FINAL

FOCUSED FEASIBILITY STUDY FOR GROUNDWATER AND SOIL GAS IR SITE 29

Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California

June 5, 2013

Prepared for:

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Prepared by:

Accord MACTEC 8A JV
2923 Pullman Street
Santa Ana, California 92705
(714) 241-7200

and

Richard Brady & Associates
3710 Ruffin Road
San Diego, California 92123
(858) 496-0500

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U.S. DEPARTMENT OF THE NAVY

REVIEW AND APPROVAL

Shane C. DeGross, PG #8147
Project Manager
Richard Brady & Associates

June 5, 2013
Date

Rain Zeng, PhD, PE #73780
Project Manager
Accord MACTEC 8A JV

June 5, 2013
Date

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ACRONYMS AND ABBREVIATIONS

§	Section
µg/L	micrograms per liter
AM8AJV	Accord MACTEC 8A Joint Venture
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BHHRA	baseline human health risk assessment
BRAC	Base Realignment and Closure
Brady	Richard Brady & Associates
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	chemical of concern
CPT	cone penetrometer test
DCE	dichloroethene
DCN	document control number
DERP	Defense Environmental Restoration Program
DHC	*Dehalococcoides* sp.
DoD	U.S. Department of Defense
DSITMS	direct sampling ion-trap mass spectrometer
DTSC	California Department of Toxic Substances Control
EC	engineering control
EDS	energy dispersive X-ray spectroscopy
EIR	environmental impact report
ERA	ecological risk assessment
FFA	Federal Facility Agreement
FFS	focused feasibility study
former NAVWPNSTA Concord	former NAVWPNSTA Seal Beach, Detachment Concord
FS	feasibility study
ft/ft	foot per foot
GAC	granular activated carbon
GRA	general response action

HI	hazard index
IC	institutional control
IR	Installation Restoration
iRACR	interim Remedial Action Completion Report
ISB	in situ (anaerobic) bioremediation
LUC	land-use control
MIP	membrane interface probe
MNA	monitored natural attenuation
MSL	mean sea level
Navy	U.S. Department of the Navy
NAVWPNSTA	Naval Weapons Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NO_X	oxides of nitrogen
O&M	operation and maintenance
PM_{10}	(airborne) particulates <10 micrometers in diameter
PPE	personal protective equipment
RAB	Restoration Advisory Board
RACR	Remedial Action Completion Report
RAO	remedial action objective
RAP	remedial action plan
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RG	remediation goal
RI	remedial investigation
ROD	Record of Decision
ROI	radius of influence
SARA	Superfund Amendments and Reauthorization Act
SCAPS	Site Characterization and Analysis Penetrometer System
Site 29 (or site)	Installation Restoration Site 29
SO_X	oxides of sulfur
SVE	soil-vapor extraction
TCE	trichloroethene

Treatability Study	*Final In Situ Anaerobic Bioremediation and* S*olar-Powered Vapor Extraction Treatability Study Work Plan* (Shaw 2011)
U.S. EPA	United States Environmental Protection Agency
VOC	volatile organic compound
Water Board	California Regional Water Quality Control Board, San Francisco Bay Region
ZVI	zero-valent iron

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EXECUTIVE SUMMARY

Accord MACTEC 8A JV (AM8AJV), a joint venture, and Richard Brady & Associates (Brady), in subcontract to AM8AJV, prepared this *Focused Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29,* on behalf of the Naval Facilities Engineering Command Base Realignment and Closure (BRAC) Program Management Office (PMO) West, in accordance with Contract Number N62473–10–D–0814, Delivery Orders 0005 and 0017. This FFS follows requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), related United States Environmental Protection Agency (U.S. EPA) technical guidance, and the U.S. Department of the Navy's *Environmental Restoration Program Manual* (Navy 2006).

The purpose of this FFS is to develop and evaluate remedial alternatives to mitigate human health and environmental risks associated with exposure to groundwater and soil gas impacted by volatile organic compounds (VOCs) at Installation Restoration (IR) Program Site 29 (Site 29 or "site"), former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California, based on the conclusions and recommendations of the *Final Remedial Investigation (RI) Report* (Brady 2011). This document uses an FFS format because the technologies used in a treatability study (Shaw 2011) currently underway have been proven to effectively treat chlorinated solvents in groundwater under the hydrogeologic conditions present at Site 29 and because soil-gas contamination will be treated using soil-vapor extraction (SVE) technology.

Site 29 is located within the south-central portion of the inland area, approximately 1,600 feet southwest of the intersection of L Street and Kinne Boulevard and approximately 1,000 feet southwest of Seal Creek (also known as Mt. Diablo Creek outside of the base). The site is located on the side of a hill underlain by silty clay and sandy gravel units.

As a result of the final RI and previous investigations, the area of Site 29 was found to be impacted with VOCs in soil gas (in the vicinity of Building IA-19) and groundwater extending approximately 850 feet downgradient. The VOC-impacted vadose zone soils extend over approximately 1 acre, and the estimated area of groundwater impact is over 6 acres.

Factors considered in determining remedial action objectives (RAOs) include potential human health and ecological risks and exposure pathways, chemicals of concern (COCs), affected media, and chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs). The RAOs are based on the planned, unrestricted future use of Site 29 (City of Concord 2010).

A baseline human health risk assessment (BHHRA) was performed to assess potential impacts to human health from exposure to chemicals in soil, soil gas, and groundwater at Site 29 (Brady 2011). Future residential (unrestricted) use, commercial/industrial worker, and construction/utility worker scenarios were evaluated. For future residential use, cancer risk estimates exceed the 10^{-4} upper limit of the risk management range, and the hazard index (HI) values exceed 1.0 for all combinations (two methods and two development scenarios). The cancer risk and noncancer hazard estimates are primarily associated with arsenic from two soil sample locations, from trichloroethene (TCE) in soil gas, and from exposure to multiple chemicals from domestic use of groundwater. The RI concluded that the metals from those two

soil locations beneath IA-25 were associated with soils impacted by lead-based paint residues. Laboratory analysis and detailed evaluation of samples via scanning electron microscope/energy dispersive x-ray spectroscopy confirmed that lead in soil beneath IA-25 is derived from lead-based paint. Paints typically contain other metals used for pigment, such as arsenic, cadmium, cobalt, chromium, and zinc. The RI concluded that the elevated concentrations of these other metals are also associated with paint residues. No further action under CERCLA was recommended for lead-based-paint-contaminated soil. For commercial/industrial worker scenarios, the risk estimates are within the risk management range and the HIs are less than 1.0. For the construction/utility worker scenarios, the risk estimates exceed the 10^{-4} upper limit of the risk management range, and the HI values exceed 1.0 for this highly exposed receptor. Risk to future construction workers is predominantly attributable to exposure to TCE in soil gas and groundwater.

Contaminants at Site 29 are generally considered unlikely to pose a hazard to ecological receptors with the exception of TCE and 1,1-dichloroethene (1,1-DCE) in soil gas and metals in soil beneath Building IA-25. Soils beneath Building IA-25 do not pose an unacceptable risk to ecological receptors if the soil and building remain unvegetated and left in place. Primary and secondary consumers (e.g., vole, meadowlark, robin, and shrew) are primarily exposed to metals through plant and soil invertebrate consumption. Soils beneath IA-25 only pose a risk to ecological receptors if the building is removed, the soils remain undisturbed, and the area is revegetated (Brady 2011).

The media affected by VOCs for which remediation alternatives are evaluated in this FFS are soil gas and groundwater. RAOs are medium-specific goals for protecting human health and the environment and consider affected media and COCs, existing and potential receptors, exposure pathways, and ARARs. The RAOs for Site 29 are as follows:

- Prevent residential exposure to VOCs via potential inhalation of soil gas through vapor intrusion at concentrations that result in a cancer risk that exceeds the risk management range of 10^{-4} to 10^{-6} and a HI greater than 1.0.
- For burrowing mammals, reduce the inhalation hazard of TCE and 1,1-DCE in shallow soil gas to a hazard quotient of less than 1.0.
- Prevent residential exposure to VOCs via potable use of groundwater containing concentrations that result in a cancer risk that exceeds the risk management range of $1x10^{-4}$ to $1x10^{-6}$ and a HI greater than 1.0.

Risks to potential future residents and construction/utility workers exceed the 10^{-4} upper limit of the risk management range and the HI of 1.0. VOCs in soil gas at the site pose a hazard to burrowing mammals. The primary pathways for human exposure were identified as inhalation of soil gas and domestic use of groundwater (Brady 2011).

The proposed remediation goals (RGs) for VOCs presented in this FFS are based on the results of the risk assessments and on unrestricted use of Site 29.

The Navy has included some form of land-use controls (LUCs) in all of the remedial alternatives for Site 29, with the exception of no action. The following four remedial action alternatives were considered for this FFS.

- **Alternative 1 – No Action.** No remedial action of any type would be conducted; this alternative serves as the baseline against which the remaining alternatives can be compared.
- **Alternative 2 – SVE with Monitored Natural Attenuation (MNA).** This alternative would institute an SVE presumptive remedy to remove VOC contamination from the vadose zone. SVE, also known as "soil venting" or "vacuum extraction" is an in situ remedial technology that reduces concentrations of volatile constituents adsorbed to soils in the unsaturated (vadose) zone. MNA of the groundwater plume is a technique used to monitor or test the progress of natural attenuation processes that can degrade contaminants in soil and groundwater. It can be used in conjunction with SVE as a finishing option, or if appropriate, as the only remediation process if the rate of contaminant degradation is fast enough to protect human health and the environment. Natural processes can then mitigate the remaining amount of pollution; regular monitoring of the groundwater can verify those reductions. Both institutional and engineering LUCs would be used to restrict use of groundwater for domestic supply and to implement mitigating requirements for structures built over the soil-vapor plume until RAOs are met.
- **Alternative 3 – SVE with Zero-Valent Iron (ZVI) Injection.** Similar to Alternative 2, SVE would be the primary technology used to treat VOCs in the vadose zone. In addition to SVE, groundwater treatment would be conducted by ZVI injection. ZVI is a strong reducing agent that is injected (in solution) into contaminated groundwater to reduce VOC concentrations. LUCs, such as fencing, signage, and land-use restrictions, would be implemented over the duration of treatment until RAOs are met.
- **Alternative 4 – SVE with In Situ (Anaerobic) Bioremediation (ISB) and Groundwater Recirculation.** ISB involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as an electron acceptor in a process called chlororespiration. The ISB treatment entails injecting biodegradable substrates (e.g., vegetable-oil emulsion) into the source area at a prescribed injection spacing to achieve the desired radius of influence in the treatment area and to target low-permeability zones. A groundwater recirculation system can be constructed to optimally distribute treatment media to contaminants over the extent of the plume where direct injection is impracticable. LUCs would be implemented similarly to Alternative 3 until RAOs are met, thereby achieving unrestricted future use of the site.

The above alternatives provide a range of options for decision makers to evaluate as part of the remedy selection process. Alternative 1 involves no engineered remediation measures, LUCs, or monitoring and is included as a baseline comparison for the other alternatives. Alternatives

2, 3 and 4 are intended to achieve unrestricted future use of the site. Alternative 2 would reduce VOCs in soil gas and manage groundwater risk through MNA and LUCs until RAOs are met. Alternatives 3 and 4 would also reduce VOCs in soil gas and manage groundwater risk through treatment.

The relative performance of remedial alternatives considered in this FFS were compared against the NCP evaluation criteria to assess the merits of each alternative and to identify key trade-offs the Navy must consider when selecting a cleanup remedy. The NCP criteria are as follows:

- Threshold criteria
  - Overall protection of the environment
  - Compliance with ARARs
- Primary balancing criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost
- Modifying criteria
  - State acceptance
  - Community acceptance

Alternatives 2, 3, and 4 meet the threshold criteria, while Alternative 1 does not. Alternatives 3 and 4 are similarly rated overall in satisfying the balancing criteria (i.e., lower ratings for some individual criteria are balanced by higher ratings for other individual criteria, resulting in overall similar ratings). Alternative 2 is rated lowest because, while it will reduce toxicity, mobility, and volume for VOCs in soil gas, it will not reduce toxicity, mobility, or volume of VOCs in groundwater through treatment. See Table ES-1 for a summary of rankings.
In addition to the nine CERCLA criteria, a comparative analysis of the sustainability of each alternative was also performed for this FFS. U.S. EPA (2010) currently defines “green” remediation as “the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.” The sustainability assessment used a green and sustainable remediation evaluation tool known as SiteWise™. Inputs into SiteWise™ are segregated into four phases of work: RI, remedial action construction, operation, and long-term monitoring. Detailed inputs include vehicle mileage, personnel and equipment, construction details, residual handling, groundwater pumped, and equipment operated for each alternative. The eight sustainability factors modeled include greenhouse gas emissions, total energy used, water impacts, oxides of nitrogen (NOx) emissions, oxides of sulfur (SOx) emissions, airborne particulate (<10 micrometers in diameter) emissions

(PM_{10}), accident risk (fatality), and accident risk (injury). The sustainability of alternatives can also be considered in remedy selection and implementation. Of the active remedial alternatives, Alternative 2 is rated the most sustainable with the factors considered. A combination of alternatives may be considered during remedy selection or during remedy optimization.

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Table ES-1. Summary of Comparative Analysis of Remedial Alternatives

Criterion[a]	Alternative 1 (No Action)	Alternative 2 (SVE with MNA)	Alternative 3 (SVE with ZVI Injection)	Alternative 4 (SVE with ISB and Groundwater Recirculation)
Overall protection of human health and the environment[b]	Not protective	Protective	Protective	Protective
Compliance with ARARs[b]	Not applicable (no ARARs)	Complies	Complies	Complies
Long-term effectiveness and permanence[c]	○	◑	●	●
Reduction of toxicity, mobility, or volume through treatment[c]	○	◑	●	●
Short-term effectiveness[c]	●	◕	◑	◑
Implementability[c]	●	◕	◑	◑
Cost[c, d]	● $0	◕ $11.1M	◔ $18.5M	◑ $14.3M

Notes:

a State and community acceptance are not shown; the state has not commented on the alternatives, and community acceptance will be assessed following the public review process.

b Threshold criterion (must be satisfied for a remedial alternative to be eligible for selection unless an ARAR waiver applies).

c Primary balancing criterion.

d Estimated cost (M = millions)

ARAR applicable or relevant and appropriate requirement

ISB in situ anaerobic bioremediation

LUC land-use control

MNA monitored natural attenuation

NCP National Oil and Hazardous Substances Pollution Contingency Plan

SVE soil-vapor extraction

ZVI zero-valent iron

Relative Performance in Satisfying NCP Criteria

Least →				Best
○	◔	◑	◕	●
(low)	(medium-low)	(medium)	(medium-high)	(high)

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Section 1 Introduction

Accord MACTEC 8A JV (AM8AJV), a joint venture, and Richard Brady & Associates (Brady), under subcontract to AM8AJV, prepared this *Focused Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord* (former NAVWPNSTA Concord) on behalf of the Naval Facilities Engineering Command, Base Realignment and Closure (BRAC) Program Management Office (PMO) West, in accordance with Contract Number N62473–10–D–0814, Delivery Orders 0005 and 0017. This FFS follows requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), related United States Environmental Protection Agency (U.S. EPA) technical guidance, and the U.S. Department of the Navy's *Environmental Restoration Program Manual* (Navy 2006).

This FFS presents discussions, analyses, and evaluations of remedial action alternatives considered for volatile organic compounds (VOCs) in soil gas and groundwater at Installation Restoration (IR) Program Site 29 (Site 29) (Figure 1-1).

CERCLA and the Superfund Amendments and Reauthorization Act (SARA) established a series of federal programs to identify, characterize, and clean up or control contamination from hazardous waste disposal and spill sites. The Defense Environmental Restoration Program, codified in SARA Section (§) 21 (10 *United States Code* §2701), is one of these programs. That program specifies Navy and Marine Corps personnel responsibilities, describes IR Program procedures, and ensures consistency with regulatory guidelines for evaluation of hazardous waste site conditions.

The Navy established the IR Program to comply with federal requirements regarding cleanup of hazardous waste sites. Specifically, the task of the program is to reduce the risk to human health and the environment from past waste-disposal operations and hazardous materials spills at Navy and Marine Corps facilities in a cost-effective manner. These federal requirements are outlined in CERCLA, as amended by SARA and its implementing regulation, the NCP.

The Navy is the lead federal agency responsible for environmental restoration at former NAVWPNSTA Concord. The U.S. EPA is the lead regulatory agency providing oversight. The Navy provides copies of draft reports to the California Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board, San Francisco Bay Region (Water Board) for comment and concurrence as part of the CERCLA process.

1.1 Purpose

The purpose of this FFS is to develop and evaluate remedial action alternatives to address human-health and ecological risks from VOCs in soil gas and groundwater.

1.2 Report Organization

This FFS is organized as follows:

Section 1 – Introduction presents the purpose and organization of this report.

Section 2 – Background describes Site 29 and summarizes the conclusions and recommendations from the *Final Remedial Investigation (RI) Report* (Brady 2011).

Section 3 – Remedial Action Objectives identifies the chemicals of concern (COCs), environmental media of interest, remedial action objectives (RAOs), and potential applicable or relevant and appropriate requirements (ARARs) that can have a bearing on the remedial action alternatives being considered, and identifies the preliminary remediation goals (RGs) for VOCs in groundwater and soil gas.

Section 4 – Identification and Screening of Remedial Technologies discusses the procedure used to reduce the broad range of technology types and process options to a small subset that is potentially applicable to the site.

Section 5 – Development and Screening of Remedial Alternatives presents remedial action alternatives.

Section 6 – Detailed Analysis of Remedial Alternatives provides a discussion of remedial alternatives evaluated in Section 4 relative to the threshold and balancing criteria.

Section 7 – Comparative Analysis of Alternatives compares the remedial action alternatives and provides a discussion of the findings of the FFS.

Section 8 – References lists the references cited in this FFS.

Appendix A presents a discussion of potential ARARs for Site 29 remedial alternatives.

Appendix B presents cost development summaries for remedial alternatives.

Appendix C presents the details of a sustainability assessment performed on active remedial alternatives.

Attachment 1 presents the methodology used to derive the proposed human health and ecological RGs.

Attachment 2 provides responses to agency comments on the draft version of this FFS.

Section 2 Background

This section summarizes background information associated with Site 29 including site location and description, historical property uses and operations, and environmental setting.

2.1 Base Description

Former NAVWPNSTA Concord is located in north-central Contra Costa County, approximately 30 miles northeast of San Francisco, California. Former NAVWPNSTA Concord is bounded on the north by Suisun Bay, on the east by private land and the City of Pittsburg, and on the south and west by the City of Concord. Former NAVWPNSTA Concord encompasses almost 13,000 acres in two holdings: the inland area (Navy) and the tidal area (transferred to the Army on October 1, 2008). A Navy-owned road and rail line link the inland area to the tidal area. The inland area lies between the Los Medanos Hills and the City of Concord and is crossed by three public roads: State Route 4, Willow Pass Road, and Bailey Road and encompasses 5,205 acres (Figure 1-1).

2.2 Site Description and Operations

Site 29 is located within the south-central portion of the inland area, approximately 1,600 feet southwest of the intersection of L Street and Kinne Boulevard and approximately 1,000 feet southwest of Mt. Diablo Creek (sometimes referred to as Seal Creek) (Figure 2-1). The site is located on the northeast side of a hill.

Site 29 includes Buildings IA-25, IA-19, and 263 (Figure 2-2). The buildings are approximately 110 feet higher in elevation than Seal Creek. Building IA-25 is a 2,300-square-foot building of wood frame construction built on raised piers. Building 263 is an approximately 15-foot-wide by 32-foot-long building constructed of 8-inch concrete blocks. The buildings are approximately 25 feet apart and connected by a covered, wooden loading dock. Both buildings are surrounded by a combination of a steep-cut slope rising to the southwest and manmade earthen berms supported with creosote-treated revetments. The berms are approximately 20 feet high with two vertical cuts (approximately 20 feet wide) through the northeastern berm revetment for vehicle and pedestrian access (SulTech 2007). Building IA-19 is located approximately 100 feet southeast of Building IA-25. Building IA-19 is an approximately180-square-foot, slab-on-grade, wooden boiler house built to provide heat to Building IA-25 (Figure 2-2).

Building IA-25 was constructed in 1945 to be used exclusively for pilot-scale development of munitions (Navy 1945; SulTech 2007). During the 1940s, hexahydro-1,3,5-trinitro-s-trianzine, pentaerythirtol tetranitrate, lead styphnate, and lead azide were developed and used as military explosives and may have been historically used at Building IA-25. Components that resulted from the breakdown of military munitions and contained initiated explosives were removed from building IA-25 (and the Site 29 area) and burned or detonated (SulTech 2007). Building IA-19 was built in 1945 along with an approximately 1,400-gallon underground storage tank and a diesel-fuel-fired boiler to provide heat to Building IA-25 (Navy 1945).

In the 1970s, Building IA-25 was renovated for munitions reworking, which involved disassembly, inspection, limited testing, replacement of firing mechanisms, reassembly, and

repacking of the ordnance items. Building 263 was constructed in 1973 and used as a breakdown cell for munitions. During this time, Buildings 263 and IA-25 were considered to be a single operating unit used as an ammunition rework and overhaul shop (Navy 1988).

By 1988, operations had transitioned to Weapons Quality Engineering Center support operations including radiographic inspections (Navy 1988). Building IA-25 was substantially remodeled in the early 1990s to repair structural damage to the flooring system and walls; repair lighting, ventilation, and heating systems; and to make other repairs necessary to comply with Navy requirements for ordnance operations buildings. The walls, floors, and ceilings were all replaced; exterior fireproof siding was added; new security and fire sprinkler systems were installed; and an addition was added to the south end. The workroom beneath the building was no longer needed, and the floors were remodeled to eliminate the trap door and bring the floor to a uniform grade. The repair order included asbestos removal and vacuuming the floor to ensure safe removal of any black powder (Navy 1988).

Buildings IA-25, IA-19, and 263 are currently unoccupied and no military operations are being conducted at Site 29. The pasture to the east of the access road is being used for cattle grazing.

2.3 Previous Investigations at Site 29

A thorough investigation history was presented in the *Final RI Report* (Brady 2011). For details on previous investigations leading up to the RI, please see Section 3 of the Final RI. Previous sampling locations, including RI sampling locations, are provided on Figure 2-3. For completeness, the following is a list of previous investigations discussed in the RI:

- Site Investigation for Building Crawl Space Surface Soils (1990)
- RCRA Facility Assessment (1992)
- Building IA-19 Underground Storage Tank Closure (1993)
- Resource, Conservation, and Recovery Act (RCRA) Facility Assessment Confirmation Study (1997)
- Closure of SWMU 13 Septic Tank (1997)
- Site Investigation for Subsurface Soils (1999)
- Draft Final Focused Feasibility Study (2003)
- Surface Soil Sampling for Arsenic (2004)
- Groundwater Monitoring (2005 and 2006)

This section will only present a summary of the RI (Brady 2011) and work currently being implemented under the *Final In Situ Anaerobic Bioremediation (ISB) and Solar-Powered Vapor Extraction Treatability Study Work Plan* (Treatability Study; Shaw 2011).

2.3.1 Final Remedial Investigation (2011)

The objectives of the RI were to characterize the nature and extent of VOC contamination, to identify source area(s), to assess risk to human health and the environment by performing a

baseline human health risk assessment (BHHRA) and a two-tiered ecological risk assessment (ERA), and to collect site information for analysis of potential remedial alternatives (Brady 2011). The RI sampling consisted of the following field activities:

- Preliminary surface soil, leach field trenching, and groundwater monitoring (May/July 2007)
- Site Characterization and Analysis Penetrometer System (SCAPS) membrane interface probe (MIP) coupled with direct sampling ion-trap mass spectrometer (DSITMS) investigations, including deep soil-gas and soil sampling (July 2007)
- Groundwater monitoring well installation and monitoring (October 2007)
- Second SCAPS MIP/DSITMS investigation (November/December 2008)
- Additional groundwater monitoring well installation and monitoring (February 2008)
- Shallow soil and soil-gas sampling (September 2009)
- Surface soil and paint chip sampling in the vicinity of Building IA-25, including scanning electron microscopy (SEM)/energy dispersive X-ray spectroscopy (EDS) analysis (September 2009)

The conceptual site model presented in the RI identified that trichloroethene (TCE) was primarily disposed of on the ground surface near Building IA-19 and the berm/driveway area of Building IA-25. The highest observed detections of TCE by MIP and shallow soil-gas data confirmed that the primary source of TCE was not the septic-system leach field as previously thought, but rather surface release area(s) between IA-19, IA-25, and the driveway area. Discontinuous soil contamination was found in portions of the approximately 45-foot-thick vadose (unsaturated) zone. Dissolved-phase TCE likely followed preferential pathways (generally more coarse-grained units) laterally and vertically into deeper stratigraphic layers as it migrated downgradient. The apparent cross-gradient component to the migration direction of TCE in groundwater appears to be due to thick sequences of finer-grained, less-permeable layers to the northeast and away from the hillside that may act to impede migration of contaminants directly downgradient. Furthermore, additional groundwater-level measurements obtained by Shaw during the Treatability Study (currently underway) corroborate the RI conclusions that Seal Creek is a losing stream. Because the creek is a losing stream and because 2011 saw substantial rainfall (and creek flow) compared to previous years, the stream may be contributing to plume shape as the stream influences groundwater flow direction near the distal end of the plume.[1] Based on MIP data, the TCE in groundwater extends approximately 725 feet northwest from the suspected primary surface release area and to a maximum depth of approximately 90 feet below ground surface (bgs) (area of monitoring well S29MW09D).

2.3.1.1 Summary of RI Risk Assessments

A BHHRA was performed to assess potential impacts to human health from exposure to chemicals in soil, soil gas, and groundwater at Site 29. Future residential (unrestricted) use,

[1]Personal communication with Dan Leigh, principal investigator for the Treatability Study being conducted by Shaw, discussing newly installed groundwater monitoring wells (April 2011).

commercial/industrial worker, and construction/utility worker scenarios were evaluated. For future residential use, cancer risk estimates exceed the 10^{-4} upper limit of the risk management range, and the HI values exceed 1.0 for all combinations (two methods and two development scenarios). The cancer risk and noncancer hazard estimates are primarily associated with arsenic from two soil sample locations beneath IA-25, TCE in soil gas, and exposure to multiple chemicals from domestic use of groundwater.

For commercial/industrial worker scenarios, the risk estimates are within the risk management range and the HIs are less than 1.0. For the construction/utility worker scenarios, the risk estimates exceed the 10^{-4} upper limit of the risk management range, and the HI values exceed 1.0 for this highly exposed receptor. Risk to future construction workers is predominantly attributable to exposure to TCE in soil gas and groundwater.

SEM/EDS analysis of soil samples confirmed that lead in soil beneath IA-25 is derived from lead-based paint. Paints typically contain other metals used for pigment, such as arsenic, cadmium, cobalt, chromium, and zinc. The RI concluded that the elevated concentrations of these other metals are also associated with paint residues. No further action under CERCLA was recommended for lead-based-paint-contaminated soil beneath IA-25. Lead-based paintrelated inorganics will be addressed under the lead-based paint program as they are not a CERCLA release. Upon transfer, the new property ownder will be responsible for ensuring lead-based paint related contamination is appropriately addressed.

Contaminants at Site 29 are generally considered unlikely to pose a hazard to ecological receptors with the exception of TCE and 1,1-dichloroethene (1,1-DCE) in soil gas and metals in soil beneath Building IA-25. Soils beneath Building IA-25 do not pose an unacceptable risk to ecological receptors if the soil and building remain unvegetated and left in place. Primary and secondary consumers (e.g., vole, meadowlark, robin, and shrew) are primarily exposed to metals through plant and soil invertebrate consumption. Soils beneath IA-25 only pose a risk to ecological receptors if the building is removed, impacted soils are left in place, and the area is naturally revegetated over those undisturbed soils. However, these conditions are not anticipated to occur because future development at the site would likely include demolition of the building, followed by demolition of the berm area and re-grading. After demolishing the building and berm area, existing surface soil would either be removed or covered with several feet of clean fill, minimizing ecological exposure to residual levels of constituents in soil

2.3.2 Summary of ISB and SVE Treatability Study Work Plan (Shaw 2011)

The purpose of the Treatability Study (Shaw 2011) is to evaluate the effectiveness of two technologies for the reduction of TCE mass in the vadose zone and shallow groundwater in the apparent source area at Site 29. Soil-vapor extraction (SVE) removes VOCs from soil by vacuuming air through the vadose zone to volatilize contaminants from the soil. The stream of air containing extracted soil vapors is then treated at the surface. ISB involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as a food source.

The ongoing Treatability Study is being conducted to evaluate the effectiveness of ISB and SVE. The scope of the Treatability Study includes injecting a bioaugmented, emulsified vegetable oil

supplemented with sodium lactate into the saturated zone (50–60 feet bgs) at 10 locations in the source area in addition to releasing hydrogen gas into the aquifer at one location.

The SVE portion of the Treatability Study involves installation of one vapor extraction well, screened between 10 and 45 feet bgs, and installation and monitoring of six new vapor monitoring wells. Groundwater and soil-vapor monitoring will be conducted over a 1-year period to determine the effectiveness of the SVE and ISB systems.

The results of the Treatability Study will be presented after monitoring events have been completed. For the purposes of this FFS, the general technologies described in the Treatability Study (Shaw 2011) are formulated into a remedial alternative for groundwater and a presumptive remedy for soil gas.

2.4 Site Characteristics

This section summarizes the regional setting and topography, land use, geology, surface water hydrology, and hydrogeology originally presented in the RI (Brady 2011).

2.4.1 Regional Setting and Topography

Former NAVWPNSTA Concord lies 10 miles west of the confluence of the Sacramento and San Joaquin Rivers. This confluence forms the Delta region, which contains more than 600 miles of interconnected and meandering tidal waterways. Drainage from former NAVWPNSTA Concord is almost exclusively to the north towards Suisun Bay (IT 1990).

Most of the western half of the inland area is characterized by gently sloping land designated as alluvial slope. Steeply sloping terrain, beginning at 100 feet above mean sea level (MSL) and rising to more than 800 feet above MSL, forms the northeast boundary of the inland area (IT 1990).

2.4.2 Current and Future Land Use

Approximately 1,000 acres of pastureland in the inland area, including the area east of the Site 29 access road, is currently leased for cattle grazing. The proposed future land use of former NAVWPNSTA Concord by the City of Concord once the base is transferred is outlined in the *Final Environmental Impact Report* (EIR) (City of Concord, 2010). During its meeting on February 23, 2010, the Concord City Council certified the Final EIR and selected the “Clustered Villages” alternative as the adopted plan for reuse (City of Concord 2010). Under the “Clustered Villages” plan, residential use is proposed for the southeast portion of the site (including the areas of Buildings IA-19 and IA-25), while parkland and commercial use is proposed to the north (Figure 2-4). The RI considered future land-use scenarios for industrial/commercial use and unrestricted use (Brady 2011).

2.4.3 Geology

Over the course of two SCAPS mobilizations during the RI, cone penetrometer test (CPT) and MIP data were acquired for 38 pushes, totaling 3,105 linear feet of CPT and MIP data. The CPT data infers that soil types vary across the study area. Clays, silts, and gravels are located in the upper 25 feet of the vadose zone, and interbedded sands, silts, and clays are located throughout the remainder of the vadose zone (approximately 25 to 45 feet bgs). CPT data for

the saturated zone infers interbedded sands, gravels, and clays to the maximum depth investigated of approximately 116 feet bgs. Lithologic logging of drill cuttings from monitoring well installation activities indicated that interbedded, gravelly sands are present in both the vadose and saturated zones, which was generally consistent with the CPT data (Brady 2011).

Distinct units, inferred to be coarse-grained strata, are observed in nearly all CPT logs. These units are distinguishable by notable peaks in cone pressure and sleeve friction. Lithologic observations made during installation of monitoring wells indicate that these high cone-pressure/sleeve-friction zones generally correlate to more coarse-grained units (sands, gravelly sands, and fine gravels). Based on this information, two-dimensional, representative cross-sections were constructed along four lines by correlating strata with high cone pressure and sleeve friction (Figures 2-5 through 2-7). The RI concluded that, in general, the coarse-grained units dip toward the north-northwest and they appear to vary in thickness and continuity, which is typical of alluvial deposits (Brady 2011).

2.4.4 Surface Water Hydrology

Site 29 lies within the Mt. Diablo/Seal Creek Watershed, which drains an area of approximately 37 square miles (Figure 2-8). This watershed is bounded to the south by the northern peak of Mt. Diablo and to the north by Suisun Bay. Streams that drain the watershed have their headwaters on the slopes of Mt. Diablo and flow via the ephemeral Mt. Diablo Creek through Clayton Valley and former NAVWPNSTA Concord to the outlet at Suisun Bay. The nearest water to the site is located at the Seal Creek (known as Mt. Diablo Creek outside the base), approximately 1,000 feet northeast of Site 29. Flow in Seal Creek along the inland area is intermittent and occurs primarily during the winter rainy season and dries out completely during the summer months (Natural Heritage Institute 2006).

2.4.5 Hydrogeology

Site 29 is located within the Clayton Valley Groundwater Basin (Figure 2-8). The beneficial uses of groundwater identified in the *Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin* (Water Board 2007) are existing municipal and potential domestic, industrial service and process, and agricultural water supplies. Depth to groundwater in the monitoring wells was measured from November 2007 through September 2009 and ranged from approximately 33 to 52 feet bgs (Brady 2011).

The RI identified that there was minor, seasonal variability over six groundwater monitoring events from November 2007 to September 2009, with only subtle increases in water levels during the February 2008 rainy season. However, the data were too limited to assess longer-term variability. In general, wells closer to Seal Creek (S29MW05 and S29MW06) appear to exhibit greater seasonal variability, which may be due to groundwater recharge from the creek during the rainy season. Overall during the period of record, water levels at the site appear to have declined approximately 1 to 3 feet. The larger water-level declines are in the wells closer to the creek (Brady 2011).

Based upon the interpreted groundwater contours from the September 2009 water-level data, groundwater flows in a northerly direction generally mimicking the topography (Figure 2-9) with a gradient of 0.01 foot per foot (ft/ft). In the pasture to the northeast in the area between wells

S29MW02 and S29MW05, the gradient is flatter and appears to be approximately 0.001 ft/ft. Groundwater flow near IA-25, where the topography is steeper, trends to the northeast with a steeper 0.04 ft/ft gradient (Brady 2011).

The RI determined that Seal Creek is a losing stream, meaning that water from the creek contributes to (recharges) groundwater. The segment of Seal Creek associated with Site 29 is ephemeral (i.e., the stream is generally dry during the summer and fall) (Brady 2011).

2.5 Conceptual Site Model

The RI identified TCE as the primary contaminant in soil, soil gas, and groundwater. During the SCAPS MIP investigation phase of the RI field effort, TCE was the predominant contaminant detected in the vadose and saturated zones. The highest observed MIP TCE response was located south of the leach field in the vadose zone at S29CP10; subsequently a monitoring well was installed near that location (Figure 2-10). In general, high MIP response was corroborated by high concentrations in fixed-base laboratory samples. MIP TCE response in general occurred mostly within the saturated zone with the exception of several locations exhibiting MIP TCE response in the vadose zone around IA-19 (e.g., S29CP06) and the leach field area. Deeper TCE response in the saturated zone was observed in most borings north of S29CP01/S29MW01 (Figure 2-10). Deeper TCE response is bounded at the northern edge of the investigation area by step-out MIP pushes where TCE was not detected at the same stratigraphic interval. Figures 2-11 through 2-13 present selected depth intervals where TCE was detected by the MIP in the vadose, shallow-saturated, and deep-saturated intervals. DCE was detected at a few locations concurrent with TCE; most were coincident with the water table with a few exceptions in the vadose zone (Brady 2011).

MIP TCE response in the vadose zone occurred primarily near Building IA-19. Shallow MIP TCE response in the vadose zone (corresponding to 6 to 20 feet above the water table) is presented in Figure 2-11. MIP TCE response in the shallow-saturated zone (2 feet above to 24 feet below the water table) had a much lower intensity than in the vadose zone and is distributed much more to the north in the downgradient direction (Figure 2-12). MIP TCE response in the deeper-saturated zone (approximately 25 to 50 feet below the water table) is less widespread and was vertically and laterally bounded by SCAPS pushes in the northern extremity of the investigation (Figure 2-13) (Brady 2011).

During the RI, soil samples were collected at the leach field beneath the leach line gravels (3 feet bgs approximately); in deep, near-water table borings (17 to 49 feet bgs respectively) co-located with soil gas samples; and in shallow soil borings (5 and 10 feet bgs respectively) also co-located with soil-gas samples. TCE was not reported above detection limits in any soil samples beneath leach field gravels. Of the shallow soil samples, TCE was reported in 6 of 15 samples. Of the deep soil samples, TCE was reported in 15 of 26 samples (please see Final RI Figure 5-12; Brady 2011).

Overall, vapor-phase VOCs (primarily TCE) are extensive in the vadose zone in the Building IA-19 area as evidenced by both field screening (on-site analysis by U.S. EPA Method 8265) and fixed-base analysis by U.S. EPA Method TO-15 (Figure 2-14). The highest detected concentrations of TCE in shallow soil gas located south of the leach field area correlate with the highest MIP TCE response in the vadose zone (Brady 2011).

TCE was the organic compound detected in groundwater most frequently and at the highest concentrations. The highest reported concentration of TCE was in a duplicate sample from S29MW01 at 8,200 micrograms per liter (µg/L) (Figure 2-15). Tetrachloroethene, also known as perchloroethene, was reported in only one sample collected from S29MW01 at an estimated concentration of 0.2 µg/L (March 2009). The only breakdown products of TCE reported above the detection limits were cis-1,2- and trans-1,2-DCE, which had concentrations ranging from about one to three orders of magnitude lower than TCE. Cis-1,2-DCE was reported in groundwater samples collected from two wells (S29MW01 and S29MW07; Figure 2-16). Trans-1,2-DCE was only reported in two samples from S29MW01. A few other VOCs were also reported sporadically across the site (mostly in S29MW01) at concentrations that were generally two to three orders of magnitude lower than TCE. These included 1,1,2-trichloroethane, 1,1-DCE, 1,2-dichloroethane, and chloroform (Brady 2011).

Dehalococcoides sp. (DHC) bacteria are known to dechlorinate chlorinated ethenes. DHC samples were collected during the RI in September 2009 from seven monitoring wells where chlorinated solvents were previously detected downgradient and within the source area at S29MW09D, -09S, -08, -07, and -06. Cell counts ranged from 0.2 to 3.2 cells per milliliter, which is well below the 1,000-cell-per-milliliter threshold considered to be the minimum DHC cell count necessary to sustain dechlorination rates (Brady 2011; Shaw 2011). Early results of the Treatability Study indicate that reductive dechlorination is now taking place, the results of which are forthcoming.

Potential groundwater-contaminant migration pathways at Site 29 are considered to be as dissolved-phase transport or adsorbed to suspended particles (clay sized). The dominant pathway is likely to be dissolved-phase transport, considering the primary contaminant type at the site (i.e., VOCs, particularly TCE).

Because the groundwater gradient flattens toward the north to northeast and as topography flattens toward the creek, the migration rate of TCE is expected to decrease with increasing distance from the area of the buildings. Attenuation factors such as dispersion and diffusion would also act to slow TCE plume migration. Natural biodegradation, which for TCE is primarily caused by reductive dechlorination facilitated by DHC bacteria, does not appear to be a significant factor at Site 29, based on the lack of significant bacterial populations and the paucity of TCE breakdown products (i.e., DCE) (Brady 2011).

Based on the site-specific geologic data obtained during the RI, the groundwater system underlying the site (to the depth investigated) is heterogeneous and consists of coarser, permeable layers (sands and gravels) interbedded with fine-grained, low-permeability layers (silts and clays) that would restrict groundwater flow. Groundwater, and therefore contaminants, would preferentially flow through the coarser-grained layers. These layers vary in thickness and continuity (Figures 2-5 through 2-7). Generally, the coarser layers in the saturated zone appear to be thicker and more continuous between S29CP31 and S29CP24 (Figure 2-5). The coarser layers appear to become thinner and more discontinuous toward the north and away from the hillside in the area of S29CP35, CP34, and CP32. In particular, at these three locations the deeper lithology exhibits a relatively thick (approximately 50-ft thick) sequence of finer-grained layers that may act to impede migration of contaminants in that direction. The shallower lithology at these three locations appears to contain some coarser-

grained layers that may have resulted in a slightly farther downgradient migration of contaminants than in the deeper layers (Brady 2011).

The RI concluded that chlorinated solvents were introduced to the subsurface primarily via surface disposal in the area between the electrical transformer and Building IA-19. This was evidenced by the highest MIP response. TCE concentrations from fixed-base soil-gas samples are located in a relatively localized area just north of building IA-19 and corroborate the MIP/DSITMS findings (Brady 2011).

VOCs likely migrated vertically downward from surface disposal areas through the vadose zone (directly as a liquid or more likely in the dissolved phase with infiltrating water) and into groundwater where preferential geologic pathways and groundwater flow facilitated migration of TCE to the north and northwest (Brady 2011).

The RI further surmised that, due primarily to varying surface topography, the depth to groundwater varies spatially across the site from approximately 33 to 52 feet bgs (2008 and 2009 measurements). Depth to groundwater at the release area was approximately 50 to 52 feet bgs. The groundwater gradient and direction also varies and is generally a subdued expression of topography. The gradient was steeper (0.04 ft/ft) with a northeast direction near the release area, becoming flatter (0.01 ft/ft) with a northerly gradient toward the north under the pasture. The gradient under the pasture to the northeast and closer to the creek is an order of magnitude flatter at approximately 0.001 ft/ft (Brady 2011).

Due to preferential pathways in coarser layers, dipping stratigraphy, and additional hydraulic influence from Seal Creek, TCE likely migrated somewhat cross-gradient[2] (Brady 2011). The variable thickness, continuity, and soil types of the alluvial deposits underlying the site indicate that the hydrogeologic conditions are heterogeneous, consisting of permeable sands and gravels interbedded with fine-grained, low-permeability layers that would restrict groundwater flow both vertically and horizontally (Brady 2011).

The RI demonstrated that dissolved-phase TCE likely followed preferential pathways (generally, more coarse-grained units) laterally and also into deeper stratigraphic layers as it migrated downgradient. The apparent cross-gradient component to the migration direction of TCE in groundwater likely is due to stratigraphic controls (Brady 2011).

Based on MIP data, TCE in groundwater extends approximately 725 feet northwest from the suspected primary surface-release area and to a maximum depth of approximately 90 feet bgs (near S29MW09D; see Figure 2-17) (Brady 2011).

[2]Personal communication with Dan Leigh, principal investigator for the Treatability Study being conducted by Shaw, discussing newly installed groundwater monitoring wells (April 2011).

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Section 3 Remedial Action Objectives

This section presents RAOs for VOC-impacted soil and groundwater at Site 29. RAOs are site-specific goals for protecting human health and the environment. The NCP stipulates that RAOs identify COCs, exposure pathways, receptors, and an acceptable chemical concentration or range of concentrations for each exposure pathway. RAOs must also comply with federal or state ARARs.

RAOs typically include either an exposure pathway or a contaminant concentration (or both) in a given media because protectiveness may be achieved in two ways: limiting or eliminating the exposure pathway or reducing contaminant concentrations (U.S. EPA 1988). Remedial alternatives that address these strategies are evaluated in this FFS. The NCP details the expectations for remedy selection in Title 40 *Code of Federal Regulations* (CFR) Part 300.430(a)(1)(iii). The RAOs for Site 29 were developed in general accordance with these expectations.

Subsequent to development of the RAOs, site-specific ARARs are identified and evaluated in this section. Proposed RGs for VOCs in soil gas and groundwater at Site 29 are also developed to satisfy the potential ARARs and together are used to formulate the RAOs.

The proposed RGs take into consideration the results of the risk assessments and allow an estimate of impacted soil and groundwater exceeding cleanup goals to be developed. The proposed RGs were developed under the premise of unrestricted use of the site. Final RGs are established for the site in the Record of Decision (ROD); however, RAOs and associated RGs are presented in the FFS to provide a basis for detailed evaluation of remedial action alternatives.

The RAOs for Site 29 are as follows:

- Prevent residential exposure to VOCs via potential inhalation of soil gas through vapor intrusion at concentrations that result in a cancer risk that exceeds the risk management range of 10^{-4} to 10^{-6} and a HI greater than 1.0.
- For burrowing mammals, reduce the inhalation hazard of TCE and 1,1-DCE in shallow soil gas to a hazard quotient of less than one.
- Prevent residential exposure to VOCs via potable use of groundwater containing concentrations that result in a cancer risk that exceeds the risk management range of 10^{-4} to 10^{-6} and a HI greater than 1.0.

3.1 Affected Media and Chemicals of Concern

The affected media are soil gas and groundwater, and the COCs are VOCs. Although metals are present in shallow soils, the RI recommended no further action under CERCLA for VOCs and metal contaminated soil.

COCs identified in the Site 29 BHHRA in groundwater are those that posed an excess cancer risk of 10^{-6} or greater for potable use of groundwater by residential or commercial receptors. VOCs in groundwater were not directly evaluated for the vapor-intrusion pathway since soil-gas data were available. However, the COCs identified from the soil gas evaluation were carried

forward to develop RGs in both soil gas and groundwater that would be protective of the vapor-intrusion pathway.

COCs for soil gas are those that posed excess cancer risk of 10^{-6} or greater via vapor intrusion for residential or commercial receptors based on modeling from soil gas (not from groundwater, because there is greater confidence in predicted indoor air concentrations via vapor intrusion from soil gas than from groundwater). There were no COCs identified on the basis of unacceptable noncancer health hazards; all COCs were carcinogens.

Based on the findings of the baseline ERA that was performed for Site 29, only two COCs in soil gas were recommended for risk management: TCE and 1,1-DCE (Brady 2011). Hazard quotients for these two VOCs were above 1.0 based on a comparison to the sitewide average concentrations (i.e., the 95% upper confidence limit on the mean) calculated for soil-gas samples collected from the extent of the burrowing mammal zone (0 to 6 feet bgs) (DTSC 1998). No other media or COCs were recommended for risk management to protect ecological receptors.

The list of COCs for soil gas and groundwater include the following:

- 1,1,2-trichloroethane (only in groundwater)
- 1,2-dichloroethane (only in groundwater)
- 1,1-DCE (only in soil gas for ecological receptors)
- benzene (groundwater and soil gas)
- chloroform (groundwater and soil gas)
- cis-1,2-DCE (only in groundwater)
- tetrachloroethene (only in groundwater)
- TCE (groundwater and soil gas)

3.2 Potential Receptors and Exposure Pathways

Future residents and construction/utility workers were the potential human receptors identified in the RI (Brady 2011). The risk calculated for these scenarios exceeded the 10^{-4} upper limit of the risk management range as well as the HI of 1.0. The primary pathways for these human receptors were identified as inhalation of soil gas and hypothetical domestic use of groundwater. Future residential developments are presumed to be supplied with potable water by the City of Concord.

VOCs in soil gas at the site also pose an inhalation exposure to burrowing animals with a hazard quotient exceeding 1.0 (Brady 2011).

3.3 Applicable or Relevant and Appropriate Requirements

Section 121(d)(1) of CERCLA (42 *United States Code* §9621[d]) states that remedial actions on CERCLA sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are

determined to be legally applicable or relevant and appropriate. The Navy identified federal ARARs and requested the state to identify ARARs. Details are presented in Appendix A.

3.4 Proposed Remediation Goals for Soil Gas and Groundwater

An RG is a chemical concentration that provides a quantitative means of identifying areas for potential remedial action, screening the types of appropriate technologies, and assessing the potential of each remedial alternative to achieve the RAOs. Proposed RGs are typically identified based on results of risk assessments, the potential beneficial uses of groundwater, and/or the ARARs analysis (Appendix A).

The methodology for deriving the site-specific proposed RGs for this FFS is discussed in greater detail in Attachment 1. Attachment 1 focuses on the methods used to develop site-specific RGs for Site 29 that are protective of human health and the environment under current and planned future land uses. Table 3-1 presents the proposed RGs based on the RI, Attachment 1, and agency-review comments on earlier versions of this report; soil-gas RGs are derived from empirical shallow soil-gas data.

3.5 Areas of Impacted Vadose Zone Soil and Groundwater

Based on site characterization during the RI, the estimated area of VOC-impacted groundwater above the proposed RGs is approximately 6 acres (Figure 3-1). The area of the VOC vapors above the proposed RGs in vadose zone soil is approximately 1 acre (Figure 3-2). For the purposes of the FFS, the area of impacted media is estimated using TCE as the primary contaminant since it is the most widespread and frequently detected.

