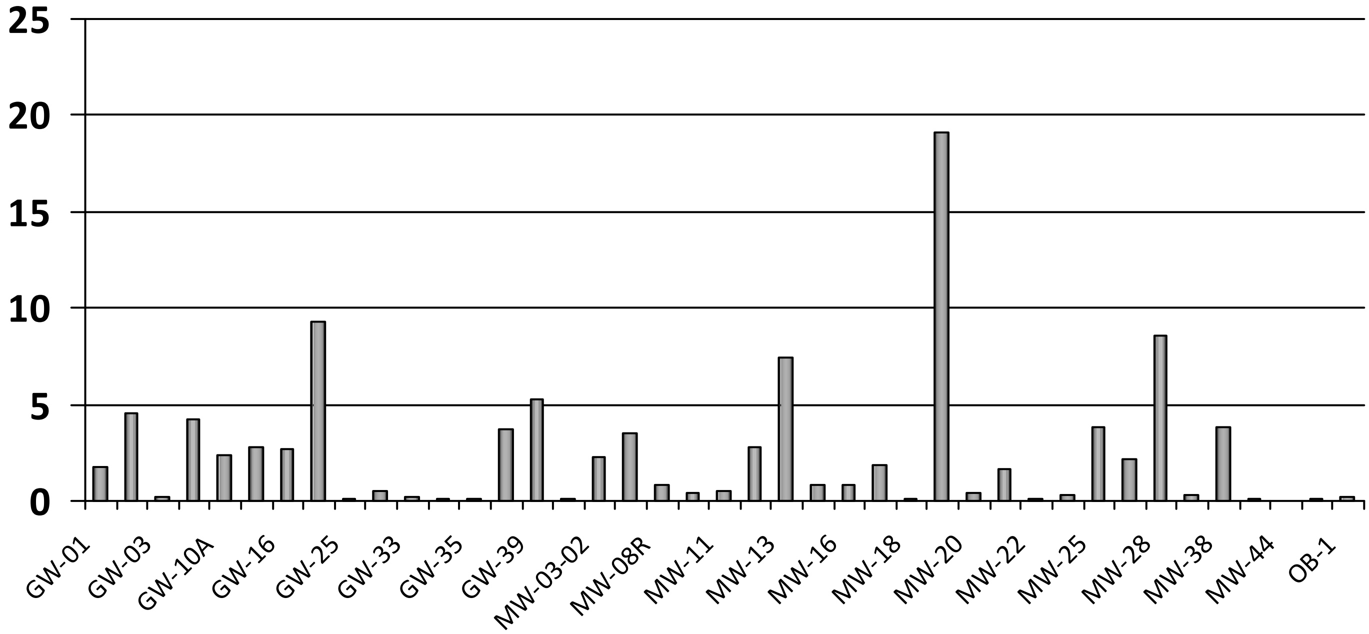
Note: Increasing (I); Probably Increasing (PI); Stable (S); Probably Decreasing (PD); Decreasing (D); No Trend (NT); Not Applicable (N/A) - Due to insufficient Data (< 4 sampling events); ND = Non-detect

MAROS Percent of Mass by Well

Project: Sandy Beach **User Name:** MV

Location: Azel Texas **State:** Texas

TRICHLOROETHYLENE (TCE) 8/17/2011



Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area
GW-01	7,138.92	124.93	1.79	0.65
GW-02	10,598.35	315.30	4.53	0.97
GW-03	25,179.61	11.02	0.16	2.30
GW-09A	30,567.44	294.21	4.23	2.79
GW-10A	49,939.81	166.05	2.38	4.56
GW-11A	39,650.03	194.29	2.79	3.62
GW-16	25,922.23	190.53	2.74	2.37
GW-24	62,856.16	648.99	9.32	5.74
GW-25	52,328.82	9.16	0.13	4.78
GW-29A	2,924.48	32.75	0.47	0.27
GW-33	56,163.95	14.74	0.21	5.13
GW-34	8,636.99	3.78	0.05	0.79
GW-35	5,429.79	6.65	0.10	0.50
GW-37	36,590.94	259.98	3.73	3.34

MAROS Percent of Mass by Well

Project: Sandy Beach **User Name:** MV

Location: Azel Texas **State:** Texas

Well	Area (ft2)	Mass (mg)	Percent of Mass	Percent of Area
GW-39	8,124.72	366.12	5.26	0.74
MW-02-01	41,766.73	7.31	0.10	3.81
MW-03-02	39,951.44	160.80	2.31	3.65
MW-07	53,209.45	242.10	3.48	4.86
MW-08R	21,036.51	58.90	0.85	1.92
MW-09	61,886.17	27.08	0.39	5.65
MW-11	10,059.15	35.21	0.51	0.92
MW-12	34,436.30	192.84	2.77	3.14
MW-13	34,048.66	518.39	7.44	3.11
MW-15	11,140.38	54.59	0.78	1.02
MW-16	3,591.95	54.06	0.78	0.33
MW-17	3,969.19	131.98	1.90	0.36
MW-18	14,043.83	6.14	0.09	1.28
MW-19	25,415.14	1,334.29	19.16	2.32
MW-20	28,951.54	31.92	0.46	2.64
MW-21	23,541.24	118.65	1.70	2.15
MW-22	9,635.60	4.22	0.06	0.88
MW-24	13,284.72	20.57	0.30	1.21
MW-25	46,962.61	262.99	3.78	4.29
MW-27	20,908.84	150.02	2.15	1.91
MW-28	48,724.04	596.87	8.57	4.45
MW-31	23,640.97	19.03	0.27	2.16
MW-38	76,836.22	268.93	3.86	7.01
MW-43	17,178.88	4.63	0.07	1.57
MW-44	987.77	0.75	0.01	0.09
MW-45	6,374.07	5.91	0.08	0.58
OB-1	2,231.26	16.82	0.24	0.20
	1,095,864.9	6,963.5	100	100