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Section 4 Identification and Screening of Remedial Technologies

This section discusses general response actions, process options, and associated technologies potentially capable of addressing VOCs identified at Site 29. The process options identified in this section were selected based on engineering judgment, experience at similar sites, site conditions, review of available reference documents, and results of the Site 29 RI (Brady 2011). Technologies retained after the screening evaluation have been assembled into remedial alternatives and are evaluated in Section 5.

SVE will be evaluated in this FFS as the presumptive remedy for soil gas, and ISB has already been identified as a favorable groundwater process option; both are currently being evaluated in a Treatability Study (Shaw 2011). Presumptive remedies are preferred technologies chosen by the U.S. EPA that are designed to streamline the feasibility study (FS) process and reduce time and costs for remediation by using similar technologies at similar sites (U.S. EPA 1993). These two technologies will be formulated into a stand-alone alternative in Section 5. Because of the focused nature of this study, only a limited screening for additional groundwater technologies is presented in this section.

4.1 General Response Actions

General response actions (GRAs) are media-specific broad categories of remedial approaches. Some response actions may stand alone as complete remedial alternatives. However, in most cases combinations of response actions are required to effectively address site-related contamination and meet RAOs. GRAs are developed on the basis of the volumes or areas of contaminated media to which these response actions might be applied (U.S. EPA 1988). In addition, the NCP requires that “no action” alternative also be considered (40 CFR §300.430[e][6]).

The following GRAs were considered for groundwater:

- LUCs include engineering controls (ECs) and institutional controls (ICs). ECs are remedies to contain and/or reduce contamination and/or physical barriers intended to limit access to property. ECs may include fences, signs, guards, landfill caps, provision of potable water, slurry walls, sheet pile, and monitoring wells. ICs include a variety of administrative and/or legal devices to maintain the viability and effectiveness of the selected remedy and any ECs. ICs are imposed to ensure that the ECs stay in place, or where there are no ECs, to ensure a restriction on land use. ICs include affirmative and negative easements, affirmative and restrictive covenants, equitable servitudes, notices (in deeds, newspapers, etc.), zoning, permits (such as construction, excavation, well drilling, etc.), agreements with regulators, and reporting on LUC maintenance (Navy 2006).
- Monitoring of site conditions provides useful information about remediation progress.
- In situ treatment involves using in-place processes (e.g., biological, physical, thermal, or chemical) to treat impacted groundwater. Physical, thermal, or chemical processes may

also be used to break down contaminants and/or alter their properties so they can be easily extracted.

4.2 Screening of Remedial Technologies and Process Options

For each remedial technology, associated process options have been identified. Remedial technologies and associated process options were screened for effectiveness, implementability, and cost. The objective of this screening was to select appropriate process options for each technology and use the selected technologies to formulate a remedial alternative. Development and evaluation of all remedial alternatives are discussed in Section 5. Because this is a limited screening for groundwater only, engineering judgment and experience at other sites was used to select reasonable technologies for screening based on site conditions.

Screening criteria (i.e., effectiveness, implementability, and cost) were applied on the basis of their relative importance to the FS process (U.S. EPA 1988). The criterion of effectiveness was given the most weight, followed by implementability, and then cost. When two or more process options yielded comparable results, cost determined the most effective option. Factors considered for the screening criteria are provided in Table 4-1. The following are brief descriptions of these three screening criteria.

Effectiveness. This evaluation focuses on: 1) the potential effectiveness of process options in handling the area of media and in meeting remediation goals; 2) the potential impacts to human health and the environment during implementation; and 3) how proven and reliable the process is with respect to the contaminants and conditions at the site.

Implementability. Technical and administrative feasibility of operating and maintaining the remedial action alternatives are considered in assessing implementability. Technical feasibility is the ability to construct, operate, and meet regulatory expectations until the remedial action is complete, including operation and maintenance (O&M). Administrative feasibility is the ability to obtain regulatory approval, availability of storage/disposal, and availability of specific equipment and technical specialists. Implementability also includes implementation-related risks associated with specific remedial actions.

Cost. Major cost items are identified for each of the remedial alternatives. Cost items are identified on the basis of costing data, vendor information, conventional cost-estimating guides, and similar prior estimates modified to suit site-specific information.

4.2.1 Screening Results for Groundwater Remedial Technologies

Table 4-1 presents GRAs, technology types, process options, and screening comments for groundwater, in addition to those already retained for this FFS and currently being subjected to a Treatability Study (Section 4). Some are applicable to soil gas as well. The screening results for process options considered suitable for addressing groundwater in the development of remedial alternatives are the following:

- LUCs will be applicable to the property
  - ICs in the form of administrative controls (e.g., deed restrictions, building code/ordinances, and construction design requirements)
  - ECs in the form of fencing, signage, construction requirements, and maintenance of land-use restrictions
- MNA
- Groundwater recirculation for treatment of the downgradient area of the plume where injection alone is impracticable
- Zero-valent iron (ZVI) injection for rapid reduction of chlorinated VOC concentrations in groundwater

A description of the retained process options is provided below.

4.2.1.1 Land-Use Controls

LUCs are any type of physical, legal, or administrative mechanism that restricts the use of, or limits access to, real property to prevent or reduce risks to human health and the environment. LUCs are required on a property where the selected remedial action allows contamination to remain at the property above levels that allow for unlimited use and unrestricted exposure. Implementation of LUCs includes requirements for monitoring and inspections and reporting to ensure compliance.

Legal mechanisms include proprietary controls such as restrictive covenants, negative easements, equitable servitudes, lease restrictions, and deed notices. Administrative mechanisms include notices, adopted local land-use plans and ordinances, construction permitting, or other existing land-use management systems that are intended to ensure compliance with land-use restrictions. LUCs are more effective if they are layered or implemented in series. Layering means using several LUCs at the same time to enhance the protectiveness of the remedy. Implementation of LUCs in series may be applied to enhance both the short- and long-term effectiveness of the remedy. Monitoring and inspections would be conducted to ensure compliance. LUCs would limit the exposure of property users to hazardous substances and protect and maintain the integrity of the remedial action.

Conveyance to a Nonfederal Entity

The Navy has determined that it will rely on proprietary controls in the form of environmental restrictive covenants as provided in the *Memorandum of Agreement* (MOA) *between the United States Department of the Navy and the California Department of Toxic Substances Control* and attached covenant models (Navy and DTSC 2000). More specifically, land-use restrictions will be incorporated into two separate legal instruments as provided in the Navy/DTSC MOA if the property is transferred to a nonfederal entity:

- Restrictive covenants included in one or more quitclaim deeds from the Navy to the property recipient

- Restrictive covenants included in one or more "Covenant to Restrict Use of Property" entered into by the Navy and DTSC as provided in the Navy/DTSC MOA and consistent with the substantive provisions of *California Code of Regulations* Title 22, §67391.1

The "Covenant to Restrict Use of Property" would incorporate the land-use restrictions into environmental restrictive covenants that run with the land and that are enforceable by DTSC and the Navy against future transferees. The quitclaim deed would include the identical land-use restrictions in environmental restrictive covenants that run with the land and that would be enforceable by the Navy against future transferees.

According to the U.S. Department of Defense's (2003) *Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions*, the following issues relating to LUCs would be addressed in the ROD and remedial design (RD) for Site 29:

1. A description of the risk or risks that necessitate the LUCs
2. Documentation of risk exposure assumptions and reasonably anticipated land uses
3. General description of the LUCs, the logic for their selection, and related deed restrictions and notifications
4. Statement of the LUC performance objectives
5. List of the parties responsible for monitoring, reporting on, and enforcing the LUCs
6. Description of the area or property covered by the LUCs
7. Expected duration of the LUCs
8. Reference to a LUC RD for implementation actions, because these details may be adjusted periodically on the basis of site conditions and other factors

Conveyance to a Federal Entity

The LUC objectives set forth above would be incorporated into a MOA or similar agreement if Site 29 is transferred by the Navy to a federal department or agency.

Implementation and Oversight

Monitoring and inspections would be conducted to assure that the LUCs were being followed. The Navy and Federal Facility Agreement (FFA) signatories and their authorized agents, employees, contractors, and subcontractors would have the right to enter Site 29 to conduct investigations, tests, or surveys; inspect field activities; or construct, operate, and maintain any response or remedial action as required or necessary under the cleanup program. These access restrictions would be included in the deed and covenant for property conveyed to a nonfederal entity and in the MOA if the property is conveyed to a federal entity.

The Navy would address LUC implementation and maintenance actions, including periodic inspections, in the draft and final RD reports to be developed and submitted to the FFA signatories for review and concurrence pursuant to the FFA. The draft and final RD reports are primary documents under the FFA.

The preliminary and final RD reports would include a section to describe required LUC implementation and actions, including:

- Requirements for CERCLA 5-year review
- Frequency and requirements for periodic monitoring or visual inspections and reporting results from monitoring and inspections
- Notification procedures to the regulators for planned property conveyance, changes, and corrective action required for the remedy
- Development of wording for LUCs and parties to be provided copies of the deed language once it has been executed
- Identification of responsibilities for Navy, U.S. EPA, DTSC, Water Board, and other government agencies for implementing, monitoring, reporting, and enforcing LUCs
- A list of LUCs with their expected duration
- Maps identifying where LUCs are to be implemented

The Navy would be responsible for implementing, inspecting, reporting on, maintaining, and enforcing the necessary LUCs described in the ROD in accordance with the final RD report. The Navy would retain ultimate responsibility for the integrity of the remedy, although the Navy may transfer these procedural responsibilities to another party by contract, property transfer agreement, or other means. Should any of the LUCs fail, the Navy would ensure that appropriate actions were taken to reestablish protectiveness of the remedy and might initiate legal action to either compel action by a third party or to recover the Navy's costs for mitigating any LUC violations discovered.

LUCs are highly effective in the short term and moderately effective in the long term, not through actively treating contaminants, but by preventing human exposure to contaminants through signs, fences, or legal restrictions (or a combination) to prevent exposure to chemicals. LUCs are easily implemented (high implementability) at a low cost; therefore, access restrictions, land-use restrictions, and covenants to restrict use of property are all retained as viable process options.

At the time of transfer, the Finding of Suitability to Transfer (FOST) document and deed will contain a restriction that the transferee in its use and occupancy of the property including but not limited to, demolition of buildings, structures or facilities and identification and/or evaluation of any lead-based paint hazards, shall be responsible for managing lead-based paint and lead-based paint hazards in accordance with applicable federal, state, and local laws and other requirements relating to lead-based paint and lead-based paint hazards. Further, the transferee will prohibit occupancy and use of buildings and structures, or portions thereof, prior to identification and/or evaluation of any lead-based paint hazards, and abatement of any hazards identified as required.

For non-residential buildings, the transferee agrees to restrict use of buildings to non-residential use until the building is demolished. If the building or land is to be used or developed for residential use, the constituents driving risk, namely lead-based paint on surfaces or in soils, must be remediated, if necessary, and the remedy must be demonstrated to present no risk for residential use.

Should a future transferee desire to release these restrictions, they would be obliged to separately remediate lead-based paint on surfaces or in soils and petition both the Navy and US EPA/DTSC independently to obtain a release of the restriction from each party.

4.2.1.2 Monitored Natural Attenuation

Natural attenuation is a process option that relies on naturally occurring, in situ biological, chemical, or physical processes to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in groundwater. These processes may include biodegradation, dilution, dispersion, sorption, and chemical or biological transformation of contaminants. Biodegradation and chemical or biological transformations reduce the mass, toxicity, or volume of contaminants; dilution and dispersion reduce contaminant concentrations; and sorption reduces contaminant mobility. MNA is a full-scale process option with demonstrated effectiveness for VOCs. Although natural attenuation can be characterized as a passive remedy because the biological, chemical, or physical processes occur naturally without human intervention, it is not equivalent to "no action" because this process option is typically implemented in conjunction with engineering (long-term monitoring) and administrative controls. Further, implementation of a MNA remedy requires modeling to demonstrate that the naturally occurring processes can successfully meet the groundwater remedial goals.

As presented in the U.S. EPA (1999) guidance document, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites,* "In the majority of cases where monitored natural attenuation is proposed as a remedy, its use may be appropriate as one component of the total remedy, that is, either in conjunction with active remediation or as a follow-up measure." It is in this type of application that MNA is appropriate at Site 29 (U.S. EPA 1997). The maximum timeframe for MNA considered for cost development in is based on the EPA recommended maximum of 30 years (EPA 1988). Groundwater would be periodically monitored to evaluate saturated zone hydraulics and variations in VOC concentrations and, if necessary, DHC population, metals, and groundwater chemistry.

4.2.1.3 Groundwater Recirculation

Groundwater recirculation wells operate by extraction of contaminated groundwater from the aquifer (i.e., from the bottom of one well), treating the contaminated water in the well by aeration, air stripping, carbon adsorption, and/or biological treatment, and then reinjection of the treated water back into the aquifer at the same or different depths (i.e., near the water table). This generates a flow field that carries treated groundwater throughout the plume. Groundwater can be recirculated through a single well or a network of injection and extraction wells to deliver treated groundwater to the impacted areas where direct injection is not practicable or cost effective due to the size of the plume and limited radius of influence (ROI) anticipated. Groundwater recirculation can be conducted over a relatively short period of time (i.e., 4 months to 1 year).

4.2.1.4 In Situ Chemical Reduction – Zero-Valent Iron Injection

ZVI is a strong reducing agent that is capable of abiotically dehalogenating several common chlorinated solvents (e.g., TCE). ZVI powder is much more reactive than granular ZVI common to permeable reactive barriers and has the potential to quickly treat the higher

concentrations of VOCs. ZVI particles can vary in size depending on the application and site conditions, but nanoscale (less than 100 nanometers in size) to microscale (micron size) ZVI particles are used for direct-injection applications. ZVI can be delivered to the treatment zone through several proprietary methods. Because of the size and nature of the plume at Site 29, a method was considered to deploy ZVI at a greater ROI than direct injection alone can satisfy. Formation fracturing or "frac" technology is considered as a favorable method either pneumatically (air/nitrogen) or hydraulically (with a guar-based solution) to deliver ZVI to contaminants in situ. ZVI slurry or powder is fluidized and injected hydraulically or pneumatically into the target interval. These fractures promote the movement and lateral distribution of the ZVI slurry to achieve a larger ROI at a lower cost than direct injection methods.

Other ZVI delivery technologies, such as EHC® or ZVI amended with other substrates to enhance the dehalogenating bacteria population, or the use of other zero-valent metals and bimetals are viable techniques. Bench-scale testing will be necessary to determine the most suitable method.

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Section 5 Development and Screening of Remedial Alternatives

The technologies and associated process options retained after the screening evaluation, as well as those retained earlier (Section 4), were assembled into remedial alternatives that address the soil-gas and groundwater contaminants at Site 29. Many of the remedial action alternatives involve a combination of the general response actions described earlier in this FFS and represent a range of technically feasible remedial responses to address the soil-gas and groundwater contaminants. This section describes the development of potential remedial alternatives for soil gas and groundwater and summarizes the screening process for the alternatives that incorporate the factors of technical effectiveness, implementability, and cost.

5.1 Formulation of Remedial Alternatives

The Navy has considered applicable remedial action alternatives to address the persistence of VOCs at Site 29. The alternatives presented will provide risk managers a range of options to address impacted soil and groundwater at the site. The following four remedial action alternatives were considered for this FFS and are discussed in this section. Combinations of these alternatives may be considered during the ROD phase.

- Alternative 1 – No Action
- Alternative 2 – SVE with MNA
- Alternative 3 – SVE with ZVI Injection
- Alternative 4 – SVE with ISB and Groundwater Recirculation

Alternative 1 involves no engineered remediation measures, LUCs, or monitoring and is included as a baseline comparison for the other alternatives. Alternative 2 would reduce the risk from VOCs in soil gas to within the risk management range and reduce exposure to groundwater primarily through LUCs. It is anticipated that Alternatives 3 and 4 would achieve unrestricted future use for the property using a more aggressive treatment approach. These alternatives will undergo a more thorough and extensive analysis in Section 6 using the nine CERCLA criteria.

5.2 Alternative 1 – No Action

This alternative would leave VOCs present at Site 29 in their existing state, with no further remedial measures or ICs to prevent unacceptable exposure to VOCs. VOCs would not be mitigated or monitored under this alternative.

Effectiveness. Risk to human receptors posed by VOCs at Site 29 would remain. By itself, this alternative would not preclude incidental exposure. Risks associated with current site use are limited unless soils are excavated in a construction trenching or excavation scenario.

Implementability. There are no engineering measures required to implement the “no action” alternative. Site 29 is presently used as pasture land for cattle. Therefore, this alternative is considered technically feasible under the current land-use scenario.

Cost. There are no costs associated with this alternative.

Conclusion. This alternative provides a baseline for comparing other remedial alternatives. The evaluation of the "no action" alternative is required under CERCLA.

5.3 Alternative 2 – SVE with MNA

SVE would remove VOCs from the vadose zone by creating a vacuum to induce subsurface airflow through the vadose zone. The vacuum would be generated by a network of vapor extraction wells connected to a blower via the extraction wells within the treatment zone. VOC-laden soil gas would then treated in an aboveground treatment system, typically granular activated carbon (GAC) filters, to remove VOCs and discharge treated vapor effluent to the atmosphere in accordance with local emission standards and permitting. Figure 5-1 illustrates the assumed SVE treatment area and groundwater monitoring well network. A conventional power supply connected to existing power lines along Willow Pass Road was used as the means for estimating costs for all remedial alternatives in this FFS.

MNA is an enhanced monitoring program that assesses natural subsurface processes (e.g., dispersion, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials) to verify that these processes continue to reduce contaminant concentrations to acceptable levels. VOCs may be attenuated by adsorption or degraded to less toxic compounds by volatilization, biodegradation, and oxidation/reduction reactions, in addition to other physical attenuation processes. Together with chemical analytical testing, MNA can include modeling, periodic testing of groundwater for pH, oxidation-reduction potential, methane, iron, nitrate, sulfate, sulfide, and other selected indicators of chemical or biological processes. Source removal or source control also should be considered in conjunction with MNA. Both institutional and engineering LUCs would be used to restrict use of groundwater for domestic supply and to implement possible building code requirements for structures built over the soil-vapor plume.

MNA is generally applied as a stand-alone technology when it can be used in a reasonable and predictable time frame, relative to other remedial options, to restore an aquifer to its designated beneficial uses (U.S. EPA 1999).

Effectiveness. SVE is expected to be effective at reducing concentrations of VOCs in soil gas. Risk to human receptors posed by VOCs at Site 29 would be reduced by mass removal of VOCs in the vadose zone and, to a lesser degree, groundwater. Site conditions, as demonstrated by the lack of breakdown products and low bacterial population, are not considered to be conductive to natural attenuation processes. Implementation of SVE alone would reduce risk of exposure via the inhalation pathway; LUCs would be effective in reducing risk to residential receptors via domestic use of groundwater.

Implementability. SVE is considered implementable given the site conditions. The electrical source needed to power the SVE system is accessible along Willow Pass Road. MNA is highly implementable with minor additions to the existing network. Installation of wells screened at deep and shallow intervals would add greater data resolution at the distal end of the plume. Site 29 is presently used as pasture land for cattle. Therefore, this alternative is considered technically feasible under the current land-use scenario.

Cost. Costs for this alternative would include SVE installation, permitting, O&M, periodic sampling to measure effectiveness, post-treatment sampling and reporting, and LUCs. Potential capital costs associated with MNA are low. However, O&M costs could be high, depending on the duration required. The cost of MNA is therefore dependent upon its duration and effectiveness.

Conclusion. This alternative is considered a viable remedy to reduce risk to current and future receptors. Alternative 2 is expected to meet RAOs for the vadose zone only and reduces groundwater exposure risk through LUCs. A combination of this alternative with another groundwater alternative may be considered in the ROD. Alternative 2 is retained for detailed analysis.

5.4 Alternative 3 – SVE with ZVI Injection

Similar to Alternative 2, SVE would be the primary technology used to treat VOCs in the vadose zone. In addition to SVE, groundwater treatment would be conducted by ZVI injection. ZVI is a strong reducing agent that is injected (in solution) into contaminated groundwater to reduce VOC concentrations. ZVI particles can vary in size depending on the application and site conditions; nanoscale (less than 100 nanometers in size) to microscale (micron size) ZVI particles are typically used for direct-injection applications. ZVI is mixed at the surface into a solution or slurry and injected directly into contaminated zones. Chlorinated VOCs are degraded by reductive degradation via hydrogenolysis or beta elimination reactions. Beta elimination degrades TCE without producing the intermediate products DCE and VC (Cook 2009). ZVI injection slurry, when combined with bacteria-amended substrate, may provide a much greater net effect. Conventional ZVI (without any bioaugmented substrate) was considered for the cost basis of this FFS.

Pneumatic or hydraulic fracturing serves to greatly increase the ROI over conventional direct injection. Special care must be taken during injection so as to not cause unintended dispersal of groundwater contaminants. Depending on the geologic formation and based on vendor-observed outcomes, fracturing can generate a large ROI (30 feet). Given the variable stratigraphy at the site, a more conservative ROI of 17 feet was considered. Pilot testing would be necessary to determine the site-specific ROI since it can vary greatly depending on the soil type and transmissivity of the formation. The current well network may be sufficient for pilot testing purposes. Figure 5-2 illustrates the assumed treatment area and groundwater monitoring well network.

LUCs, such as fencing, signage, and short-term land-use restrictions, would be implemented over the duration of SVE and groundwater treatment until RAOs are met. This alternative would be effective in reducing VOCs in soil gas and groundwater such that unrestricted use could be achieved.

Alternately, if the groundwater plume is not responding to treatment within the proposed timeframe for the alternative, then additional active remedial alternatives may be considered. Further refinement of this alternative would be performed during RD/remedial optimization.

Effectiveness. ZVI is highly effective in treating dissolved-phase VOCs. ZVI is expected to significantly reduce contaminant mass. Risk to human receptors posed by VOCs at Site 29 would be reduced by mass removal of VOCs in soil gas via SVE and reduction of VOCs in

groundwater by ZVI treatment. This alternative by itself would reduce risk of exposure via the inhalation pathway and domestic use of groundwater.

Implementability. Alternative 3 is considered implementable given the site conditions. ZVI slurry is easy to inject; however, careful handling and delivery must be performed as agglomeration of the slurry can impede even distribution in groundwater. Site 29 is presently used as pasture land for cattle. Therefore, this alternative is considered technically feasible under the current land-use scenario.

Cost. Costs for SVE implementation in this alternative are similar to SVE in other alternatives. ZVI-specific costs include bench-scale testing, injection, installation of additional monitoring wells to conduct periodic sampling to measure effectiveness, post-treatment sampling and reporting, and LUCs. Additional ZVI injections may be necessary, but were not assumed in the cost development for this FFS.

Conclusion. This alternative is considered a viable remedy to reduce risk to current and future receptors. Alternative 3 is expected to meet RAOs for the vadose zone and groundwater through removal and destruction of VOCs. A combination of this alternative with another groundwater alternative may be considered in the ROD. Alternative 3 is retained for detailed analysis.

5.5 Alternative 4 – SVE with ISB and Groundwater Recirculation

This alternative involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as an electron acceptor in a process called chlororespiration. TCE will biodegrade to nontoxic ethene under highly reducing conditions. The reducing conditions required to facilitate chlororespiration may be created in situ by the addition of a biodegradable organic substrate (e.g., lactate, molasses, or vegetable oils) in conjunction with a dechlorinating bacteria culture. This can result in bioreduction of TCE in the source area and thereby reduce the toxicity of the plume.

The ISB treatment entails injecting a vegetable-oil emulsion or like substance and a dechlorinating bioaugmentation culture into the source area at a prescribed injection spacing to achieve the desired ROI in the treatment area and to target low-permeability zones. An oil emulsion is used as a biodegradable substrate that will enhance degradation of the chlorinated VOCs. Microbes will use the oil emulsion as a carbon source for growth. Fermentation of the oil will result in the release of molecular hydrogen (H_2). Hydrogen is used as an electron donor and chlorinated ethenes are used as an electron acceptor by dechlorinating bacteria in a biologically mediated oxidation-reduction reaction that generates energy for their life processes. During this process, the dechlorinating microbes replace the chlorine atom on the chlorinated compound with a hydrogen atom, thereby converting the relatively oxidized TCE to a more reduced compound, DCE. This process of reductive dechlorination sequentially reduces toxic TCE to nontoxic, nonchlorinated ethene (Shaw 2011).

Depending on the outcome of the Treatability Study, alternate injection formulas may be viable (e.g., lactate or lactoil, biogeochemical augmentation, or reducing agents [as discussed in Alternative 3]) to treat the immediate source area. If injected substrate alone is inadequate in reducing chlorinated ethene concentrations, groundwater will be amended to enhance the

biogeochemical degradation processes. Similar to bioaugmentation, biogeochemical amendment would be conveyed through direct injection or a groundwater recirculation system. As an option to consider, a substrate solution consisting of a soluble organic substrate (e.g., lactate/lactoil) and water amended with a sulfate source (e.g., magnesium sulfate) and a soluble iron source would be introduced through injection or recirculation. Further refinement of the injection media and recirculation cells would be performed during the full-scale RD/remedial optimization.

Because the size of the plume is large and the expected ROI for injections is low (approximately 7 feet based on the Treatability Study [Shaw 2011]), treatment of the lower-concentration downgradient margin of the plume will be facilitated by a groundwater recirculation system with a network of injection and extraction wells. Groundwater will be sequestered into upgradient, central, and downgradient recirculation zones so as not to mix source-area groundwater with lower-concentration groundwater. Because the native DHC population is insufficient in sustaining reductive dechlorination, groundwater would be amended with a bacterial culture and substrate such as lactate at a prescribed rate (i.e., once every 3 hours, for 1/2 hour) during recirculation (Figure 5-3). Special care must be taken during injection and recirculation to avoid unintended dispersal of groundwater contaminants.

LUCs, such as fencing, signage, and short-term land-use restrictions, would be implemented over the duration of SVE and groundwater treatment until RAOs are met. This alternative would be effective in reducing VOCs in soil gas and groundwater such that unrestricted use could be achieved.

Effectiveness. SVE combined with ISB is expected to be highly effective at reducing concentrations of VOCs in soil gas and groundwater if groundwater conditions are maintained at favorable levels for bioaugmentation. Risk to human receptors posed by VOCs at Site 29 would be reduced by mass removal of VOCs in soil gas via SVE and reductive dechlorination of VOCs to inert ethene in groundwater. This alternative by itself would reduce risk of exposure via the inhalation pathway and domestic use of groundwater.

Implementability. ISB is considered implementable given the current site conditions. Site 29 is presently used as pasture land for cattle. In the absence of additional hydrogeologic data, there is some uncertainty in design of the groundwater recirculation system. The design presented in this FFS is based on professional judgment and limited hydrogeologic data obtained during the Treatability Study (Shaw 2011). Therefore, this alternative is considered technically feasible under the current land-use scenario.

Cost. Costs for this alternative are similar to the other alternatives with respect to SVE. ISB-specific costs would include microbial culture, oil emulsion, drilling costs for injection and installation of additional monitoring wells to measure treatment effectiveness, O&M of wells, periodic sampling to measure effectiveness, post-treatment sampling and reporting, and LUCs. Additional ISB injections may be necessary but were not assumed in the cost development for this FFS.

Conclusion. This alternative is considered a viable remedy to reduce risk to current and future receptors. Alternative 4 is expected to meet RAOs for soil gas and groundwater. A combination of this alternative with another groundwater alternative may be considered in the ROD. Alternative 4 is retained for detailed analysis.

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Section 6 Detailed Analysis of Remedial Alternatives

This section provides a description and detailed analysis of each of the remedial alternatives for Site 29 that have been retained following the initial screening in Section 5. Section 6.1 summarizes the criteria used to assess the retained remedial alternatives as specified in the NCP. Sections 6.2 through 6.5 describe the evaluation conducted on each of the retained remedial alternatives. The detailed analysis assesses these alternatives against seven of the nine evaluation criteria defined in the NCP. Collectively, these nine evaluation criteria address CERCLA requirements and technical and policy considerations important in the selection of remedial alternatives.

6.1 Review of CERCLA Criteria

Detailed analyses of remedial action alternatives provide decision makers with relevant information to adequately compare the alternatives, select a remedy, and demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD. Each remedial alternative considered for detailed analysis in this section was assessed against the following requirements under CERCLA:

- Protection of human health and the environment
- Compliance with ARARs, unless a waiver is justified in the ROD
- Cost effectiveness
- Use of permanent solutions, treatment technologies, or resource recovery technologies to the maximum extent practicable
- Satisfying the preference for treatment as a principal element, or providing an explanation in the ROD as to why the preference was not met

To satisfy these requirements, each remedial action alternative was evaluated against the following criteria defined in the NCP at 40 CFR §300.430(e)(q)(iii):

- Threshold criteria
  - Overall protection of the environment
  - Compliance with ARARs
- Primary balancing criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility, or volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost

As mentioned previously, the following two modifying criteria are briefly discussed in this FFS. These criteria will be evaluated in consideration of regulatory comments received on this FFS and on public comments on the preferred remedial alternative to be presented in the Proposed Plan:

- State acceptance
- Community acceptance

The following subsections describe each of these nine criteria as they relate to the detailed analyses of the remedial action alternatives being considered herein for Site 29.

6.1.1 Overall Protection of Human Health and the Environment

This criterion assesses the extent to which an alternative protects human health and the environment, considering site characteristics and expected risk reduction. Evaluation of the overall protection of human health and the environment afforded by each remedial alternative draws on assessments made under several other NCP criteria, especially short-term effectiveness, long-term effectiveness and permanence, and compliance with ARARs.

The following issues are addressed for each alternative under this criterion:

- Reduction in risk to human health and the environment
- Ability to achieve RAOs for Site 29

6.1.2 Compliance with ARARs

This criterion examines whether an alternative would comply with ARARs as defined by CERCLA § 121 and identified in Appendix A. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA should be discussed.

6.1.3 Long-Term Effectiveness and Permanence

This criterion examines the impact of a remedial alternative in the long term, defined in U.S. EPA (1988) guidance as the time after RAOs are met. Evaluation of a remedial alternative relative to its long-term effectiveness and permanence is made considering the following four factors:

- Magnitude of the residual risk to human and environmental receptors from remaining affected groundwater and soil gas at the completion of remedial activities
- Type, degree, and adequacy of long-term management (including engineering controls, monitoring, and O&M) required for affected groundwater and soil gas remaining at the site
- Long-term reliability of ECs and/or ICs to provide continued protection to human and environmental receptors from affected groundwater and soil gas
- Potential need to replace components of the remedy and continuing need for repairs or maintenance

6.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

According to CERCLA, preferred cleanup alternatives use technologies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances compared to baseline (i.e., pre-cleanup) levels (i.e., compared to the "no action" alternative). This means using treatment technologies that accomplish one or more of the following:

- Reduce the exposure to contaminated soil gas and groundwater
- Reduce the mobility of contaminated soil gas and groundwater
- Immobilize or remove contaminants in the subsurface
- Reduce the total mass of contaminants in the subsurface
- Reduce the volume of contaminant-impacted soil gas and groundwater
- Irreversibly reduce contaminant mobility

Alternatives that do not use treatment technologies to achieve these goals do not significantly reduce the toxicity, mobility, or volume of contaminants. An exception is when RCRA-hazardous soil is treated prior to off-site disposal to meet land disposal restrictions, thereby reducing the toxicity and mobility of the contaminants.

Evaluation of the remedial alternatives for reduction of toxicity, mobility, or volume considers the following:

- Treatment processes
- Amount of hazardous materials that would be destroyed or treated, including how principal threats would be addressed
- Degree of expected reduction in toxicity, mobility, or volume measured as a percentage of baseline levels
- Degree to which the treatment is irreversible
- Type and quantity of treatment residuals

6.1.5 Short-Term Effectiveness

This criterion considers how an alternative affects human health and the environment during cleanup (i.e., the short term). "Short term" is defined as the time required to plan, design, construct, and operate a system of cleanup until RAOs are achieved (U.S. EPA 1988). The following four factors are considered:

- Short-term risks that might be posed to the surrounding community
- Potential impacts on workers during construction and O&M as well as the effectiveness and reliability of the protective measures that would be taken

- Potential environmental impacts of the remedial action (Section 6.1.10) and the effectiveness and reliability of mitigation measures that would be taken during implementation
- Time required before RAOs are achieved (i.e., short-term duration)

6.1.6 Implementability

This criterion evaluates the technical and administrative feasibility of an alternative. The availability of required equipment, materials, and services is also considered. When implementability is assessed, the following factors are considered:

- Technical feasibility, that is, the relative ease of implementing or completing an action based on site-specific constraints, including the use of established technologies such as:
  - Constructability of components necessary for the alternative
  - Operational reliability or the likelihood that a technology would meet specified efficiency levels or performance goals
  - Ability of the owner to undertake future remedial actions that may be required and the difficulty of implementing such actions
  - Ability of the owner to monitor the effectiveness of the remedy
- Administrative feasibility, including the ability (as well as the time) required to obtain approvals from government regulatory agencies or other government entities
- Availability of services and materials required to implement the alternative, such as:
  - Manufacturers of treatment media (ZVI or ISB)
  - Equipment (e.g., injection equipment capable of achieving target depths) and specialists
  - Time needed to develop new or innovative technologies; time required for bench-scale and pilot-scale tests
  - Potential for obtaining competitive bids, a factor that may be particularly important for innovative technologies

6.1.7 Cost

A cost estimate is presented for each remedial alternative based on prior investigative data using procedures outlined in U.S. EPA (1987, 1988, 2000) guidance. These cost estimates are based on the engineering concepts presented in this FFS. All cost estimates are presented in January 2011 dollars and were compiled using Remedial Action Cost Engineering and Requirements software (RACER) Version 10.3 (dated December 2009). The costs are order-of-magnitude estimates intended for comparison of the alternatives presented in this FFS and are subject to change during actual RD. Appendix B presents additional cost details and assumptions.

The following costs were calculated for each alternative:

- Capital costs are those costs initially incurred to build or install the remedial action (e.g., construction of a SVE system and related site work).
- O&M costs are post-construction costs necessary to ensure or verify the continued effectiveness of a remedial action (e.g., treatment system repair and replacement, soil-gas and groundwater monitoring as well as associated professional/technical labor services).
- Periodic costs are those costs which occur only once every few years (e.g., 5-year reviews, well redevelopment, and equipment replacement) or expenditures that occur only once during the entire remedial time frame (e.g., site closeout, remedy failure/replacement) (U.S. EPA 2000). These costs may be either capital or O&M.
- Total costs are estimates consisting of capital costs, O&M costs, and periodic costs. In addition, total costs include prime contractor markups, subcontractor markups, prime contractor markups on subcontractors, contingency costs, and owner costs for implementation of the alternative.
- Present value is the amount of money that, if invested in the initial year of the remedial action at a given interest rate and disbursed as needed, would be sufficient to cover all costs associated with the alternative.

6.1.8 State Acceptance

This criterion evaluates the remedial alternatives with respect to the concerns of state agencies. The State of California will review and comment on this FFS. Responses to agency comments will be included in the draft final and final versions of this FFS, which will be modified as appropriate. State comments will also be considered in finalizing the proposed plan and ROD. The criterion of state acceptance is briefly assessed in Sections 6 and 7.

6.1.9 Community Acceptance

Community concerns regarding each remedial alternative are assessed under this criterion. Comments will be solicited from community members during the public review period for this FFS. These comments will be considered in the remedy selection process. A summary of public comments and responses will be included in the ROD. Although community acceptance will be evaluated after the public comment period for the proposed plan, this criterion is briefly assessed in Sections 6 and 7.

6.1.10 Sustainability Considerations

As an additional factor in the short-term effectiveness CERCLA criterion, a comparative analysis of the sustainability of Alternatives 2, 3, and 4 is also included. U.S. EPA (2010) currently defines “green” remediation as “the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions.” U.S. EPA (2009) guidance regarding green remediation is provided in the document entitled *Principles for Greener Cleanups*. DTSC (2009) guidance also describes the importance of considering sustainability in addition to the nine CERCLA criteria.

Green and sustainable remediation must still meet threshold requirements for protectiveness, NCP requirements, and other site-specific cleanup objectives (e.g., the nine criteria discussed above). Thus, green and sustainable remediation is intended to decrease the environmental footprint of the cleanup action, rather than trade cleanup objectives for other environmental objectives. Sustainability strategies are integrated into the remedy where feasible, consistent with U.S. EPA (2010) guidance.

An assessment of the sustainability of each of the active alternatives (Alternatives 2, 3, and 4) was conducted for this FFS. The sustainability assessment utilized a green and sustainable remediation evaluation tool known as SiteWise™, which was developed jointly in 2010 by the United States Army Corps of Engineers and Navy to support green and sustainable remediation assessments by calculating the environmental footprint for various metrics. Inputs to SiteWise™ are broken down into four phases of work: RI, remedial action construction, remedial action operation, and long-term monitoring. Within each work phase the inputs are further divided into categories including material production, transportation, equipment use, and residual handling. Detailed inputs to SiteWise™ include vehicle miles for personnel and equipment; construction details for new or existing wells; residual handling of wastes; volume of groundwater pumped; equipment (other than excavators and drill rigs) operated for each alternative including type of fuel used; electrical pumps/motors used, duration, and horsepower or hydraulic head for each; and additional materials used. The eight sustainability factors modeled include greenhouse gas emissions, total energy used, water impacts, oxides of nitrogen (NO_X) emissions, oxides of sulfur (SO_X) emissions, particulate (<10 micrometers in diameter) (PM_{10}) emissions, accident risk (fatality), and accident risk (injury).

For the purposes of this evaluation, standard equipment was assumed with conventional fuels (diesel or gasoline), with no particulate filters fitted to diesel-powered machinery. Local travel to and from the site was assumed for each of the four phases of work. The sustainability assessment model outputs from SiteWise™ for Alternatives 2, 3, and 4 are included in Appendix C. They include a comparative assessment of each of the sustainability factors and calculated values for each of the sustainability categories.

6.2 Alternative 1 – No Action

Per the NCP (40 CFR §300.430[e][6]), this alternative must be evaluated in the same manner as the other remedial alternatives considered in this FFS.

The “no action” alternative provides a baseline against which other remedial alternatives are compared. Alternative 1 involves no engineered remediation measures, administrative controls, ICs, or monitoring for impacted soil gas and groundwater at Site 29. This alternative would not include any activities to prevent potentially unacceptable exposure to VOCs in soil gas or groundwater. If implemented, this alternative would be considered a final remedy for the site. No monitoring or periodic reviews would be conducted to verify the protectiveness of this alternative.

6.2.1 Evaluation by Threshold Criteria

The following subsections compare Alternative 1 against the threshold criteria of the NCP.

6.2.1.1 Overall Protection of Human Health and the Environment

Alternative 1 is not considered protective of human health and the environment. This alternative has no mechanisms to prevent unacceptable exposure to VOC vapors in soil gas or dissolved-phase VOCs in groundwater. Potential impacts of this alternative could include inhalation of vapors by burrowing mammals or by human receptors (should structures be built over the source area) or domestic use of groundwater.

6.2.1.2 Compliance with ARARs

ARARs do not apply to the "no action" alternative; according to CERCLA § 121, the requirement to meet ARARs applies only when a response action is taken. This alternative involves no steps to prevent access to, reduce, remove, contain, or treat soil gas and groundwater. This alternative would provide no additional protection to human health or the environment if exposure routes should develop.

6.2.2 Evaluation by Balancing Criteria

The following subsections compare the "no action" alternative against the balancing criteria of the NCP.

6.2.2.1 Long-Term Effectiveness and Permanence

Alternative 1 is not considered effective. Concentrations of VOCs above the proposed RGs would remain, with no controls to prevent unacceptable exposure. This alternative requires no maintenance, long-term management, or other action. There would be no remedial measures implemented under or long-term effectiveness and permanence associated with Alternative 1. Although site access restrictions are currently in place to reduce the potential for human exposure to impacted soil gas, there would be no means to restrict future exposure under unrestricted land use or reduce exposure to burrowing mammals.

6.2.2.2 Reduction of Toxicity, Mobility, or Volume through Treatment

No active treatment would be performed for Alternative 1. VOCs do attenuate over time, however concentrations in soil gas and groundwater would be expected to persist above the proposed RG over the timeframe (30 years [U.S. EPA 1988]) selected as the comparison metric for this FFS. No treatment processes would be used to reduce toxicity, mobility, or volume of impacted soil gas or groundwater for Alternative 1.

6.2.2.3 Short-Term Effectiveness

Because Alternative 1 would not involve any active measures such as construction or other intrusive activities, the proposed RGs and RAOs would not be met. There would be no adverse short-term impacts to site workers, surrounding land uses, or the environment associated with this alternative. Because there are no remedial measures designed to address the RAOs or any measures such as ICs or monitoring to assess effectiveness, the time required to achieve proposed RGs cannot be assessed.

6.2.2.4 Implementability

Alternative 1 would be easy to implement because it requires no action. However, no measures would be included to monitor the effectiveness of the remedy.

6.2.2.5 Cost

There are no direct costs associated with this alternative.

6.3 Alternative 2 – SVE with MNA

Alternative 2 would involve installation of SVE wells to extract VOCs from the vadose zone and treat them ex situ before releasing to the atmosphere. Additionally, four additional groundwater monitoring wells (two water table wells, two deep wells) would be installed at the projected terminus of the groundwater plume. Components of Alternative 2 are described below.

6.3.1 Description

Alternative 2 consists of the following primary components

- Remedial design
- Installation of 25 SVE wells to a depth of 40 feet
- Installation of 20 vapor monitoring wells
- Installation of approximately ¼-mile power line connection to power the SVE system
- O&M of the SVE system
- Installation of four groundwater monitoring wells (two at 60 and two at 80 feet bgs). Wells would be screened across the water table and at a deeper hydrogeologic interval similar to that of S29MW09D.
- SVE performance monitoring for VOCs
- Groundwater monitoring of VOCs, DHC, and MNA parameters as follows:
  - Quarterly – Years 1 and 2
  - Semiannually – Years 3 and 4
  - Annually – Year 5
  - Annually – Years 6 through 30 (analytical suite is subject to be reduced to a shortened list of analytes, but presumed for costing purposes to be the full suite of VOCs, DHC, and MNA parameters)
- Reporting and periodic reviews
- Preparation of an interim Remedial Action Closure Report (iRACR) for soil gas
- Preparation of a final Remedial Action Closure Report (RACR) after satisfaction of the RAOs

- System decommissioning

Alternative 2 is considered a long-term remedial alternative, as such the maximum recommended duration was selected as the cost comparison metric (U.S. EPA 1988). The assumed duration of this alternative is 30 years, including post-remediation performance monitoring. Soil-gas sampling would be discontinued once the Navy and regulatory agencies agree that the effectiveness of the SVE remedy has been verified *and* vadose zone VOCs at Site 29 no longer present an unacceptable risk to human health and the environment, or the mass removal rate is approaching asymptotic levels after temporary shutdown periods and appropriate optimization of the SVE system. Based on typical operation time for SVE systems, soil heterogeneity, and contaminant concentrations, it is assumed that the SVE system will be operational for a period of 5 years (FRTR 2002). MNA will proceed until the plume degrades to RAO levels and/or regulatory agencies agree that no further monitoring is required, until the plume is stable, or until the groundwater beneath Site 29 is de-designated as a beneficial-use aquifer. Figure 5-1 illustrates the assumed SVE treatment area and groundwater monitoring well network.

6.3.1.1 SVE System Construction and O&M

Under this and all alternatives where SVE is the soil-gas remedy, SVE wells would be installed over a 1-acre area immediately adjacent to Building IA-19 and the roadway/pasture area. Although the detailed design of the SVE system would be developed during the RD phase, it is expected that the system would consist of a series of air extraction and inlet wells constructed to a depth of approximately 40 feet bgs, with 30-foot screens. Wells would be connected to a vacuum extraction and treatment system through a network of manifolds and valves to allow flexibility of operation. The SVE system should consist of a network of vapor monitoring probes to monitor system effectiveness and in situ conditions and monitoring ports to allow monitoring of extracted vapor.

Because effluent from the SVE system would likely contain chlorinated VOCs, the system may need to comply with Bay Area Air Quality Management District requirements. Off-gas from the system would likely need to be treated before discharging to the atmosphere. Among the technologies that could be deployed to achieve treatment, aboveground equipment may include a vapor-liquid separator (known as a liquid knockout tank) to collect condensate. To address the vapor-phase effluent, the tank will be connected to the vacuum pump/blower and a vapor treatment system consisting of GAC units designed for the removal of chlorinated solvents from the extracted soil gas. Spent carbon would be regenerated (either on site or off site) for reuse or disposed of offsite.

Baseline, step-, and constant-rate testing would be conducted to determine optimal performance. Routine SVE O&M may consist of weekly site visits including GAC change-outs and system performance monitoring.

6.3.1.2 Monitored Natural Attenuation

Under this alternative, MNA of the groundwater plume would consist of installation of up to four additional groundwater monitoring wells installed to similar depths as S29MW09S and S29MW09D (60 and 80 feet bgs, respectively) at the projected terminus of the plume.
The remaining well network should be sufficient to conduct annual MNA during the 30-year timeframe for this alternative component.

6.3.1.3 LUCs

Under Alternative 2, LUCs have been assumed for the purpose of this FFS; however, the actual ICs and ECs to be implemented would be established in the RD/remedial action documentation. ICs would be tailored toward future uses of the property, which is anticipated to be residential, commercial, and open space.

For Alternative 2, the IC objectives are assumed to include the following:

- Prohibit future domestic use of groundwater.
- Prohibit alteration, disturbance, or removal of remedy components (e.g., monitoring wells, SVE system components, and signage) and any activities that would jeopardize the integrity of the remedy without prior review and written approval from the regulatory agencies.
- Allow future access for monitoring, inspections, and maintenance of remedy components to ensure continued effectiveness of the remedy.

ECs in the form of fencing and signage would remain in place until the SVE system was deconstructed. Additional ECs may require construction of vapor barriers protective of building occupants, should structures be built over the vapor plume. Signage would remain in place indefinitely to notify persons of active groundwater monitoring wells, restrictions against tampering, and hazards associated with domestic use of groundwater.

6.3.1.4 5-Year Reviews and Reporting

The purpose of 5-year reviews is to evaluate whether a remedy that has been implemented at a site remains protective of human health and the environment. The methods used in assessing the implementation and performance of the selected remedy as well as the findings and conclusions of these evaluations are documented in 5-year review reports.

A 5-year review report provides a clear statement as to whether the selected remedy is being protective or if it is expected to become protective sometime in the future. In the event a 5-year review finds deficiencies to exist in remedy implementation or in the performance of the remedy itself that could lead to non-protectiveness of human health and the environment, the 5-year review report would identify such issues and provide recommendations as to how these issues can be resolved. Similarly, if the 5-year review finds that assumptions, regulatory requirements, and/or analytical methods used to establish cleanup goals for the COCs at the time of selecting and implementing the remedy have changed during the 5 years covered by the review, which could lead to non-protectiveness of human health and the environment, then the 5-year review would identify such changes and provide recommendations as to how to address such issues. As such, the 5-year review report would contain recommendations of specific actions that would provide the means for the remedy to become or to continue being protective.

An RD document for the SVE system and groundwater monitoring program would be prepared, in addition to a LUC RD. An iRACR would be prepared, documenting the completion of the SVE system installation and implementation of LUCs.

In addition, after every groundwater monitoring event, a summary report of the results of that monitoring event would be prepared. A duration of 30 years is assumed for costing purposes

for this alternative. Six 5-year reviews are assumed to be conducted as required under CERCLA and NCP requirements. At the completion of SVE and groundwater RAOs, a final RACR would be prepared. All reports would be submitted to the appropriate regulatory agencies.

6.3.2 Evaluation by Threshold Criteria

The following subsections compare Alternative 2 against the threshold criteria of the NCP.

6.3.2.1 Overall Protection of Human Health and the Environment

Alternative 2 is considered protective of human health and the environment. The SVE system would effectively remove VOCs from vadose zone soils and would remove a limited mass of VOCs from groundwater. Restriction of groundwater for domestic use through LUCs would be considered protective of human health and the environment. As documented in the RI, Seal Creek is a losing stream (groundwater does not contribute to Seal Creek); therefore, there are no ecological receptors impacted by site groundwater. Annual groundwater monitoring and 5-year reviews would provide information to evaluate remedy effectiveness and support future remedial action decisions.

6.3.2.2 Compliance with ARARs

Alternative 2 is expected to meet potential chemical-, location-, and action-specific ARARs. A detailed analysis of potential ARARs associated with remedial action at Site 29 is provided in Appendix A.

6.3.3 Evaluation by Balancing Criteria

The following subsections compare Alternative 2 against the balancing criteria of the NCP.

6.3.3.1 Long-Term Effectiveness and Permanence

For Alternative 2, all accessible vadose zone soil with VOC concentrations exceeding the proposed RGs would be treated to achieve RAOs. VOC mass in groundwater may be slightly reduced by SVE. Alternative 2 would require annual groundwater monitoring, LUC inspections, and annual reports. LUCs would be implemented to prohibit potable use of groundwater and to prohibit actions that could damage remedy components. Groundwater monitoring for MNA would be implemented using a monitoring plan, which may be updated as needed.

6.3.3.2 Reduction of Toxicity, Mobility, or Volume through Treatment

Treatment and LUCs are the primary components of Alternative 2. SVE would provide irreversible chemical reduction of vadose zone VOCs in the area treated. No treatment would occur for groundwater. There is no active treatment process associated with Alternative 2 that would reduce the toxicity, mobility, or volume of VOCs in groundwater.

6.3.3.3 Short-Term Effectiveness

Alternative 2 would involve vehicle travel through a relatively undeveloped area for SVE system setup, O&M, groundwater monitoring, and LUC inspections. Construction and operation of the SVE system may disrupt wildlife for the duration of the remedy, intermittently for approximately 5 years.

Personal protective equipment (PPE) and standard chemical handling procedures are assumed to sufficiently mitigate threats posed to workers during SVE installation, O&M, and groundwater monitoring. Some risk is inherent with SVE and groundwater monitoring well installation.

Fugitive emissions from the SVE system are anticipated during the course of operation; however, adherence to Bay Area Air Quality Management District permit provisions would be strictly followed. Because the site is situated in an open pasture, the impacts of SVE emissions on the surrounding community are considered negligible. The estimated time to reach preliminary RGs in soil gas is 5 years. Implementation of this alternative would not be expected to have potential adverse effects on the surrounding community or the environment.

6.3.3.4 Implementability

The equipment and materials are anticipated to be readily available. Because power to the inland area has been decommissioned and solar power may be cost prohibitive, electrical power to the SVE system can be supplied from an on-site generator or supplied from existing power lines along Willow Pass Road, approximately ¼ mile from the site. Periodic groundwater sampling is a routine and common activity and should not be incompatible with the current and anticipated site use. Access to monitoring wells would need to be maintained to allow for sampling. Administrative activities would entail managing treatment activities and groundwater monitoring.

6.3.3.5 Cost

The present-value cost for Alternative 2 is approximately $11.1 million (Table 6-1). Major cost components for this alternative are associated with installation of the power line, O&M, performance monitoring of the SVE system, and long-term groundwater monitoring for MNA. Appendix B provides supporting details and costing assumptions.

6.4 Alternative 3 – SVE with ZVI Injection

In addition to the same SVE components mentioned above in Alternative 2, Alternative 3 would involve injecting ZVI into the saturated zone to rapidly reduce chlorinated VOCs. Similar to Alternative 2, this alternative would require installation of up to four additional groundwater monitoring wells to measure performance of the ZVI treatment of the plume. Components of Alternative 3 are described below.

6.4.1 Description

Alternative 3 consists of the following primary components:

- Remedial design
- Installation of a SVE system (discussed in Alternative 2)

- Installation of four groundwater monitoring wells (two at 60 and two at 80 feet bgs).
- O&M of the SVE system SVE performance monitoring for VOCs
- Bench-scale/pilot testing for ZVI
- ZVI injections (assumed 275 spaced on 30-foot centers) to an average depth of 80 feet bgs
- Groundwater monitoring of VOCs, DHC, metals, and MNA parameters as follows:
  - Quarterly – Year 1 and 2
  - Semiannually – Years 3 and 4
  - Annually – Year 5
  - Annually – Years 6 through 15 (analytical suite is subject to be reduced to a shortened list of analytes, but presumed for costing purposes to be the full suite of VOCs, DHC, metals, and MNA parameters)
- Soil-gas and groundwater monitoring reports and periodic reviews
- Preparation of an iRACR for soil gas
- Preparation of a RACR after satisfaction of the RAOs
- System decommissioning

The assumed duration of this alternative is 15 years, including one round of injections over the course of several months, post-treatment performance monitoring, and MNA. Groundwater monitoring of MNA would be discontinued once the Navy and regulatory agencies agree that the effectiveness of the remedies have been verified and that VOCs at Site 29 no longer present an unacceptable risk to human health and the environment. Figure 5-2 illustrates the assumed ZVI treatment area and groundwater monitoring well network.

6.4.2 Evaluation by Threshold Criteria

The following subsections compare Alternative 3 against the threshold criteria of the NCP.

6.4.2.1 Overall Protection of Human Health and the Environment

Alternative 3 is considered protective of human health and the environment. SVE and ZVI injection are active treatment options that would reduce VOC concentrations in soil gas and groundwater. Soil-gas and groundwater sampling would provide information to evaluate remedy effectiveness and support future remedial action decisions.

6.4.2.2 Compliance with ARARs

Alternative 3 is expected to meet potential chemical-, location-, and action-specific ARARs. A detailed analysis of potential ARARs associated with remedial action at Site 29 is provided in Appendix A.

6.4.3 Evaluation by Balancing Criteria

The following subsections compare Alternative 3 against the balancing criteria of the NCP.

6.4.3.1 Long-Term Effectiveness and Permanence

For Alternative 3, all chlorinated VOCs exceeding the proposed RGs in groundwater would be treated to achieve RAOs. LUCs would only need to remain in effect for the duration of the remedy (approximately 15 years). The ZVI process is expected to be successful at reducing VOC concentrations in groundwater, thereby reducing future health risks. ZVI typically persists in the aquifer for several months and will continue to provide treatment thereby reducing the effect of rebound. If the initial ZVI treatment does not meet the proposed RGs, then a second injection event could be conducted to achieve RGs. Groundwater monitoring for MNA would be implemented using a monitoring plan, which may be updated as needed.

Additionally, as with Alternative 2, all accessible vadose zone soil with VOC concentrations exceeding the proposed RGs would be treated using SVE to achieve RAOs.

6.4.3.2 Reduction of Toxicity, Mobility, or Volume through Treatment

Treatment is the primary component of Alternative 3. SVE and ZVI combined would provide irreversible chemical destruction of chlorinated VOCs in the area treated. Under Alternative 3, the toxicity of soil gas and groundwater would be reduced, and the mass of VOCs in the treatment area would be reduced by treatment. ZVI injection with fracturing can be used to target specific hydrogeologic units where TCE was detected by MIP. ZVI injection with hydraulic fracturing has an expected higher ROI than direct injection and pneumatic fracturing technologies.

6.4.3.3 Short-Term Effectiveness

In addition to equipment already mentioned regarding SVE for Alternative 2, Alternative 3 would involve transportation of drilling equipment and surface mixing of ZVI. Once the ZVI injections are completed, this alternative would be expected to reduce VOCs to below the proposed RGs.

PPE and standard chemical handling procedures are assumed to sufficiently mitigate threats posed to workers during ZVI injection. During the RD stage, measures to mitigate potential generation of undesirable byproducts from the ZVI process would be considered and implemented as needed. The estimated time to reach the proposed RGs in groundwater is approximately 1 year, including bench-scale testing, RD, and field implementation activities. Injection activities would require appropriate precautions (e.g., utility line survey and mitigation of potential human exposure). Groundwater and soil sampling activities are routine tasks that have been performed regularly at Site 29. The estimated time to reach preliminary RGs in soil gas is 5 years. Implementation of this alternative would not be expected to have potential adverse effects on the surrounding community or the environment.

6.4.3.4 Implementability

The equipment and materials are anticipated to be readily available. Bench-scale testing would be required prior to ZVI injection to obtain the parameters and data required for a full-scale

implementation. ZVI injection contractors are available; however, contractors offering ZVI delivery by formation fracturing (this FFS considers hydraulic fracturing most viable) are somewhat limited as the technology is proprietary. Special care must be taken to avoid unintended dispersal of groundwater contaminants, such as monitoring ROI and injection volume.

Periodic groundwater sampling is a routine and common activity and should not be incompatible with the current and anticipated site use. Access to monitoring wells would need to be maintained to allow for sampling. Administrative activities would entail managing treatment activities and groundwater monitoring.

6.4.3.5 Cost

The present-value cost for Alternative 3 is approximately $18.5 million (Table 6-1). Major cost components for this alternative are associated with ZVI injection, SVE O&M, and MNA. Appendix B provides supporting details and costing assumptions.

6.5 Alternative 4 – SVE with ISB and Groundwater Recirculation

Alternative 4 would include the same SVE components mentioned in Alternative 2 to remedy the vadose zone and ISB and groundwater recirculation to treat the saturated zone. The details of the recirculation system would be further refined in the RD and bench-scale or pilot testing, but would likely involve injecting a biodegradable organic substrate, such as emulsified vegetable oil, amended with bacterial culture and other substrates at select locations in the source area. Because the size of the plume is large and the expected ROI of injection is low, it is not suitable to deliver the substrate via direct injection across the entire plume area. Therefore a groundwater recirculation system would be installed to effectively deliver substrate to the whole plume. Direct injection of bioenhanced substrate, biochemical substrate, or chemical oxidants could be focused on the source area or target specific hydrogeologic units where focused delivery of substrate into high-concentration zones would be needed.

As with Alternatives 2 and 3, this alternative would require installation of four new groundwater monitoring wells to measure performance of the ISB treatment of the plume. Components of Alternative 4 are described below.

6.5.1 Description

Alternative 4 consists of the following primary components:

- Remedial design
- Installation of an SVE system (discussed in Alternative 2)
- Installation of four groundwater monitoring wells
- Installation of 20 groundwater recirculation wells to a depth of 80 feet
- Construction of the groundwater circulation system
- O&M of the SVE and groundwater recirculation systems

- SVE and groundwater recirculation performance monitoring
- Injection of substrate amended with a bacteria culture at approximately 200 locations to an average depth of 70 feet bgs with an assumed ROI of 7 feet
- Groundwater monitoring of VOCs, DHC, metals, and MNA parameters as follows:
  - Quarterly – Years 1 and 2
  - Semiannually – Years 3 and 4
  - Annually – Year 5
  - Annually – Years 6 through 15 (analytical suite is subject to be reduced to a shortened list of analytes, but presumed for costing purposes to be the full suite of VOCs, DHC, metals, and MNA parameters)
- Groundwater monitoring reports and periodic reviews
- Preparation of an iRACR for soil gas
- Preparation of a RACR after satisfaction of the RAOs
- System decommissioning

The assumed duration of this alternative is 15 years, including post-treatment performance monitoring. MNA would be discontinued once the Navy and regulatory agencies agree that the effectiveness of the ISB remedy has been verified and that the saturated zone VOCs at Site 29 no longer present an unacceptable risk to human health and the environment. Figure 5-3 illustrates the assumed ISB and groundwater recirculation treatment area.

6.5.2 Evaluation by Threshold Criteria

The following subsections compare Alternative 4 against the threshold criteria of the NCP.

6.5.2.1 Overall Protection of Human Health and the Environment

Alternative 4 is considered protective of human health and the environment. SVE and ISB are active treatment options that would reduce VOC concentrations in soil gas and groundwater. Soil-gas and groundwater sampling would provide information to evaluate remedy effectiveness and support future remedial action decisions.

6.5.2.2 Compliance with ARARs

Alternative 4 is expected to meet potential chemical-, location-, and action-specific ARARs. A detailed analysis of potential ARARs associated with remedial action at Site 29 is provided in Appendix A.

6.5.3 Evaluation by Balancing Criteria

The following subsections compare Alternative 4 against the balancing criteria of the NCP.

6.5.3.1 Long-Term Effectiveness and Permanence

For Alternative 4, all vadose- and saturated-zone VOCs exceeding preliminary RGs would be treated to achieve RAOs. LUCs would only need to remain in effect for the duration of the remedy. Some risk is inherent with any injection system in that rebound may occur and additional injections may be necessary.

The groundwater recirculation system would require piping and construction, but would be effective in delivering amended groundwater to treatment zones. The long-term effectiveness is greatly dependent on a sound understanding of hydrogeologic conditions and, as with any groundwater circulation system, may not deliver treatment to every area of the plume. LUCs to prohibit site access and domestic use of groundwater would remain in place until satisfaction of RAOs, which is assumed to be 15 years.

6.5.3.2 Reduction of Toxicity, Mobility, or Volume through Treatment

Treatment is the primary component of Alternative 4. SVE combined with ISB would provide removal and/or destruction of VOCs in the vadose and saturated zones in the area treated. ISB may not be as effective as ZVI in delivering treatment to the contamination in specific hydrogeologic zones, vertically and horizontally across the plume, as the groundwater recirculation system is a less precise approach to delivering treatment by relying on groundwater flow and induced gradient between wells. ZVI can be applied in a more precise approach, using CPT/MIP data collected in the RI to target key transmissive units throughout the plume where TCE was detected by MIP. Movement of site groundwater may increase contaminant mobility.

6.5.3.3 Short-Term Effectiveness

In addition to those already mentioned regarding SVE for Alternative 2, Alternative 4 would also involve installation and operation of the groundwater recirculation system and ISB injection. ISB injection would be conducted over a period of 4 months to 1 year. Groundwater recirculation is assumed to be conducted over 5 years.

ISB injection and groundwater recirculation are relatively routine remediation practices. PPE and standard chemical handling procedures are presumed to mitigate threats to workers during ISB injection and recirculation system O&M. The estimated time to reach preliminary RGs is the between 5 and 15 years. Implementation of this alternative would not be expected to have potential adverse effects on the surrounding community or the environment.

6.5.3.4 Implementability

Alternative 4 includes bench-scale testing to assess groundwater recirculation design and ISB injection. Although a Treatability Study (Shaw 2011) is currently underway, additional data may be required for design of the recirculation system. Contractors able perform ISB injection services are available.

Periodic groundwater sampling is a routine and common activity and should not be incompatible with the current and anticipated site use. Access to monitoring wells would need to be maintained to allow for sampling. Administrative activities would entail managing treatment

activities and groundwater monitoring. Special care must be taken to avoid unintended dispersal of groundwater contaminants.

6.5.3.5 Cost

The present-value cost for Alternative 4 is approximately $14.3 million (Table 6-1). Major cost components for this alternative are associated with ISB injection, O&M of the SVE and recirculation systems, and MNA. Appendix B provides supporting details and costing assumptions.

Section 7 Comparative Analysis of Alternatives

This section presents a comparative analysis of the remedial action alternatives presented and evaluated in Section 6. The purpose of this section is to compare the potential advantages and disadvantages of each remedial action alternative to one another in relation to the nine NCP evaluation criteria. Table 7-1 summarizes a comparative analysis of each remedial action alternative against the five balancing criteria. The two modifying criteria (state and community acceptance) are also briefly discussed in this section. Evaluation of these modifying criteria will be documented in the Proposed Plan and ROD once formal comments have been received on this FFS and a remedy selection decision has been made.

Sustainability is an additional evaluation that supplements the short-term effectiveness criterion and is also evaluated in this section. This evaluation was performed using the green and sustainable remediation assessment tool SiteWise™.

7.1 Overall Protection of Human Health and the Environment

Alternatives 2, 3, and 4 are protective of human health and the environment. Alternative 2 reduces exposure to vapor-phase VOCs and would rely on LUCs to prevent human exposure to groundwater. Alternative 3 provides the flexibility to treat the saturated zone with greatest ROI over the target hydrogeologic zones. Additionally, if bench-scale testing deems it favorable, ZVI can be combined with a bacteria-amended substrate to deliver both the rapidly reductive ZVI and *dehalococcoides* sp. bacteria to the target interval. The overall effectiveness of ISB for Alternative 4 is likely to be lower than Alternative 3 because distribution of treatment material to target hydrogeologic zones can be more challenging with groundwater recirculation and direct-pressure injection versus injection via formation fracturing techniques, which yield a much higher ROI.

Alternative 1 offers no protection of human health and the environment.

7.2 Compliance with ARARs

No ARARs apply to Alternative 1 because no active remedial actions would be taken; therefore, compliance with ARARs is not applicable. Alternative 2 likely would not meet chemical-specific ARARs since groundwater would not be actively remediated and VOCs may persist indefinitely; however this alternative would be compliant with ARARs with LUCs in place. Alternatives 3 and 4 would comply with identified chemical-, location-, and action-specific potential ARARs.

7.3 Long-Term Effectiveness and Permanence

Alternatives 3 and 4 are rated high in long-term effectiveness and permanence and are considered clean-closure alternatives that could remove or destroy all impacted soil gas and groundwater with VOC concentrations above the proposed RGs from Site 29. Once the success of these treatments is verified, no long-term O&M or monitoring would be needed. Alternatives 3 and 4 are considered to have similar long-term effectiveness and permanence because both would deliver treatment directly to the target hydrogeologic zones. Groundwater recirculation is more of a “blanket approach” to delivering treatment to contamination, whereas

injection can be used to target key intervals where TCE is known to be present as documented by the SCAPS MIP logs (see RI Appendix B). Although ISB injections would be used to target key zones, the expected ROI is less than that expected with formation fracturing techniques.

Alternative 2 is rated medium because, although the SVE system and LUCs would reduce the potential for exposure, the long-term effectiveness would depend on continued O&M and adherence to LUCs.

Alternative 1 is rated low in long-term effectiveness and permanence because no remedial measures would be implemented to protect human health.

7.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 and 4 are both rated high under this criterion because both are similar, active, in situ treatment technologies that would reduce the toxicity, mobility, and volume of VOCs resulting in harmless end products. Alternative 3 may provide a more rapid reduction of VOCs over the treatment period.

Alternative 2 is rated medium under this criterion because it does not involve active treatment of groundwater. Groundwater would only be passively treated via vapor-phase removal of VOCs from the SVE system.

7.5 Short-Term Effectiveness

Of the four remedial alternatives, Alternative 1 is rated the highest in this criterion because there would be no short-term impacts (i.e., potential risks to site workers or the local community, dust, or transportation impacts). Alternative 2 is rated the next highest because it has fewer short-term impacts (as defined above) than Alternatives 3 and 4.

Alternatives 3 and 4 involve transportation and deployment of heavy equipment and/or chemical/biological treatment media to the site, which has limited access due to slope, wildlife, and frequent wet soil conditions of the pasture area. Site worker risks and other short-term impacts would be mitigated by health and safety plans, use of PPE, and standard dust control and stormwater protection measures.

7.5.1 Sustainability Assessment of Remedial Alternatives

Alternative 1 was not modeled in SiteWise™, but by the nature of the no action alternative would be most sustainable. Of all the sustainability factors evaluated, Alternative 2 ranked most favorable (smaller environmental footprint) whereas Alternatives 3 and 4 ranked comparably. Based on SiteWise™ model outputs, calculated emissions of NO_X, SO_X, and PM_{10} for Alternative 4 are higher than the other alternatives, due primarily to installation, operation, and residual handling of the groundwater recirculation system. The calculated injury and fatality risks to workers for Alternative 3 are higher than the other alternatives, primarily from handling of treatment materials on the surface. Alternative 2 ranked most favorably for all sustainability factors among the active alternatives. Some uncertainties are inherent with the SiteWise™ model; for example, the type of equipment used in Alternatives 3 and 4 could affect the overall evaluation. Assumptions built into the FFS, such as the maximum amount of groundwater possibly removed, would also have a substantial effect. Inherent complexities and

field logistics (including bench-scale testing) could also significantly increase its ranking through all of the sustainability factors.

Alternative 2 offers the least impact based on the SiteWise™ model. The greatest overall impact for Alternative 2 is related to travel associated with long-term monitoring and O&M, whereas Alternatives 3 and 4 have shorter O&M and long-term monitoring timelines. Alternative 4 was modeled to have the highest water impacts and NO_X, SO_X, and PM_{10} emissions primarily due to groundwater recirculation well installation, operation, and abandonment. Alternative 3 was modeled to have the highest greenhouse gas emissions and total energy used since consumables expended in the injection process are a more apparent factor.

The SiteWise™ model should not be considered an exacting demonstration of actual possible environmental impacts, but rather as a comparison between the three alternatives evaluated. Based on the model, Alternative 2 is overall the most sustainable.

7.6 Implementability

Alternative 1 is rated high in implementability because it involves no action. Alternative 2 is rated medium-high in implementability because it would only involve installation of the SVE system and additional groundwater monitoring wells, both of which are considered routine, well-established technologies.

Alternatives 3 and 4 are similarly rated (medium) because they are similar in delivery of treatment to contamination, complexity, material handling, and surface mixing. Additionally, operation of drilling equipment during the wet season would be challenging for site workers. Alternative 4 may be slightly more complex because drilling 20 recirculation wells and conveyance piping may be more challenging at the site than direct injection alone. Additionally, complex hydrogeology could limit the ability of groundwater recirculation to address every area of the plume. Bench-scale testing would be required for Alternatives 3 and 4 but is not considered to be a significant factor in implementability. Uncertainty remains in achieving the expected ROI using formation fracturing. It is expected that a greater ROI may be reached with hydraulic methods rather than pneumatic. Pilot- or bench-scale testing would alleviate the uncertainty regarding the ROI.

7.7 Cost

The estimated costs for the remedial alternatives are summarized in Table 6-1. Cost estimates are conceptual and are presented solely for comparing alternatives in this FFS; they should not be used for budgetary or planning purposes because actual costs may change based on the final RD and bench-scale results.

Alternative 1 is rated highest under the cost criterion, as no costs are incurred. Alternative 2 is rated medium-high (less cost). Alternatives 3 and 4 are similarly rated because present-worth costs are similar when a ±30% to 50% cost adjustment is considered; however, Alternative 4 is ranked above Alternative 3 on base cost alone. The total cost of Alternative 3 is higher than Alternatives 2 and 4 because material costs and formation fracturing are significant cost drivers.

7.8 State Acceptance

This criterion evaluates remedial alternatives with respect to meeting the concerns of state regulatory agencies. The State of California will review and comment on this FFS and the proposed plan. Responses to state comments will be included in the draft final and final versions of these documents.

7.9 Community Acceptance

This criterion assesses issues of concern to the community for each remedial alternative. Comments will be solicited from community members during the public review period for this FFS and again during the proposed plan. Community comments will be considered in the remedy selection process.

7.10 Conclusions

A summary of the comparative analysis is presented in Table 7-2. Alternatives 2, 3, and 4 meet the threshold criteria, while Alternative 1 does not. Alternatives 3 and 4 are similarly rated overall in satisfying the balancing criteria (i.e., lower ratings for some individual criteria are balanced by higher ratings for other individual criteria, resulting in overall similar ratings). Alternative 2 is rated lowest because it will not reduce toxicity, mobility, or volume through treatment. Sustainability of alternatives is also a consideration in remedy selection and implementation. Consequently, Alternative 2 is rated the most favorable of the alternatives based solely on SiteWise™ sustainability factors. A combination of alternatives may be considered during remedy selection or during remedy optimization.

Section 8 References

Brady (Richard Brady & Associates, Inc.). 2011. *Final Remedial Investigation for Installation Restoration Program Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California*. March 4.

City of Concord. 2010. *Concord Community Reuse Plan, Final Environmental Impact Report*. Concord Community Reuse Project Office. February 23.

Cook, S.M. 2009. *Assessing the Use and Application of Zero-Valent Iron Nanoparticle Technology for Remediation at Contaminated Sites*. Prepared for U.S. EPA Offices of Solid Waste and Emergency Response and Superfund Remediation and Technology Innovation. August.

DTSC (California Department of Toxic Substances Control). 1998. Human and Ecological Risk Division (HERD) Ecological Risk Assessment (ERA) Note Number 1 re: Depth of Soil Samples Used to Set Exposure Point Concentration for Burrowing Mammals and Burrow-Dwelling Birds in Ecological Risk Assessments. Available online at http://www.dtsc.ca.gov/AssessingRisk/upload/econote1.pdf. May 15.

———. 2009. *Interim Advisory for Green Remediation*. December.

FRTR (Federal Remediation Technology Roundtable). 2002. *Remediation Technologies Screening Matrix and Reference Guide, 4th Edition*. http://www.frtr.gov/matrix2/top_page.html.

IT (IT Corporation). 1990. *Site Investigation at Building IA-25 Naval Weapons Station Concord, California, Report of Findings*. February.

Natural Heritage Institute. 2006. *Mt. Diablo Creek Watershed Inventory, Final Report*. June 30.

Navy (U.S. Department of the Navy). 1945. Bldg. IA-25 Plan and Elevations, Drawing number 373-373.

———. 1988. Site Approval/Explosive Safety RC1-89, N60036.

———. 2006. *Environmental Restoration Program Manual*. August.

Navy (U.S. Department of the Navy) and DTSC (California Department of Toxic Substances Control). 2000. *Memorandum of Agreement between the United States Department of the Navy and the California Department of Toxic Substances Control*. Use of model "Covenant to Restrict Use of Property" at installations being closed and transferred by the Navy.

Shaw (Shaw Environmental & Infrastructure Group). 2011. *Final In Situ Anaerobic Bioremediation and Solar-Powered Vapor Extraction Treatability Study Work Plan*. February.

SulTech. 2007. *Final Sampling and Analysis Plan (Field Sampling Plan/Quality Assurance Project Plan) for the Remedial Investigation at Installation Restoration Site 29 Naval Weapons Station Seal Beach Detachment Concord, Concord, California*. May.

U.S. Department of Defense. 2003. *Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions.* October.

U.S. EPA (United States Environmental Protection Agency). 1987. *Remedial Action Costing Procedures Manual.* EPA/600/8-87/049. October.

———. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3-01. EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October.

———. 1993. *Presumptive Remedies: Policy and Procedures.* Office of Solid Waste and Emergency Response. Directive No. 9355.0-47FS. September.

———. 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Final*. OSWER Directive 9200.4-17P. April.

———. 2000. *Guidance for Data Quality Objectives Process for Hazardous Waste Site Investigations*. Office of Environmental Information. January.

———. 2009. *Principles for Greener Cleanups.* Office of Solid Waste and Emergency Response. August 27.

———. 2010. *Superfund Green Remediation Strategy.* Offices of Soil Waste and Emergency Response and Superfund Remediation and Technology Innovation. September.

Water Board (California Regional Water Quality Control Board, San Francisco Bay Region). 2007. *Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin.* January. Available online at: http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml.

Figures

Figure 1-1. Site Location Map

Figure 2-1. Site Vicinity Map

Figure 2-2. Site Map

Figure 2-3. Previous Sampling Locations

Figure 2-4. City of Concord – Clustered Villages Preferred Reuse Plan (January 2009)

Figure 2-5. Cross Section A–A'

Figure 2-6. Cross Section B–B' & C–C'

Figure 2-7. Cross Section D–D'

Figure 2-8. Hydrogeologic Basins and Surface Water Hydrology

Figure 2-9. Groundwater Elevation Contour Map (September 2009)

Figure 2-10. MIP Vertical Profile, TCE Response

Figure 2-11. MIP TCE Response, 120–110 feet MSL, Vadose Zone

Figure 2-12. MIP TCE Response, 90–80 feet MSL, Near Water Table Saturated Zone

Figure 2-13. MIP TCE Response, 65–50 feet MSL, Deeper Saturated Zone

Figure 2-14. Soil Gas – TCE TO-15 and Field Screening Analytical Results

Figure 2-15. TCE in Groundwater

Figure 2-16. DCE in Groundwater

Figure 2-17. Conceptual Site Model

Figure 3-1. Estimated Area of TCE in Groundwater Above the Proposed Remediation Goal

Figure 3-2. Estimated Area of TCE in Soil Gas Above the Proposed Remediation Goal

Figure 5-1. Alternatives 2, 3, and 4 – Presumptive Soil Gas Remedy

Figure 5-2. Alternative 3 – ZVI Injection

Figure 5-3. Alternative 4 – In Situ Bioremediation

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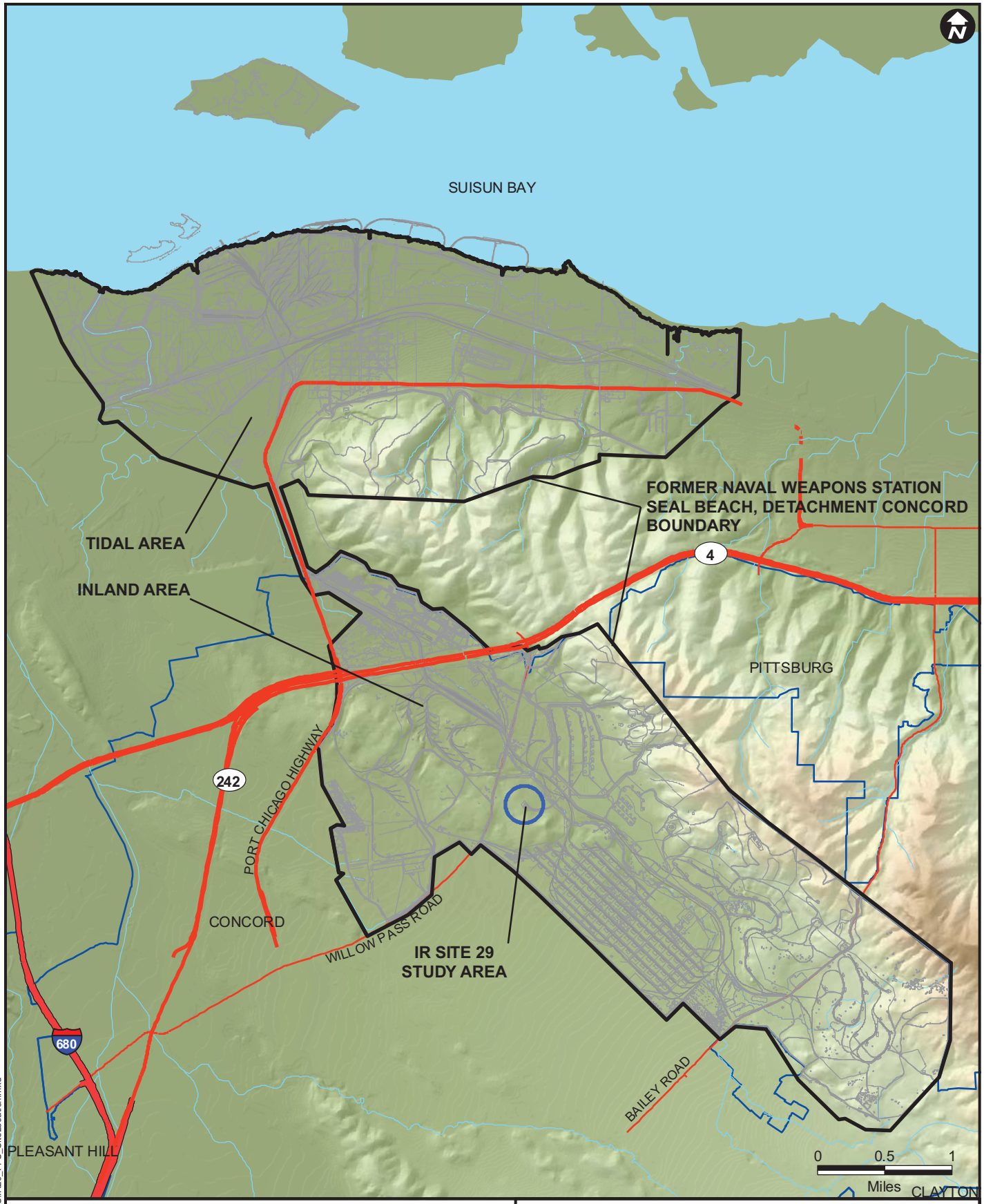

LEGEND

- FREEWAY
- HIGHWAY
- MAJOR ROAD
- CITY LIMIT
- CREEK / DRAINAGE

ELEVATION (FEET)

HIGH : 1172

LOW : -1

SITE LOCATION MAP

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 1-1

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Accord MACTEC 8A JV | BRADY

LEGEND

FENCE

SITE VICINITY MAP

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-1

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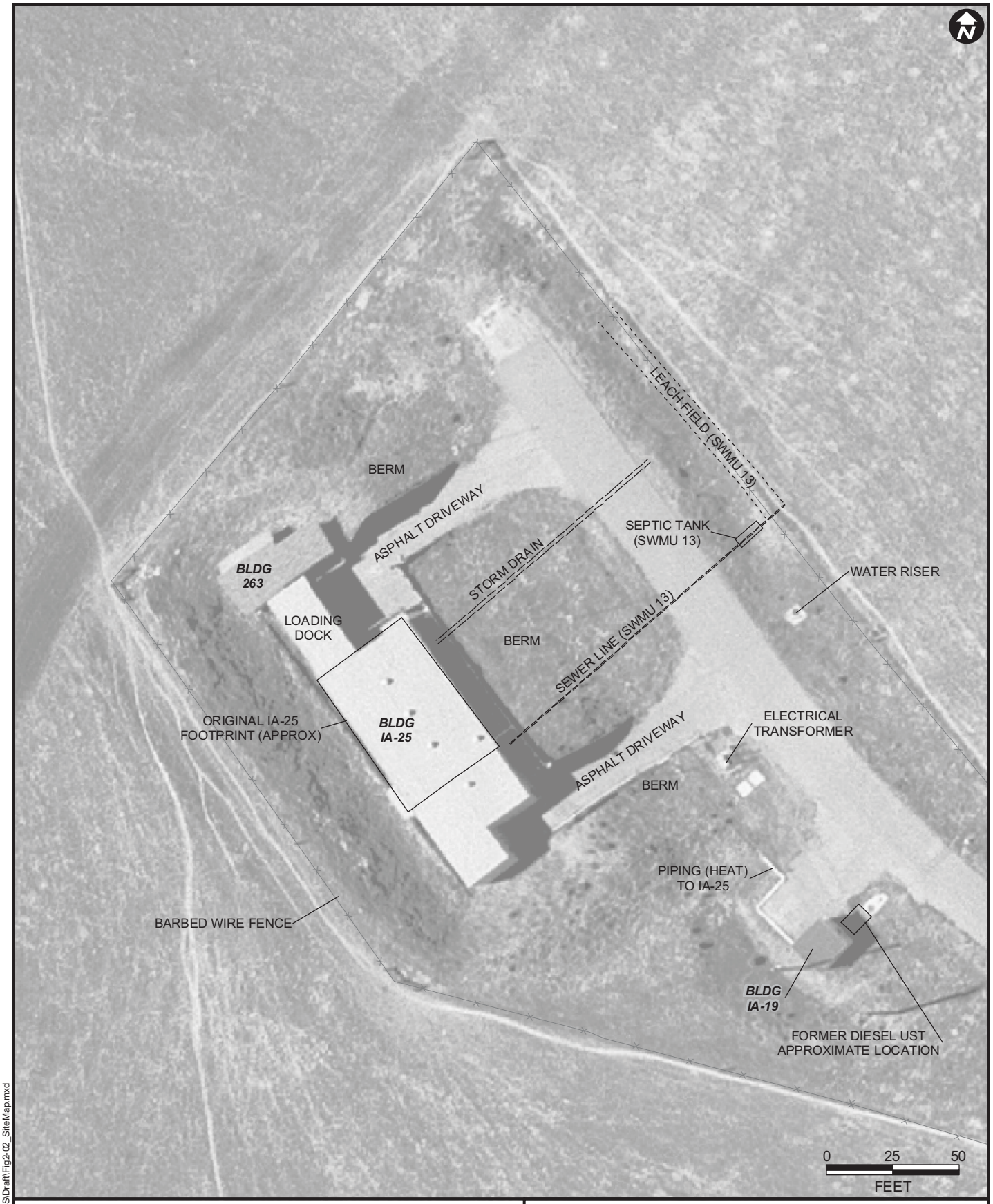
Accord MACTEC 8A JV | BRADY



NOTES:
1. LOCATION OF ORIGINAL IA-25 FOOTPRINT IS APPROXIMATED. SUBSEQUENT PHASES OF BUILDING MODIFICATIONS PROCEEDED THROUGH THE LATE 1990'S.
2. PIPING FROM IA-19 TO IA-25 WAS USED TO SUPPLY HEATED WATER TO HEAT BUILDING IA-25.
3. EARTHEN BERMS ARE SUPPORTED BY CREOSOTE SOAKED TIMBERS.

SITE MAP

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-2

Accord MACTEC 8A JV | BRADY

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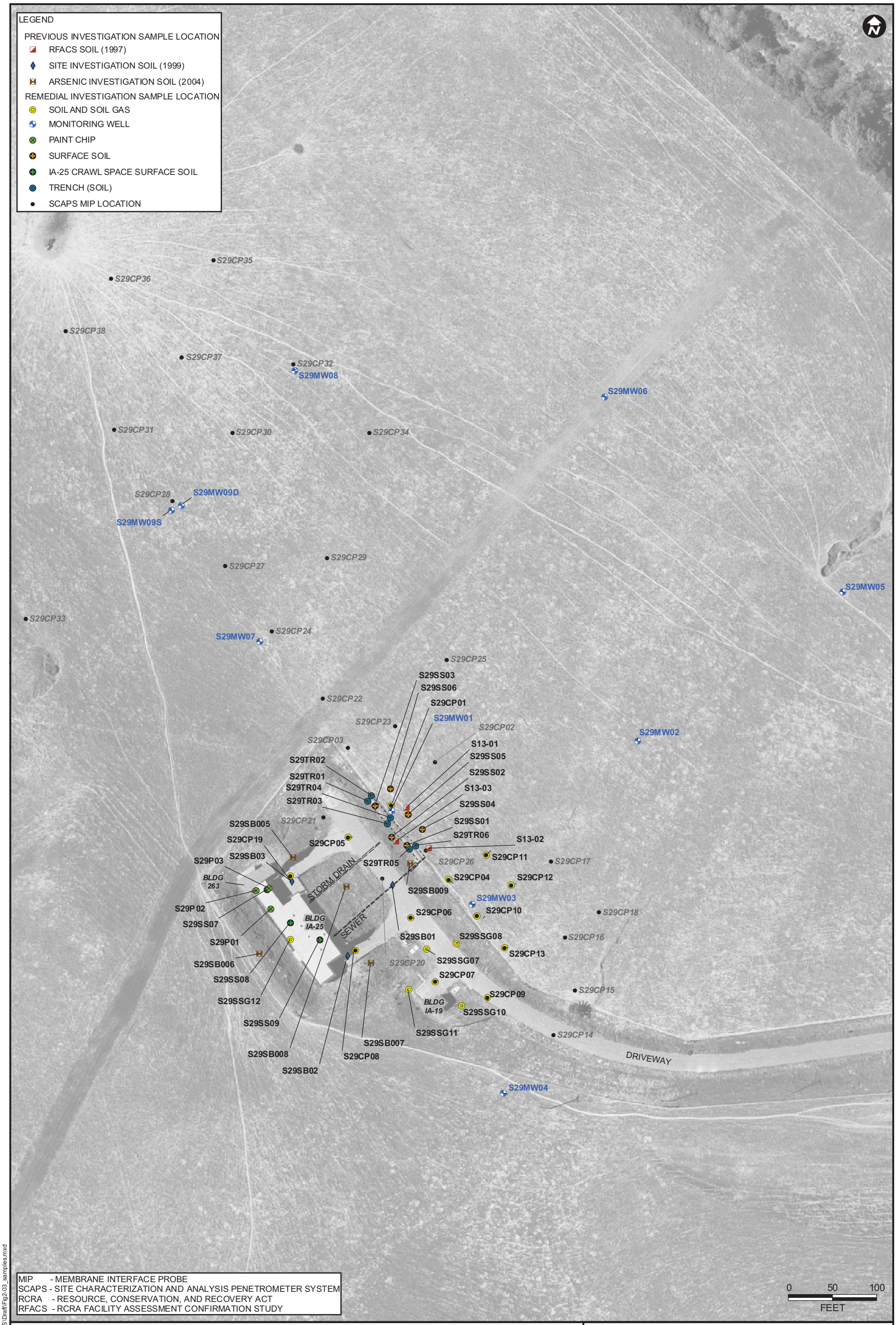

MIP - MEMBRANE INTERFACE PROBE
SCAPS - SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
RCRA - RESOURCE, CONSERVATION, AND RECOVERY ACT
RFACS - RCRA FACILITY ASSESSMENT CONFIRMATION STUDY

NOTES:
1. ONLY PREVIOUS SAMPLE LOCATIONS AND RI SAMPLE LOCATIONS WITH VALIDATED DATA USED IN THE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS ARE PRESENTED ON THIS MAP.

2. SCAPS MIP LOCATIONS WITH GRAY ITALIC LETTERING INDICATE LOCATIONS WHERE ONLY MIP DATA EXISTS AND SAMPLES FOR FIXED BASE LABORATORY ANALYSIS WERE NOT COLLECTED. SOME SCAPS LOCATIONS ARE CO-LOCATED WITH SOIL AND SOIL GAS SAMPLES COLLECTED FOR FIXED BASE LABORATORY ANALYSIS (S29CPXX INDICATES A SCAPS LOCATION). SCAPS MIP DATA ARE SEMI-QUALITATIVE AND ARE NOT USED IN RISK ASSESSMENTS.

PREVIOUS SAMPLING LOCATIONS

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-3

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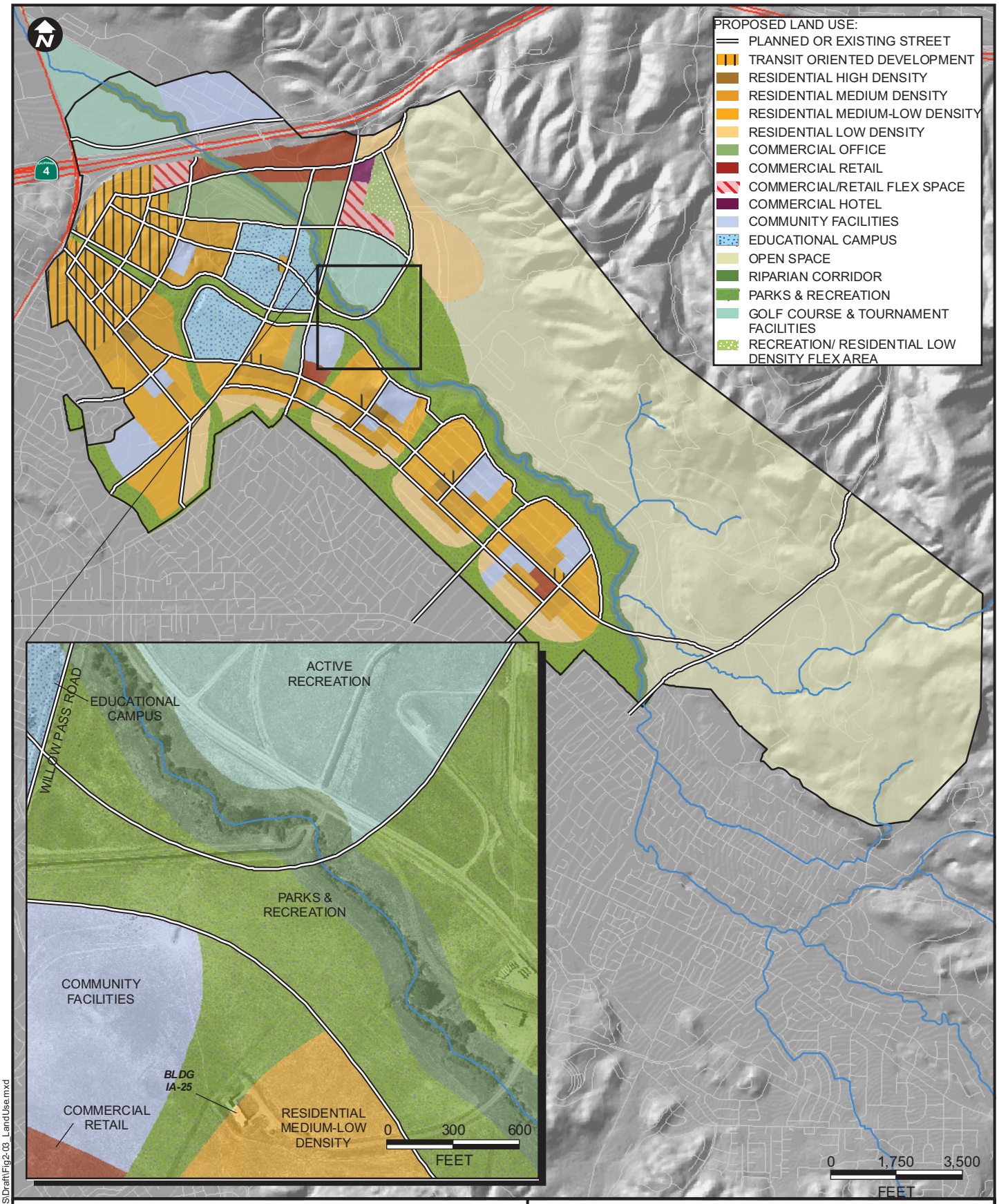
Accord MACTEC 8A JV BRADY



SOURCE:
CITY OF CONCORD, PREFERRED REUSE PLAN, JANUARY 30, 2009
AVAILABLE ONLINE
WWW.CONCORDREUSEPROJECT.ORG

CITY OF CONCORD - CLUSTERED VILLAGES PREFERRED REUSE PLAN (JANUARY 2009)

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-4

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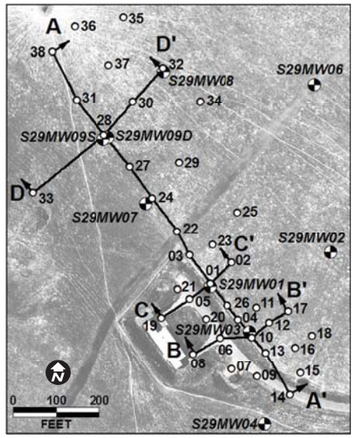
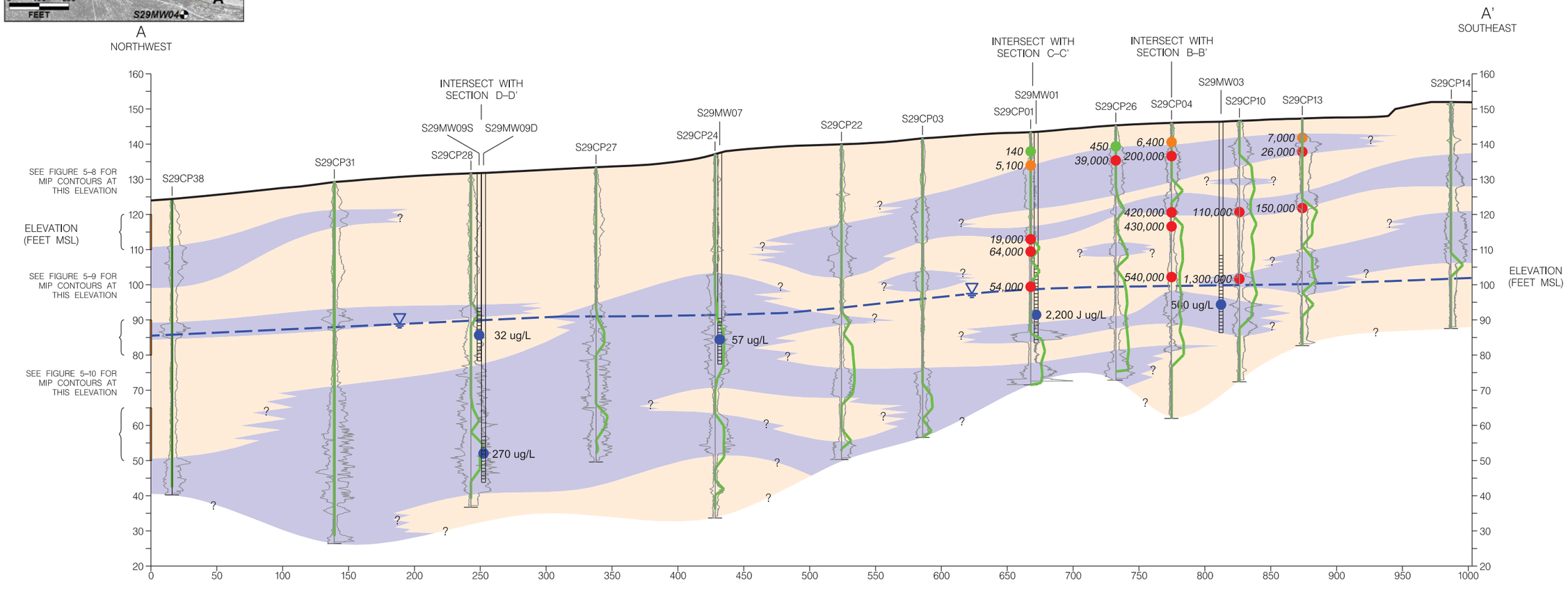
Accord MACTEC 8A JV | BRADY



SECTION A–A'
(VIEW LOOKING NORTHEAST)



VERTICAL SCALE:
1 inch=30 feet

HORIZONTAL SCALE:
1 inch=80 feet

NOTES:

1. ALL RESULTS SHOWN ARE FOR TRICHLOROETHENE (TCE), WATER RESULTS ARE IN MICROGRAMS PER LITER (ug/L) AND SOIL GAS RESULTS ARE IN MICROGRAMS PER CUBIC METER (ug/m^3).
2. THIS FIGURE SHOWS INTERPRETED LITHOLOGICAL CONTACTS. THESE REPRESENT GENERALIZED BOUNDARIES BETWEEN GROUPS OF DOMINANTLY COARSE AND FINE-GRAINED LITHOLOGIC LAYERS. SIGNIFICANT VARIABILITY IN GRAIN SIZE, EXTENT, AND CONTINUITY OF INDIVIDUAL LAYERS WITHIN THESE GROUPINGS ARE LIKELY.

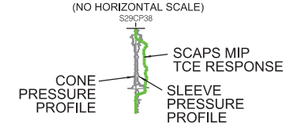
LEGEND

TCE IN SOIL GAS BY METHOD TO-15 (ug/m^3)
- NOT DETECTED
- 27 - 527
- 528- 10000
- >10000

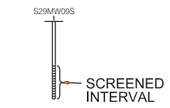
APPROXIMATE WATER TABLE

TCE IN GROUNDWATER (ug/L) SAMPLE COLLECTED FROM MONITORING WELL

VERTICAL PROFILES OF ANALYTICAL DATA
(NO HORIZONTAL SCALE)



GROUNDWATER MONITORING WELL

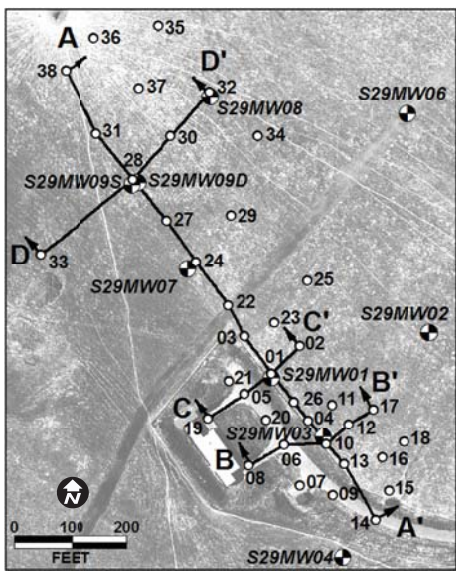


SOIL PROPERTIES
- FINE-GRAINED
- COARSE-GRAINED

CROSS SECTION A-A'

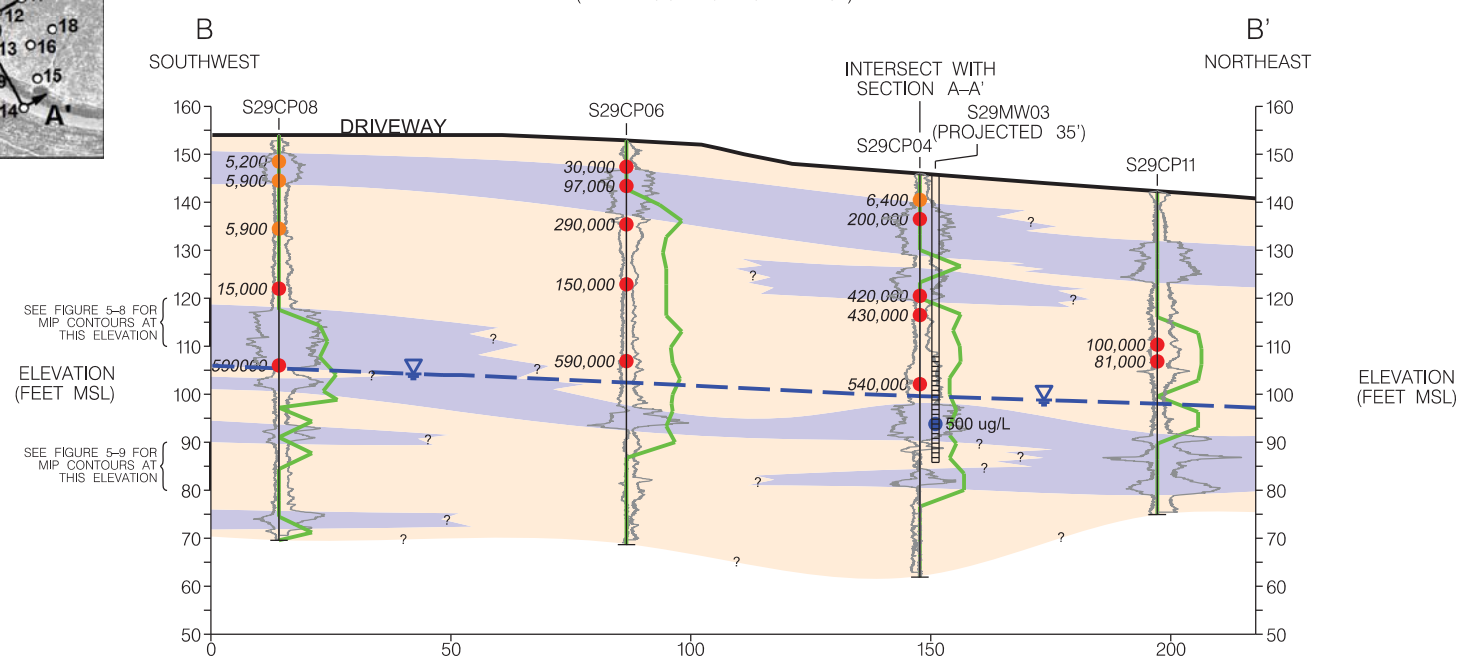
May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-5

Accord MACTEC 8A JV | BRADY



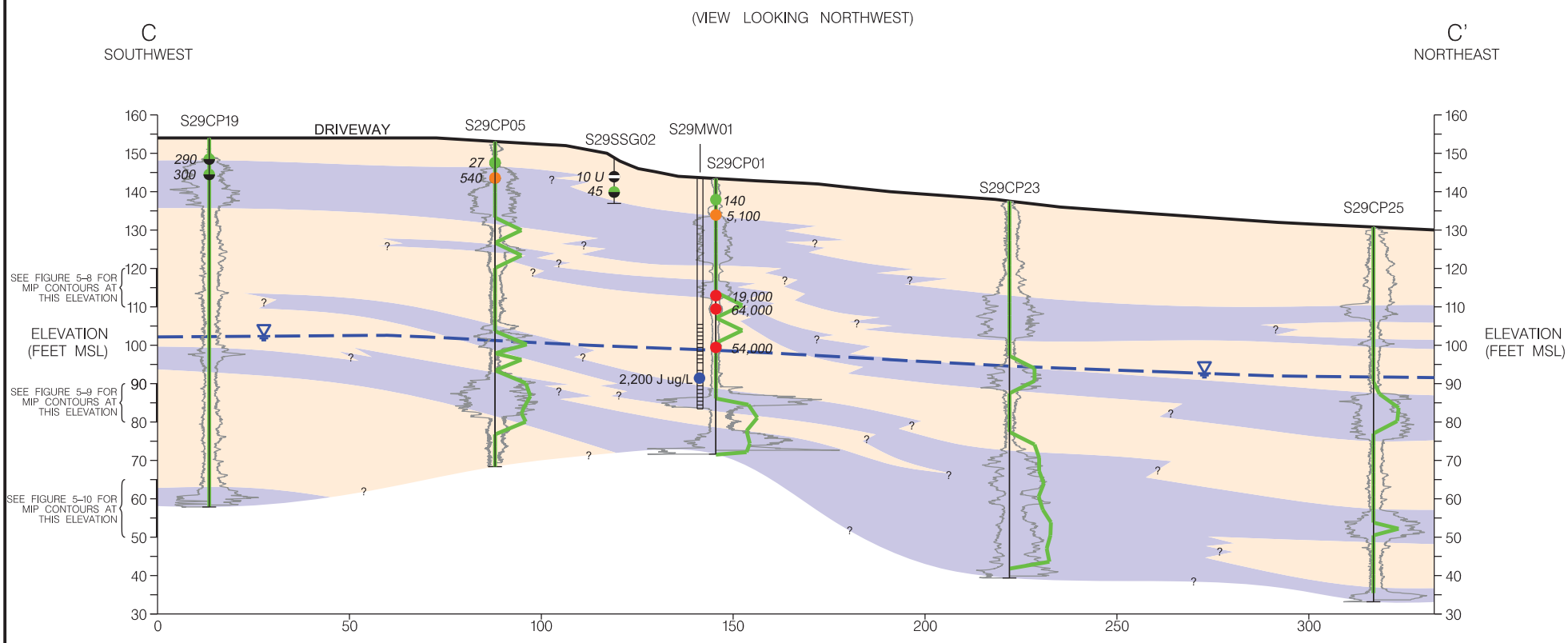
SECTION B–B'

(VIEW LOOKING NORTHWEST)



SECTION C–C'

(VIEW LOOKING NORTHWEST)



0 20 40

HORIZONTAL & VERTICAL SCALE:
1 inch=40 feet

NOTES:

1. ALL RESULTS SHOWN ARE FOR TRICHLOROETHENE (TCE), WATER RESULTS ARE IN MICROGRAMS PER LITER (ug/L) AND SOIL GAS RESULTS ARE IN MICROGRAMS PER CUBIC METER (ug/m³).
2. THIS FIGURE SHOWS INTERPRETED LITHOLOGICAL CONTACTS. THESE REPRESENT GENERALIZED BOUNDARIES BETWEEN GROUPS OF DOMINANTLY COARSE AND FINE-GRAINED LITHOLOGIC LAYERS. SIGNIFICANT VARIABILITY IN GRAIN SIZE, EXTENT, AND CONTINUITY OF INDIVIDUAL LAYERS WITHIN THESE GROUPINGS ARE LIKELY.

LEGEND

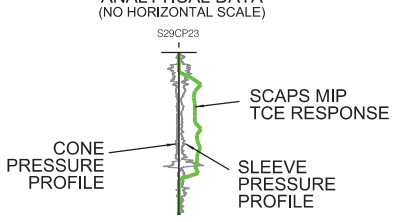
TCE IN SOIL GAS BY METHOD TO-15 (ug/m³)

SCREEN SAMPLE	REGULAR SAMPLE	
		NOT DETECTED
		27 - 527
		528- 10000
		>10000

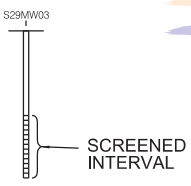
APPROXIMATE WATER TABLE

TCE IN GROUNDWATER (ug/L) SAMPLE COLLECTED FROM MONITORING WELL

VERTICAL PROFILES OF ANALYTICAL DATA
(NO HORIZONTAL SCALE)



GROUNDWATER MONITORING WELL



SOIL PROPERTIES

FINE-GRAINED

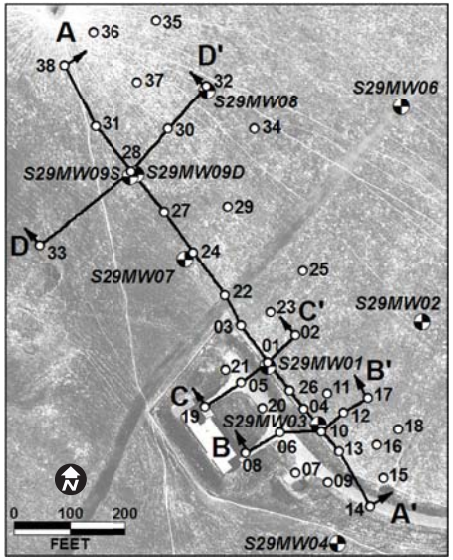
COARSE-GRAINED

CROSS SECTION B-B' & C-C'		
May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-6

Accord MACTEC 8A JV | BRADY

NOTES:

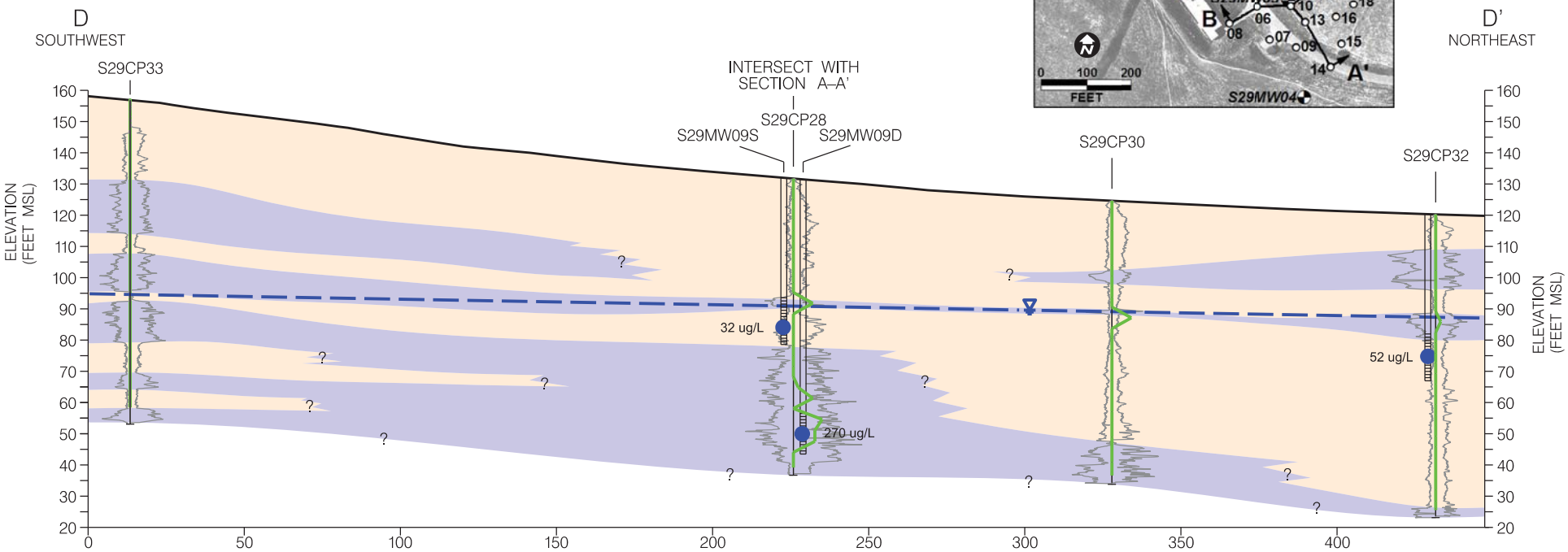
1. ALL RESULTS SHOWN ARE FOR TRICHLOROETHENE (TCE), WATER RESULTS ARE IN MICROGRAMS PER LITER (ug/L).
2. THIS FIGURE SHOWS INTERPRETED LITHOLOGICAL CONTACTS. THESE REPRESENT GENERALIZED BOUNDARIES BETWEEN GROUPS OF DOMINANTLY COARSE AND FINE-GRAINED LITHOLOGIC LAYERS. SIGNIFICANT VARIABILITY IN GRAIN SIZE, EXTENT, AND CONTINUITY OF INDIVIDUAL LAYERS WITHIN THESE GROUPINGS ARE LIKELY.



0 25 50

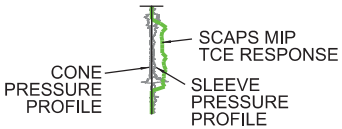
HORIZONTAL & VERTICAL SCALE:
1 inch=50 feet

SECTION D–D'
(VIEW LOOKING NORTHWEST)

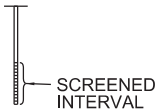


LEGEND

VERTICAL PROFILES OF ANALYTICAL DATA
(NO HORIZONTAL SCALE)



GROUNDWATER MONITORING WELL



APPROXIMATE WATER TABLE

TCE IN GROUNDWATER (ug/L) SAMPLE COLLECTED FROM MONITORING WELL

SOIL PROPERTIES
FINE-GRAINED
COARSE-GRAINED

CROSS SECTION D-D'		
May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-7

Accord MACTEC 8A JV BRADY

LEGEND

CREEK / DRAINAGE

WATERSHED BOUNDARY:

MOUNT DIABLO CREEK

GROUNDWATER BASIN:

CLAYTON VALLEY

PITTSBURG PLAIN

YGNACIO VALLEY

HYDROGEOLOGIC BASINS AND SURFACE WATER HYDROLOGY

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-8

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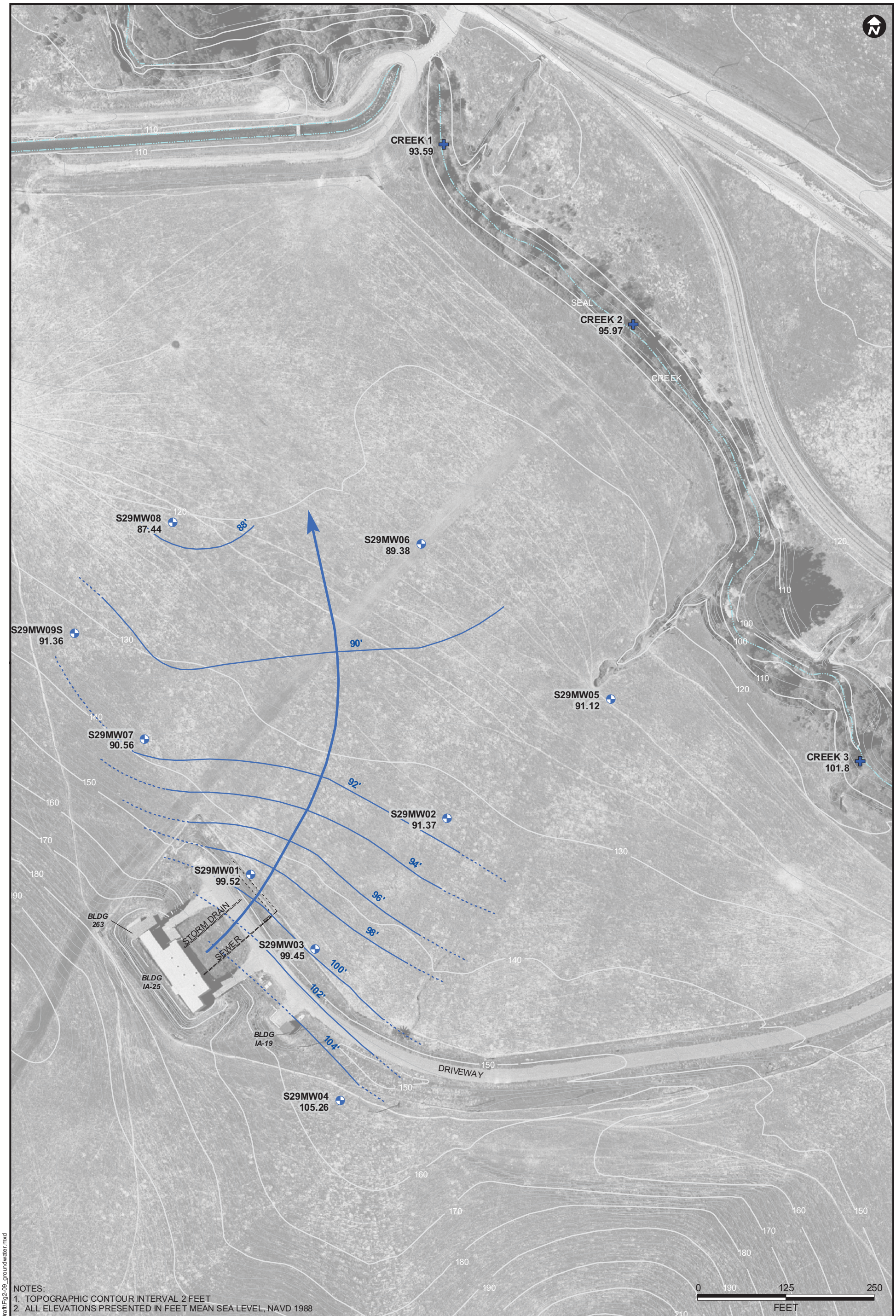
Accord MACTEC 8A JV | BRADY



NOTES:
1. TOPOGRAPHIC CONTOUR INTERVAL 2 FEET
2. ALL ELEVATIONS PRESENTED IN FEET MEAN SEA LEVEL, NAVD 1988

LEGEND

- SEAL CREEK ELEVATION SURVEY POINT
- MONITORING WELL USED FOR WATER LEVEL MEASUREMENT
- S29MW01 — WELL ID
- 88.65 — GROUNDWATER ELEVATION (FEET MEAN SEA LEVEL)

GROUNDWATER ELEVATION CONTOURS SEPTEMBER 2009

- INTERPRETED GROUNDWATER ELEVATION
- ESTIMATED GROUNDWATER ELEVATION
- INTERPRETED FLOW DIRECTION

GROUNDWATER ELEVATION CONTOUR MAP (SEPTEMBER, 2009)

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-9

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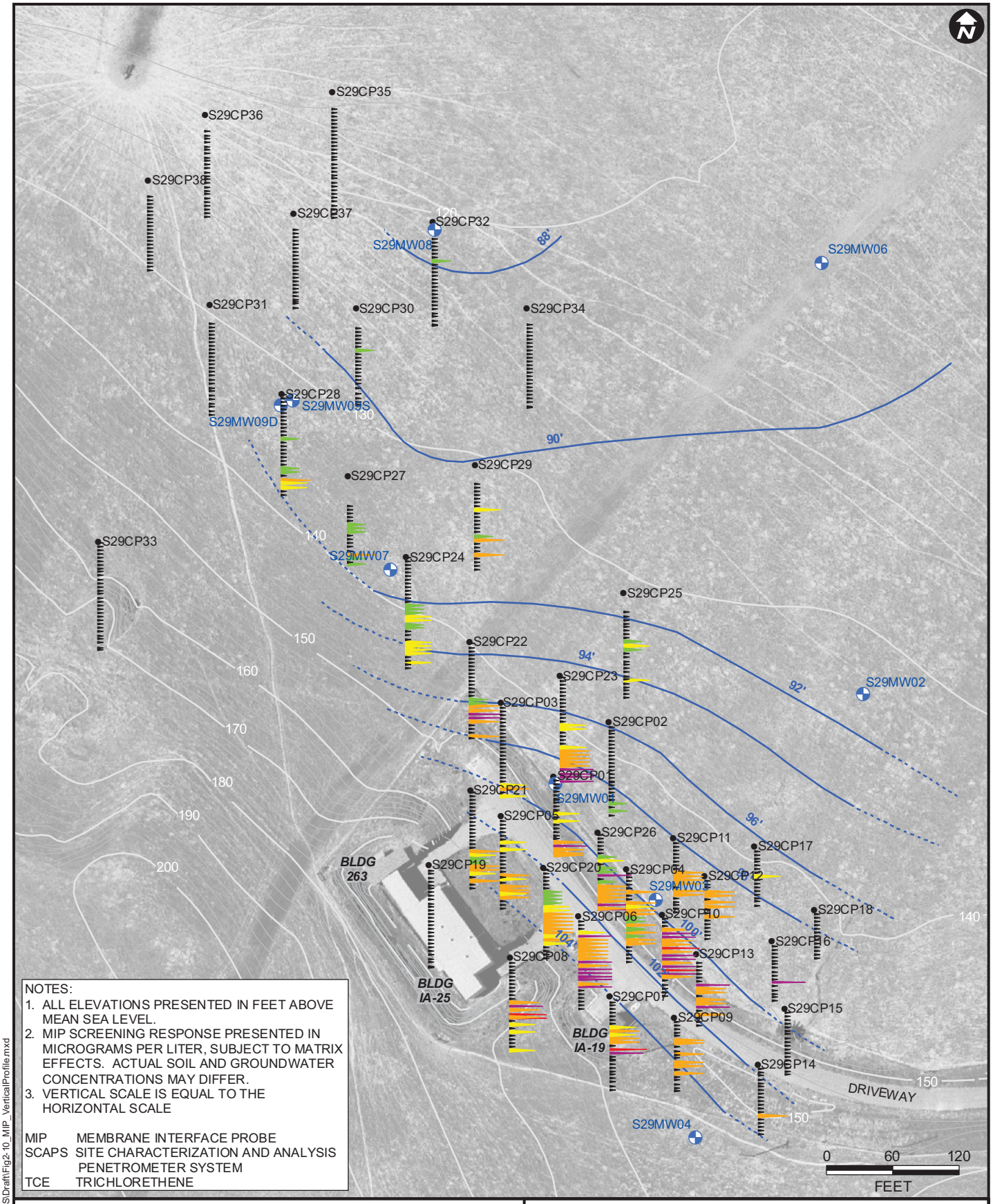
Accord MACTEC 8A JV | BRADY



NOTES:
1. ALL ELEVATIONS PRESENTED IN FEET ABOVE MEAN SEA LEVEL.
2. MIP SCREENING RESPONSE PRESENTED IN MICROGRAMS PER LITER, SUBJECT TO MATRIX EFFECTS. ACTUAL SOIL AND GROUNDWATER CONCENTRATIONS MAY DIFFER.
3. VERTICAL SCALE IS EQUAL TO THE HORIZONTAL SCALE

MIP MEMBRANE INTERFACE PROBE
SCAPS SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
TCE TRICHLORETHENE

LEGEND
- MONITORING WELL
- SCAPS PUSH LOCATION

GROUNDWATER ELEVATION CONTOURS (SEPTEMBER 2009)
- INTERPRETED ELEVATION
- ESTIMATED ELEVATION

SCAPS VERTICAL PROFILETCE MIP RESPONSE
- NON DETECT
- >5 - 500
- 501 - 1,000
- 1,001 - 10,000
- 10,001 - 100,000
- 100,001 - 600,000

MIP VERTICAL PROFILE TCE RESPONSE

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-10

Accord MACTEC 8A JV | BRADY

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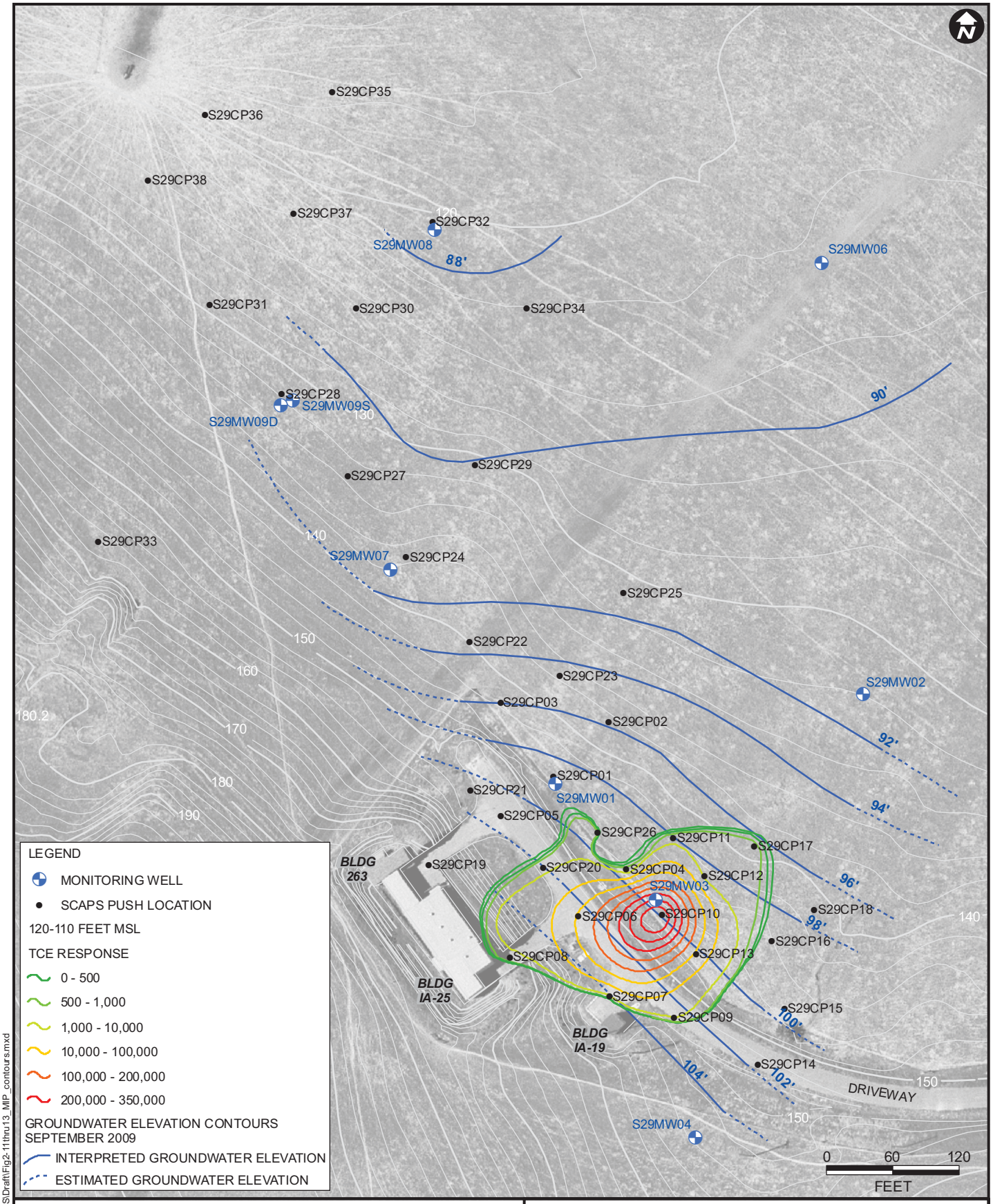

NOTES:
1. ALL ELEVATIONS PRESENTED IN FEET ABOVE MEAN SEA LEVEL.
2. MIP SCREENING RESPONSE PRESENTED IN MICROGRAMS PER LITER, SUBJECT TO MATRIX EFFECTS. ACTUAL SOIL AND GROUNDWATER CONCENTRATIONS MAY DIFFER.

MSL MEAN SEA LEVEL
MIP MEMBRANE INTERFACE PROBE
SCAPS SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
TCE TRICHLORETHENE

MIP TCE RESPONSE
120-110 FEET MSL
VADOSE ZONE

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-11

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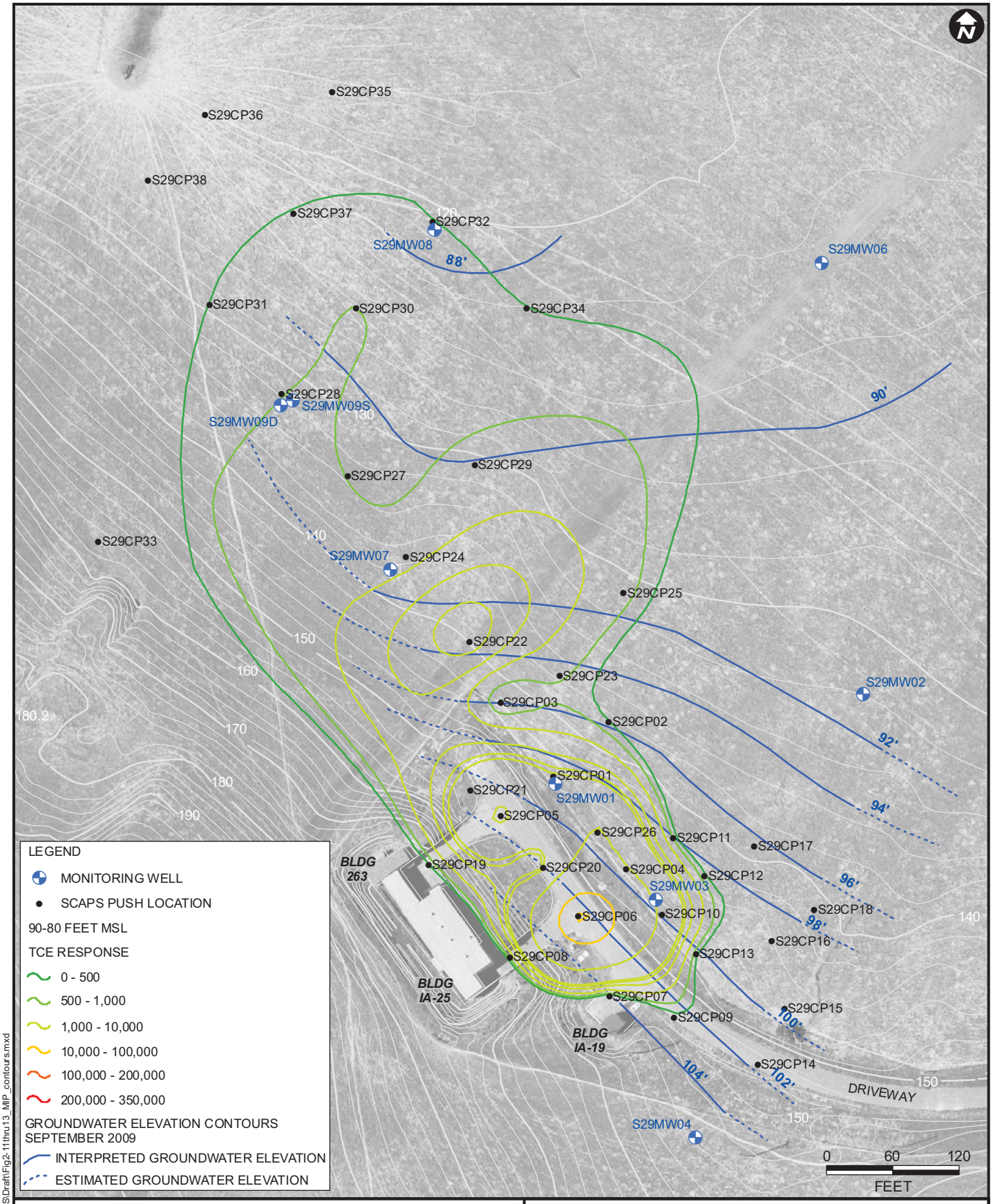
Accord MACTEC 8A JV | BRADY



NOTES:
1. ALL ELEVATIONS PRESENTED IN FEET ABOVE MEAN SEA LEVEL.
2. MIP SCREENING RESPONSE PRESENTED IN MICROGRAMS PER LITER, SUBJECT TO MATRIX EFFECTS. ACTUAL SOIL AND GROUNDWATER CONCENTRATIONS MAY DIFFER.

MSL MEAN SEA LEVEL
MIP MEMBRANE INTERFACE PROBE
SCAPS SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
TCE TRICHLORETHENE

MIP TCE RESPONSE
90-80 FEET MSL
NEAR WATER TABLE SATURATED ZONE

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-12

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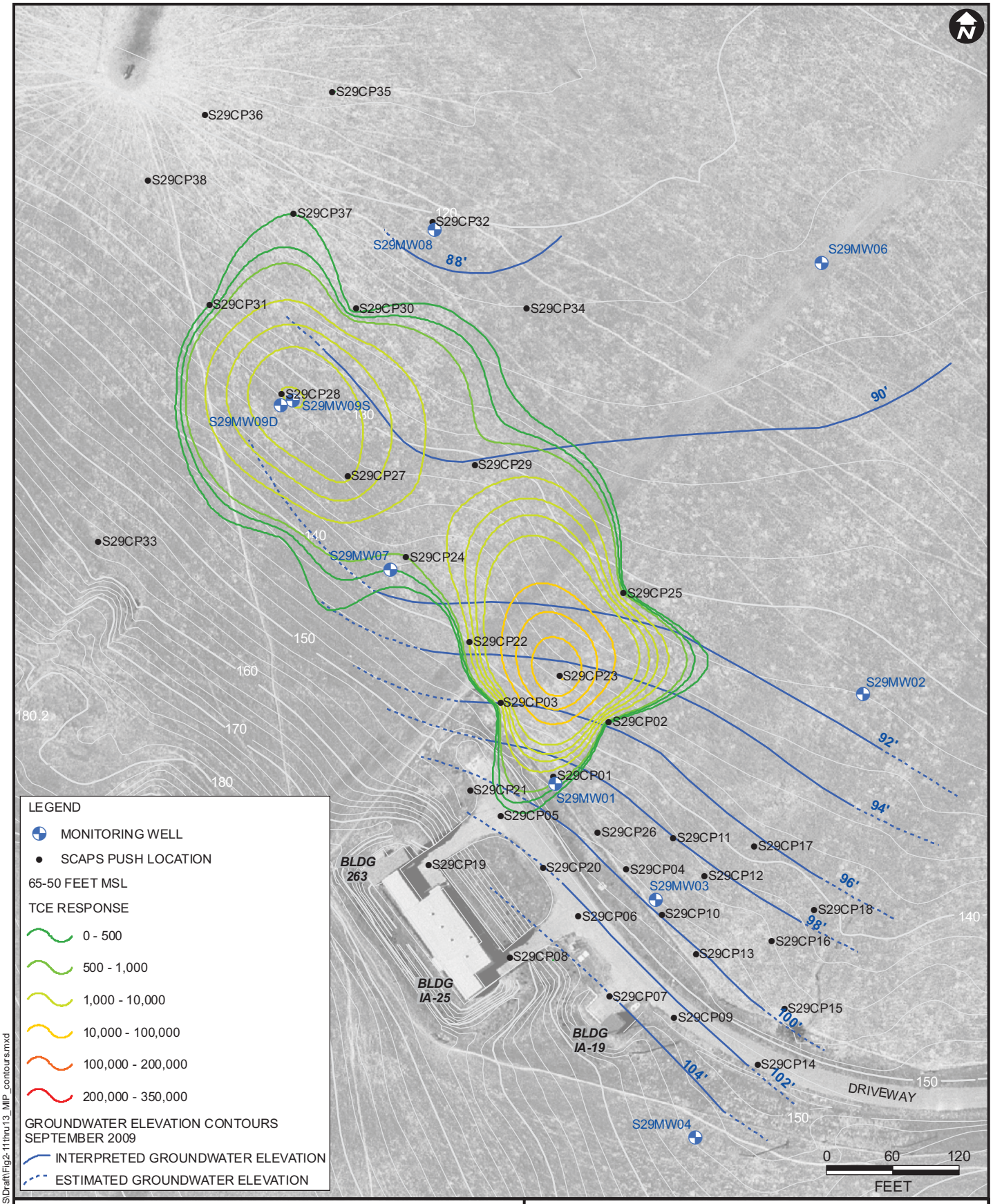
Accord MACTEC 8A JV | BRADY



NOTES:
1. ALL ELEVATIONS PRESENTED IN FEET ABOVE MEAN SEA LEVEL.
2. MIP SCREENING RESPONSE PRESENTED IN MICROGRAMS PER LITER, SUBJECT TO MATRIX EFFECTS. ACTUAL SOIL AND GROUNDWATER CONCENTRATIONS MAY DIFFER.

MSL MEAN SEA LEVEL
MIP MEMBRANE INTERFACE PROBE
SCAPS SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
TCE TRICHLORETHENE

MIP TCE RESPONSE
65-50 FEET MSL
DEEPER SATURATED ZONE

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-13

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Accord MACTEC 8A JV | BRADY

NOTES:
1. RESULT UNITS ARE IN MICROGRAMS PER CUBIC METER
2. RESULTS ARE PRESENTED ALONG A VERTICAL DEPTH AXIS
3. VERTICAL SCALE IS EQUAL TO THE HORIZONTAL SCALE
4. FOR SAMPLE RESULTS WHERE BOTH FIELD SCREENING AND TO-15 ANALYSES WERE PERFORMED, ONLY TO-15 RESULTS ARE POSTED.

J = ESTIMATED
U = NOT REPORTED ABOVE DETECTION LIMIT

LEGEND

TCE IN SOIL GAS BY METHOD TO-15
- NOT DETECTED
- 27 - 527
- 528 - 10000
- 10001 - 1300000

TCE IN SOIL GAS (FIELD SCREENING)
- NOT DETECTED
- 27 - 527
- 528 - 10000
- 10001 - 1300000

VERTICAL SAMPLE DEPTH

SOIL GAS - TCE TO-15 AND FIELD SCREENING ANALYTICAL RESULTS

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-14

Accord MACTEC 8A JV | BRADY

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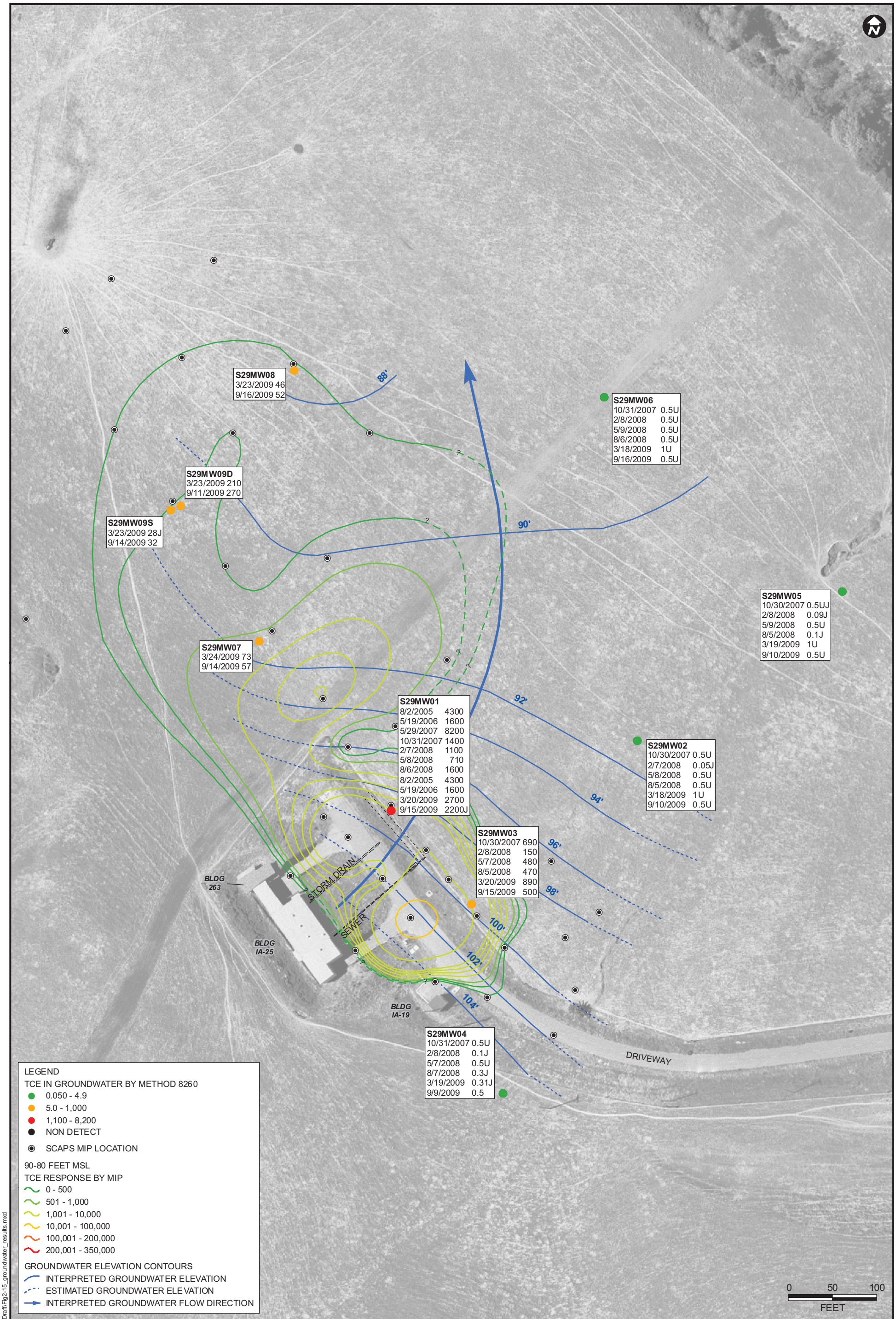

NOTES:
1. ALL ELEVATIONS PRESENTED IN FEET ABOVE MEAN SEA LEVEL
2. MIP SCREENING RESPONSE PRESENTED IN MICROGRAMS PER LITER, SUBJECT TO MATRIX EFFECTS. ACTUAL SOIL AND GROUNDWATER CONCENTRATIONS MAY DIFFER
4. EPA METHOD 8260 RESULT UNITS ARE IN MICROGRAMS PER LITER

MIP MEMBRANE INTERFACE PROBE
SCAPS SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
TCE TRICHLORETHENE

TCE IN GROUNDWATER

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-15

Accord MACTEC 8A JV | BRADY

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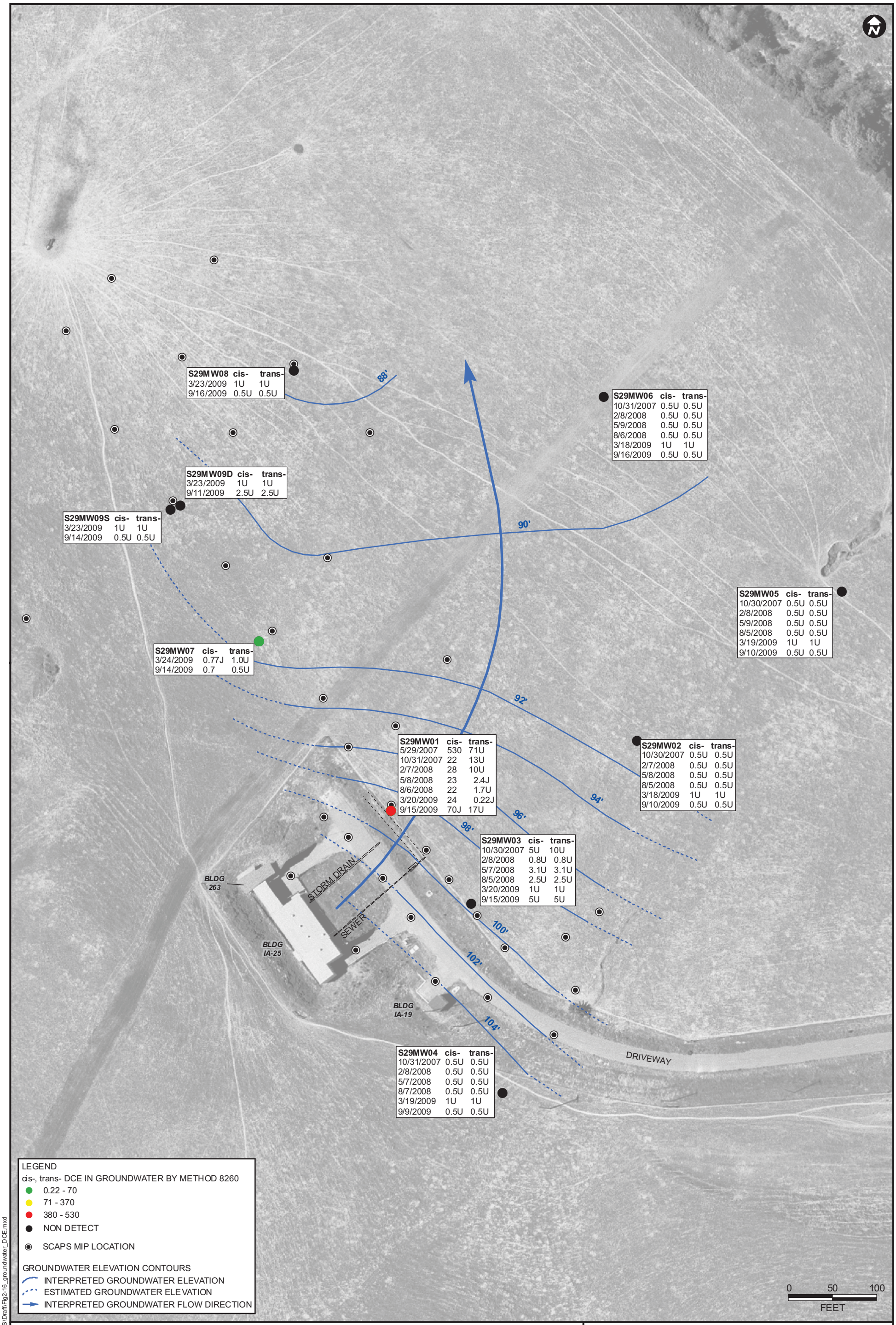

NOTES:
1. ALL ELEVATIONS PRESENTED IN FEET ABOVE MEAN SEA LEVEL.
2. ONLY DETECTED RESULTS OF CIS-1,2 AND TRANS-1,2 DCE ISOMERS ARE PRESENTED ON THE MAP.
3. DATA ARE SYMBOLIZED ON CIS-1,2 DCE RESULTS.
4. RESULT UNITS ARE IN MICROGRAMS PER LITER

ND NOT DETECTED ABOVE REPORTING LIMIT
DCE DICHLOROETHENE

DCE IN GROUNDWATER

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-16

Accord MACTEC 8A JV | BRADY

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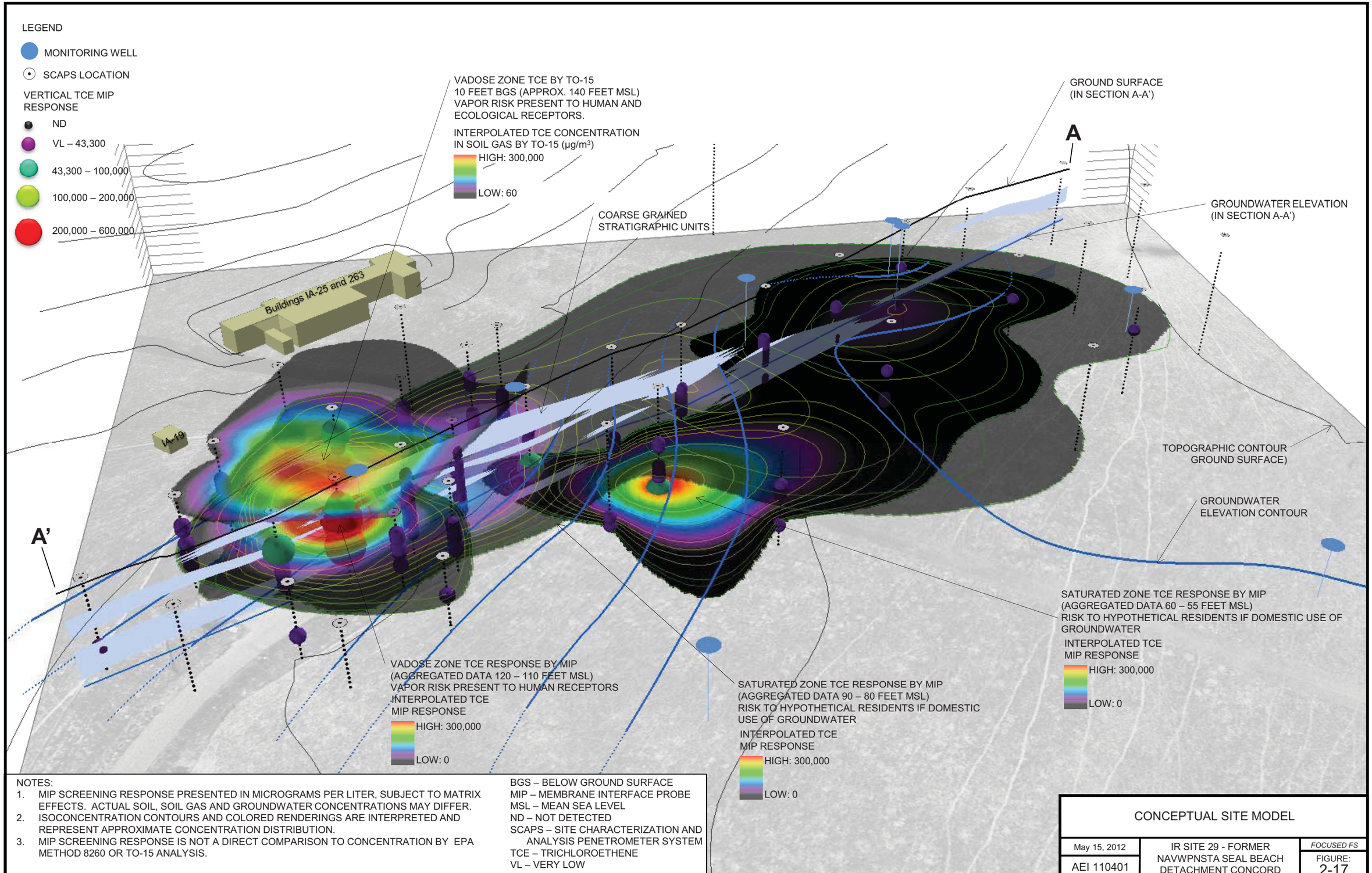

NOTES:
1. MIP SCREENING RESPONSE PRESENTED IN MICROGRAMS PER LITER, SUBJECT TO MATRIX EFFECTS. ACTUAL SOIL, SOIL GAS AND GROUNDWATER CONCENTRATIONS MAY DIFFER.
2. ISOCONCENTRATION CONTOURS AND COLORED RENDERINGS ARE INTERPRETED AND REPRESENT APPROXIMATE CONCENTRATION DISTRIBUTION.
3. MIP SCREENING RESPONSE IS NOT A DIRECT COMPARISON TO CONCENTRATION BY EPA METHOD 8260 OR TO-15 ANALYSIS.

BGS – BELOW GROUND SURFACE
MIP – MEMBRANE INTERFACE PROBE
MSL – MEAN SEA LEVEL
ND – NOT DETECTED
SCAPS – SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM
TCE – TRICHLOROETHENE
VL – VERY LOW

CONCEPTUAL SITE MODEL

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 2-17

Accord MACTEC 8A JV | BRADY

NOTE
1. TREATABILITY STUDY DATA NOT YET RELEASED
2. CONCENTRATION BASED ON THE MAXIMUM REPORTED IN THE REMEDIAL INVESTIGATION

LEGEND

TCE IN GROUNDWATER BY METHOD 8260 IN MICROGRAMS PER LITER

- 0.050 - 4.9
- 5.0 - 1,000
- 1,100 - 8,200

TREATABILITY STUDY MONITORING WELL

APPROXIMATE GROUNDWATER TREATMENT AREA

ESTIMATED AREA OF TCE IN GROUNDWATER ABOVE THE PROPOSED REMEDIATION GOAL

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 3-1

Accord MACTEC 8A JV | BRADY

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LEGEND

APPROXIMATE SOIL GAS TREATMENT AREA

NOTES
1. RESULT UNITS ARE IN MICROGRAMS PER CUBIC METER

MAXIMUM CONCENTRATION OF TCE FOR ALL DEPTHS REPORTED

- 10 - 1,000
- 1,001 - 10,000
- 10,001 - 100,000
- 100,001 - 1,300,000

ESTIMATED AREA OF TCE IN SOIL GAS ABOVE THE PROPOSED REMEDIATION GOAL

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 3-2

Accord MACTEC 8A JV | BRADY

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EXISTING WELL

NEW WELL

DEEP

WATER TABLE

SVE WELL

APPROXIMATE RADIUS OF INFLUENCE

SVE TREATMENT AREA

ALTERNATIVES 2, 3 AND 4
PRESUMPTIVE SOIL GAS REMEDY

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 5-1

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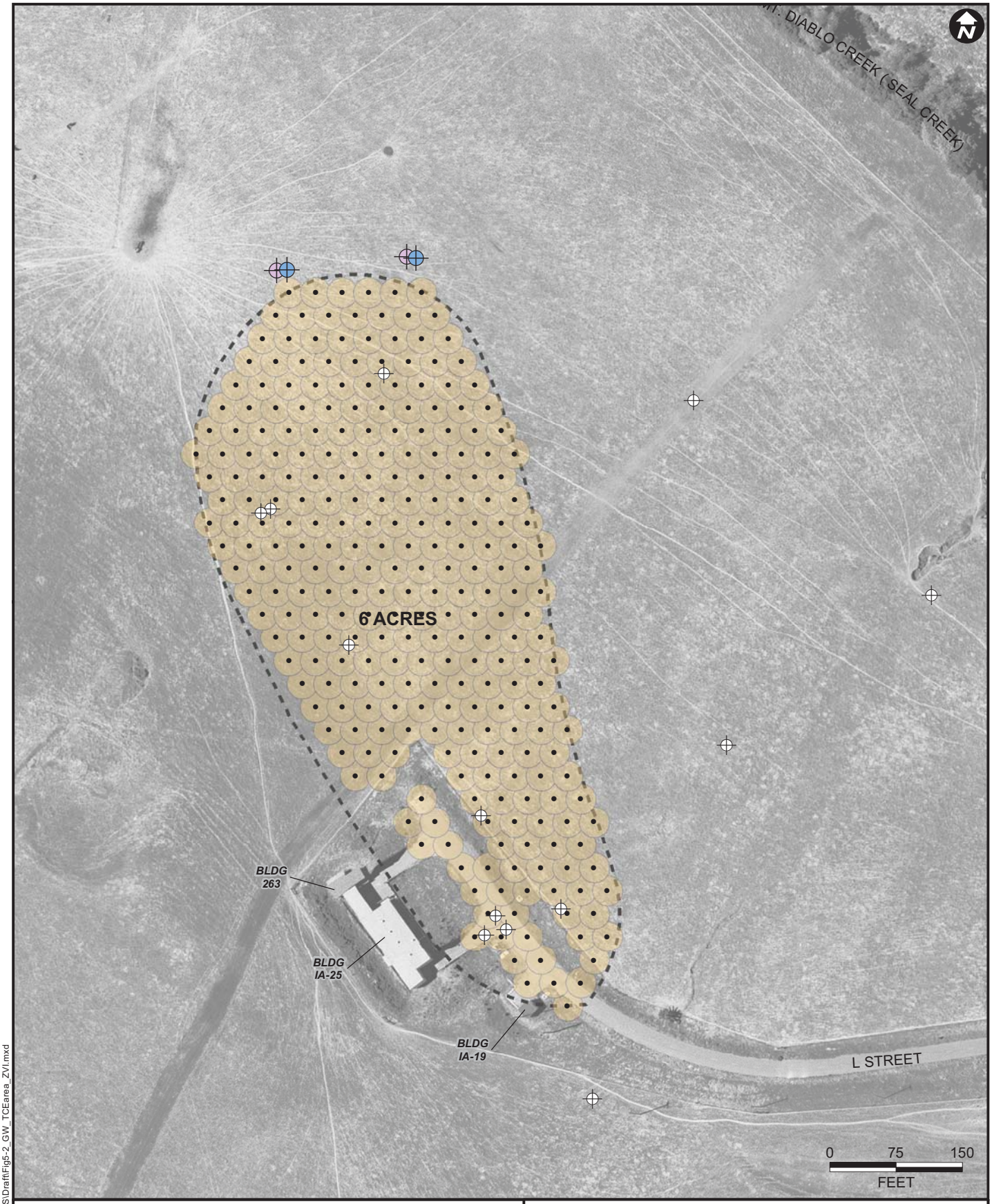
Accord MACTEC 8A JV | BRADY



EXISTING WELL
NEW WELL
DEEP
WATER TABLE
ZVI INJECTION LOCATION
RADIUS OF INFLUENCE
TREATMENT AREA

ALTERNATIVE 3
ZVI INJECTION

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 5-2

Accord MACTEC 8A JV BRADY

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EXISTING WELL

NEW WELL

DEEP

WATER TABLE

ISB INJECTION LOCATION

RECIRCULATION WELL

EXTRACTION

INJECTION

RADIUS OF INFLUENCE

TREATMENT AREA

ALTERNATIVE 4 - GROUNDWATER IN-SITU BIOREMEDIATION

May 15, 2012	IR SITE 29 - FORMER NAVWPNSTA SEAL BEACH DETACHMENT CONCORD	FOCUSED FS
AEI 110401		FIGURE: 5-3

Accord MACTEC 8A JV BRADY

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Tables

Table ES-1. Summary of Comparative Analysis of Remedial Alternatives
Table 3-1. Proposed Remediation Goals Protective of Human Health and Ecological Receptors
Table 4-1. Limited Screening of Remedial Technologies and Process Options for Groundwater at IR Site 29
Table 6-1. Summary of Cost Estimates for Site 29 Remedial Alternatives
Table 7-1. Comparative Analysis of Remedial Alternatives by Balancing Criteria
Table 7-2. Summary of Comparative Analysis of Remedial Alternatives

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Table 3-1. Proposed Remediation Goals Protective of Human Health and Ecological Receptors

Proposed RGs for Groundwater (Based on Potential Exposures for Human Receptors)			
Chemical of Concern[a]	**CAS #**	**Remedial Goal (µg/L)**	**Basis[b]**
1,1,2-trichloroethane	79-00-5	5	MCL
1,2-dichloroethane	107-06-2	0.5	MCL
benzene[c]	71-43-2	1	MCL
chloroform	67-66-3	0.19	risk-based
cis-1,2-dichloroethene	156-59-2	6	MCL
tetrachloroethene	127-18-4	5	MCL
trichloroethene	79-01-6	5	MCL

Proposed RGs for Soil Gas (Based on Potential Exposures for Human and Ecological Receptors)				
Chemical of Concern[d]	**CAS #**	**Remediation Goals (µg/m^3)**		
		USEPA Method 1 Residential[e]	**USEPA Method 1 Commercial/Industrial[f]**	**Ecological**
1,1-dichloroethene	75-35-4	--	--	600
benzene	71-43-2	160	4,800	--
chloroform	67-66-3	50	1,500	--
trichloroethene	79-01-6	660/323[g]	20,000	6,429

Notes:

-- Not an unacceptable risk contributor for this receptor; no remedial goals needed.

µg/L microgram(s) per liter

µg/m^3 micrograms per cubic meter

CAS Chemical Abstract Service

MCL Maximum Contaminant Level

RG remediation goal

a Only chemicals of concern identified for risk management in the baseline human and ecological risk assessments are presented in this table. Although some inorganics, pesticides, and polycyclic aromatic hydrocarbons (PAHs) were initially identified in the human health risk assessment as potential risk drivers for groundwater, it was concluded that inorganics are attributed to background concentrations. Pesticides and PAHs were infrequently detected and not considered chemicals of concern. Regulatory approval was given to remove pesticides from the groundwater monitoring program and PAHs were detected once in 45 samples (see Section 5 of the *Final Remedial Investigation* [Brady 2011]).

b Most stringent of Federal and California promulgated MCL value is presented. If Federal or California MCLs are not available, the USEPA tap-water regional screening level (RSL) from USEPA (2012) was used, which is a risk-based value.

c Benzene was not detected in groundwater above the remediation goal, but was included due to elevated soil gas detections.

d For vapor intrusion based on soil gas data, only chemicals that were identified as chemicals of concern in the human health or ecological risk assessments are included (i.e., contributing cancer risk greater than 1×10^{-6} [applies to human health] or noncancer hazard greater than 1 [applies to ecological health]).

e Residential RGs based on the federal (USEPA Method 1) approach are listed. Residential RGs based on DTSC Method 2 that differ include: benzene (87 µg/m^3), chloroform (430 µg/m^3), and trichloroethene (1,300 µg/m^3). Differences between methods are detailed in Section 3 of the human health risk assessment (Appendix G to the RI; Brady, 2011). In addition, table and footnote soil gas RGs differ from those originally presented in Table 1 of

Attachment 1; during agency review of a previous version, it was noted that an inconsistent residence mixing volume was used in development of the soil gas attenuation factors, differing from that used in groundwater modeling. Values in the table and this footnote have been down-adjusted to correct for the prior inconsistency (see the response to the City of Concord's Comment #6 in Attachment 2).

f Commercial/Industrial RGs based on the federal (USEPA Method 1) approach are listed. Commercial/Industrial RGs based on DTSC Method 2 that differ include: benzene (1,300 $\mu g/m^3$) and chloroform (6,500 $\mu g/m^3$). Differences between methods are detailed in Section 3 of the human health risk assessment (Appendix G of the RI; Brady, 2011).

g The residential RG for TCE in soil gas (660 $\mu g/m^3$) was calculated using 2009 toxicity criteria for TCE as the human health risk assessment (Appendix G to the RI; Brady, 2011) and Attachment 1 of this FFS were prepared prior to issuing of the IRIS TCE toxicity revision in 2011. The updated residential RG for TCE (323 $\mu g/m^3$), using 2011 toxicity criteria is presented here for consideration in the Record of Decision. The updated RG is calculated using the same site specific and building height parameters as the 2009-based RG.

Table 4-1. Limited Screening of Remedial Technologies and Process Options for Groundwater at IR Site 29*

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
LUCs	ICs	Governmental controls and proprietary controls	Administrative or legal devices to maintain the viability and effectiveness of the selected remedy and any ECs. Governmental controls (administrative) include land-use planning/zoning, permitting, building codes and ordinances. Proprietary controls (legal devices) are contractual mechanisms including deed restrictions, covenants, easements, or equitable servitudes. The general objective of ICs would be to prevent exposure to soil gas and groundwater posing unacceptable risk until the Navy and the regulatory agencies concur that further protective measures are no longer required.	Should be effective in preventing or limiting access or exposure to contamination. Generally, a layering strategy of system of mutually reinforcing LUCs is most effective.	Readily implementable. There is precedent for the use of ICs at Navy facilities.	Low capital costs. Low to moderate O&M costs to manage the ICs.	Retained for consideration as a component of remedial alternatives. In general, ICs will be part of all active remediation alternatives at Site 29, including the planned SVE for soil gas. Specific ICs are further developed in the Section 6.
LUCs	ECs	Physical Barriers	Intended to limit access to contaminated areas. Such controls include fencing, placing warning signs, and maintaining land-use restrictions on activities that involve disturbing subsurface materials.	Although suitable for soil gas, ECs are not considered effective for groundwater due to the depth to groundwater and the extremely low potential for contact with the groundwater. Groundwater at the site is not currently pumped or used for any purpose.	Readily implementable.	Low capital costs, with low to moderate O&M costs.	Retained for consideration as a component of remedial alternatives. In general, ECs will be part of all active remediation alternatives at Site 29, including the planned SVE for soil gas. Specific ECs are further developed in Section 6.
MNA	Groundwater monitoring, modeling	Groundwater sampling and analysis, natural attenuation monitoring, and modeling	Naturally occurring in situ processes reduce contaminant concentration and volume over time. Groundwater monitoring is performed to assess the progress of MNA.	MNA alone is not expected to be effective at reducing the concentration of contaminants at Site 29. Results of sampling performed during the RI, including bacterial sampling to test for VOC-degrading bacteria, indicate that VOCs at the site are not degrading naturally at any reasonable rate, if at all. Degradation products of TCE have generally not been found at the site, except on a very limited basis.	Highly implementable using common technologies and methods. The existing network of monitoring wells is available to support MNA and could easily be supplemented with additional wells if necessary.	Low capital cost. O&M cost could be high and is dependent on MNA effectiveness and duration.	Retained for further consideration component of remedial alternatives. Active remedial technologies may require MNA to track plume degradation and to justify site closure.

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Table 4-1. Limited Screening of Remedial Technologies and Process Options for Groundwater at IR Site 29*

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
Containment	Hydraulic controls with ex situ treatment	Extraction/ injection	Extraction and/or injection wells are used to modify the hydraulic gradient and control vertical and/or lateral migration of contaminants. The process is not designed to reduce contaminant concentrations; however, the extracted groundwater would require treatment using ex situ technologies.	Generally effective in limiting vertical and/or horizontal migration of groundwater contaminants. Effectiveness is reduced, however, because groundwater would be brought to the surface and treated, increasing the potential for human health exposure over the long term.	Although hydraulic control could be implemented based on the hydrogeology, this technology overall is not considered implementable as there are no nearby sewer lines to dispose of treated water, disposal of treated water to the Seal Creek riparian corridor is problematic, and extraction and treatment of groundwater over the long term may pose technical and administrative challenges. In addition, hydraulic containment systems typically must operate for extended periods (many years or decades).	Moderate to high in capital cost (no nearby discharge points) and high in O&M cost relative to other technologies, primarily due to the large quantity of water needing treatment over extended periods.	Eliminate from further consideration based on high cost, lack of adequate discharge mechanism, and the potential for additional exposure to groundwater brought to the surface (less desirable). In addition, based on the known extent of the plume and the hydrogeologic conditions (i.e., groundwater does not recharge Seal Creek), it does not appear that plume containment is necessary. Plume migration is not a significant concern because of a very flat groundwater gradient.
Groundwater extraction and ex situ treatment	Extraction and ex situ physical or chemical treatment	Extraction, adsorption/ absorption, advanced oxidation	Groundwater extraction wells collect impacted groundwater using pumps prior to ex situ treatment. The extracted groundwater is then treated to remove or destroy contaminants using ex situ technologies.	Although contaminant mass may be reduced, groundwater pumping has been shown to be inefficient and costly as the sole remedy for reducing contaminants to drinking water standards. In addition, effectiveness is reduced because groundwater would be brought to the surface and treated, increasing the potential for human health exposure over the long term.	Although pump and treat could be implemented based on the hydrogeology, this technology overall is not considered implementable as there are no nearby sewer lines to dispose of treated water, disposal of treated water to the Seal Creek riparian corridor is problematic, and extraction and treatment of groundwater over the long term may pose technical and administrative challenges. In addition, pump-and-treat systems typically must operate for extended periods (many years or decades).	Moderate to high in capital cost (no nearby discharge points) and high in O&M cost relative to other technologies, primarily due to the large quantity of water needing treatment over extended periods. In addition, costs for pump-and-treat systems are difficult to predict, primarily due to the uncertain endpoint of the remedy.	Eliminate from further consideration based on high cost, lack of adequate discharge mechanism, long duration, limited implementability and effectiveness, and potential for additional exposure to groundwater brought to the surface (less desirable).
Groundwater extraction and in situ treatment	Extraction and in situ, chemical or biological treatment	Groundwater recirculation	Groundwater extraction wells collected impacted groundwater downgradient of the treatment area (or cell). Pumped groundwater is augmented at the surface with chemical or biological agents and reinjected upgradient of the treatment area or cell.	Groundwater recirculation is very effective in delivering treatment to the contaminated area and influencing flow through the aquifer, especially in instances where direct injection is impracticable.	Considered highly implementable. Groundwater recirculation wells are easily installed with conventional equipment. Groundwater is transported and augmented above the surface via conveyance piping and reinjected.	Moderate to high capital cost for design, installation and O&M, but significantly less costly than direct injection alone when expected injection radius of influence is low.	Retain for evaluation as a stand-alone alternative or a component of a remedial alternative.

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Table 4-1. Limited Screening of Remedial Technologies and Process Options for Groundwater at IR Site 29*

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
In situ treatment	Physical treatment	Air sparging	Air is injected into the saturated zone to remove contaminants, typically VOCs, through volatilization. A vapor extraction system is usually implemented to remove the vapors that have been volatilized from groundwater. In addition, air sparging can be enhanced by adding oxygen and nutrients to the injected air stream to facilitate growth of naturally occurring microbes and accelerate aerobic bioremediation.	Moderate to low. Airflow through a heterogeneous, saturated zone may not be uniform, thus contaminant removal efficiency will vary and it could be difficult to control the volatilized VOCs. Additionally, air sparging may negatively impact the vadose zone downgradient of the source area if the extraction system does not adequately capture the sparged vapor-phase VOCs.	Implementation of air sparging at Site 29 is expected to be difficult due to subsurface heterogeneities. Vapor collection could also be complicated by the complex, interbedded geology at the site.	Moderate to high capital cost for design testing and installation. Moderate O&M cost over a relatively short operational time frame compared to pump and treat. Performance monitoring is required in groundwater and vadose zone, which would increase cost.	Eliminate from further consideration based on effectiveness, limited implementability, and high potential cost.
In situ treatment	Thermal treatment	Electrical resistive heating	Uses electrodes embedded in the subsurface to create a concentrated flow of current. Electrical resistance in soil generates heat greater than 100ºC (boiling point), producing steam and volatilizing VOCs, which are recovered via vacuum extraction. The extracted VOC vapors are then treated using ex situ treatment technologies (e.g., GAC, thermal oxidizer). Other potential treatment mechanisms are enhanced biodegradation and abiotic reactions, such as hydrolysis. The treatment area is covered with a site cap or plenum to mitigate any fugitive emissions that might occur from the subsurface.	Potential effectiveness at Site 29 considered very effective. Electrical resistance heating can be an extremely rapid form of remediation with case studies of effective treatment of soil and groundwater in less than 40 days. It is typically used for DNAPL plumes or other high-concentration source areas, so effectiveness may be limited at Site 29 as the highest concentrations are generally a few thousand µg/L of TCE and rapidly decline away from the source area where concentrations still exceed action criteria but electrical resistance heating may not be effective. Electrical resistive heating can be more effective in finer-grained than in coarser-grained soils; in the source area this could help remove contaminants that may be present in the clays and silts. In addition, reaching and maintaining the higher temperatures needed to induce volatilization deeper in an aquifer can be a challenge.	Rated low in implementability for Site 29 due to sensitive ecological receptors and the lack of an electrical source needed to supply power to the electrodes, it may only be effective in a limited source area around the highest concentrations in groundwater. Although solar power is being explored as part of the SVE pilot study, the potential use of solar for electrical resistive heating that has high power consumption is unknown. There is anticipated to be additional effort expended on site-specific treatability studies, which are necessary to evaluate effectiveness. The full-scale SVE system planned for soil-gas remediation would need to be modified to account for off-gassing and steam capture for an electrical resistive heating remedy for groundwater, including consideration of treatment and disposal of an increased volume of extracted water (steam).	Higher capital costs for electrode and thermal monitoring well installation, and treatability studies coupled with modifications to the SVE system to capture volatilized vapors and steam from groundwater. In addition, because there is no electricity source at the site, capital costs would be incurred to route sufficient power to operate the electrodes. The duration and cost of O&M over the life of the project could be lower than other technologies.	Eliminate from further consideration on the basis of low implementability and probable higher cost. Other in situ remediation technologies offer better, more cost-effective potential for source reduction.

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Table 4-1. Limited Screening of Remedial Technologies and Process Options for Groundwater at IR Site 29*

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
In situ treatment	Chemical/ biological treatment	PRB	A PRB is a permeable, vertical wall containing a treatment medium (chemical or biological) that allows the passage of water while degrading or removing contaminants. PRBs are typically installed by trenching (for shallower applications), but can be constructed as an array of overlapping borings (deep soil mixing) in a line for deeper applications. Innovative methods such as modified backhoes with slurry support, caisson excavation, hydraulic fracturing, and jetting have been used in recent years.	Potential effectiveness at Site 29 considered moderate to low. The hydrogeologic and physical conditions at Site 29 would greatly complicate and may compromise effectiveness of a PRB. PRBs work best at sites with coarser subsurface materials (e.g., sands), a steady flow of groundwater, and contaminants at less than 50 feet deep. The complex interbedded geology, variable groundwater flow directions, depth of contamination, and distribution of fine-grained layers would make an effective PRB system difficult to design and monitor.	Moderately implementable. Major implementability issues related to constructability due to the depth that would be needed to treat groundwater at Site 29, and long-term O&M. Although the PRB itself is relatively low maintenance, a sufficient groundwater monitoring network designed specifically for the PRB is required to evaluate long-term performance. Depending on performance due to site-specific conditions, PRBs may require optimization and/or replacement during the life of the remedy; the life cycle of a PRB is difficult to estimate. PRBs require detailed characterization of the hydrogeology and geochemistry and groundwater modeling to evaluate potential effects on groundwater flow patterns and contaminant migration as a result of the PRB. For Site 29, trenching methods would be impractical because groundwater is too deep to safely trench.	High capital cost (particularly for deeper installations) and relatively low O&M cost compared to other process options; however, this cost could escalate substantially if the PRB needs replacing or optimizing during the remedy. In addition, long-term monitoring costs would be incurred. Overall, may be more cost effective compared to traditional pump and treat, but less cost effective compared to other in situ injection treatment methods.	Eliminate from further consideration because of the moderate to low effectiveness given the site conditions, implementability issues, and relatively higher expected cost compared to some other potential remedies.
In situ treatment	Chemical treatment	ISCO	Oxidants are injected into the subsurface to destroy the contaminants or convert them to innocuous compounds. Several oxidant mixtures are available and applicability depends on various site-specific factors. Typical oxidants used are hydrogen peroxide, Fenton's reagent, ozone, permanganate, and persulfate. Different injection methods can be employed, such as direct injection, injection or infiltration wells or galleries, recirculation wells, and trenches.	Potential moderate to high effectiveness at Site 29. ISCO can chemically oxidize the VOCs present in the Site 29 groundwater. However, hydrogeologic and geochemical conditions must be well understood as ISCO performance is site specific.	Moderately implementable. Handling reagents requires special engineering controls. The potential for multiple injections should not be underestimated. Critical design factors are oxidant selection and dose, overcoming natural oxidant demand, and oxidant delivery methods. Additional effort is anticipated for pilot- and/or bench-scale treatability studies to evaluate and maximize these design factors. Oxidant handling and safety by field crews is an important consideration and, in this sense, may be less implementable than other in situ methods. Subsurface heterogeneities could complicate subsurface delivery.	Moderate to high in capital cost. The duration and cost of O&M over the life of the project could be significantly lower than other technologies such as PRBs or pump and treat because treatment times can be relatively rapid. However, multiple injections may be needed.	Eliminate from further consideration because uncertainty and costs related to bench-scale testing, handling of oxidant, and effectiveness are not favorable. Soil chemistry may have a negative effect on chemical oxidant mixtures thus requiring additional volume and/or additional injections.

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Table 4-1. Limited Screening of Remedial Technologies and Process Options for Groundwater at IR Site 29*

General Response Action	Remedial Technology	Process Option	Description	Effectiveness	Implementability	Cost	Conclusion
In situ treatment	Chemical treatment	ZVI	ZVI is a strong reducing agent. ZVI in solution is injected into contaminated groundwater to reduce VOCs. ZVI particles can vary in size depending on the application and site conditions. ZVI is mixed at the surface into a solution or slurry and injected directly into contaminated groundwater. Chlorinated VOCs are degraded by reductive degradation via hydrogenolysis or beta elimination reactions. Beta elimination degrades TCE without producing the intermediate products DCE and VC (Cook 2009).	Potentially highly effective at Site 29. ZVI tends to be more effective in treating dissolved-phase VOCs because the specific gravity is similar to water, whereas EZVI (see below) has a slightly higher specific gravity. Since VOCs at Site 29 are present in groundwater in the dissolved phase (DNAPL is not present), ZVI would adequately reduce contaminant mass. The larger surface area of nanoscale ZVI has proven to be very effective in reducing VOCs.	Considered implementable. ZVI slurry is easier to inject than EZVI since storage and mixing of the emulsion is not a factor. Subsurface heterogeneities could complicate ZVI delivery.	Material costs for microscale ZVI are significantly less than nanoscale. Rapid degradation of chlorinated VOCs would result in low O&M costs over the life of the project.	Retain for evaluation as a stand-alone alternative or a component of a remedial alternative.
In situ treatment	Chemical treatment	EZVI	Similar to ZVI, EZVI is a solution of nano- or microscale ZVI, food-grade surfactant, biodegradable oil, and water. EZVI is mixed at the surface and injected directly into contaminated groundwater. EZVI is effective in treating DNAPL because the exterior oil emulsion membranes are hydrophobic. The oil can also enhance biodegradation. Addition of catalysts to iron nano- or microparticles can enhance degradation.	Potential moderate to high effectiveness at Site 29. EZVI is very effective in treating a DNAPL source area because the emulsion increases specific gravity of the slurry, thereby mixing with the DNAPL. Nanoparticles are highly reactive resulting in relatively rapid reduction of contaminant concentrations, especially if DNAPL is present. Nano- or microscale EZVI can chemically reduce TCE effectively. Concentration reductions on the order of 90% or more have been reported in the literature over relatively short periods, for example, days to months. Iron nano- or microparticles increase pH and decrease ORP, which could enhance anaerobic biodegradation. However, hydrogeologic and geochemical conditions must be well understood as performance is site specific. One potential limitation is that EZVI may not achieve widespread distribution in groundwater due to agglomeration into larger particles, although research is ongoing to improve distribution.	Considered moderate to highly implementable. Depending on the quantity required, EZVI can be mixed at the surface or brought to the site ready to inject; however, storage problems are known to exist. Subsurface heterogeneities could complicate EZVI delivery.	Material costs are potentially higher than ZVI because of the emulsion material and storage/handling. Rapid degradation of chlorinated VOCs would result in low O&M costs over the life of the project.	Eliminate from further consideration because DNAPL is not present at the site.

*Because in situ bioremediation using injection of solutions into groundwater is currently being evaluated as an alternative and is currently under development in the *Final In Situ Anaerobic Bioremediation and Solar-Powered Vapor Extraction Treatability Study Work Plan* (Shaw 2011), the in situ biological process option was not screened in this table. This table is intended to screen additional potential technologies and process options for one additional groundwater remedial alternative.

Acronyms/Abbreviations:

µg/L – micrograms per liter
°C – degrees Celsius
DCE – dichloroethene
DNAPL – dense nonaqueous-phase liquid
EC – engineering control
EZVI – emulsified zero- valent iron
GAC – granular activated carbon
IC – institutional control
ISCO – in situ chemical oxidation
LUC – land-use control
MNA – monitored natural attenuation
O&M – operation and maintenance
ORP – oxidation reduction potential
PRB – permeable reactive barrier
RI – remedial investigation
SVE – soil-vapor extraction
TCE – trichloroethene
VC – vinyl chloride
VOC – volatile organic compound
ZVI – zero-valent iron

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Table 6-1. Summary of Cost Estimates for Site 29 Remedial Alternatives

Alternative	Duration of Alternative	Capital Cost	O&M Cost	Total Cost[a]	Net Present Value[b]
1 – No Action	extensive	$0	$0	$0	$0
2 – SVE with Monitored Natural Attenuation	30 years	$9,935,563	$3,225,333	$13,160,896	$11,126,320
3 – SVE with ZVI Injection[c]	15 years	$16,725,012	$3,225,333	$19,950,345	$18,501,556
4 – SVE with ISB and Groundwater Recirculation[c]	15 years	$12,349,737	$3,225,333	$15,575,070	$14,275,814

Notes:

a total cost includes 20% contingency

b real discount rate of 2.3% was used to calculate net present value

c the implementation of ZVI and ISB components in Alternatives 3 and 4 is short-term (less than 1 year), execution of monitored natural attenuation, if needed, is assumed to be 15 years for comparison purposes

Acronyms/Abbreviations:

ISB – in situ (anaerobic) bioremediation

LUC – land-use control

SVE – soil-vapor extraction

ZVI – zero-valent iron

O&M – operation and maintenance

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Table 7-1. Comparative Analysis of Remedial Alternatives by Balancing Criteria

Alternative	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost*
Parameters Considered: **Alternatives and Components**	• Residual risk at completion • Long-term management of contaminants • Reliability of ICs • Need to replace components • Continuing repair/maintenance needs	• Treatment processes to reduce exposure • Degree of reduction in toxicity, mobility, or volume through treatment • Degree of irreversibility • Treatment residuals generated	• Short-term risks to community • Threats to workers during construction and O&M • Environmental impacts • Time until preliminary RGs are met	• Ease of construction and operation • Operational reliability • Ability to undertake future remedial options • Ability to monitor effectiveness • Ability to obtain governmental approvals • Availability of services and materials	• Net present value • Capital costs • O&M costs
1 – No Action	**Low**	**Low**	**High**	**High**	**High**
Components: • No remedial measures of any kind	Alternative 1 is not considered effective. Concentrations of VOCs in soil gas and groundwater above the preliminary RGs would remain for some time, with no controls to prevent unacceptable exposure. This alternative requires no maintenance, long-term management, or other action. There would be no remedial measures or long-term effectiveness and permanence of Alternative 1.	No active treatment would be performed. Although VOC concentrations in soil gas and groundwater would attenuate over time, concentrations above the preliminary RGs would be expected to remain over the timeframe (30 years) selected as the comparison metric for this FFS. No treatment processes would be used to reduce toxicity, mobility, or volume of impacted soil for Alternative 1.	Because Alternative 1 does not involve any active measures to remediate the site, preliminary RGs and RAOs would not be met. Alternative 1 would not involve construction or other intrusive activities. There would be no adverse short-term impacts to site workers, the surrounding community, or the environment. The time required to achieve preliminary RGs cannot be assessed.	Alternative 1 would be easy to implement because it requires no action.	No direct costs are incurred.
2 – SVE with MNA	**Medium**	**Medium**	**Medium-High**	**Medium-High**	**Medium-High**
Components: • RD • SVE installation • Well installation • SVE O&M for 5 years • Long-term well maintenance • MNA of the groundwater plume for 30 years • LUCs, including annual inspections • iRACR at completion of 5 years of SVE • RACR at year 30 for LUCs and groundwater • Annual reports and 5-year reviews	SVE is an effective means of achieving RAOs in the vadose zone and will likely have some positive effect in groundwater. There is the possibility of rebound of VOCs off-gassing from the aquifer back into the vadose zone at the source area. Alternative 2 would require continual groundwater monitoring, LUC inspections, and annual reports. LUCs would be implemented to prohibit potable use of groundwater, residential land use, and actions that could damage remedy components. Annual LUC inspections would be performed, as required, to assess their continuing effectiveness. The long-term effectiveness of LUCs would depend on continued adherence to LUC protocols.	The toxicity and mobility of VOCs would be reduced to RAOs for the vadose zone. However, VOCs in groundwater would be only minimally reduced by SVE. Groundwater monitoring would only serve as a means to monitor plume stability over time. Exposure to VOCs in groundwater would be managed with LUCs.	Because the site is in an undeveloped area, there would be minimal adverse short-term impacts to the surrounding community. Construction of the SVE system may disrupt wildlife for a short period of time. This alternative would not take a significant amount of time to implement. VOCs in groundwater would not be treated or removed; therefore, time to achieve preliminary RGs would be indefinite. Field activities associated with this alternative (groundwater monitoring and periodic site visits) would result in more short-term impacts than other active alternatives. No significant short-term risks to the community are anticipated from the implementation of this alternative, unless the site is redeveloped. The calculated risk to workers for Alternative 2 is lower than Alternatives 3 and 4. Calculated air emissions (NO_x, SO_x, and PM_{10}) associated with this alternative result primarily from long-term monitoring.	Alternative 2 is readily implementable. SVE system, groundwater monitoring-well installation, and LUC implementation are not expected to pose significant challenges.	The present-value comparative cost of Alternative 2 is $11.1M, which is lower than the other active alternatives. Refer to Appendix B for a cost-summary breakdown for this alternative.

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Table 7-1. Comparative Analysis of Remedial Alternatives by Balancing Criteria

Alternative	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost*
Parameters Considered: **Alternatives and Components**	• Residual risk at completion • Long-term management of contaminants • Reliability of ICs • Need to replace components • Continuing repair/maintenance needs	• Treatment processes to reduce exposure • Degree of reduction in toxicity, mobility, or volume through treatment • Degree of irreversibility • Treatment residuals generated	• Short-term risks to community • Threats to workers during construction and O&M • Environmental impacts • Time until preliminary RGs are met	• Ease of construction and operation • Operational reliability • Ability to undertake future remedial options • Ability to monitor effectiveness • Ability to obtain governmental approvals • Availability of services and materials	• Net present value • Capital costs • O&M costs
3 – SVE with ZVI Injection	**High**	**High**	**Medium**	**Medium**	**Medium-Low**
Components: • RD • Installation of an SVE system (discussed in Alternative 2) • Installation of four groundwater monitoring wells (two at 60 feet bgs, two at 80 feet bgs). • O&M of the SVE system performance monitoring for VOCs • Bench-scale/pilot testing for ZVI • ZVI injections (assumed 275 spaced on 30-foot centers) to an average depth of 80 feet bgs • Groundwater monitoring of VOCs, DHC, metals, and MNA parameters as follows: o Quarterly – Years 1 & 2 o Semiannually – Years 3 & 4 o Annually – Year 5 o Annually – Years 6 through 15 (analytical suite is subject to be reduced to a shortened list of analytes, but presumed for costing purposes to be the full suite of VOCs, DHC, metals, and MNA parameters) • Soil-gas and groundwater monitoring reports and periodic reviews • Preparation of an iRACR for soil gas • Preparation of a RACR after satisfaction of the RAOs	For Alternative 3, all vadose- and saturated-zone VOCs exceeding preliminary RGs would be treated to achieve RAOs. Some risk is inherent with any injection system because rebound may occur and additional injections may be necessary; however, for ZVI the risk of additional injections is less than in situ chemical oxidation with permanganate. LUCs to prohibit site access and domestic use of groundwater would only remain in place until satisfaction of RAOs, which is assumed to be 5 years.	Treatment is the primary component of Alternative 3. SVE combined with ZVI would provide irreversible removal and/or chemical destruction of VOCs in the vadose and saturated zones in the area treated. ZVI injection with pneumatic fracturing can be targeted to specific hydrogeologic units where TCE was detected by MIP. ZVI can increase dissolved metals concentrations, but such increases are expected to be localized and temporary as the aquifer returns to natural conditions.	Alternative 3 would involve construction of the SVE system and ZVI injections over approximately 6–9 months. Alternative 3 would involve transportation, mixing, and injection of a significant quantity of ZVI. Once the injections are completed, this alternative would reduce VOCs to the preliminary RGs. Additionally, ZVI has a longer residence time in situ than other reducing agents; therefore, rebound is expected to be minimal. ZVI injection is a fairly routine remediation practice; PPE and standard chemical handling procedures are assumed to sufficiently mitigate threats posed to workers during ZVI treatment. The estimated time to reach preliminary RGs for soil gas and groundwater is 5 years, including the pre-design investigation, bench-scale testing, RD and field activities, SVE installation, and operation. Groundwater RGs may be achieved in months, whereas SVE may take up to 5 years. The calculated risk to workers for Alternative 3 is higher than for Alternatives 2 and 4, primarily from handling of treatment materials. Calculated air emissions (NO_x, SO_x, and PM_{10}) associated with this alternative, result primarily from drilling equipment use but are significantly lower than Alternative 4.	Alternative 3 includes bench-scale/pilot testing to assess ZVI design parameters. ZVI treatment is expected to reliably reduce VOCs in groundwater. Contractors to perform ZVI injection services are available; however, contractors who can perform pneumatic fracturing are limited. Difficulties may be encountered with reaching target injection depth in some cases.	The present-value comparative cost of this alternative is $18.5M, which is comparable to Alternative 4 and higher than Alternative 2. Refer to Appendix B for a cost-summary breakdown for this alternative.

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Table 7-1. Comparative Analysis of Remedial Alternatives by Balancing Criteria

Alternative	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost*
Parameters Considered: **Alternatives and Components**	• Residual risk at completion • Long-term management of contaminants • Reliability of ICs • Need to replace components • Continuing repair/maintenance needs	• Treatment processes to reduce exposure • Degree of reduction in toxicity, mobility, or volume through treatment • Degree of irreversibility • Treatment residuals generated	• Short-term risks to community • Threats to workers during construction and O&M • Environmental impacts • Time until preliminary RGs are met	• Ease of construction and operation • Operational reliability • Ability to undertake future remedial options • Ability to monitor effectiveness • Ability to obtain governmental approvals • Availability of services and materials	• Net present value • Capital costs • O&M costs
4 – SVE with ISB and Groundwater Recirculation	**High**	**High**	**Medium**	**Medium**	**Medium**
Components: • RD • Installation of an SVE system (discussed in Alternative 2) • Installation of four groundwater monitoring wells • Installation of 20 groundwater recirculation wells to a depth of 80 feet • Construction of the groundwater circulation system • O&M of the SVE and groundwater recirculation systems • SVE and groundwater recirculation performance monitoring • Injection of substrate amended with a bacteria culture at approximately 200 locations to an average depth of 70 feet bgs with an assumed radius of influence of 7 feet • Groundwater monitoring of VOCs, DHC, metals, and MNA parameters as follows: o Quarterly – Years 1 & 2 o Semiannually – Years 3 & 4 o Annually – Year 5 o Annually – Years 6 through 15 (analytical suite is subject to be reduced to a shortened list of analytes, but presumed for costing purposes to be the full suite of VOCs, DHC, metals, and MNA parameters) • Groundwater monitoring reports and periodic reviews • Preparation of an iRACR for soil gas • Preparation of a RACR after satisfaction of the RAOs	For Alternative 4, all vadose- and saturated-zone VOCs exceeding preliminary RGs would be treated to achieve RAOs. LUCs would only need to remain in effect for the duration of the remedy (5 years). Some risk is inherent with any injection system because rebound may occur and additional injections may be necessary. The groundwater recirculation system would require appreciable aboveground piping and construction, but would be effective in delivering amended groundwater to treatment zones. Detailed analysis of the hydraulic gradient in target soil horizons would be necessary to ensure contamination is not spread. The long-term effectiveness is greatly dependent on a sound understanding of hydrogeologic conditions and, as with any groundwater circulation system, may not deliver treatment to every area of the plume. LUCs to prohibit site access and domestic use of groundwater would only remain in place until satisfaction of RAOs, which is assumed to be 5 years.	Treatment is the primary component of Alternative 4. SVE combined with ISB would provide irreversible removal and/or chemical destruction of VOCs in the vadose and saturated zones in the area treated. ISB may not be as effective as ZVI in delivering treatment to specific hydrogeologic zones vertically and horizontally across the plume since the groundwater recirculation system is a less focused approach to delivering treatment to the contamination. Movement of site groundwater may increase contaminant mobility.	Alternative 4 would involve construction of the SVE system followed by installation and operation of the groundwater recirculation system and ISB injection. Groundwater recirculation and ISB injection would be conducted between 4 months to 1 year. ISB injection and groundwater recirculation are relatively routine remediation practices. PPE and standard chemical-handling procedures are presumed to mitigate threats to workers during ISB injection and recirculation system O&M. The estimated time to reach preliminary RGs is the same as Alternative 3. The calculated risk to workers for Alternative 4 is slightly lower than Alternative 3 and higher than Alternative 2. Calculated air emissions (NOx, SOx, and PM10) associated with this alternative, resulting primarily from installation and operation of the groundwater recirculation system, are higher than Alternatives 2 and 3.	Alternative 4 includes bench-scale/pilot testing to assess groundwater recirculation design and ISB injection. Although a Treatability Study (Shaw 2011) is currently underway, additional data may be required for the recirculation system. Contractors to perform ISB injection services are available. Storage and delivery of ISB substrate may be logistically challenging; however, once the recirculation system is in place, the scheduling and sequencing of ISB injections should be readily implementable.	The present-value comparative cost of this alternative is $14.3M, which is comparable to Alternative 3 and higher than Alternative 2. Refer to Appendix B for a cost-summary breakdown for this alternative.

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Table 7-1. Comparative Analysis of Remedial Alternatives by Balancing Criteria

Notes:

*A low-ranking, under-the-cost criterion means present-value comparative costs are higher (less desirable), and a high rating means comparative costs are lower (more desirable).

Acronyms/Abbreviations:

bgs – below ground surface
DHC – *Dehalococcoides* sp.
IC – institutional control
iRACR – Interim Remedial Action Completion Report
ISB – in situ anaerobic bioremediation
LUC – land-use control
M – million
MIP – membrane interface probe
NO_x – oxides of nitrogen
O&M – operation and maintenance
PM_{10} – particulate matter with particle size 10 microns or smaller (in air)
PPE – personal protective equipment
RACR – Remedial Action Completion Report
RAO – remedial action objective
RD – remedial design
RG – remediation goal
SO_x – oxides of sulfur
SVE – soil-vapor extraction
TCE – trichloroethene
VOC – volatile organic compound
ZVI – zero-valent iron

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Table 7-2. Summary of Comparative Analysis of Remedial Alternatives

Criterion[a]	Alternative 1 (No Action)	Alternative 2 (SVE with MNA)	Alternative 3 (SVE with ZVI Injection)	Alternative 4 (SVE with ISB and Groundwater Recirculation)
Overall protection of human health and the environment[b]	Not protective	Protective	Protective	Protective
Compliance with ARARs[b]	Not applicable (no ARARs)	Complies	Complies	Complies
Long-term effectiveness and permanence[c]	○	◑	●	●
Reduction of toxicity, mobility, or volume through treatment[c]	○	◑	●	●
Short-term effectiveness[c]	●	◕	◑	◑
Implementability[c]	●	◕	◑	◑
Cost[c, d]	● $0	◕ $11.1M	◔ $18.5M	◑ $14.3M

Notes:

a State and community acceptance are not shown; the state has not commented on the alternatives, and community acceptance will be assessed following the public review process.

b Threshold criterion (must be satisfied for a remedial alternative to be eligible for selection unless an ARAR waiver applies).

c Primary balancing criterion.

d Estimated cost (M = millions)

ARAR applicable or relevant and appropriate requirement

ISB in situ anaerobic bioremediation

LUC land-use control

MNA monitored natural attenuation

NCP National Oil and Hazardous Substances Pollution Contingency Plan

SVE soil-vapor extraction

ZVI zero-valent iron

Relative Performance in Satisfying NCP Criteria

Least →				Best
○	◔	◑	◕	●
(low)	(medium-low)	(medium)	(medium-high)	(high)

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Appendix A

Applicable or Relevant and Appropriate Requirements

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ATTACHMENT

Attachment A1. Department of Fish and Game Identified ARARs Memorandum to Jim Pinasco dated 24 May 2011 and DTSC E-mail Memorandum with List of ARARs dated 16 May 2011

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ACRONYMS AND ABBREVIATIONS

§	section
ARAR	applicable or relevant and appropriate requirement
BAAQMD	Bay Area Quality Management District
Basin Plan	*Water Quality Control Plan for San Francisco Bay Basin*
CAA	Clean Air Act
Cal. Code Regs.	*California Code of Regulations*
Cal. Fish & Game Code	*California Fish & Game Code*
CCC	California Civil Code
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
ch.	chapter
COC	chemical of concern
CWA	Clean Water Act
CWC	California Water Code
DCA	dichloroethane
DCE	dichloroethene
DFG-OSPR	California Department of Fish and Game, Office of Spill Prevention and Response
div.	division
DTSC	California Department of Toxic Substances Control
e-mail	electronic mail
ESA	Endangered Species Act
Fed. Reg.	*Federal Register*
FFA	Federal Facilities Agreement
FFS	focused feasibility study
former NAVWPNSTA Concord	former NAVWPNSTA Seal Beach, Detachment Concord
FS	feasibility study
ISB	in situ anaerobic bioremediation
LUC	land-use control

MBTA	Migratory Bird Treaty Act
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/L	milligrams per liter
MNA	monitored natural attenuation
MUN	municipal and domestic supply
NAAQS	National Ambient Air Quality Standard(s)
Navy	U.S. Department of the Navy
NAVWPNSTA	Naval Weapons Station
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
PCE	perchloroethene (also known as tetrachloroethene)
Porter-Cologne Act	Porter-Cologne Water Quality Control Act
pt.	part
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
Res.	Resolution(s)
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SFBRWQCB	California Regional Water Quality Control Board, San Francisco Bay Region
SIP	State Implementation Plan
Site 29 (or site)	Installation Restoration Site 29
STLC	soluble threshold limit concentration
SVE	soil-vapor extraction
SWRCB	State Water Resources Control Board
TBC	to be considered
TCA	trichloroethane
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
tit.	title
TSCA	Toxic Substances Control Act
TTLC	total threshold limit concentration

USC	*United States Code*
U.S. EPA	United States Environmental Protection Agency
VOC	volatile organic compound
WET	waste extraction test
WQO	water quality objective
ZVI	zero-valent iron

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Section 1 Introduction

This appendix to the *Focused Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29,* identifies and evaluates potential federal and State of California applicable or relevant and appropriate requirements (ARARs) from the universe of regulations, requirements, and guidance. It also sets forth the Department of the Navy's (Navy's) determinations regarding those potential ARARs for each remedial action alternative (RAA) retained for detailed analysis in this FFS for Installation Restoration Site 29 (Site 29 or "site"), former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California (former NAVWPNSTA Concord).

This evaluation includes an initial determination of whether the potential ARARs actually qualify as ARARs and a comparison for stringency between the federal and state regulations to identify the controlling ARARs. The identification of ARARs is an iterative process. The final determination of ARARs will be made by the Navy in the Record of Decision (ROD), after public review, as part of the response-action selection process.

1.1 Summary of CERCLA and NCP Requirements

Section (§) 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (42 *United States Code* [42 USC] §9621[d]), as amended, states that remedial actions on CERCLA sites must attain (or the decision document must justify the waiver of) any federal or more stringent state environmental standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate.

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address circumstances at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to the conditions at the site. An applicable federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than federal ARARs.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is 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 similar to the circumstances of the proposed response action and are well suited to the conditions of the site (U.S. EPA 1988a). A requirement must be determined to be both relevant *and* appropriate to be considered an ARAR.

The criteria for determining relevance and appropriateness are listed in 40 CFR §300.400(g)(2) and include the following:

- The purpose of both the requirement and the CERCLA action
- The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site
- The substances regulated by the requirement and the substances found at the CERCLA site

- The actions or activities regulated by the requirement and the response action contemplated at the CERCLA site
- Any variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site
- The type of place regulated and the type of place affected by the release or CERCLA action
- The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or proposed in the CERCLA action
- Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site

According to CERCLA ARARs guidance (U.S. EPA 1988a), a requirement may be "applicable" or "relevant and appropriate," but not both. ARARs must be identified on a site-specific basis and involve a two-part analysis: first, a determination whether a given requirement is applicable; then, if it is not applicable, a determination whether it is both relevant and appropriate. It is important to explain that some regulations may be applicable or, if not applicable, may still be relevant and appropriate. When the analysis determines that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable (U.S. EPA 1988a).

Tables included in this appendix present each potential ARAR with an initial determination of ARAR status (i.e., applicable, relevant and appropriate, or not an ARAR). For the determination of relevance and appropriateness, the pertinent criteria were examined to determine whether the requirements addressed problems or situations sufficiently similar to the circumstances of the release or response action contemplated and whether the requirement was well suited to the site. A negative determination of relevance and appropriateness indicates that the requirement did not meet the pertinent criteria. Negative determinations are documented in the tables of this appendix and are discussed in the text only for specific cases.

To qualify as a state ARAR under CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a state requirement must be

- a state law or regulation,
- an environmental or facility siting law or regulation,
- promulgated (of general applicability and legally enforceable),
- substantive (not procedural or administrative),
- more stringent than federal requirements,
- identified in a timely manner, and
- consistently applied.

To constitute an ARAR, a requirement must be substantive. Therefore, only the substantive provisions of requirements identified as ARARs in this analysis are considered to be ARARs. Permits are considered to be procedural or administrative requirements. Provisions of generally relevant federal and state statutes and regulations that were determined to be procedural or nonenvironmental, including permit requirements, are not considered ARARs. CERCLA §121(e)(1), 42 USC §9621(e)(1), states, "No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely on-site, where such remedial action is selected and carried out in compliance with this section." The term *on-site* is defined for purposes of this ARARs discussion as "the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action" (40 CFR §300.5).

Nonpromulgated advisories or guidance issued by federal or state governments are not legally binding and do not have the status of ARARs. Such requirements may, however, be useful and are "to be considered" (TBC). TBC requirements (40 CFR §300.400[g][3]) complement ARARs but do not override them. They are useful for guiding decisions regarding cleanup levels or methodologies when regulatory standards are not available.

Pursuant to U.S. EPA (1988a) guidance, ARARs are generally divided into three categories: chemical-, location-, and action-specific requirements. This classification was developed to aid in the identification of ARARs; some ARARs do not fall precisely into one group or another. ARARs are identified on a site-specific basis for remedial actions where CERCLA authority is the basis for cleanup.

As the lead federal agency, the Navy has primary responsibility for identifying federal ARARs at Site 29. Potential federal ARARs that have been identified for the site are discussed in Section 1.2.2. Pursuant to the definition of the term *on-site* in 40 CFR §300.5, the on-station areas that are part of this action include the volatile organic compound (VOC) plume extending downgradient of the source, which is considered to be the on-site boundary for groundwater for purposes of this ARARs analysis. Extraction wells, VOC treatment facilities, injection wells, and conveyance systems connecting those items are defined as "on-site."

Identification of potential state ARARs was initiated through Navy requests that the California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) identify potential state ARARs, an action described in more detail in Section 1.2.3. Potential state ARARs that have been identified for Site 29 are discussed below.

1.2 Methodology Description

The process of identifying and evaluating potential federal and state ARARs is described in this subsection.

1.2.1 General

As the lead federal agency, the Navy has primary responsibility for identification of potential ARARs for Site 29. In preparing this ARAR analysis, the Navy undertook the following measures, consistent with CERCLA and the NCP:

- Identified federal ARARs for each remedial action alternative addressed in the focused feasibility study (FFS), taking into account site-specific information for Site 29
- Reviewed potential ARARs identified by the state to determine whether they satisfy CERCLA and NCP criteria that must be met in order to constitute state ARARs
- Evaluated and compared federal ARARs and their state counterparts to determine whether state ARARs are more stringent than the federal ARARs or are in addition to the federally required actions
- Reached a conclusion as to which federal and state ARARs are the most stringent and/or "controlling" ARARs for each alternative

The remedial action objectives for this FFS are:

- Reduce the risk of exposure to vapor-phase VOCs in shallow soil to residential receptors by reducing the concentration of VOCs in soil gas to within the risk management range of 10^{-6} to 10^{-4}. For burrowing mammals, reduce the inhalation hazard of trichloroethene (TCE) and 1,1-dichloroethene (1,1-DCE) in shallow soil gas.
- Reduce the risk of exposure to VOCs in groundwater (via potable use) by reducing the concentration of VOCs in groundwater to within the risk management range of 10^{-6} to 10^{-4}.

Remedial action alternatives retained for detailed analysis in this FFS are designed to accomplish these remedial action objectives (RAOs). The Site 29 remedial action alternatives considered for detailed analysis, and for which an ARAR analysis is presented in this appendix, are as follows:

- Alternative 1 – no action
- Alternative 2 – soil-vapor extraction (SVE) with monitored natural attenuation (MNA)
- Alternative 3 – SVE with zero-valent iron (ZVI) injection
- Alternative 4 – SVE with in situ anaerobic bioremediation (ISB) and groundwater recirculation

1.2.2 Identifying and Evaluating Federal ARARs

The Navy is responsible for identifying federal ARARs as the lead federal agency under CERCLA and the NCP. The final determination of federal ARARs will be made when the Navy issues the ROD. The federal government implements a number of federal environmental statutes that are the source of potential federal ARARs, either in the form of the statutes or regulations promulgated thereunder. Examples include the Resource Conservation and Recovery Act (RCRA), the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Toxic Substances Control Act (TSCA), and their implementing regulations. See NCP preamble at 55 *Federal Register* (Fed. Reg.) 8764–8765 (1990) for a more complete listing.

The Navy reviewed the proposed response action and alternatives against all potential federal ARARs, including but not limited to those set forth at 55 Fed. Reg. 8764–8765 (1990), in order

to determine whether they were applicable or relevant and appropriate using the CERCLA and NCP criteria and procedures for ARARs identification by lead federal agencies.

1.2.3 Identifying and Evaluating State ARARs

The process of identifying and evaluating potential state ARARs by the state and the Navy is described in this subsection.

1.2.3.1 Solicitation of State ARARs under NCP

U.S. EPA (1988b) guidance recommends that the lead federal agency consult with the state when identifying state ARARs for response actions. In essence, the CERCLA/NCP requirements at 40 CFR §300.515 for response actions provide that the lead federal agency request that the state identify chemical- and location-specific state ARARs upon completion of site characterization. The requirements also provide that the lead federal agency request identification of all categories of state ARARs (chemical, location, and action specific) upon completion of identification of remedial alternatives for detailed analysis. The state must respond within 30 days of receipt of the lead federal agency requests. The remainder of this subsection documents the Navy's efforts to date to identify and evaluate state ARARs.

The Navy followed the process set forth in 40 CFR §300.515 and Section 10.6 of the Federal Facilities Agreement (FFA) (U.S. EPA 2001) for remedial actions in seeking state assistance with identification of state ARARs.

1.2.3.2 Chronology of Efforts to Identify State ARARs

The following chronology summarizes the Navy's efforts to obtain state assistance with identification of state ARARs for the remedial action at Site 29. Key correspondence between the Navy and the state agencies relating to this effort has been included in the Administrative Record for this FFS.

The Navy formally requested state chemical-, location-, and action-specific ARARs for Site 29 in a letter to DTSC dated 12 April 2011. Following the Navy solicitation for ARARs from DTSC, DTSC (Jim Pinasco) responded via electronic mail (e-mail) on 16 May 2011. The e-mail included a list of general ARARs for the DTSC included in Attachment A1. Pertinent requirements from the general list were included in the evaluation of state ARARs in this document. In addition, the California Department of Fish and Game (DFG) identified a list of ARARs in a memorandum dated 24 May 2011 to Jim Pinasco. The memorandum was forwarded to Navy and it is included in Attachment A1.

1.3 General Approach to Requirements of the Federal Resource Conservation and Recovery Act

RCRA is a federal statute passed in 1976 to meet four goals: protection of human health and the environment, reduction of waste, conservation of energy and natural resources, and elimination of the generation of hazardous waste as expeditiously as possible. The Hazardous and Solid Waste Amendments of 1984 significantly expanded the scope of RCRA by adding new

corrective action requirements, land disposal restrictions, and technical requirements. RCRA, as amended, contains several provisions that are potential ARARs for CERCLA sites.

Substantive RCRA requirements are applicable to response actions on CERCLA sites if the waste is a RCRA hazardous waste and either

- the waste was initially treated, stored, or disposed of after the effective date of the particular RCRA requirement; or
- the activity at the CERCLA site constitutes treatment, storage, or disposal as defined by RCRA (U.S. EPA 1988a).

The preamble to the NCP indicates that state regulations that are components of a federally authorized or delegated state program are generally considered federal requirements and potential federal ARARs for the purposes of ARARs analysis (55 Fed. Reg. 8666, 8742 [1990]). The State of California received approval for its base RCRA hazardous waste management program on 23 July 1992 (57 Fed. Reg. 32726 [1992]). The State of California "Environmental Health Standards for the Management of Hazardous Waste," set forth in Title 22 *California Code of Regulations* (Cal. Code Regs.), Division 4.5 (Cal. Code Regs. tit. 22, div. 4.5), were approved by U.S. EPA as a component of the federally authorized State of California RCRA program. On 26 September 2001, California received final authorization of its revised State Hazardous Waste Management Program from U.S. EPA (63 Fed. Reg. 49118 [2001]).

The regulations of Cal. Code Regs. tit. 22, div. 4.5 are therefore a source of potential federal ARARs for CERCLA response actions. The exception is when a state regulation is "broader in scope" than the corresponding federal RCRA regulations. In that case, such regulations are not considered part of the federally authorized program or potential federal ARARs. Instead, they are purely state law requirements and potential state ARARs.

The U.S. EPA notice of 23 July 1992, approving the State of California RCRA program (57 Fed. Reg. 32726 [1992]), specifically indicated that the state regulations addressed certain non-RCRA, state-regulated hazardous wastes that fell outside the scope of federal RCRA requirements. Cal. Code Regs. tit. 22, div. 4.5 requirements would be potential state ARARs for such non-RCRA, state-regulated wastes.

A key threshold question for the ARARs analysis is whether the contaminants at Site 29 could constitute federal hazardous waste as defined under RCRA and the state's authorized program or qualify as non-RCRA, state-regulated hazardous waste. A discussion of waste characterization is included in Section 1.4.

1.4 Waste Characterization

Selection of ARARs involves the characterization of wastes as described below.

1.4.1 RCRA Hazardous Waste Determination

Federal RCRA hazardous waste determination is necessary to determine whether a waste is subject to RCRA requirements at Cal. Code Regs. tit. 22, div. 4.5 and other state requirements at Cal. Code Regs. tit. 23, div. 3, Chapter (ch.) 15. The first step in the RCRA hazardous waste

characterization process is to evaluate contaminated media at the site(s) and determine whether the contaminant constitutes a "listed" RCRA waste. The preamble to the NCP states that "…it is often necessary to know the origin of the waste to determine whether it is a listed waste and that, if such documentation is lacking, the lead agency may assume it is not a listed waste" (55 Fed. Reg. 8666, 8758 [1990]).

This approach is confirmed in U.S. EPA (1988a) guidance for CERCLA compliance with other laws as follows.

> *To determine whether a waste is a listed waste under RCRA, it is often necessary to know the source. However, at many Superfund sites, no information exists on the source of wastes. The lead agency should use available site information, manifests, storage records, and vouchers in an effort to ascertain the nature of these contaminants. When this documentation is not available, the lead agency may assume that the wastes are not listed RCRA hazardous wastes, unless further analysis or information becomes available that allows the lead agency to determine that the wastes are listed RCRA hazardous wastes.*

RCRA hazardous wastes that have been assigned U.S. EPA hazardous waste numbers (or codes) are listed in Cal. Code Regs. tit. 22, §66261.30–66261.33. The lists include hazardous waste codes beginning with the letters "F," "K," "P," and "U."

Knowledge of the exact source of a waste is required for source-specific listed wastes (K waste codes). Some knowledge of the nature or source of the waste is required even for listed wastes from nonspecific sources, such as spent solvents (F waste codes) or commercial chemical products (P and U waste codes). These listed RCRA hazardous wastes are restricted to commercially pure chemicals used in particular processes such as degreasing.

P and U wastes cover only unused and unmixed commercial chemical products, particularly spilled or off-specification products (U.S. EPA 1991a). Not every waste containing a P or U chemical is a hazardous waste. To determine whether a CERCLA investigation-derived waste contains a P or U waste, there must be direct evidence of product use. In particular, all the following criteria must be met. The chemicals must be

- discarded (as described in 40 CFR §261.2[a][2]);
- either off-specification commercial products or a commercially sold grade;
- not used (i.e., soil contaminated with spilled unused wastes is a P or U waste); and
- the sole, active ingredient in a formulation.

Available historical information reviewed during the *Final Remedial Investigation (RI) Report* (Brady 2011) indicates that TCE was used on site and then disposed of to the ground. This matches the F001 and F002 spent solvents listing at Cal. Code Regs. tit. 22, §66261.31 for spent halogenated solvents used for degreasing. Therefore, the TCE disposed of at Site 29 may be a listed RCRA hazardous waste. And by extension of this reasoning, waste generated during the remedial action may be classified as RCRA-listed hazardous waste.

The second step in the RCRA hazardous waste characterization process is to evaluate potential hazardous characteristics of the waste. The evaluation of characteristic waste is described in U.S. EPA (1988a) guidance as follows:

> *Under certain circumstances, although no historical information exists about the waste, it may be possible to identify the waste as RCRA characteristic waste. This is important in the event that (1) remedial alternatives under consideration at the site involve on-site treatment, storage, or disposal, in which case RCRA may be triggered as discussed in this section; or (2) a remedial alternative involves off-site shipment. Since the generator (in this case, the agency or responsible party conducting the Superfund action) is responsible for determining whether the wastes exhibit any of these characteristics (defined in 40 CFR §261.21–261.24), testing may be required. The lead agency must use best professional judgment to determine, on a site-specific basis, if testing for hazardous characteristics is necessary.*
>
> *In determining whether to test for the toxicity characteristic using the extraction procedure (EP) toxicity test, it may be possible to assume that certain low concentrations of waste are not toxic. For example, if the total waste concentration in soil is 20 times or less the EP toxicity concentration, the waste cannot be characteristic hazardous waste. In such a case, RCRA requirements would not be applicable. In other instances, where it appears that the substances may be characteristic hazardous waste (ignitable, corrosive, reactive, or EP toxic), testing should be performed.*

Hazardous waste characteristics, as defined in 40 CFR §261.21–261.24, are commonly referred to as ignitability, corrosivity, reactivity, and toxicity. California environmental health standards for the management of hazardous waste set forth in Cal. Code Regs. tit. 22, div. 4.5 were approved by U.S. EPA as a component of the federally authorized California RCRA program. Therefore, the characterization of RCRA waste is based on the state requirements.

The characteristics of ignitability, corrosivity, reactivity, and toxicity are defined in Cal. Code Regs. tit. 22, §66261.21–66261.24. According to Cal. Code Regs. tit. 22, §66261.24(a)(1)(A), "A waste that exhibits the characteristic of toxicity pursuant to subsection (a)(1) of this section has the EPA Hazardous Waste Number specified in Table I of this section which corresponds to the toxic contaminant causing it to be hazardous." Table I assigns hazardous waste codes beginning with the letter "D" to wastes that exhibit the characteristic of toxicity; D waste codes are limited to "characteristic" hazardous wastes.

According to Cal. Code Regs. tit. 22, §66261.10, waste characteristics can be measured by an available standardized test method or be reasonably classified by generators of waste based on their knowledge of the waste, provided that the waste has already been reliably tested or there is documentation of chemicals used. Soil and groundwater contamination at Site 29 is not ignitable, corrosive, or reactive, as defined in Cal. Code Regs. tit. 22, §66261.21–66261.23. This determination was based on knowledge of the nature and concentrations of contaminants.

The requirements at Cal. Code Regs. tit. 22, §66261.24 list the toxic contaminant concentrations that determine the characteristic of toxicity. The concentration limits are in milligrams per liter

(mg/L). These units are directly comparable to total concentrations in waste groundwater and surface water. For waste soils, these concentrations apply to the extract or leachate produced by the toxicity characteristic leaching procedure (TCLP).

A waste is considered hazardous if the contaminants in the wastewater or in the soil TCLP extract equal or exceed the TCLP limits. TCLP testing is required only if total contaminant concentrations in soil equal or exceed 20 times the TCLP limits because TCLP uses a 20-to-1 dilution for the extract (U.S. EPA 1988a).

The maximum concentrations of contaminants in soil samples at the site were compared to the TCLP limits at Cal. Code Regs. tit. 22, §66261.24(a)(1). None of the concentrations exceeded 20 times the listed concentrations. Therefore, the contaminated soil is determined not to be a RCRA hazardous waste, based on the toxicity characteristic.

The analytical data collected during the RI (Brady 2011) have been evaluated to determine whether there is a potential for classification of extracted groundwater as a D040 RCRA characteristic hazardous waste due to concentrations of TCE. The toxicity characteristic concentration for TCE is 500 micrograms per liter. Based on the RI data, this concentration was exceeded in groundwater samples at the site. Therefore, groundwater waste generated at the site may meet the definition of RCRA hazardous waste due to toxicity.

1.4.2 California-Regulated, Non-RCRA Hazardous Waste

A waste determined not to be a RCRA hazardous waste may still be considered a California-regulated, non-RCRA hazardous waste. The state's RCRA program is broader in scope in its hazardous waste determination. Cal. Code Regs. tit. 22, §66261.24(a)(2) lists the total threshold limit concentrations (TTLCs) and the soluble threshold limit concentrations (STLCs) for non-RCRA hazardous waste. The state applies its own leaching procedure, the Waste Extraction Test (WET), which uses a different acid reagent and has a different dilution factor (tenfold). There are other state requirements that may be broader in scope than federal ARARs for identifying non-RCRA wastes regulated by the state. These may be potential ARARs for wastes not covered under federal ARARs. See additional subsections of Cal. Code Regs. tit. 22, §66261.24. A waste is considered hazardous if its total concentrations exceed the TTLCs or if the extract concentrations from the WET exceed the STLCs. A WET is required when the total concentrations exceed STLCs but are less than TTLCs (Cal. Code Regs. tit. 22, div. 4.5, ch. 11, Appendix II [b]). Based on comparison to maximum concentrations, the soil and groundwater at Site 29 are not expected to meet non-RCRA hazardous waste criteria.

Since the TCE at Site 29 may be a RCRA-listed hazardous waste, determining whether the waste meets the non-RCRA hazardous waste may not be necessary since the waste would need to be handled as RCRA-listed hazardous waste.

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Section 2 Chemical-Specific ARARs

Chemical-specific ARARs are generally health- or risk-based numerical values or methodologies applied to site-specific conditions that result in the establishment of a cleanup level. Many potential ARARs associated with particular response alternatives (such as closure or discharge) can be characterized as action-specific but include numerical values or methodologies to establish them; therefore, they fit into both categories (chemical and action specific). To simplify the comparison of numerical values, most action-specific requirements that include numerical values are included in this chemical-specific section and, if repeated in the action-specific section, the discussion refers back to this section.

This section presents the ARARs determination conclusions that address numerical values for groundwater, soil, and air and a summary of the potential ARARs followed by a more detailed discussion of the ARARs. Potential federal and state numerical standards are listed in Table A2-1. Potential federal and state chemical-specific ARARs are summarized in Tables A2-2 and A2-3, respectively.

2.1 Summary of ARARs Conclusions by Medium

Groundwater and soil gas are the environmental media of concern for this remedial action. However, groundwater, soil, and air are potentially affected by the Site 29 remedial action. The conclusions for ARARs pertaining to these media are presented in the following sections.

2.1.1 Groundwater ARARs Conclusions

The chemicals of concern (COCs) in groundwater at Site 29 are TCE, 1,1,2-trichloroethane (TCA), 1,2-dichloroethane (DCA), cis-1,2-DCE, tetrachloroethene (PCE or perchloroethene), chloroform, and benzene. The substantive provisions of the following requirements are the most stringent of the potential federal chemical-specific ARARs for groundwater:

- Federal maximum contaminant level (MCL) for TCE, 1,1,2-TCA, 1,2-DCA, cis-1,2-DCE, PCE, and benzene in drinking water as promulgated by U.S. EPA under the Safe Drinking Water Act (SDWA) at 40 CFR §141.61(a), and nonzero maximum contaminant level goals (MCLGs) at 40 CFR §141.50(b) for 1,1,2-TCA
- RCRA groundwater protection standards in Cal. Code Regs. tit. 22, §66264.94(a)(1), (a)(3), (c), (d), and (e)

The substantive provisions of the following requirements are the most stringent of the potential state chemical-specific ARARs for groundwater:

- State primary MCLs for benzene, cis-1,2-DCE, and 1,2-DCA at Cal. Code Regs. tit. 22, §64444(a) that are more stringent than federal MCLs
- State Water Resources Control Board (SWRCB 1988) Resolution (Res.) 88-63
- *Water Quality Control Plan for the San Francisco Bay Basin* (Region 2) (Basin Plan) (California Regional Water Quality Control Board, San Francisco Bay Region [SFBRWQCB] 2007) establishing water quality objectives (WQOs), beneficial uses, and waste discharge limitations

Table A2-1. Criteria and Standards for Chemicals of Concern in Groundwater
(units reported in micrograms per liter)

Analyte	CONCENTRATION			
	U.S. EPA SAFE DRINKING WATER ACT[a]		California Maximum Contaminant Level[d]	Controlling ARAR Contaminant Level
	Maximum Contaminant Level[b]	Maximum Contaminant Level Goal[c]		
Volatile Organic Compounds				
benzene	5	0	1	1
chloroform	not available	not available	not available	not available
1,2-dichloroethane (1,2-DCA)	5	0	0.5	0.5
cis-1,2-dichloroethene (cis-1,2-DCE)	70	70	6	6
Tetrachloroethene (PCE)	5	0	5	5
1,1,2-trichloroethane (1,1,2-TCA)	5	3	5	3
Trichloroethene (TCE)	5	0	5	5

Notes:

a Current Drinking Water Standards, Office of Water, 1 July 1999 (U.S. EPA 1999)

b 40 CFR §141.61

c 40 CFR §141.50

d Cal. Code Regs. tit. 22, §64444

2.1.2 Soil ARARs Conclusions

The VOCs in soil are one of the media of concern for this FFS. Soil vapor poses an unacceptable risk at Site 29.

2.1.3 Air ARARs Conclusions

The proposed SVE and treatment could potentially affect air quality. Therefore, ARARs for air quality protection were identified.

2.2 Detailed Discussion of ARARs by Medium

The following subsections provide a detailed discussion of federal and state ARARs by medium.

2.2.1 Groundwater ARARs

Site 29 is located within the Clayton Valley Groundwater Basin. Groundwater flow throughout the basin in general mimics, but is a subdued expression of, topography. Wells in the

surrounding area pump groundwater for various uses. An irrigation well for the municipal golf course is located approximately 10,000 feet north of Site 29. Several groundwater wells operated by Contra Costa County Water District are located adjacent to Mallard Reservoir, more than 13,000 feet west of Site 29.

2.2.1.1 Federal

Under the SDWA and RCRA, a significant issue in identifying ARARs for groundwater is whether the groundwater at the site can be classified as a source of drinking water. The U.S. EPA groundwater policy is set forth in the preamble to the NCP (55 Fed. Reg. 8666, 8752–8756 [1990]). This policy uses the protocols in the U.S. EPA's (1986) *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy*. Under this policy, groundwater is classified in one of three categories (Class I, II, or III) on the basis of ecological importance, its ability to be replaced, and vulnerability. Class I groundwater is irreplaceable groundwater currently used by a substantial population or groundwater that supports a vital habitat. Class II consists of groundwater currently used or that might be used as a source of drinking water in the future. Class III groundwater is groundwater that cannot be used for drinking water because of its poor quality (e.g., high salinity or widespread, naturally occurring contamination) or insufficient quantity. The U.S. EPA guidelines define Class III groundwater as groundwater with total dissolved solids concentrations over 10,000 mg/L and a yield of less than 150 gallons per day (U.S. EPA 1986). Class III groundwater can also be classified based on economic or technological treatability tests as well as quality or quantity.

The groundwater at Site 29 has been determined to be a Class I groundwater since it is an existing drinking water source downgradient from the site.

Safe Drinking Water Act

U.S. EPA has promulgated drinking water standards for public water supply systems pursuant to its authority under the SDWA. These drinking water standards consist of primary and secondary MCLs and MCLGs. These standards are applicable requirements for drinking water quality "at the tap" of the end users of the regulated public water supply systems. They are not directly applicable to in situ groundwater and therefore do not qualify as applicable federal ARARs for groundwater response actions. However, they may be relevant and appropriate requirements for such actions.

U.S. EPA provided policy guidance in the 1990 NCP preamble directing that the U.S. EPA (1986) guidelines for groundwater classification be followed in determining when federal primary MCLs may be relevant and appropriate for groundwater response actions (see 55 Fed. Reg. 8666, 8752–8756 [1990]). The intent of this policy is to focus CERCLA cleanup efforts based on groundwater quality (classification).

MCLs for the action at Site 29 are found at 40 CFR §141.61(a) for benzene, 1,2- DCA, cis-1,2-DCE, PCE, 1,1,2-TCA, and TCE. Although MCLs are developed using cost and technical considerations, U.S. EPA considers them to be protective of human health as well.

U.S. EPA has also developed MCLGs to serve as guidance for establishing MCLs. MCLGs for organic contaminants are promulgated at 40 CFR §141.50. An MCLG is set at a level at which

no adverse health effects may arise, with a margin of safety. An MCL is required to be set as close as possible to its corresponding MCLG, taking into consideration the best technology, treatment techniques, and other factors, including cost. For noncarcinogens, MCLs generally are set equal to MCLGs. MCLGs for carcinogens are set at the zero level.

The NCP states that MCLGs that are set at levels above zero should be considered to be relevant and appropriate requirements for groundwater that is a potential source of drinking water (40 CFR §300.430[e][2][I][B] and 55 Fed. Reg. 8666, 8750–8754 [1990]). Two groundwater COCs at Site 29 have nonzero MCLGs: 1,1,2-TCA and cis-1,2-DCE. MCLGs for these COCs are considered to be relevant and appropriate requirements.

Secondary MCLs are nonenforceable, federal contaminant levels intended as guidelines for the states. Because they are nonenforceable, federal secondary MCLs are not potential ARARs.

Although the point of compliance for MCLGs and MCLs under the SDWA is at the tap, U.S. EPA has determined that for CERCLA remedies, nonzero MCLGs or MCLs should be obtained throughout the contaminated plume or at and beyond the edge of the waste management area, when waste is left in place (55 Fed. Reg. 8666, 8753 [1990]).

RCRA Hazardous Waste

The federal RCRA requirements at 40 CFR Part (pt.) 261 do not apply in California because the state RCRA program is authorized. The authorized state RCRA requirements are therefore considered potential federal ARARs (Section 1.3). The applicability of RCRA requirements depends on whether the waste is a RCRA hazardous waste; whether the waste was initially treated, stored, or disposed of after the effective date of the particular RCRA requirement; and whether the activity at the site constitutes treatment, storage, or disposal as defined by RCRA. However, RCRA requirements may be relevant and appropriate even if they are not applicable. Examples include activities that are similar to those defined as RCRA treatment, storage, or disposal for waste that is similar to RCRA hazardous waste.

The determination of whether a waste is a RCRA hazardous waste can be made by comparing the site waste to the definition of RCRA hazardous waste. The RCRA requirements at Cal. Code Regs. tit. 22, §66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100 are potential ARARs because they define RCRA hazardous waste. A waste can meet the definition of hazardous waste if it has the toxicity characteristic of hazardous waste. This determination is made by using the TCLP. The maximum concentrations allowable for the TCLP listed in Cal. Code Regs. tit. 22, §66261.24(a)(1)(B) are potential federal ARARs for determining whether the site has hazardous waste. If the site waste has concentrations exceeding these values, it is determined to be a characteristic RCRA hazardous waste (Section 1.4.1).

RCRA Groundwater Protection Standards

Groundwater concentration limits for RCRA-regulated units are promulgated at Cal. Code Regs. tit. 22, §66264.94. For corrective action programs, Cal. Code Regs. tit. 22, §66264.94(c) states that the concentrations of compounds must not exceed the background level of that constituent in groundwater or, if achieving background is shown to be technologically or economically infeasible, some higher concentration limit that is set as part of the corrective action program. In

no event shall a concentration limit greater than background exceed applicable statutes or regulations or the lowest concentration determined to be technologically or economically achievable (Cal. Code Regs. tit. 22 §66264.94[e]).

These standards are not "applicable" because Site 29 does not contain a RCRA waste management unit. However, the wastes being addressed by the Site 29 remedial actions may be classified as RCRA hazardous wastes. Therefore, substantive provisions of Cal. Code Regs. tit. 22, §66264.94(a)(1), (a)(3), (c), (d), and (e) are "relevant and appropriate" and, therefore, potential federal ARARs for groundwater at Site 29 because the wastes at the site are similar or identical to RCRA hazardous wastes.

The RCRA groundwater protection standard provisions of Cal. Code Regs. tit. 22, §66264.95 indicate that the point of compliance at which the protection standards apply is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends through the uppermost aquifer underlying the regulated unit.

Water Quality Criteria

Section 304(a)(1) of the CWA (33 USC §1314[a][1]) directs U.S. EPA to publish and periodically update the National Recommended Water Quality Criteria (NRWQC). These standards are intended to protect human health and aquatic life from contamination in surface water. The NRWQC are updated in the *Federal Register*. The latest list of the NRWQC dated 2006 is available on the Internet at http://www.epa.gov/waterscience/criteria/ wqcriteria.html. If criteria are not listed for a particular pollutant, U.S. EPA does not have any national recommended water quality criteria established.

These criteria are to reflect the latest scientific knowledge on the identifiable effects of pollutants on public health and welfare, aquatic life, and recreation. These criteria serve as guidance to states in adopting water quality standards under §303(c) of the CWA (33 USC §1313[c]) that protect aquatic life from acute and chronic effects.

The applicability of surface water criteria to groundwater is discussed in CERCLA §121(d)(2)(B)(i) (42 USC §9621[d][2][B][i]), 40 CFR §300.430(e), and the NCP preamble (55 Fed. Reg. 8666, 8754–8755 [1990]). Although the NRWQC are nonenforceable guidelines, they may be potentially relevant and appropriate for groundwater only in the absence of promulgated MCLs or MCLGs. In such cases, the NRWQC may be adjusted to reflect only drinking water use and be used as cleanup goals for the response action. Since there are adequate MCLs and MCLGs identified for the COCs, the NRWQC are not potential ARARs.

Water Quality Standards

On 22 December 1992, U.S. EPA promulgated federal water quality standards under the authority of the federal CWA §303(c)(2)(B), 33 USC ch. 26, §1313(c)(2)(B), in order to establish water quality standards required by the CWA where the State of California and other states had failed to do so (57 Fed. Reg. 60848 [1992]). These standards have been amended over the years in the *Federal Register* including amendments of the National Toxics Rule (60 Fed. Reg. 22228 [1995]). These water quality standards, as amended, are codified at 40 CFR §131.36.

U.S. EPA promulgated a rule on 18 May 2000 to fill a gap in California's water quality standards. The gap was created in 1994 when a state court overturned the state's water quality control plans that contained water quality criteria for priority toxic pollutants. The rule, commonly called the California Toxics Rule, is codified at 40 CFR §131.38. These federal criteria are legally applicable in the State of California for inland surface waters and enclosed bays and estuaries for all purposes and programs under the CWA.

The water quality standards contained in 40 CFR §131.36 and 131.38 are potential applicable federal ARARs for groundwater cleanup response actions that discharge to surface water. However, since discharge to surface water is not proposed for this FFS, these are not potential ARARs.

2.2.1.2 State

The state has identified the following potential ARARs for groundwater cleanup at the site:

- State primary and secondary MCLs, Cal. Code Regs. tit. 22, §64444
- SWRCB Res. 68-16, 88-63, and 92-49
- Water quality control plans for the San Francisco Bay Basin (Basin Plan (SFBRWQCB 2007)
- Porter-Cologne Water Quality Control Act (Porter-Cologne Act), California Water Code (CWC) §§13241, 13243, 13263(a), 13269, and 13360

SWRCB Res. 88-63, Adoption of Policy Entitled "Sources of Drinking Water." SWRCB Res. 88-63 establishes criteria to help the regional water quality control boards (RWQCBs) identify potential sources of drinking water (SWRCB 1988). According to this resolution, all groundwater in California is considered suitable or potentially suitable for domestic or municipal freshwater supply except in cases where any one of the following water quality and production criteria is met.

- Total dissolved solids concentrations exceed 3,000 mg/L (or electrical conductivity is greater than 5,000 micromhos per centimeter) and the RWQCB does not reasonably expect the groundwater to supply a public drinking water system.
- Groundwater is contaminated, either by natural processes or by human activity unrelated to a specific pollution incident, and cannot reasonably be treated for domestic use either by best management practices or best economically available treatment practices.
- The groundwater does not provide sufficient water to supply a single well capable of producing an average sustained yield of 200 gallons per day.

SWRCB Res. 88-63 has been incorporated by reference into the Basin Plan. The Navy has determined that the substantive provisions of this policy are potential state ARARs for this FFS. The groundwater at Site 29 meets the criteria for a drinking water under SWRCB Res. 88-63 and is considered a potential source of drinking water.

Water Quality Control Plan for San Francisco Bay Basin (Basin Plan)

The Navy accepts the substantive provisions of the Basin Plan, pertaining to beneficial use, WQOs, and discharge prohibitions, as potential ARARs. The Basin Plan for the San Francisco Bay Basin was prepared and implemented by SFBRWQCB (2007) to protect and enhance the quality of the waters in the San Francisco Bay Basin. The Basin Plan establishes location-specific beneficial uses and WQOs for the surface water and groundwater of the region and is the basis of the SFBRWQCB regulatory programs. The Basin Plan includes both numeric and narrative WQOs for specific groundwater sub-basins. The WQOs are intended to protect the beneficial uses of the waters of the region and to prevent nuisance.

Beneficial use and reuse of water are key aspects of the Basin Plan for the San Francisco Bay Basin. Site 29 is located in the Clayton Valley Groundwater Basin, which has the following beneficial use designations (SFBRWQCB [2007], as amended through 31 December 31 2010):

- MUN – municipal and domestic supply (existing)
- AGR – agricultural supply (potential)
- IND – industrial service supply (potential)
- PROC – industrial process supply (potential)

WQOs have been established for the groundwater. All groundwater shall be maintained free of organic chemical constituents in concentrations that adversely affect beneficial uses. At a minimum, MUN-designated groundwater shall not contain concentrations of constituents in excess of MCLs. The listed numerical WQOs for drinking water sources are the same MCLs included as ARARs below.

Primary and Secondary State MCLs

Primary and secondary state MCLs are set forth in Cal. Code Regs. tit. 22 §64444 (Maximum Contaminant Levels – Organic Chemicals). The Navy has determined that the substantive provisions of the standards in Cal. Code Regs. tit. 22, §64444(a) for benzene, 1,2-DCA, and cis-1,2-DCE constitute potential "relevant and appropriate" state ARARs for the groundwater at Site 29 as listed in Table A2-3.

Porter-Cologne Water Quality Control Act

The Porter-Cologne Act became Division 7 of the *California Water Code* in 1969. The Porter-Cologne Act requires each regional board to formulate and adopt basin plans for all areas within the region (CWC §13240). It also requires each regional board to establish WQOs that will protect the beneficial uses of the water basin (CWC §13241) and to prescribe waste discharge requirements that would implement the basin plan for any discharge of waste to the waters of the state (CWC §13263[a]).

Other sections of the Porter-Cologne Act include CWC §13243, which allows regional boards to specify conditions or areas where waste discharge is not permitted. CWC §13269 provides the boards' authority for waivers for reports or compliance with requirements as long as it is not

against the public interest. CWC §13360 specifies circumstances for regional boards to order compliance in a specific manner.

The Navy accepts the substantive provisions of CWC §§13241, 13243, 13263(a), 13269, and 13360 of the Porter-Cologne Act as enabling legislation as implemented through the beneficial uses, WQOs, and discharge prohibitions of the Basin Plan, SWRCB Res. 88-63, and state primary MCLs as potential state ARARs.

CWC §13304 sets forth enforcement authority and an enforcement process (orders issued by the state) and is procedural in nature. It does not constitute an ARAR because it does not itself establish or contain substantive environmental "standards, requirements, criteria, or limitations" (CERCLA §121 [42 USC §9621]) and is not in itself directive in intent. Through its enforcement authority and procedures, substantive state environmental standards set forth in other statutes, regulations, plans, and orders are enforced. In addition, CWC §13304 is no more stringent than the substantive requirements of the potential state ARARs identified in the above paragraphs or potential federal ARARs for groundwater.

State Water Resources Control Board Res. 92-49 and 68-16

State Water Resources Control Board Res. 92-49. This resolution, as amended on 21 April 1994 and 2 October 1996, is titled *Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under CWC §13304.* This resolution contains policies and procedures for the regional boards that apply to all investigations and cleanup and abatement activities for all types of discharges subject to CWC §13304.

SWRCB Res. 68-16. This resolution, titled *Statement of Policy with Respect to Maintaining High Quality of Waters in California,* establishes the policy that high-quality waters of the state "shall be maintained to the maximum extent possible" consistent with the "maximum benefit to the people of the state." It provides that whenever the existing quality of water is better than the required applicable water quality policies, such existing high-quality water will be maintained until it has been demonstrated to the state that any change will be consistent with maximum benefit to the people of the state, will not unreasonably affect present and anticipated beneficial use of such water, and will not result in water quality less than that prescribed in the policies. It also states that any activity that produces or may produce a waste or increased volume or concentration of waste and that discharges or proposes to discharge to existing high-quality waters will be required to meet waste discharge requirements that will result in the best practicable treatment or control of the discharge necessary to ensure that a) pollution or a nuisance will not occur and b) the highest water quality consistent with maximum benefit to the people of the state will be maintained (SWRCB 1968).

Cleanup to below background water quality conditions is not required by the SWRCB under the Porter-Cologne Act. SWRCB Res. 92-49 II.F.1 (SWRCB 1992) provides that regional boards may require cleanup and abatement to "conform to the provisions of the Resolution No. 68-16 of the State Water Board, and the Water Quality Control Plans of the State and Regional Water Quality Control Boards, provided that under no circumstances shall these provisions be interpreted to require cleanup and abatement which achieves water quality conditions that are better than background conditions."

Navy's Position Regarding SWRCB Res. 92-49 and 68-16. The Navy recognizes that the key substantive requirements of Cal. Code Regs. tit. 22, §66264.94 (and the identical requirements of Cal. Code Regs. tit. 23, §2550.4 and Section III.G of SWRCB Res. 92-49) require cleanup to background levels of constituents unless such restoration proves to be technologically or economically infeasible and an alternative cleanup level of constituents will not pose a substantial present or potential hazard to human health or the environment. In addition, the Navy recognizes that these provisions are more stringent than corresponding provisions of 40 CFR §264.94 and, although they are federally enforceable via the RCRA program authorization, they are also independently based on state law to the extent that they are more stringent than the federal regulations.

The Navy has also determined that SWRCB Res. 68-16 is not a chemical-specific ARAR for determining response action goals. However, SWRCB Res. 68-16 is a potential action-specific ARAR for regulating new discharges, such as treated groundwater, into the aquifer. The Navy has determined that further migration of already-contaminated groundwater is not a discharge governed by the language in Res. 68-16. More specifically, the language of SWRCB Res. 68-16 indicates that it is prospective in intent, applying to new discharges in order to maintain existing high-quality waters. It is not intended to apply to restoration of waters that are already degraded.

The Navy's position is that SWRCB Res. 92-49 and 68-16 and Cal. Code Regs. tit. 23, §2550.4 do not constitute chemical-specific ARARs for this remedial action because they are state requirements and are not more stringent than federal ARAR provisions of Cal. Code Regs. tit. 22, §66264.94. The NCP set forth in 40 CFR §300.400(g)(4) provides that only state standards more stringent than federal standards may be ARARs (see also CERCLA §121(d)(2)(A)(ii) [42 USC §9621(d)(2)(A) (ii)]).

The substantive technical standard in the equivalent state requirements (i.e., Cal. Code Regs. tit. 23, div. 3, ch. 15 and SWRCB Res. 92-49 and 68-16) is identical to the substantive technical standard in Cal. Code Regs. tit. 22, §66264.94. This section of Cal. Code Regs. tit. 22 will likely be applied in a manner consistent with equivalent provisions of other regulations, including SWRCB Res. 92-49 and 68-16.

State of California's Position Regarding SWRCB Res. 92-49 and 68-16. The state does not agree with the Navy determination that SWRCB Res. 92-49 and 68-16 and certain provisions at Cal. Code Regs. tit. 23, div. 3, ch. 15 are not ARARs for this response action. SWRCB (1994) has interpreted the term "discharges" in the CWC to include the movement of waste from soils to groundwater and from contaminated to uncontaminated water. However, the state agrees that the proposed action would comply with SWRCB Res. 92-49 and 68-16, and compliance with the Cal. Code Regs. tit. 22 provisions should result in compliance with the Cal. Code Regs. tit. 23 provisions. The state does not intend to dispute the ROD, but reserves its rights if implementation of the Cal. Code Regs. tit. 22 provisions is not as stringent as state implementation of Cal. Code Regs. tit. 23 provisions. Because Cal. Code Regs. tit. 22 regulation is part of the state's authorized hazardous waste control program, it is also the state's position that Cal. Code Regs. tit. 22, §66264.94 is a state ARAR and not a federal ARAR (United States v. State of Colorado, 990 F.2d 1565 [1993]).

Whereas the Navy and the State of California have not agreed on whether SWRCB Res. 92-49 and 68-16 and Cal. Code Regs. tit. 23, §2550.4 are ARARs for this response action, this FFS documents each party's position on the resolutions but does not attempt to resolve the issue.

RCRA Requirements. State RCRA requirements included within the U.S. EPA–authorized RCRA program for California are considered to be potential federal ARARs and are discussed in the previous section. The exception is when a state regulation is "broader in scope" than the corresponding federal RCRA regulations. In that case, such regulations are not considered part of the federally authorized program or potential federal ARARs. Instead, they are purely state law requirements and potential state ARARs.

State requirements such as the non-RCRA, state-regulated hazardous waste requirements may be potential state ARARs because they are not within the scope of the federal ARARs (57 Fed. Reg. 60848). The Cal. Code Regs. tit. 22, div. 4.5 requirements that are part of the state-approved RCRA program would be potential state ARARs for non-RCRA, state-regulated hazardous wastes.

2.2.2 Soil ARARs

The key threshold question for soil ARARs is whether the wastes generated during remedial action at Site 29 could be classified as hazardous waste. The soil may be classified as federal hazardous waste as defined by RCRA and the state-authorized program or as non-RCRA, state-regulated hazardous waste. If the soil is determined to be hazardous waste, the appropriate requirements will apply.

2.2.2.1 Federal

Federal requirements evaluated as potential ARARs for soil are discussed in the subsections below.

RCRA Hazardous Waste and Groundwater Protection Standards

The federal RCRA requirements at 40 CFR pt. 261 do not apply in California because the state RCRA program is authorized. The authorized state RCRA requirements are therefore considered potential federal ARARs (Section 1.3). The applicability of RCRA requirements depends on whether the waste is a RCRA hazardous waste; whether the waste was initially treated, stored, or disposed after the effective date of the particular RCRA requirement; and whether the activity at the site constitutes treatment, storage, or disposal as defined by RCRA. However, RCRA requirements may be relevant and appropriate even if they are not applicable. Examples include activities that are similar to the definition of RCRA treatment, storage, or disposal for waste that is similar to RCRA hazardous waste.

Determination of whether a waste is a RCRA hazardous waste can be made by comparing site waste to the definition of RCRA hazardous waste. RCRA requirements at Cal. Code Regs. tit. 22, §66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100 are potential ARARs because they define RCRA hazardous waste. A waste can meet the definition of hazardous waste if it has the toxicity characteristic of hazardous waste. This determination is made by using the TCLP. The maximum concentrations allowable for the TCLP listed in §66261.24(a)(1)(B) are potential federal ARARs for determining whether hazardous waste is

present at the site. If the site waste has concentrations exceeding these values, it is determined to be a characteristic RCRA hazardous waste (Section 1.4.1).

The requirements at Cal. Code Regs. tit. 22, §66264.94(a)(1), (a)(3), (c), (d), and (e) are potential federal ARARs for contamination in the vadose zone (i.e., the unsaturated zone). These sections set concentration limits for the unsaturated zone as well as for groundwater and surface water. These requirements are considered to be potential federal ARARs because they are part of the approved state RCRA program.

2.2.2.2 State

State requirements evaluated as potential ARARs for soil are discussed in the subsection below.

RCRA Requirements

State RCRA requirements included within the U.S. EPA–authorized RCRA program for California are considered to be potential federal ARARs and are discussed in the previous section. The exception is when a state regulation is broader in scope than the corresponding federal RCRA regulations. In that case, such regulations are not considered part of the federally authorized program or potential federal ARARs. Instead, they are purely state law requirements and potential state ARARs.

State requirements such as the non-RCRA, state-regulated hazardous waste requirements may be potential state ARARs because they are not within the scope of the federal ARARs (57 Fed. Reg. 60848). The Cal. Code Regs. tit. 22, div. 4.5 requirements that are part of the state-approved RCRA program would be potential state ARARs for non-RCRA, state-regulated hazardous wastes.

2.2.3 Air ARARs

For this FFS, the COCs in groundwater are VOCs. Soil vapor extraction is one of the treatment technologies being considered for VOC removal in both the shallow groundwater unit and the soil. Therefore, there is the potential for VOCs to be released into the air. ARARs for air are discussed in greater detail under action-specific requirements.

2.2.3.1 Federal

The Clean Air Act (CAA) air emission requirements are discussed below.

Clean Air Act

The CAA establishes the National Ambient Air Quality Standards (NAAQS) in 40 CFR §50.4–50.12. NAAQS are not enforceable in and of themselves; they are translated into source-specific emissions limitations by the state (U.S. EPA 1990). Substantive requirements of the Bay Area Air Quality Management District (BAAQMD) rules that have been approved by U.S. EPA as part of the State Implementation Plan (SIP) under the CAA are potential federal ARARs for air emissions (CAA §110). The SIP includes rules for emissions restrictions for particulates, organic compounds, and hazardous air pollutants, as well as standards of performance for new sources.

2.2.3.2 State

BAAQMD Rules 401 and 1401 were identified by the state as ARARs for the potential air emissions at Site 29. These are not potential federal ARARs because they are not included in the SIP (see discussion of federal ARARs under the CAA above).

Section 3 Location-Specific ARARs

Potential location-specific ARARs are identified and discussed in this section. The discussions are presented based on various attributes of the site location, such as whether it is within a floodplain. Additional surveys will be performed in connection with the response action design and implementation to confirm location-specific ARARs where inadequate siting information currently exists or in the event of changes to planned facility locations.

3.1 Summary of Location-Specific ARARs

There are potential biological resources that may trigger location-specific requirements by the Site 29 removal action. The conclusions for ARARs pertaining to these resources are presented in the following subsections.

3.1.1 Cultural Resources ARARs Conclusions

There are no cultural resources at Site 29.

3.1.2 Wetlands Protection/Floodplain Management Conclusions

There are no wetlands at Site 29 and it is not within a 100-year floodplain.

3.1.3 Hydrologic Resources Conclusions

There are no hydrologic resources at Site 29.

3.1.4 Biological Resources Conclusions

There are threatened species (red-legged frog and tiger salamander) and migratory birds (golden eagle) that may be present at Site 29. The following were identified as potential ARARs for the Site 29 remedial action:

- Substantive provisions of the federal Endangered Species Act of 1973 (16 USC §§1531–1543)
- Substantive provisions of the federal Migratory Bird Treaty Act of 1972 (16 USC §703)
- Substantive provisions of California Fish & Game Code (Cal. Fish & Game Code) §§2080 and 3511

3.1.5 Coastal Resources Conclusions

Site 29 is not within the coastal zone.

3.1.6 Geologic Characteristics Conclusions

Site 29 does not have geological characteristics for which ARARs were identified.

3.2 Detailed Discussion of ARARs

The following subsections provide a detailed discussion of federal and state ARARs by location-specific resources. Pertinent and substantive provisions of the potential ARARs listed and described below were reviewed to determine whether they are potential federal or state ARARs for the Site 29 FFS.

Location-specific ARAR determinations are summarized in Tables A3-1 (federal) and A3-2 (state). ARAR determinations are presented in the column with the heading "ARAR Determination." Determinations of status for location-specific ARARs were generally based on maps or lists included in the regulation or prepared by the administering agency. References to the document or agency consulted are provided in the "Comments" column and may be provided in footnotes to the table. Specific issues concerning some of the requirements are discussed in the following sections.

3.2.1 Cultural Resources ARARs

The following requirements were evaluated, but Site 29 did not have any of the regulated features.

- National Historic Preservation Act of 1966, as amended (16 USC §470–470x-6, 36 CFR pt. 800, and 40 CFR §6.301[b])
- Archaeological and Historic Preservation Act (16 USC §469–469c-1 and 40 CFR §6.301[c])
- Historic Sites, Buildings, and Antiquities Act of 1935 (16 USC §§461–467 and 40 CFR §6.301[a])
- Archaeological Resources Protection Act of 1979, as amended (Pub. L. No. 96-95 and 16 USC §470aa–470mm)]

3.2.2 Wetlands Protection and Floodplains Management

The following requirements were evaluated, but Site 29 did not have any of the regulated features.

- Exec. Order No. 11990, Protection of Wetlands
- Exec. Order No. 11988, Floodplain Management
- CWA §404, 33 USC §1344
- RCRA (42 USC §§6901–6991[i]) and Cal. Code Regs. tit. 22, §66264.18(b)

3.2.3 Hydrologic Resources ARARs

The following requirements were evaluated, but Site 29 did not have any of the regulated features.

- Wild and Scenic Rivers Act (substantive provisions of 16 USC §§1271–1287)

- Fish and Wildlife Coordination Act (substantive provisions of 16 USC §§661–666c)
- Rivers and Harbors Act of 1899 (substantive provisions of 33 USC §§401–413)]

3.2.4 Biological Resources ARARs

The following requirements were evaluated, but Site 29 did not have any of the regulated features.

- Endangered Species Act of 1973 (substantive provisions of 16 USC §§1531–1543)
- Migratory Bird Treaty Act of 1972 (substantive provisions of 16 USC §§703–712)
- Marine Mammal Protection Act (substantive provisions of 16 USC §§1361–1421h)
- Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§1801–1882)
- National Wildlife Refuge System Administration Act of 1996 (16 USC §668dd–668ee and substantive provisions of 50 CFR §27.11–27.97)
- Wilderness Act (16 USC §§1131–1136 and 50 CFR §35.1–35.14)
- California Endangered Species Act (Cal. Fish & Game Code, ch. 1.5, §§2050–2116)]

3.2.4.1 Federal

Federal requirements evaluated as potential ARARs for biological resources are discussed in the subsections below.

Endangered Species Act of 1973

The Endangered Species Act (ESA) of 1973 (16 USC §§1531–1543) provides a means for conserving various species of fish, wildlife, and plants that are threatened with extinction. The ESA defines an endangered species and provides for the designation of critical habitats. Federal agencies may not jeopardize the continued existence of any listed species or cause the destruction or adverse modification of critical habitat. Under §7(a) of the ESA (16 USC §1536[a][2]), federal agencies must carry out conservation programs for listed species. The Endangered Species Committee may grant an exemption for agency action if reasonable mitigation and enhancement measures such as propagation, transplantation, and habitat acquisition and improvement are implemented (16 USC §1536[h][1][B]).

The red-legged frog and the tiger salamander may be present at Site 29. Therefore, substantive provisions for the Endangered Species Act at 16 USC §§1531–1543 are potentially applicable for the remedial action at Site 29.

Migratory Bird Treaty Act of 1972

The Migratory Bird Treaty Act (MBTA) (16 USC §§703–712) protects migratory bird species. The substantive provisions at 16 USC §703 prohibit at any time, using any means or manner, the pursuit, hunting, capturing, and killing or the attempt to take, capture, or kill any migratory bird. The MBTA also prohibits the possession, sale, export, and import of any migratory bird or any part of a migratory bird, as well as nests and eggs. A list of migratory birds for which this requirement applies is found at 50 CFR §10.13. It is the Navy's position that this act is not legally applicable to Navy actions; however, the Department of Defense recently signed (July 2006) a Memorandum of Understanding with the United States Fish and Wildlife Service. The MBTA will continue to be evaluated as a potentially relevant and appropriate requirement for Navy CERCLA response actions.

The golden eagle has been observed in the vicinity of Site 29. Therefore, substantive provisions at 16 USC §703 are potentially relevant and appropriate for this remedial action.

Marine Mammal Protection Act

The Marine Mammal Protection Act (16 USC §§1361–1421h) prohibits the taking of a marine mammal on the high seas or in a harbor or other place under the jurisdiction of the United States. It prohibits the possession, transport, and sale of a mammal or marine mammal product, unless authorized under law. The prohibitions that are potentially pertinent to CERCLA actions are at 16 USC §1372(a)(2).

There are no marine mammals expected at Site 29.

Magnuson-Stevens Fishery Conservation and Management Act of 1976, as Amended

The purpose of the Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§1801–1882) is to conserve and manage the fishery resources found off the coasts of the United States, the anadromous species (i.e., fish that live in the sea mostly, but breed in fresh water), and the continental shelf fishery resources of the United States. It establishes a fishery conservation zone within which the United States has exclusive fishery management prerogatives.

There are no fisheries at Site 29 or in nearby areas potentially affected by the remedial action.

National Wildlife Refuge System Administration Act of 1966

The National Wildlife Refuge System Administration Act of 1966 (16 USC §668dd–668ee) and its implementing regulations at 50 CFR pts. 25–37 establish wildlife refuges that are maintained for the primary purpose of developing a national program of wildlife and ecological conservation and rehabilitation. These refuges are established for the restoration, preservation, development, and management of wildlife and wild land habitats; protection and preservation of endangered or threatened species and their habitats; and management of wildlife and wild lands to obtain the maximum benefit from these resources.

The National Wildlife Refuge System Administration Act contains the following substantive requirements that are potential ARARs. The act prohibits any person from disturbing, injuring,

cutting, burning, removing, destroying, or possessing any property within any area of a wildlife refuge. The act also prohibits the taking or possessing of any fish, bird, mammal, or other wild vertebrate or invertebrate animals or nest or eggs within any refuge area or otherwise occupying any such area unless such activities are done with a permit or permitted by express provision of law. The act also regulates the use of audio equipment as well as motorized vehicles, aircraft, and boats in wildlife refuges. It prohibits construction activities, disposal of waste, and the introduction of plants and animals into any wildlife refuge. The prohibitions under the act are codified at 50 CFR pt. 27.

No wildlife refuges are potentially affected by the remedial action.

Wilderness Act

The Wilderness Act (16 USC §1131) and its accompanying implementing regulations (50 CFR §35.1–35.14) create the National Wilderness Preservation System. The intent of the law is to administer and manage units of this system (i.e., wilderness areas) in order to preserve their wilderness character and to leave them unimpaired for future use as wilderness.

There are no wilderness areas potentially affected by the remedial action.

3.2.4.2 State

The following sections of the Cal. Fish & Game Code have been identified by the state as potential ARARs.

California Endangered Species Act

The California Endangered Species Act is set forth in the Cal. Fish & Game Code §§2050–2116. The substantive provisions in Cal. Fish & Game Code §2080 prohibit the "take" of endangered or threatened species. A "take" is defined at Cal. Fish & Game Code §86, and means to hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.

California Fish & Game Code Sections 2080 and 1908

California Fish & Game Code §2080 is not applicable because the United States of America has not waived sovereign immunity in the Federal Endangered Species Act for this State of California requirement. The tiger salamander is a state threatened species. The substantive provisions of Cal. Fish & Game Code §2080 meet the pertinent NCP criteria under 40 CFR Section 300.400(g)(2)(vii) and are "relevant and appropriate" because the tiger salamander may be present at the site and protection of this vulnerable resource allows it to be "used" in the sense that it continues to provide its unique value to the state of California.

The Navy accepts Cal. Fish & Game Code §2080 as a state ARAR subject to the following conditions. The State of California, through DFG's Office of Spill Prevention and Response (DFG-OSPR), concurs that this statute addresses prohibited conduct but does not provide for or prescribe affirmative measures to avoid a "taking." Notwithstanding the absence of specific affirmative measures in the statute, the Navy will implement reasonable measures to ensure adequate protection of ecological receptors during response action construction following issuance of a CERCLA decision document pursuant to the Navy's obligations under CERCLA to

select removal or remedial actions that are protective of human health and the environment (see §121(b)(1) of CERCLA). The Navy will coordinate with the State, through the Department of Fish and Game – Office of Spill Prevention and Response (DFG-OSPR), prior to implementation of such reasonable measures. The Navy understands that the State reserves the right to conduct periodic site visits during removal or remedial activities to confirm implementation of avoidance measures.

California Fish & Game Code §1908 states, "No person shall import into this state, or take, possess, or sell within this state, except as incident to the possession or sale of the real property on which the plant is growing, any native plant, or any part or product thereof, that the commission determines to be an endangered native plant or rare native plant." Cal. Fish & Game Code §1901 defines "native plant" as a plant growing in a wild uncultivated state that is normally found native to the plant life of this state. A species, subspecies, or variety is endangered when its prospects of survival and reproduction are in immediate jeopardy from one or more causes. A species, subspecies, or variety is rare when, although not presently threatened with extinction, it is in such small numbers throughout its range that it may become endangered if its present environment worsens. This requirement is not an ARAR because endangered and rare plant species are not present at the site.

Fully Protected Species

Cal. Fish & Game Code §3511. This section states that fully protected birds or parts thereof may not be taken or possessed at any time. The list of fully protected birds includes: American peregrine falcon (*Falco peregrinus anatum*), California brown pelican, California black rail (*Laterallus jamaicensis coturniculus*), California clapper rail (*Rallus longirostris obsoletus*), California condor (*Gymnogyps californianus*), California least tern (*Sterna albifrons browni*), golden eagle, greater sandhill crane (*Grus canadensis tabida*), light-footed clapper rail (*Rallus longirostris levipes*), southern bald eagle (*Haliaeetus leucocephalus leucocephalus*), trumpeter swan (*Cygnus buccinator*), white-tailed kite (*Elanus leucurus*), and Yuma clapper rail (*Rallus longirostris yumanensis*).

Cal. Fish & Game Code §3511 is not applicable because the United States of America has not waived sovereign immunity in the Federal Endangered Species Act for this State of California requirement. The golden eagle is a fully protected bird. The substantive provisions of Cal. Fish & Game Code §3511 meet the pertinent NCP criteria under 40 CFR Section 300.400(g)(2)(vii) and are "relevant and appropriate" because the tiger salamander may be present at the site and protection of this vulnerable resource allows it to be "used" in the sense that it continues to provide its unique value to the state of California.

The Navy accepts Cal. Fish & Game Code §3511 as a state ARAR subject to the following conditions. The State of California, through DFG-OSPR, concurs that this statute addresses prohibited conduct but does not provide for or prescribe affirmative measures to avoid a "taking." Notwithstanding the absence of specific affirmative measures in the statute, the Navy will implement reasonable measures to ensure adequate protection of ecological receptors during response action construction following issuance of a CERCLA decision document pursuant to the Navy's obligations under CERCLA to select removal or remedial actions that are protective of human health and the environment (see §121[b][1] of CERCLA). The Navy will coordinate

with the State, through DFG-OSPR, prior to implementation of such reasonable measures. The Navy understands that the State reserves the right to conduct periodic site visits during removal or remedial activities to confirm implementation of avoidance measures.

Other California Fish & Game Code Requirements

The following requirements were identified by the state as potential ARARs.

Cal. Fish & Game Code §3005(a). This section prohibits the taking of birds and mammals, including taking by poison.

Cal. Fish & Game Code Section 3005 is not applicable because the United States of America has not waived sovereign immunity in the Federal Endangered Species Act for this State of California requirement. Pursuant to 40 CFR Section 300.400(g)(2) of the NCP, the Navy has determined that this requirement is not "relevant and appropriate" because it does not address problems or situations sufficiently similar to the circumstances of the release or CERCLA response action and is not well suited to the site based upon the pertinent provisions of Subsections 300.400(g)(2)(i) and (iv) of the NCP. CERCLA response actions are intended to respond to releases of hazardous substances in order to protect human health and the environment including environmental receptors. In contrast, the purpose of this state requirement is to regulate and set forth conditions for the "taking" of the species addressed by those requirements. Moreover, that purpose is achieved through the regulation of intentional conduct directed at the species as opposed to incidental "take" (or possession, etc.) of species in the course of lawful activity such as CERCLA remedial action. The focus on intentional conduct is not well suited to the circumstances at CERCLA sites. In summary, the purposes of this state requirement and the actions that it regulates do not include responding to releases of hazardous substances. Therefore, it is not "relevant and appropriate" based upon the pertinent provisions of Subsections 300.400(g)(2)(i) and (iv) of the NCP.

Cal. Fish & Game Code §3503. It is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto.

The Navy has determined that Cal. Fish & Game Code §3503 is not a state ARAR because it is not applicable or relevant and appropriate. The State of California, through DFG-OSPR, asserts that §3503 is a state ARAR because it is relevant and appropriate. Whereas the Navy and the State have not agreed upon whether §3503 is an ARAR, this FFS documents each party's position on the statute but does not attempt to resolve the issue. Nonetheless, the Navy agrees that it will undertake measures in order to generally avoid harm to nests and eggs when there is potential that they may be impacted by response-action construction. The State will not dispute the selected remedy for failure to identify §3503 as an ARAR because the State has determined that the mutually agreed measures to generally avoid harm will result in substantive compliance with the state requirement.

Cal. Fish & Game Code §4800. It is unlawful to take, injure, possess, transport, import, or sell any mountain lion or any part or product thereof.

The Navy has determined that Cal. Fish & Game Code §4800 is not a state ARAR because it is not applicable or relevant and appropriate. The State of California, through DFG-OSPR, asserts

that Cal. Fish & Game Code §4800 is a state ARAR because it is relevant and appropriate. Whereas the Navy and DFG-OSPR have not agreed upon whether Cal. Fish & Game Code §4800 is an ARAR, this FFS documents each party's position on the statute but does not attempt to resolve the issue. Nonetheless, the Navy agrees that it will undertake measures in order to generally avoid harm to mountain lions when there is potential that they may be impacted by response action construction. The State will not dispute the selected remedy for failure to identify §4800 as an ARAR because the State has determined that the mutually agreed upon measures to generally avoid harm will result in substantive compliance with the state requirement.

Cal Code Regs. Tit. 14, §460. Fisher, marten, river otter, desert kit fox, and red fox may not be taken at any time.

The Navy has determined that Cal. Code Regs. tit. 14, §460 is not a state ARAR because it is not applicable or relevant and appropriate. The State of California, through DFG-OSPR, asserts that Cal. Code Regs. tit. 14, §460 is a state ARAR because it is relevant and appropriate. Whereas the Navy and the State have not agreed upon whether Cal. Code Regs. tit. 14, §460 is an ARAR, this FFS documents each party's position on the statute but does not attempt to resolve the issue. Nonetheless, the Navy agrees that it will undertake measures in order to generally avoid harm to fisher, marten, river otter, desert kit fox, and red fox when there is potential that they may be impacted by removal action construction. The State will not dispute the selected remedy for failure to identify Cal. Code Regs. tit. 14, §460 as an ARAR because the State has determined that the mutually agreed upon measures to generally avoid harm will result in substantive compliance with the state requirement.

Cal. Fish & Game Code §3503.5. This section prohibits the take, possession, or destruction of any birds in the orders of Falconiformes or Strigiformes (birds of prey) or to take, possess, or destroy the nests or eggs of such birds.

The State has withdrawn its previous identification of this requirement as a state ARAR in light of Navy's identification of the substantive provisions of the MBTA as a "relevant and appropriate" federal ARAR for this action.

California Fish & Game Code §5650(a), (b), and (c)

Cal. Fish & Game Code §5650(a), (b), and (c) prohibits depositing or placing, where it can pass into waters of the state, any petroleum products, factory refuse, sawdust, shavings, slabs or edgings, and any substance deleterious to fish, plant life, or bird life. Section 5650(b) of the Cal. Fish & Game Code states that this section does not apply to a discharge or a release that is expressly authorized pursuant to, and in compliance with, the terms and conditions of a waste discharge requirement pursuant to Cal. Water Code §13263 or a waiver issued pursuant to Cal. Water Code §13269, subdiv. (a) issued by the SWRCB or a RWQCB after a public hearing, or that is expressly authorized pursuant to, and in compliance with, the terms and conditions of a federal permit for which the SWRCB or RWQCB has, after a public hearing, issued a water quality certification pursuant to Cal. Water Code §13160. If the remedial action could place deleterious substances such as contaminated soil where they could pass into waters, Cal. Fish & Game Code §5650(a), (b), and (c) may be relevant and appropriate.

Fish and Game Commission Wetlands Policy

California Fish and Game Commission Wetland Policy (adopted 1987) is included in Fish & Game Code Addenda.

The Fish and Game Commission wetlands policy was included in the state's identification of ARARs as discussed in Section 1.2.3. However, the Fish and Game Commission Wetlands Policy is not a regulation, but was suggested as a TBC requirement. Since adequate ARARs have been identified for the protection of wetlands, no TBC requirement is necessary for this remedial action.

3.2.5 Coastal Resources ARARs

The following requirements were evaluated, but Site 29 did not have any of the regulated features.

- Coastal Zone Management Act (substantive provisions of 16 USC §§1451–1464, 15 CFR pt. 930)
- California Coastal Act of 1976 (Cal. Pub. Res. Code §§30000–30900; Cal. Code Regs. tit. 14, §§13001–13666.4)]

3.2.6 Geologic Characteristics ARARs

The following requirement was evaluated, but Site 29 did not have any of the regulated features.

- RCRA (42 USC §§6901–6991[i[), hazardous waste facility siting criteria, Cal. Code Regs. tit. 22, §66264.18(a) and (c)]

3.2.6.1 Federal

The state location-specific RCRA requirements for geologic characteristics are part of the federally approved program and are evaluated below as potential federal ARARs.

Resource Conservation and Recovery Act (42 USC §§6901–6991[i])

Hazardous waste facilities must be sited in accordance with the following RCRA requirements.

- Seismic considerations (Cal. Code Regs. tit. 22, §66264.18[a]) – portions of new facilities or facilities undergoing substantial modification where transfer, treatment, storage, or disposal of hazardous waste will be conducted shall not be located within 61 meters (200 feet) of a fault that has had displacement in Holocene time.

No faults are within 200 feet of Site 29.

- Salt dome formations, salt bed formations, and underground mines and caves (Cal. Code Regs. tit. 22, §66264.18[c]) – the placement of any noncontainerized or bulk liquid hazardous waste in any salt dome formation, salt bed formation, or underground mine or cave is prohibited.

No salt domes, mines, or caves have been identified at Site 29.

Because there are no faults within 200 feet of and no salt domes, mines, or caves at Site 29, Cal. Code Regs. tit. 22, §66264.18(b) and (c) are not potential ARARs.

3.2.6.2 State

Other state location-specific requirements for geologic characteristics were not identified for evaluation as potential state ARARs.

Section 4 Action-Specific ARARs

This FFS evaluates remedial action alternatives for Site 29 at former NAVWPNSTA Concord. This ARAR analysis evaluates the following activities/actions: no action, LUCs, monitoring (including monitored natural attenuation [MNA]), SVE with injection of ZVI, and ISB. One or a combination of these activities is included in the remedial action alternatives being evaluated for the site:

- Alternative 1 – No action
- Alternative 2 – SVE with MNA
- Alternative 3 – SVE with ZVI injection
- Alternative 4 – SVE with ISB and Groundwater Recirculation.

Detailed descriptions of the remedial alternatives are provided in the main text of this FFS.

Tables A4-1 and A4-2 present and evaluate federal and state potential action-specific ARARs for Site 29, respectively. A discussion of the requirements determined to be pertinent to each activity/action included in the remedial action alternatives being evaluated for Site 29 is presented in this section. A discussion of how the alternative complies with each identified ARAR is also provided.

4.1 Alternative 1 – No Action

There is no need to identify ARARs for the no action alternative because ARARs apply to "any removal or remedial action conducted entirely on-site" and "no action" is not a removal or remedial action (CERCLA §121[e], 42 USC §9621[e]). CERCLA §121 (42 USC §9621) cleanup standards for selection of a Superfund remedy, including the requirement to meet ARARs, are not triggered by the no action alternative (U.S. EPA 1991b). Therefore, a discussion of compliance with action-specific ARARs is not appropriate for this alternative.

4.2 Alternative 2 – SVE with MNA

This alternative includes SVE, treatment of the soil gas to remove VOCs, monitoring, and LUCs.

4.2.1 Soil-Vapor Extraction

SVE will remove VOCs from the vadose zone and groundwater by creating a vacuum to induce subsurface airflow through the vadose zone. The vacuum is generated by a network of vapor extraction wells connected to a blower via extraction wells within the treatment zone. VOC-laden soil gas will be treated in an aboveground treatment system, typically granular-activated-carbon filters, to remove and discharge to the atmosphere in accordance with air ARARs. Criteria for "Shutoff" of SVE Systems

SVE systems used to remove VOCs from the vadose zone and groundwater at Site 29 will be operated until one of the following two conditions is reached:

1. (a) remaining vadose zone VOC concentrations no longer cause modeled groundwater concentrations to exceed the groundwater cleanup standards (based on

interpretation of soil-gas data using appropriate vadose zone fate and transport and groundwater mixing-zone models), and (b) representative groundwater concentrations measured within the SVE system radius of influence (ROI) have achieved groundwater cleanup standards.

2. VOCs in the vadose zone and groundwater within the ROI of the SVE system have been removed to the extent technically and economically feasible. That is, the incremental benefit of attaining further reduction in the concentration of VOCs is exceeded by the incremental cost of achieving those reductions through pump and treat.

The Navy will demonstrate that vadose zone cleanup standards have been achieved for part (a) of condition (1) through an examination of the current effects of remaining vadose zone contamination on groundwater based on an interpretation of soil-gas data using appropriate vadose zone fate and transport and groundwater mixing-zone model(s) (using a mixing zone extending to a depth of 10 feet below the water table). If it is demonstrated that soil-gas concentrations of COCs in the vadose zone no longer cause modeled groundwater concentrations to exceed the cleanup standards, the parties agree that the demonstration for part (a) of condition (1) has been made.

The Navy will demonstrate that groundwater cleanup standards have been achieved for part (b) of condition (1) through collection of groundwater samples from monitoring wells. If it is demonstrated that the representative groundwater concentrations of COCs meet the groundwater cleanup standards, then the demonstration for part (b) of condition (1) has been made.

If it is determined that the cleanup standards in condition (1) cannot be achieved, the Navy will demonstrate that VOCs in the vadose zone and groundwater within the ROI of the SVE have been removed by SVE to the extent technically and economically feasible as set forth in condition (2), by analyzing the following six factors:

1. Whether the mass removal rate is approaching asymptotic levels after temporary shutdown periods and appropriate optimization of the SVE system (see Section 4.4.1.1)
2. The additional cost of continuing to operate the SVE system when mass removal reaches asymptotic levels
3. The predicted effectiveness and cost of further enhancements of the SVE system (e.g., additional vapor extraction wells) beyond optimization of the existing system
4. Whether discontinuing the SVE will significantly prolong the time to attain the groundwater cleanup standard
5. Historical data that present the SVE system operating costs per unit of VOC mass removed from the vadose zone and groundwater and the concurrent soil-gas and groundwater VOC concentrations, both as a function of time
6. Historical data that present the groundwater pump-and-treat system operating costs per unit of VOC mass removed from the groundwater and the concurrent groundwater VOC concentrations, both as a function of time

The SVE system may be cycled on and off in order to optimize the operation and/or evaluate the factors listed above (also see Section 4.2.1.2).

Determination of Asymptotic Conditions

The Navy will track the cumulative mass of VOCs removed by the SVE system and plot the data as a function of time to help determine how quickly the cumulative mass removed approaches asymptotic levels. It is expected that the resulting graph of cumulative VOC mass removed versus time will follow the general curve defined by the following exponential decay equation:

$$M(t) = \text{Sum}(Mi) - KT(1 - e^{(-t/T)})$$

where

M(t) = total cumulative mass removed at time t

Mi = total mass removed from vapor extraction well "i"

KT = maximum cumulative total mass that the SVE system approaches asymptotically

T = the constant, or resident time equal to the amount of time at which the SVE system removes approximately 63% of KT (theoretically, T is equivalent to V/Q, or the volume of soil gas in the vadose zone being remediated [V] divided by the volumetric flow rate of the SVE system [Q])

t = any time during system operation at which cumulative mass removed is calculated

i = any vapor extraction well for which total mass removed is calculated

The above equation will be used as a guide to help determine when asymptotic conditions have been reached. The "asymptote" to the mass removal curve is that total/cumulative maximum mass (KT, defined above) that the SVE system attempts to remove but approaches with ever-decreasing speed. Asymptotic conditions will have been reached when the upper limb of this curve is substantially linear and the slope of the curve approaches zero. The specific procedures used to evaluate whether the data are asymptotic will be defined during the remedial design phase of work. However, it is not expected that field data will match the theoretical equation exactly. Therefore, it will be necessary to use best professional judgment based on field data to conclude that asymptotic conditions have been reached.

To assess whether there are zones where the SVE system has not removed VOCs, cycling will be used to allow residual vadose zone contamination to re-equilibrate. The treatment system will be shut down temporarily for a suitable period after asymptotic conditions are reached. This will allow VOC concentrations to reestablish in the soil gas. After cycling, soil-gas monitoring probes will be sampled to determine the remaining characteristic of the precycling conditions or to indicate a spike increase in soil-gas concentration, then additional treatment may be warranted. The decision to shut off or restart any part of the remediation system will be made jointly by all FFA signatories.

4.2.1 Federal ARARs

4.2.1.1 SVE Treatment System

Federal laws that give rise to potential ARARs for actions to be undertaken as part of SVE include RCRA and CAA. These requirements are described in the following paragraphs.

Waste streams created in the course of implementing the remedial action would be subject to RCRA requirements for determining whether wastes would be classified as hazardous. Hazardous waste determinations for the soil cuttings generated from the installation of the monitoring wells and the spent carbon generated from the off-gas treatment would be made at the time the waste is generated. If these wastes are determined to be hazardous, then the appropriate requirements for storing, manifesting, and transporting these materials for final disposal would need to be followed. The waste storage and characterization ARARs are called out for monitoring in Section 4.2. 1.3.

The treatment with carbon would be conducted in a tank system similar to a RCRA tank system. Therefore, the RCRA tank system requirements were evaluated to determine whether they were relevant and appropriate for the groundwater treatment. The substantive provisions of the following RCRA tank system requirements may be relevant and appropriate for the storage and/or treatment of groundwater: Cal. Code Regs. tit. 22, §66264.192(a), (b), (c), (e), (f) and (g); 66264.193(b), (c), (d), (e); 66264.194(a) and (b); 66264.195(a), (b), and (c); 66264.196(b) except (b)(5) and (7); and 66264.197(a) and (b). These requirements include design, secondary containment, inspection, and closure requirements. The alternative requirements for tank systems for temporary units at §66264.553 may replace the tank system requirements as long as the system is protective of human health and the environment.

4.2.1.2 Monitoring

Groundwater monitoring would serve as a means to monitor plume stability and possible degradation over time to ensure the plume is not migrating into areas where groundwater is used for domestic use. The groundwater monitoring will include MNA parameters for evaluating natural attenuation.

All the SVE alternatives being evaluated for Site 29 include a groundwater and vadose zone monitoring component. Federal and state requirements that pertain to groundwater and vadose zone monitoring for corrective action programs are described in the following subsections. Portions of the RCRA groundwater protection standards contained in Cal. Code Regs. tit. 22 are considered to be relevant and appropriate for the groundwater and soil impacted by releases from Site 29 because the hazardous constituents being addressed by this action are similar or identical to those found in RCRA hazardous wastes. In addition to concentration limits for groundwater, Cal. Code Regs. tit. 22, §66264.100 requires that a water quality monitoring program be established to demonstrate the effectiveness of a corrective action program. Substantive provisions of the following requirements apply to the development and implementation of a groundwater monitoring program:

- Monitoring at Cal. Code Regs. tit. 22, §66264.91(a)(1)–(4), and (c)
- COCs at Cal. Code Regs. tit. 22, §66264.93.

- Concentration limits (Section 2)
- Monitoring points and points of compliance at Cal. Code Regs. tit. 22, §66264.95(a) and (b)
- Monitoring parameters at Cal. Code Regs. tit. 22, §66264.98(e)(1)–(5), (i), (j), (k)(1)–(3), (4)(A) and (D), (5), (7)(C) and (D), (n)(1), (2)(B), and (C)
- Statistical method for detecting a release at Cal. Code Regs. tit. 22, §66264.97(b)(1)(A), (b)(1)(D)(1) and (2), (b)(4)–(7), (e)(6), (12)(A) and (B), (13), and (15)
- Evaluation monitoring at Cal. Code Regs. tit. 22, §66264.99(b), (e)(1)–(6), (f)(3), and (g)
- Corrective action monitoring at Cal. Code Regs. tit. 22, §66264.100(d) and (g)(1)

RCRA requirements for identification and management of solid and hazardous wastes are also potential federal action-specific ARARs identified for monitoring. Soil cuttings and water generated in the course of installing and developing monitoring wells would be subject to RCRA requirements at Cal. Code Regs. tit. 22, §66262.10(a) and §66262.11 to determine whether such wastes should be classified as hazardous.

The Navy has determined that soil and well development water at Site 29 may be classified as RCRA-listed hazardous wastes. However, testing would still be required to be able to classify these materials with respect to the RCRA hazardous waste characteristics. This determination would be made at the time the waste is generated.

Requirements for storing and characterizing this waste for final disposal will need to be followed.

4.2.1.3 Waste Storage and Characterization Requirements

The substantive RCRA on-site waste generation and characterization requirements at Cal. Code Regs. tit. 22, §§66262.10(a), 66262.11, and 66264.13(a) and (b) were identified as potentially applicable ARARs for characterizing waste prior to off-site disposal. The substantive provisions of the following RCRA storage and handling requirements are potentially applicable federal ARARs for this alternative since the waste planned to be generated may be hazardous:

- Cal. Code Regs. tit. 22, §66262.34 for accumulating waste
- Cal. Code Regs. tit. 22, §66264.171–174, .175(a) and (b), .177, and .178 for container storage
- Cal. Code Regs. tit. 22, §66264.553 (b), (d), (e), and (f) for temporary unit alternatives for containers

4.2.1.4 Clean Air Act

The SVE system is a potential source of air pollutants that will be treated in the carbon filtration system. The new source review rule BAAQMD 2-301 requires Best Available Control Technology for any new source. The carbon treatment unit will meet these requirements. In addition, the requirements of BAAQMD 8-47-301 emission control requirements are potential

ARARs for the SVE system. These require the SVE system to be vented to a control device that reduces emissions to the atmosphere by at least 90% by weight. The substantive provisions of BAAQMD Rule 2-301 and 8-47-301 are potentially applicable federal ARARs since they are part of the SIP.

4.2.1.5 Land-Use Controls for Sites Transferring to Nonfederal Entities

LUCs, including both institutional and engineering controls, will be used to restrict use of groundwater for domestic supply and to implement building code requirements for structures built over the soil-vapor plume. No federal ARARs were identified for LUCs. The following State requirements were identified.

State statutes that have been accepted by the Navy as ARARs for implementing institutional controls and entering into an Environmental Restriction Covenant and Agreement with DTSC include substantive provisions of the California Civil Code (CCC) §1471. DTSC promulgated a regulation on 19 April 2003 regarding "Requirements for Land Use Covenants" at Cal. Code Regs. tit. 22, §67391.1. The substantive provisions of this regulation have been determined to be "relevant and appropriate" state ARARs by the Navy.

The substantive provisions of CCC §1471 are the following general narrative standard: "…to do or refrain from doing some act on his or her own land…where…: (c) Each such act relates to the use of land and each such act is reasonably necessary to protect present or future human health or safety or the environment as a result of the presence on the land of hazardous materials, as defined in Section 25260 of the Health and Safety Code." This narrative standard would be implemented through incorporation of restrictive environmental covenants in the deed at the time of transfer. These covenants would be recorded with the environmental restriction covenant and agreement and run with the land.

U.S. EPA agrees that the substantive portions of the state statutes and regulations referenced in this section are ARARs. U.S. EPA specifically considers §§(a)(1), (a)(2), (d), (e)(1) and (e)(2) of Cal. Code Regs., tit. 22 §67391.1 to be ARARs for this FSS. DTSC's position is that all of the state statutes and regulations referenced in this section are ARARs.

4.2.2 State ARARs

The state identified pertinent requirements for evaluation monitoring at Cal. Code Regs. tit. 27, §20425 and Cal. Code Regs. tit. 23, §2550.9 and corrective action monitoring at Cal. Code Regs. tit. 27, §20430 and Cal. Code Regs. tit. 23, §2550.10. However, these were determined to be not more stringent than essentially the same requirements at Cal. Code Regs. tit. 22 §§66264.99 and 66264.100 that were determined to be potential federal ARARs.

The state also identified clean closure requirements at Cal. Code Regs. tit. 27, §21090(f). The requirements at Cal. Code Regs. tit. 27, §21090(f) were determined to be not more stringent than requirements identified at Cal. Code Regs. tit. 22, §66264.228(a), (b), (e)–(k), (m), and (o)–(q) that were identified as potential federal ARARs.

The state identified the National Pollutant Discharge Elimination System (NPDES) General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities (SWRCB Order 2009-0009-DWQ, NPDES No. CAS000002). This requirement

applies when there is one or more acre of soil disturbance. This remedial action does not include soil disturbance of one or more acres. Therefore, this requirement is not a potential ARAR for this remedial action.

4.3 Alternative 3 – SVE with ZVI Injection

This alternative is the same as Alternative 2 except that ZVI will be injected into the groundwater to degrade VOCs. The ARARs identified for Alternative 2 are also ARARs for this alternative. In addition, the following potential ARARs were identified.

Underground injection requirements of SDWA are codified at 40 CFR §144.12. The substantive provisions prohibit injection activities that allow movement of contaminants into underground sources of drinking water that may result in violations of MCLs or adversely affect health. The injection of ZVI is expected to comply with these requirements. The materials to be injected are carefully calculated to assist with meeting MCLs.

4.4 Alternative 4 – SVE with ISB and Groundwater Recirculation

This alternative is the same as Alternative 2 except that a biodegradable substrate will be injected into the groundwater to degrade VOCs. The ARARs identified for Alternative 2 are also ARARs for this alternative. In addition, the following potential ARARs were identified.

Underground injection requirements of SDWA are codified at 40 CFR §144.12. The substantive provisions prohibit injection activities that allow movement of contaminants into underground sources of drinking water that may result in violations of MCLs or adversely affect health. The injection of biodegradable organic substrates is expected to comply with these requirements. The materials to be injected are carefully calculated to assist with meeting MCLs.

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Section 5 References

Brady (Richard Brady & Associates, Inc.). 2011. *Final Remedial Investigation for Installation Restoration Program Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California*. March 4.

SFBRWQCB (California Regional Water Quality Control Board, San Francisco Bay Region). 2007. *Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin.* January. Available online at: http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml.

SWRCB (California State Water Resources Control Board). 1968. Resolution No. 68-16. Statement of Policy With Respect to Maintaining High Quality Waters in California.

———. 1988. Resolution No. 88-63. Sources of Drinking Water.

———. 1992. Resolution No. 92-49 (as amended on 21 April 1994 and 02 October 1996): Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304.

———. 1994. Application of State Water Board Resolution No. 68-16 to Cleanup of Contaminated Groundwater. February.

U.S. EPA (United States Environmental Protection Agency). 1986. Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy.

———. 1988a. CERCLA Compliance With Other Laws Manual, Draft Guidance (Part I). EPA/540/G-89/006, Office of Emergency and Remedial Response, Washington, DC. August.

———. 1988b. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. OSWER Directive 9355.3-01, -02. EPA/540/G-89/004. October.

———. 1991a. Management of Investigation-Derived Wastes During Site Inspections. EPA/540/G-91/009. May.

———. 1991b. ARARs Q's and A's: General Policy, RCRA, CWA, SDWA, Post-ROD Information, and Contingent Waivers. OSWER Directive No. 9234.2-01/FS-A, Washington, DC. June.

———. 1999. National Recommended Water Quality Criteria – Correction. Office of Water, EPA 822-Z-99-001. April.

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Tables

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Table A2-2. Potential Federal Chemical-Specific[a] ARARs by Medium

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
GROUNDWATER				
Safe Drinking Water Act (42 USC, Chapter 6A, §300[f]–300[j]-26)[c]				
National primary drinking water standards are health-based standards for public water systems (MCLs).	Public water system.	40 CFR §141.11–141.13, excluding §141.11(d)(3), 141.15, 141.16, 141.61(a) and (c), and 141.62(b)	Relevant and appropriate	MCLs were identified for the COCs in groundwater: trichloroethene (TCE), perchloroethene (PCE), benzene, 1,2- dichloroethane (1,2-DCA), and cis-1,2-dichloroethene (cis-1,2-DCE).
MCLGs pertain to known or anticipated adverse health effects (also known as recommended MCLs).	Public water system.	40 CFR §141.50(a)	Relevant and appropriate	The MCLG for 1,1,2-TCA is 3 micrograms per liter, and the MCLG for cis-1,2-DCE is 70 micrograms per liter.
Resource Conservation and Recovery Act (42 USC, Chapter 82, §§6901–6991[i])[c]				
Defines RCRA hazardous waste. A solid waste is characterized as toxic, based on the TCLP, if the waste exceeds the TCLP maximum concentrations.	Waste.	Cal. Code Regs. tit. 22, §66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100	Applicable	Substantive provisions are potentially applicable for characterizing waste generated at the site.
Groundwater Protection Standards: requirements to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for COCs in the uppermost aquifer underlying the waste management area of	A regulated unit that receives or has received hazardous waste before 26 July 1982 or regulated units that ceased receiving hazardous waste prior to 26 July 1982 where constituents in or derived	Cal. Code Regs. tit. 22, §66264.94(a)(1) and (3), (c), (d), and (e)	Relevant and appropriate	Substantive provisions are potentially applicable for the unsaturated zone monitoring and for setting cleanup levels at the site protective of groundwater.

Table A2-2. Potential Federal Chemical-Specific[a] ARARs by Medium (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
concern at the POC.	from the waste may pose a threat to human health or the environment.			
The POC is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends through the uppermost aquifer underlying the regulated unit.	Hazardous waste treatment or disposal.	Cal. Code Regs. tit. 22, §66264.95	Relevant and appropriate	Potentially relevant and appropriate if contamination cannot be cleaned up within the plume.
SOIL				
Resource Conservation and Recovery Act (42 USC, Chapter 82, §§6901–6991[i])[c]				
Defines RCRA hazardous waste. A solid waste is characterized as toxic, based on the TCLP, if the waste exceeds the TCLP maximum concentrations.	Waste.	Cal. Code Regs. tit. 22, §66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100	Applicable	Substantive provisions are potentially applicable for characterizing waste generated at the site.
Groundwater Protection Standards: requirements to ensure that hazardous constituents entering the groundwater from a regulated unit do not exceed the concentration limits for COCs in the uppermost aquifer underlying the waste management area of concern at the POC.	A regulated unit that receives or has received hazardous waste before 26 July 1982 or regulated units that ceased receiving hazardous waste prior to 26 July 1982 where constituents in or derived from the waste may pose a threat to human health or the environment.	Cal. Code Regs. tit. 22, §66264.94(a)(1) and (3), (c), (d), and (e)	Relevant and appropriate	Substantive provisions are potentially applicable for the unsaturated zone monitoring and for setting cleanup levels at the site protective of groundwater.

Table A2-2. Potential Federal Chemical-Specific[a] ARARs by Medium (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
AIR[d]				
Clean Air Act (42 USC, Chapter 85, §§7401–7671)[c]				
NAAQS: Primary and secondary standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Contamination of air affecting public health and welfare.	40 CFR §50.4–50.12	—	Not enforceable and therefore not an ARAR.
Provisions of SIP approved by U.S. EPA under Section 110 of Clean Air Act.	Major sources of air pollutants.	42 USC §7401; portions of 40 CFR §52.220 applicable to BAAQMD	Applicable	Potentially applicable through BAAQMD regulations called out below.

Notes:

a Many potential action-specific ARARs contain chemical-specific limitations and are addressed in the action-specific ARAR tables.

b Only the substantive provisions of the requirements cited in this table are potential ARARs.

c Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader; listing statutes and policies does not indicate that the Department of the Navy accepts the statutes or policies as potential ARARs; specific potential ARARs are addressed in the table below each general heading; only pertinent, substantive requirements of the specific citations are considered potential ARARs.

d See Section 4.4 for more discussion regarding air requirements related to the SVE system.

Acronyms/Abbreviations:

§(§)	section(s)
ARAR	applicable or relevant and appropriate requirement
Cal. Code Regs.	*California Code of Regulations*
CFR	*Code of Federal Regulations*
COC	chemical of concern
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
NAAQS	National Ambient Air Quality Standards (primary and secondary)
POC	point of compliance

Table A2-2. Potential Federal Chemical-Specific[a] ARARs by Medium (continued)

RCRA	Resource Conservation and Recovery Act
SIP	State Implementation Plan
SVE	soil-vapor extraction
TCLP	toxicity characteristic leaching procedure
tit.	title
USC	*United States Code*
U.S. EPA	United States Environmental Protection Agency

Table A2-3. Potential State Chemical-Specific[a] ARARs by Medium

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
GROUNDWATER, SURFACE WATER, SOIL, SEDIMENTS, AND AIR				
State and Regional Water Quality Control Boards[c]				
A RWQCB, in a water quality control plan or in waste discharge requirements, may specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted.	—	CWC, Division 7 (Porter-Cologne Act), §§13241, 13243, 13263(a), 13269, and 13360	Applicable	The Department of the Navy accepts the substantive provisions of §13243 of the Porter-Cologne Water Quality Control Act enabling legislation, as implemented through the beneficial uses, WQOs, waste discharge requirements, promulgated policies of the Basin Plan for the San Francisco Bay Region, as potential ARARs.
	—	CWC, Division 7, §13304	Not an ARAR	Section 13304 does not constitute an ARAR because it does not itself establish or contain substantive environmental "standards, requirements, criteria or limitations" (CERCLA §121) and is not in itself directive in intent. In addition, §13304 is not more stringent than the substantive requirements of the potential state and federal ARARs identified in this table and Table A2-2.
Describes the water basins in San Francisco Bay Region, establishes beneficial uses of groundwater and surface water, establishes WQOs, including narrative and numerical standards, establishes implementation plans to meet WQOs and protect beneficial uses, and incorporates statewide water quality control plans and policies.	—	Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) (CWC §13240)	Applicable	Substantive requirements pertaining to beneficial uses, WQOs, and certain statewide water quality control plans are potential state ARARs for protecting water. The requirements of the Basin Plan will be used to set cleanup levels protective of the surface water for this removal action.

Table A2-3. Potential State Chemical-Specific[a] ARARs by Medium (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
California Department of Toxic Substances Control[c]				
Definition of "non-RCRA hazardous waste."	Waste.	Cal. Code Regs. tit. 22, §66261.3(a)(2)(C) or 66261.3(a)(2)(F), 66261.22(a)(3) and (4), 66261.24(a)(2)–(a)(8), 66261.101(a)(1) and (a)(2)	Applicable	Substantive provisions are potentially applicable for determining whether a waste is a non-RCRA hazardous waste.
State MCL list.	Source of drinking water.	Cal. Code Regs. tit. 22, §64431 and 64444	—	Substantive provisions are potentially applicable for benzene, 1,2-DCA, and cis-1,2-DCE because they are more stringent than federal MCLs.
State and Regional Water Quality Control Boards[c]				
Describes requirements for RWQCB oversight of investigation and cleanup and abatement activities resulting from discharges of hazardous substances. RWQCB may decide on cleanup and abatement goals and objectives for the protection of water quality and beneficial uses of water within each region. Establishes criteria for "containment zones" where cleanup to established water-quality goals is not economically or technically practicable.	—	Policies and procedures for investigation and cleanup and abatement of discharges under CWC §13304, SWRCB Res. 92-49	Not an ARAR	Not more stringent than federal ARARs at Cal. Code Regs. tit. 22, §66264.94.

Table A2-3. Potential State Chemical-Specific[a] ARARs by Medium (continued)

Requirement	Prerequisite	Citation[b]	ARAR Determination	Comments
Establishes the policy that high-quality waters of the state "shall be maintained to the maximum extent possible" consistent with the "maximum benefit to the people of the State." It provides that whenever the existing quality of water is better than that required by applicable water quality policies, such existing high-quality water will be maintained until it has been demonstrated to the state that any change will be consistent with maximum benefit to the people of the state, will not unreasonably affect present and anticipated beneficial use of such water, and will not result in water quality less than that prescribed in the policies. It also states that any activity that produces or may produce a waste or increased volume or concentration of waste and that discharges or proposes to discharge to existing high-quality waters will be required to meet waste-discharge requirements that will result in the best practicable treatment or control of the discharge.	—	Statement of Policy With Respect to Maintaining High Quality of Waters in California, SWRCB Res. 68-16	Not an ARAR	Not an ARAR for existing contamination or further migration of existing contaminant plumes in groundwater. See Section 2.2.1.2 for further discussion.
Incorporated into all regional board basin plans. Designates all groundwater and surface waters of the state as drinking water except where the TDS is greater than 3,000 ppm, the well yield is less than 200 gpd from a single well, the water is a geothermal resource or in a water conveyance facility, or the water cannot reasonably be treated for domestic use using either best management practices or best economically achievable treatment practices.	—	SWRCB Res. 88-63 (Sources of Drinking Water Policy)	Applicable	The groundwater at Site 29 meets the criteria for a drinking water source.

Table A2-3. Potential State Chemical-Specific[a] ARARs by Medium (continued)

Notes:

a many potential action-specific ARARs contain chemical-specific limitations and are addressed in the action-specific ARAR tables

b only the substantive provisions of the requirements cited in this table are potential ARARs

c statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Department of the Navy accepts the entire statutes or policies as potential ARARs; specific potential ARARs are addressed in the table below each general heading; only pertinent substantive requirements of specific citations are considered potential ARARs

Acronyms/Abbreviations:

§(§)	section(s)
ARAR	applicable or relevant and appropriate requirement
Cal. Code Regs.	*California Code of Regulations*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWC	*California Water Code*
DCA	dichloroethane
DCE	dichloroethene
gpd	gallons per day
MCL	maximum contaminant level
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
Res.	Resolution
RWQCB	(California) Regional Water Quality Control Board San Diego Region
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
tit.	title
WQO	water quality objective

Table A3-1. Potential Federal Location-Specific ARARs

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
National Historic Preservation Act of 1966, as Amended (16 USC §470–470x-6)[b]					
Historic project owned or controlled by federal agency	Action to preserve historic properties; planning of action to minimize harm to properties listed on or eligible for listing on the National Register of Historic Places.	Property included in or eligible for the National Register of Historic Places.	16 USC §470–470x-6 36 CFR part 800	Not an ARAR	No potentially eligible property for listing on the National Register is at the site.
Archaeological and Historic Preservation Act (16 USC §469–469c-1)[b]					
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	Construction on previously undisturbed land would require an archaeological survey of the area. Data recovery and preservation would be required if significant archaeological or historical data were found on-site. The responsible official or Secretary of the Interior is authorized to undertake data recovery and preservation.	Regulated alteration of terrain caused as a result of a federal construction project or federally licensed activity or program where action may cause irreparable harm, loss, or destruction of significant artifacts.	16 USC §469–469c-1	Not an ARAR	No potential historical resources are expected.
Historic Sites, Buildings, and Antiquities Act of 1935 (16 USC §§461–467)[b]					
Historic sites	Avoid undesirable impacts on landmarks.	Areas designated as historic sites.	16 USC §461–467	Not an ARAR	No potential landmarks are at the site.

Table A3-1. Potential Federal Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Archaeological Resources Protection Act of 1979, as Amended (16 USC §470aa–470mm)[b]					
Archaeological resources on federal land	Prohibits unauthorized excavation, removal, damage, alteration, or defacement of archaeological resources located on public lands unless such action is conducted pursuant to a permit.	Archaeological resources on federal land.	Public Law No. 96-95 16 USC §470aa–470mm	Not an ARAR	No potential historical resources are expected.
Clean Water Act of 1977, as Amended, §404 (33 USC §1344)[b]					
Wetland	Action to prohibit discharge of dredged or fill material into wetland without permit.	Wetland as defined by Executive Order No. 11990 §7.	33 USC §1344	Not an ARAR	No dredge or fill is proposed.
Resource Conservation and Recovery Act (42 USC §§6901–6991[i])[b]					
Within 100-year floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	Cal. Code Regs. tit. 22, §66264.18(b)	Not an ARAR	Site 29 is not within a 100-year floodplain.
Wild and Scenic Rivers Act (16 USC §§1271–1287)[b]					
Within area affecting national wild, scenic, or recreational river	Avoid taking or assisting in action that will have direct adverse effect on scenic river.	Activities that affect or may affect any of the rivers specified in 16 USC §1276(a).	16 USC §§1271–1287	Not an ARAR	There is no wild or scenic river at the site.
Fish and Wildlife Coordination Act (16 USC §§661–666c)[b]					
Area affecting stream or other water body	Action taken should protect fish or wildlife.	Diversion, channeling, or other activity that modifies a stream or other water body and affects fish or wildlife.	16 USC §662	Not an ARAR	No diversion, channeling, or other activity that would modify the stream is planned that would potentially affect wildlife.

Table A3-1. Potential Federal Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Rivers and Harbors Act of 1899 (33 USC §§401–413)[b]					
Navigable waters	Permits required for structures or work in or affecting navigable waters.	Activities affecting navigable waters.	33 USC §403 33 CFR §322	Not an ARAR	No navigable waters at Site 29.
Endangered Species Act of 1973 (16 USC §§1531–1543)[b]					
Habitat upon which endangered species or threatened species depend	Federal agencies may not jeopardize the continued existence of any listed species or cause the destruction or adverse modification of critical habitat. The Endangered Species Committee may grant an exemption for agency action if reasonable mitigation and enhancement measures such as propagation, transplantation, and habitat acquisition and improvement are implemented.	Determination of effect upon endangered or threatened species or their habitat. Critical habitat upon which endangered species or threatened species depend.	16 USC §1531-1543	Applicable	Site 29 may have the threatened tiger salamander and red-legged frog.
Migratory Bird Treaty Act of 1972 (16 USC §§703–712)[b]					
Migratory bird area	Protects almost all species of native migratory birds in the U.S. from unregulated "take," which can include poisoning at hazardous waste sites.	Presence of migratory birds.	16 USC §703	Relevant and appropriate	Substantive provisions are potentially relevant and appropriate for migratory birds at or near the site, such as the golden eagle. The remedial action will be conducted in a manner to minimize effects on migratory birds.

Table A3-1. Potential Federal Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Marine Mammal Protection Act (16 USC §§1361–1421h)[b]					
Marine mammal area	Protects any marine mammal in the U.S. except as provided by international treaties from unregulated "take."	Presence of marine mammals.	16 USC §1372(a)(2)	Not an ARAR	No marine mammals suspected at the site.
Magnuson-Stevens Fishery Conservation and Management Act of 1976, as Amended (16 USC §§1801–1882)[b]					
Fishery under management	Provides for conservation and management of specified fisheries within specified fishery conservation zones.	Presence of managed fisheries.	16 USC §1801–1882	Not an ARAR	No fisheries located at the site.
National Wildlife Refuge System Administration Act of 1996 (16 USC §668dd–668ee)[b]					
Wildlife refuge	No person shall take any animal or plant on any national wildlife refuge, except as authorized under 50 CFR §27.51. The disposing or dumping of wastes is prohibited.	Area designated as part of National Wildlife Refuge System.	16 U.S.C §668dd–668ee Substantive provisions of 50 CFR §27.11–27.97	Not an ARAR	No wildlife refuge at the site.
Wilderness Act (16 USC §§1131–1136)[b]					
Wilderness area	Area must be administered in such a manner as will leave it unimpaired as wilderness and preserve its wilderness character.	Federally owned area designated as wilderness area.	16 USC §1131–1136 50 CFR §35.1–35.14	Not an ARAR	No wilderness area at the site.

Table A3-1. Potential Federal Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Coastal Zone Management Act (16 U.S.C. §§1451–1464)[b]					
Within coastal zone	Conduct activities in a manner consistent with approved state management programs.	Activities affecting the coastal zone including lands thereunder and adjacent shore land.	16 USC §1456(c) 15 CFR §930	Not an ARAR	The site is not located within the coastal zone.
Resource Conservation and Recovery Act (42 U.S.C. §§6901–6991[i])[b]					
Within 61 meters (200 feet) of a fault displaced in Holocene time	New treatment, storage, or disposal of hazardous waste prohibited.	RCRA hazardous waste; treatment, storage, or disposal of hazardous waste.	Cal. Code Regs. tit. 22, §66264.18(a)	Not an ARAR	The known faults are ¾-mile or more away from Site 29.
Within salt dome formation, underground mine, or cave	Placement of noncontainerized or bulk liquid hazardous waste prohibited.	RCRA hazardous waste; placement.	Cal. Code Regs. tit. 22, §66264.18(c)	Not an ARAR	No salt domes, underground mines, or caves are known to be at the site.

Notes:

a Only the substantive provisions of the requirements cited in this table are potential ARARs.

b Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Department of the Navy accepts the entire statutes or policies as potential ARARs; specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific citations are considered potential ARARs.

Acronyms/Abbreviations:

§(§) section(s)
ARAR applicable or relevant and appropriate requirement
Cal Code Regs. *California Code of Regulations*
CFR *Code of Federal Regulations*
RCRA Resource Conservation and Recovery Act
tit. title
USC *United States Code*

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Table A3-2. Potential State Location-Specific ARARs

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Endangered or threatened species	No person shall import, export, take, possess, or sell any endangered or threatened species or part or product thereof.	Threatened or endangered species determination on or before 01 January 1985.	Cal. Fish & Game Code §2080	Relevant and appropriate	Cal. Fish & Game Code §2080 is not applicable because the USA has not waived sovereign immunity in FESA for this State of California requirement. The tiger salamander is a state threatened species. The substantive provisions of Cal. Fish & Game Code §2080 meet the pertinent NCP criteria under 40 CFR §300.400(g)(2)(vii) and are "relevant and appropriate" because the tiger salamander may be present at the site and protection of this vulnerable resource allows it to be "used" in the sense that it continues to provide its unique value to the state of California. The Navy accepts Cal. Fish & Game Code §2080 as a state ARAR subject to the following conditions. The State of California, through DFG-OSPR, concurs that this statute addresses prohibited conduct but does not provide for or prescribe affirmative measures to avoid a "taking." Notwithstanding the absence of specific affirmative measures in the statute, the Navy will implement reasonable measures to ensure adequate protection of ecological receptors during response action construction following issuance of a CERCLA decision document pursuant to the Navy's obligations under CERCLA to select removal or remedial actions that are protective of human health and the environment (see CERCLA §121(b)(1)). The Navy will coordinate with the state, through DFG-OSPR, prior to implementation of such reasonable measures. The Navy understands that the state reserves the right to conduct periodic site visits during removal or remedial activities to confirm implementation of avoidance measures.

Table A3-2. Potential State Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Fully protected birds	This section states that fully protected birds or parts thereof may not be taken or possessed at any time.	A fully protected species must be potentially affected.	Cal. Fish & Game Code §3511	Relevant and appropriate	Cal. Fish & Game Code §3511 is not applicable because the USA has not waived sovereign immunity in the FESA for this State of California requirement. The golden eagle is a fully protected bird. The substantive provisions of Cal. Fish & Game Code §3511 meet the pertinent NCP criteria under 40 CFR Section 300.400(g)(2)(vii) and are "relevant and appropriate" because the tiger salamander may be present at the site and protection of this vulnerable resource allows it to be "used" in the sense that it continues to provide its unique value to the state of California. The Navy accepts Cal. Fish & Game Code §3511 as a state ARAR subject to the following conditions. The State of California, through DFG-OSPR, concurs that this statute addresses prohibited conduct but does not provide for or prescribe affirmative measures to avoid a "taking." Notwithstanding the absence of specific affirmative measures in the statute, the Navy will implement reasonable measures to ensure adequate protection of ecological receptors during response action construction following issuance of a CERCLA decision document pursuant to the Navy's obligations under CERCLA to select removal or remedial actions that are protective of human health and the environment (see CERCLA §121(b)(1)). The Navy will coordinate with the state, through DFG-OSPR, prior to implementation of such reasonable measures. The Navy understands that the state reserves the right to conduct periodic site visits during removal or remedial activities to confirm implementation of avoidance measures.

Table A3-2. Potential State Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Fisher marten, river otter, desert kit fox, and red fox	Fisher, marten, river otter, desert kit fox, and red fox may not be taken at any time.	A fisher, marten, river otter, desert kit fox, or red fox must be potentially harmed.	Cal. Code Regs. tit. 14, §460	Not an ARAR	Cal. Code Regs. tit. 14, §460 is not applicable because the USA has not waived sovereign immunity for this State of California requirement. The activities regulated by this section are not sufficiently similar to the circumstance of the release or response action alternatives to be relevant and appropriate and are not well suited to the site pursuant to 40 CFR §300.400(g)(2)(i) and (iv) of the NCP. The purpose of this section is to prevent the taking of the species specified. In contrast, the Navy response action alternatives are intended to respond to releases of hazardous substances in order to protect human health and the environment. Therefore, Cal. Code Regs. tit. 14, §460 is not a "relevant and appropriate" ARAR. However, ecological risk assessments will take into account representative receptors specific for each location. In addition, any species that are present and are federal and/or state endangered, threatened, or fully protected species will be addressed by ARARs related to those designations.
Area with birds or mammals	This section prohibits the taking of birds and mammals, including taking by poison.		Cal. Fish & Game Code §3005	Not an ARAR	Cal. Fish & Game Code §3005 is not applicable because the USA has not waived sovereign immunity in the FESA for this State of California requirement. Pursuant to 40 CFR §300.400(g)(2) of the NCP, the Navy has determined that this requirement is not "relevant and appropriate" because it does not address problems or situations sufficiently similar to the circumstances of the release or CERCLA response action and is not well suited to the site based upon the pertinent provisions of Subsections 300.400(g)(2)(i) and (iv) of the NCP. CERCLA response actions are intended to respond to releases of hazardous substances in order to protect human health and the environment including environmental receptors. In contrast, the purpose of this state requirement is to regulate and set forth conditions for the "taking" of the species addressed by those requirements. Moreover, that purpose is achieved through the regulation of intentional conduct directed at the species as opposed to

Table A3-2. Potential State Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
					incidental "take" (or possession, etc.) of species in the course of lawful activity such as CERCLA remedial action. The focus on intentional conduct is not well suited to the circumstances at CERCLA sites. In summary, the purposes of this state requirement and the actions that it regulates do not include responding to releases of hazardous substances. Therefore, it is not "relevant and appropriate" based upon the pertinent provisions of Subsections 300.400(g)(2)(i) and (iv) of the NCP. Although this requirement is not an ARAR, the Navy will coordinate with other natural resource trustees throughout the CERCLA remedial action process. The Navy's ecological risk assessment process takes into account representative environmental receptors for the site, and final remediation/cleanup goals will ensure that they are adequately protected from exposure to CERCLA hazardous stances that present unacceptable risk. In addition, any species that are present and are federal and/or state endangered, threatened, or fully protected species will be addressed by ARARs related to those designations.

Table A3-2. Potential State Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Bird nest or eggs	It is unlawful to take, possess, or needlessly destroy the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto.	Bird nests or eggs on site.	Cal. Fish & Game Code §3503	Not an ARAR	Cal. Fish & Game Code §3503 is not applicable because the USA has not waived sovereign immunity for this State of California requirement. The activities regulated by this section are not sufficiently similar to the circumstance of the release or response action alternatives to be relevant and appropriate and are not well suited to the site pursuant to 40 CFR §300.400(g)(2)(i) and (iv) of the NCP. The purpose of this section is to prevent the taking of the species specified. In contrast, the Navy response action alternatives are intended to respond to releases of hazardous substances in order to protect human health and the environment. Therefore, Cal. Fish & Game Code §3503 is not a "relevant and appropriate" ARAR. However, ecological risk assessments will take into account representative receptors specific for each location. In addition, any species that are present and are federal and/or state-endangered, threatened, or fully protected species will be addressed by ARARs related to those designations.
Falconiformes or Strigiformes	It is unlawful to take, possess, or destroy any birds in the orders Falconiformes or Strigiformes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird.	Falconiformes or Strigiformes birds on site.	Cal. Fish & Game Code §3503.5	Not an ARAR	The state has withdrawn its previous identification of this requirement as a state ARAR in light of the Navy's identification of the substantive provisions of the Migratory Bird Treaty Act as a "relevant and appropriate" federal ARAR for this action.

Table A3-2. Potential State Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Mountain lion	It is unlawful to take, injure, possess, transport, import, or sell any mountain lion or any part or product thereof.	A mountain lion must be potentially affected by the response action.	Cal. Fish & Game Code §4800	Not an ARAR	Cal. Fish & Game Code §4800 is not applicable because the USA has not waived sovereign immunity for this State of California requirement. The activities regulated by this section are not sufficiently similar to the circumstance of the release or response action alternatives to be relevant and appropriate and are not well suited to the site pursuant to 40 CFR §300.400(g)(2)(i) and (iv) of the NCP. The purpose of this section is to prevent the taking of the species specified. In contrast, the Navy response action alternatives are intended to respond to releases of hazardous substances in order to protect human health and the environment. Therefore, Cal. Fish & Game Code §4800 is not a "relevant and appropriate" ARAR. However, ecological risk assessments will take into account representative receptors specific for each location. In addition, any species that are present and are federal and/or state-endangered, threatened, or fully protected species will be addressed by ARARs related to those designations.
Waters of the State	Prohibits the passage of enumerated substances or materials into waters of the state deleterious to fish, plant life, or birds.	Discharge not authorized under California Water Code §13263 or a waiver issued pursuant to subdivision (a) of §13269.	Cal. Fish & Game Code §5650 (a), (b), and (c)	Not an ARAR	Cal. Fish & Game Code §5650 is not applicable because the USA has not waived sovereign immunity for this State of California requirement. While no direct deposition of material is expected to enter into or impact waters of the state, the substantive portions of this standard will be complied with as an ARAR. Any removal action taking place in an area that may impact waters of the state will be conducted in such a way as to ensure that materials dug up will not be released into the water column.

Table A3-2. Potential State Location-Specific ARARs (continued)

Location	Requirement	Prerequisite	Citation[a]	ARAR Determination	Comments
Wetlands	California Fish and Game Commission Wetland Policy (adopted 1987) included in Cal. Fish & Game Code Addenda.	None	Not available	Not an ARAR	Not a potential ARAR. This is not a promulgated requirement. There are adequate ARARs identified for wetlands at Site 29; therefore, this is not a TBC requirement.

Notes:

a Only the substantive provisions of the requirements cited in this table are potential ARARs.

b Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Navy accepts the entire statutes or policies as potential ARARs; specific potential ARARs follow each general heading; only substantive requirements of the specific citations are considered potential ARARs.

Acronyms/Abbreviations:

§(§)	section(s)
ARAR	applicable or relevant and appropriate requirement
Cal Code Regs.	*California Code of Regulations*
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
DFG-OSPR	California Department of Fish and Game, Office of Spill Prevention and Response
FESA	Federal Endangered Species Act
Navy	Department of the Navy
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
TBC	to be considered
tit.	title
USA	United States of America

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Table A4-1. Potential Federal Action-Specific ARARs

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Resource Conservation and Recovery Act (42 USC §§6901–6991[i])*							
On-site waste generation	Person who generates waste shall determine if that waste is hazardous.	Generator of waste.	Cal. Code Regs. tit. 22, §66262.10(a), 66262.11	2, 3, 4			Substantive provisions are potentially applicable where hazardous waste may be generated.
	Requirements for analyzing waste to determine whether waste is hazardous.	Generator of waste.	Cal. Code Regs. tit. 22, §66264.13(a) and (b)	2, 3, 4			Substantive provisions are potentially applicable where hazardous waste may be generated.
Hazardous waste accumulation	On-site hazardous waste accumulation is allowed for up to 90 days as long as the waste is labeled and dated and stored in containers in accordance with §66262.171–178 or in tanks, on drip pads, inside buildings, etc.	Accumulate hazardous waste.	Cal. Code Regs. tit. 22, §66262.34	2, 3, 4			Substantive provisions are potentially applicable for storing waste on site.
Site closure	Minimize the need for further maintenance controls and minimize or eliminate, to the extent necessary to protect human health and the environment, postclosure escape of hazardous waste, hazardous constituents, leachate, contaminated rainfall or runoff, or waste decomposition products to groundwater, surface water, or the atmosphere.	Hazardous waste management facility.	Cal. Code Regs. tit. 22, §66264.111(a) and (b)		2, 3, 4		

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Clean closure	During the partial and final closure periods, all contaminated equipment, structures, and soils shall be properly disposed of or decontaminated by removing all hazardous waste and residues.	Hazardous waste management facility.	Cal. Code Regs. tit. 22, §66264.114		2, 3, 4		Substantive provisions are potentially relevant and appropriate for closure.
Container storage	Containers of RCRA hazardous waste must be: • maintained in good condition, • compatible with hazardous waste to be stored, and • closed during storage except to add or remove waste.	Storage in a container of RCRA hazardous waste not meeting small-quantity generator criteria before treatment, disposal, or storage elsewhere.	Cal. Code Regs. tit. 22, §66264.171, 66264.172, and 66264.173	2, 3, 4			Substantive provisions are potentially applicable for storing waste in containers.
	Inspect container storage areas weekly for deterioration.	Storage in a container of RCRA hazardous waste	Cal. Code Regs. tit. 22, §66264.174	2, 3, 4			Substantive provisions are potentially applicable for storing waste in containers.
	Place containers on a sloped, crack-free base and protect from contact with accumulated liquid. Provide containment system with a capacity of 10% of the volume of containers of free liquids. Remove spilled or leaked waste in a timely manner to prevent overflow of the containment system.	Storage in a container of RCRA hazardous waste not meeting small-quantity generator criteria before treatment, disposal, or storage elsewhere.	Cal. Code Regs. tit. 22, §66264.175(a) and (b)	2, 3, 4			Substantive provisions are potentially applicable for storing waste in containers.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
	Keep containers of ignitable or reactive waste at least 50 feet from the facility property line.	Ignitable or reactive waste.	Cal. Code Regs. tit. 22, §66264.176				Not an ARAR. Ignitable or reactive waste is not suspected.
	Keep incompatible materials stored near each other separated by a dike or other barrier.	Storage in a container of RCRA hazardous waste	Cal. Code Regs. tit. 22, §66264.177	2, 3, 4			Substantive provisions are potentially applicable for storing waste in containers.
	At closure, remove all hazardous waste and residues from the containment system, and decontaminate or remove all containers and liners.	Storage in a container of RCRA hazardous waste	Cal. Code Regs. tit. 22, §66264.178	2, 3, 4			Substantive provisions are potentially applicable for storing waste in containers.
Clean closure	Remove or decontaminate all waste residues, contaminated containment system components (liners, etc.), contaminated subsoils, and structures and equipment contaminated with waste and leachate, and manage them as hazardous waste. If waste is left on site, closure and postclosure care requirements are necessary.	Surface impoundments, containers or tank liners, and hazardous waste residues or contaminated soil. Not applicable to material treated, stored, or disposed of only before the effective date of the requirements, or if treated in situ or consolidated within the area of contamination.	Cal. Code Regs. tit. 22, §66264.228(a), (b), (e)–(k), (m), and (o)–(q) except as it cross-references procedural requirements such as closure plans and annual reports.		2, 3, 4		Substantive provisions are potentially relevant and appropriate for removal of all waste for clean closure.
Temporary unit	Alternative requirements that are protective of human health or the environment may replace design, operating, or closure standards for temporary tanks and container storage areas.	Temporary storage of RCRA hazardous waste	Cal. Code Regs. tit. 22, §66264.553(b) and (d)–(f)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for temporary storage in containers.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action	**2: SVE with MNA**	**3: SVE with ZVI Injection**	**4: SVE with ISB and Groundwater Recirculation**				
Closure with postclosure care	Postclosure care, after completion of closure of the unit and continuing for 30 years after that date, shall consist of at least the following: (A) monitoring and reporting in accordance with the requirements of articles 6, 11, 12, 13, and 14 of this chapter; and (B) maintenance and monitoring of waste containment systems in accordance with the requirements of articles 6, 11, 12, 13, and 14 of this chapter. Any time during the postclosure period, (A) shorten the postclosure care period, or (B) extend the postclosure care period, based on whether the postclosure period is sufficient to protect human health and the environment.	RCRA-permitted land-based unit containing hazardous waste.	Cal. Code Regs. tit. 22, §66264.117(b)(1) and (2)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for leaving waste in place until clean closure or no threat to human health or the environment.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Closure with postclosure care (continued)	Postclosure use of property, on or in which hazardous wastes remain after partial or final closure, shall not disturb the integrity of the final cover, liner(s), or other containment system components or the function of the facility's monitoring systems, unless the disturbance is: (1) necessary to the proposed use of the property and will not increase the potential hazard to human health or the environment; or (2) necessary to reduce a threat to human health or the environment. No construction, filling, grading, excavating, or mining shall occur without the issuance of a variance consistent with subsection (d).	RCRA land-based unit containing hazardous waste.	Cal. Code Regs. tit. 22, §66264.117(d)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for leaving waste in place until clean closure or no threat to human health or the environment.
Monitoring	Owners/operators of a RCRA surface impoundment, waste pile, land treatment unit, or landfill shall conduct a monitoring and response program for each regulated unit.	Surface impoundment, waste pile, land treatment unit, or landfill for which constituents in or derived from waste in the unit may pose a threat to human health or the environment.	Cal. Code Regs. tit. 22, §66264.91(a)(1)–(4) and (c), except as it cross-references permit requirements		2, 3, 4		Substantive provisions are potentially relevant and appropriate for a monitoring program.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Monitoring constituents of concern	Constituents of concern are the waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste contained in the regulated unit.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, §66264.93		2, 3, 4		Substantive provisions are potentially relevant and appropriate for a monitoring program.
Monitoring	The point of compliance is a vertical surface, located at the hydraulically downgradient limit of the waste management area, that extends through the uppermost aquifer underlying the regulated unit.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, §66264.95(a) and (b)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for a monitoring program.
	Requirements for monitoring groundwater, surface water, and the vadose zone.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, §66264.97(d), (e)(6), and (e)(12)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for a monitoring program.
	Requirements for a detection monitoring program.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, §66264.98(e)(1-5), (i), (j), (k)(1-3), (4)(A) and (D),(5), (7)(C) and (D), (n)(1), (2)(B), and (C)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for a monitoring program.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Monitoring (continued)	Requirements for an evaluation monitoring program.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, §66264.99(b), (e)(1)–(6), (f)(3), and (g)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for a monitoring program.
Monitoring	The owner or operator shall establish and implement, in conjunction with the corrective action measures, a water quality monitoring program that will demonstrate the effectiveness of the corrective action program and be effective in determining compliance with the water quality protection standard and in determining the success of the corrective action measures under subsection (c) of this section.	Hazardous waste treatment, storage, or disposal facility.	Cal. Code Regs. tit. 22, §66264.100(d)	2, 3, 4			Substantive provisions are potentially relevant and appropriate for a monitoring program.
Discharge to surface waters, including storm water	Owners and operators of construction activities must be in compliance with discharge standards, including substantive provisions of the general requirements for storm water plans and BMPs.	One or more acres of soil disturbance	CWA §402 (33 USC ch. 26, §1342) and 40 CFR §122.44(k)(2) and (4); 40 CFR 450.21				Not an ARAR since soil disturbance is not expected to be an acre or more.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Discharge to surface waters, including storm water	All direct dischargers meet technology-based requirements including the best control technology and the best available technology economically achievable.	One or more acres of soil disturbance	CWA Section 301(b) (33 USC ch. 26, §1311)				Not an ARAR since soil disturbance is not expected to be an acre or more.
Safe Drinking Water Act (42 USC §300[f]–300[j]-26)*							
Injection	The UIC program prohibits injection activities that allow movement of contaminants into underground sources of drinking water that may result in violations of MCLs or adversely affect health.	Underground injection	40 CFR §144.12, excluding the reporting requirements in §144.12(b) and 144.12(c)(1)		3, 4		Injection of ZVI or bioremediation wells would be Class V wells under the UIC program. There are currently no specific technical requirements for injection into Class V wells. Substantive provisions of the UIC rules are relevant and appropriate only to the extent necessary to ensure that reinjection of treated groundwater would not cause the shallow aquifer to violate primary drinking water regulations.
Groundwater treatment	Requirements for the design and installation of new tank systems (e.g., strength, tightness testing, damage control, support, and corrosion control).	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §§66264.192(a)–(c) and (e)–(g)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for SVE treatment of soil gas in tanks.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
	Requirements for secondary containment of tank systems.	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §§66264.193(b)–(f)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for SVE treatment of soil gas in tanks.
	Requirements for operation of tank systems including spill prevention and prohibitions of material that could cause failure.	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §§66264.194(a) and (b)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for SVE treatment of soil gas in tanks.
	Requirements for inspection of tank systems including inspection of overflow protection, corrosion, release, detection equipment, and cathodic protection.	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §§66264.195(a)–(c)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for SVE treatment of soil gas in tanks.
	Requirements for response to leaks and spills from tank systems (e.g., removal of system from use if appropriate, containment, cleanup, and emergency procedures).	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §§66264.196(b) except (b)(5) and (b)(7)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for SVE treatment of soil gas in tanks.
	Requirements for closure and postclosure care of tank systems decontamination, clean closure, and leaving waste in place at closure.	Tank systems for transferring, storing, or treating hazardous waste.	Cal. Code Regs. tit. 22, §§66264.197(a) and (b)		2, 3, 4		Substantive provisions are potentially relevant and appropriate for SVE treatment of soil gas in tanks.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Clean Air Act (42 USC §§7401–7671)*							
Dust emissions	Provisions of State Implementation Plan approved by U.S. EPA under Section 110 of CAA.	Discharge to air	40 USC §7410; portions of 40 CFR §52.220	2, 3, 4			Substantive provisions for the BAAQMD Rules listed below are potentially applicable for the SVE treatment system.
	Apply BACT to any new or modified source that has the potential to emit 10 pounds or more per highest day of precursor organic compounds (POC), non-precursor organic compounds (NPOC), nitrogen oxides (NOx), sulfur dioxide (SO_2), PM_{10}, or carbon monoxide (CO).	Discharge to air	BAAQMD Regulation 2-301	2, 3, 4			Substantive provisions are potentially applicable for the SVE treatment system.
	Any air stripping and SVE operations that emit benzene, vinyl chloride, perchloroethylene, methylene chloride, and/or trichloroethylene shall be vented to a control device that reduces emissions to the atmosphere by at least 90% by weight.	Discharge to air	BAAQMD Regulation 8-47-301	2, 3, 4			Substantive provisions are potentially applicable for the SVE activities.

Table A4-1. Potential Federal Action-Specific ARARs (continued)

Note:

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Department of the Navy accepts entire statutes or policies as potential ARARs; specific potential ARARs are addressed in the table below each general heading; only substantive requirements of specific citations are considered potential ARARs.

Acronyms/Abbreviations:

§(§) – section(s)
A – applicable
ARAR – applicable or relevant and appropriate requirement
BAAQMD – Bay Area Air Quality Management District
BACT – Best Available Control Technology
CAA – Clean Air Act
Cal. Code Regs. – *California Code of Regulations*
CFR – *Code of Federal Regulations*
ISB – in situ (anaerobic) bioremediation
MCL – maximum contaminant level
MNA – monitored natural attenuation
PM_{10} – airborne particulate matter, less than 10 micrometers in diameter
RA – relevant and appropriate
RCRA – Resource Conservation and Recovery Act
SVE – soil-vapor extraction
TBC – to be considered
tit. – title
UIC – underground injection control
USC – *United States Code*
U.S. EPA – United States Environmental Protection Agency
ZVI – zero-valent iron

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Table A4-2. Potential State Action-Specific ARARs

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
State Water Resources Control Board*							
Monitoring	Requires evaluation monitoring once a significant release is detected.	Release detected	Cal. Code Regs. tit. 27, §20425, and tit. 23, §2550.9				Not an ARAR. The release has already been evaluated and this remedial action is the corrective action.
	Requires implementation of corrective action measures that ensure cleanup levels are achieved throughout the zone affected by the release by removing the waste constituents or treating them in place. Source control may be required. Also requires monitoring to determine the effectiveness of the corrective actions.	Release confirmed	Cal. Code Regs. tit. 27, §20430, and tit. 23, §2550.10				Not an ARAR. Not more stringent than federal ARARs identified at Cal. Code Regs. Tit. 22, §66264.100.
Clean Closure	When the discharger has successfully completed clean closure, the landfill shall no longer be subject to the SWRCB-promulgated requirements of this title; otherwise, the discharger shall close the landfill and carry out postclosure maintenance as though the discharger had not attempted clean closure. For the purpose of this paragraph, the discharger shall have successfully clean-closed a landfill only if all waste materials, contaminated components of the containment system, and affected geologic materials (including soils and rock beneath and surrounding the unit and groundwater polluted by a release from the unit) are either removed and discharged to an appropriate unit or treated to the extent that they no longer pose a threat to water quality; and all remaining containment features are inspected for contamination and, if contaminated, discharged in accordance with paragraph (f)(1).	Previous release	Cal. Code Regs. tit. 27, §21090(f)				Not an ARAR. Not more stringent than federal ARARs identified for clean closure at Cal. Code Regs. Tit. 22, §66264.228(a), (b), (e)–(k), (m), and (o)–(q).

Table A4-2. Potential State Action-Specific ARARs (continued)

Action	Requirement	Prerequisite	Citation	ARAR Determination			Comments
				A	RA	TBC	
1: No Action 2: SVE with MNA 3: SVE with ZVI Injection 4: SVE with ISB and Groundwater Recirculation							
Stormwater discharge	NPDES General Permit for Storm Water Discharges Associated with Construction and Land Disturbance Activities (General Permit).	Construction that disturbs one or more acres.	SWRCB Order 2009-0009-DWQ, NPDES No. CAS000002				Not an ARAR. This remedial action is not expected to disturb an acre or more of soil.

Note:

* Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader; listing the statutes and policies does not indicate that the Department of the Navy accepts the entire statutes or policies as potential ARARs; specific potential ARARs are addressed in the table below each general heading; only substantive requirements of the specific actions are considered potential ARARs.

Acronyms/Abbreviations:

§ – section
A – applicable
ARAR – applicable or relevant and appropriate requirement
BMP – best management plan
Cal. Code Regs. – *California Code of Regulations*
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
MNA – monitored natural attenuation
NPDES – National Pollutant Discharge Elimination System
RA – relevant and appropriate
SWRCB – State Water Resources Control Board
TBC – to be considered
tit. – title

Attachment

Attachment A1. Department of Fish and Game Identified ARARs Memorandum to Jim Pinasco dated 24 May 2011 and DTSC E-mail Memorandum with List of ARARs dated 16 May 2011

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Department of Fish and Game Identified ARARs Memorandum to
Jim Pinasco dated 24 May 2011

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State of California

Memorandum

Date: May 24, 2011

To: Jim Pinasco, Remedial Project Manager
Department of Toxic Substances Control
8800 Cal Center Drive
Sacramento, CA 95826-3200

From: Carolyn Rech, Staff Environmental Scientist
Department of Fish and Game
Office of Spill Prevention and Response
1700 K Street, Suite 250
Sacramento, CA 95811

Subject: **Identification of State "Applicable" or "Relevant and Appropriate" Requirements (ARARs) for Former Naval Weapons Station Seal Beach Detachment Concord (Concord NWS), Inland Sites Including Installation Restoration (IR) Program Site 29, Contra Costa County (Site #200022).**

This memorandum is in response to your recent request for potential State ARARs for Navy Inland Sites including IR Site 29. The California Department of Fish and Game, Office of Spill Prevention and Response (DFG-OSPR) appreciates the opportunity to provide ARARs for the Former Concord NWS. The DFG is the State's Trustee for fish and wildlife resources pursuant to Fish and Game Code Section 711.7. The DFG is also designated as a Trustee for natural resources pursuant to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 107 (f)(2)(B). The ARARs provided on the attached table are for the protection of State fish, wildlife and plants and their habitat at Concord NWS, including IR Site 29, and are applicable to all IR, Solid Waste Management Unit, and Munitions Response Program sites.

ARARs were previously provided for Seal Beach Naval Weapons Station, Detachment Concord, Non-Tidal Area Sites via memorandum in 2005 (Gray, 2005). The enclosed table provides an updated, comprehensive list of State natural resource ARARs that apply to all Concord NWS sites. Compliance with these ARARs is applicable to all phases of the CERCLA remediation process.

DFG-OSPR appreciates this opportunity to provide State laws and regulations to guide the planned cleanup of all Concord NWS sites, including Site 29. If you have any questions regarding the subject ARARs or require further details, please contact Carolyn Rech via telephone at 916-327-9961, or via e-mail: crech@ospr.dfg.ca.gov.

Reviewer: Tami Nakahara, Environmental Scientist
Wendy Johnson, Staff Counsel

Reference List

Gray, F. 2005. Memorandum to Jim Pinasco, DTSC. RE: Applicable or Relevant and Appropriate Requirements for the Seal Beach Naval Weapons Station, Detachment Concord, Non-Tidal Area Sites, Contra Costa County (Site 200022). March 9. Sacramento, CA.

cc: Melinda Garvey, Remedial Project Manager
United States Environmental Protection Agency, Region 9
75 Hawthorne St.
San Francisco, CA 94105

John Krause, Associate Wildlife Biologist
California Department of Fish and Game
Bay Delta Region (3)
P.O. Box 47
Yountville, CA 94599

Alan Friedman, P.E., Water Resources Engineer
San Francisco Regional Water Quality Control Board
1515 Clay Street, Suite 1400
Oakland, CA 95826

Dan Cordova, Endangered Species
Carolyn Marn, Ph. D., Environmental Contaminants
Sonce de Vries, Environmental Contaminants
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2605
Sacramento, CA 95825-1846

CALIFORNIA DEPARTMENT OF FISH AND GAME
LOCATION AND ACTION SPECIFIC ARARs AND TBCs
Former Naval Weapons Station Seal Beach Detachment Concord (Concord NWS), Inland Sites Including IR Site 29

LOCATION	STANDARD	SPECIFIC CITATION	ARAR/TBC EXPLANATION
Aquatic habitat/species	Action must be taken if toxic materials are placed where they can enter waters of the State. There can be no release that would have a deleterious effect on species or habitat.	Fish and Game Code section 5650 (a), (b) & (f)	This code section prohibits depositing or placing where it can pass into waters of the state any petroleum products (Section 5650(a)(1)), factory refuse (section 5650(a)(4)), sawdust, shavings, slabs or edgings (section 5650(a)(3)), and any substance deleterious to fish, plant life or bird life (section 5650(a)(6)). These are substantive, promulgated environmental protection requirements. These requirements impose strict criminal liability on violators. (*People v. Chevron Chemical Company (1983) 143 Cal. App. 3d 50).* This imposition of strict criminal liability imposes a standard that is more stringent than federal law. The extent to which each section of 5650 is relevant and appropriate depends on the site characterization and the potential for contaminants to enter state waters. There are numerous State waters on Concord NWS that are near or in CERLA sites where contaminated material may be released into State waters. State waters at Concord NWS include Mount Diablo Creek, Indian Springs Pond, Cistern Pond, vernal pools and numerous un-named creeks, drainages and ponds.
Wildlife Species	Action must be taken to prohibit the taking of birds and mammals, including the taking by poison.	Fish and Game Code section 3005 (Stats. 1957, c. 456, p. 1353 section 3005)	This code section prohibits the taking of birds and mammals, including taking by poison. "Take" is defined by Fish and Game Code section 86 to include killing. "Poison" is not defined in the code. Although there is no state authority on this point, federal law recognizes that poison, such as Strychnine, may effect incidental taking. (*Defenders of Wildlife v. Administrator, Environmental Protection Agency (1989) 882. F. 2d. 1295*. This code section imposes a substantive, promulgated environmental protection requirement, and is relevant and appropriate because birds and mammals will potentially be exposed to contaminated sediments during remedial activities unless efforts are taken to minimize exposure.

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LOCATION	STANDARD	SPECIFIC CITATION	ARAR/TBC EXPLANATION
Rare native plants	Action must be taken to conserve native plants. There can be no releases and/or actions that would have a deleterious effect on species or habitat.	Fish and Game Code section 1908 (Added by Stats. 1977, c. 1181, p. 3869, section 8)	Section 1908 imposes a substantive requirement by forbidding any "person" to take rare or endangered native plants. California Code of Regulations Title 14 section 670.2 provides a listing of the plants of California that have been declared to be Endangered, Threatened or Rare. Fish and Game Code section 67 provides the definition of "person" as any natural person or any partnership, corporation, limited liability company, trust, or other type of association. Whether the federal government or contractors acting on behalf of the federal government would fall within that definition is a potential issue. To the extent that there are rare or endangered plants on site, section 1908 would be an ARAR. If remedial activities may potentially affect these plants, this code section is relevant and appropriate. Numerous rare or endangered plants that may occur or are known to occur on Concord NWS include, but are not limited to, large-flowered fiddleneck (*Amsinckia grandiflora*), big tarplant (*Blepharizonia plumose*), Contra Costa Goldfields (*Lasthenia conjugens*), and round-leaved filaree (California macrophylla).
Endangered Species	Action must be taken to conserve endangered species. There can be no releases and/or actions that would have a deleterious effect on species or habitat.	Fish and Game Code section 2080 (Added by Stats. 1984, c. 1240, section 2).	This section prohibits the take, possession, purchase or sell within the state, of any species (including rare native plant species), or any product thereof, that the commission determines to be an endangered or threatened species, or the attempt of any of these acts. This section is relevant and appropriate to the extent that there are endangered or threatened species in the area which have the potential of being affected if actions are not taken to conserve the species. Special status species that may be affected by remedial activities include California tiger salamander, Alameda whipsnake, Black Rail, Least Bell's Vireo, and Swainson's Hawk. This section prohibits releases and/or actions that would result in take of species. Take may occur if investigatory and/or construction equipment is operating in habitat utilized by these species.

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LOCATION	STANDARD	SPECIFIC CITATION	ARAR/TBC EXPLANATION
Fully protected bird species/habitat	Action must be taken to prevent the taking of fully protected birds.	Fish and Game Code section 3511 (Added by Stats.1970, c. 1036, p. 1848 section 4)	This section provides that it is unlawful to take or possess any of the following fully protected birds: (a). American Peregrine Falcon (b). Brown Pelican (c). California Black Rail (d). California Clapper Rail (e). California Condor (f). California Least Tern (g). Golden Eagle (h). Greater Sandhill Crane (i). Light-footed Clapper Rail (j). Southern Bald Eagle (k). Trumpeter Swan (l). White-tailed Kite (m). Yuma Clapper Rail This section is relevant and appropriate because fully protected birds and/or their habitat including American Peregrine Falcon, California Black Rail, California Clapper Rail, Golden Eagle, and White-tailed Kite may be on or near remedial sites.

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LOCATION	STANDARD	SPECIFIC CITATION	ARAR/TBC EXPLANATION
Fully Protected Mammals	Actions must be taken to assure that no fully protected mammals are taken or possessed at any time.	Fish and Game Code section 4700 (Added by Stats. 1970, c. 1036, p. 1848 section 6)	This section prohibits the take or possession of any of the fully protected mammals or their parts. The following are fully protected mammals: (a) Morro Bay kangaroo rat (b) Bighorn sheep except Nelson bighorn sheep (c) Northern elephant seal (d) Guadalupe fur seal (e) Ring-tailed cat (f) Pacific right whale (g) Salt marsh harvest mouse (h) Southern sea otter (i) Wolverine This section is relevant and appropriate to the extent that such mammals and/or their habitat are located on or near the site. Habitat for the ringtail cat may be near remediation sites.
Birds	Action must be taken to avoid the take or destruction of the nest or eggs of any bird.	Fish and Game Code section 3503	This section prohibits the take, possession, or needless destruction of the nest or eggs of any bird, except as otherwise provided by this code or any regulation made pursuant thereto. This section is relevant and appropriate to the extent that nesting birds and/or their habitat are located on or near the site.
Birds of Prey	Action must be taken to prevent the take, possession, or destruction of any birds-of prey or their eggs.	Fish and Game Code section 3503.5 (Added by Stats. 1985, c. 1334, section 6)	This section prohibits the take, possession, or destruction of any birds in the orders of Falconiformes or Strigiformes (birds-of-prey) or to take, possess, or destroy the nest or eggs of any such bird except as otherwise provided by this code or any regulation adopted pursuant thereto. This section is relevant and appropriate to the extent that such species and/or their eggs are located on or near the site. Numerous raptors are known to occur at Concord NWS.
Furbearing Mammals	Action must be taken to avoid take.	Title 14 C.C.R. section 460 (effective 07/01/59)	Regulation makes it unlawful to take Fisher, marten, river otter, desert kit fox, and red fox. This section is relevant and appropriate to the extent that these species and/or their habitat are located on or near remedial sites. River otter and red fox may occur at Concord NWS.

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LOCATION	STANDARD	SPECIFIC CITATION	ARAR/TBC EXPLANATION
Specially Protected Mountain Lion	Action must be taken to avoid injuring, taking, possessing or transporting any mountain lion.	Fish and Game Code sections 4800 et. seq.	Mountain lions are specially protected mammals in California. It is unlawful to take, injure, possess, transport, or sell any mountain lion or any part or product thereof. Violation of this section is a misdemeanor. Concord NWS is within the natural range of mountain lions; therefore they may occur in or near remedial site.
Wetlands	Actions must be taken to assure that there is "no net loss" of wetlands acreage or habitat value. Action must be taken to preserve, protect, restore and enhance California's wetland acreage and habitat values.	Fish and Game Commission Wetlands Policy (adopted 1987) included in Fish and Game Code Addenda	This policy seeks to provide for the protection, preservation, restoration, enhancement and expansion of wetland habitat in California. Further, it opposes any development or conversion of wetland that would result in a reduction of wetland acreage or habitat value. It adopts the USFWS definition of a wetland which utilizes hydric soils, saturation or inundation, and vegetable criteria, and requires the presence of at least one of these criteria (rather than all three) in order to classify an area as a wetland. This policy is not a regulatory program and should be included as a TBC. There are numerous seasonal and perennial wetlands at Concord NWS in or near remedial sites.

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DTSC E-mail Memorandum with List of ARARs
dated 16 May 2011

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-----Original Message-----
From: Jim Pinasco [mailto:jpinasco@dtsc.ca.gov]
Sent: Monday, May 16, 2011 9:48
To: Crosby, Julie A CIV NAVFAC SW, PACO
Subject: RE: arars

Good morning Julie:

Attached you should find a listing of General ARARs for DTSC.

I have not paired them down due to my unexpected absence,

but will work with the Navy to come up with a final list applicable

to site 29. Thanks for your kind words.
Jim P.

Requirement	Citation	Auth	Description	ARAR Status	Comments	Applicable Sites
CHEMICAL-SPECIFIC ARARs						
Non-zero MCLGs (TI Waiver)	40 CFR Part 141	US	Establishes a nonenforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety.	Rel. and Approp.	The NCP states that MCLGs are relevant and appropriate (based upon the circumstances of the release) as groundwater cleanup standards for groundwater and surface water that have been determined to be current or future drinking water sources. Under CERCLA 121(b), Congress states that non-zero MCLGs shall be attained when there is no MCL for the contaminant of concern.	
National Drinking Water Regulations – Primary MCLs (TI Waiver)	40 CFR Part 141	US	Establishes the maximum permissible level of a contaminant in water that is delivered to any user of a public water system. Levels are derived from health-based considerations.	Rel. and Approp.	Federal MCLs are superceded by the California MCLs, if the California standards are more stringent.	
National Primary Drinking Water Standards	40 CFR Part 141.61		Maximum contaminant levels and monitoring and analytical requirements for organic chemicals	Rel. and Approp.		
Federal Ambient Water Quality Criteria	Clean Water Act § 304	US	Sets criteria for water quality based on toxicity to aquatic organisms and human health.			
Toxic Substances Control Act (TSCA)	40 CFR Parts 750 and 761	US	Regulates PCB-contaminated material	Rel. and Approp.	Federal facilities may have regulatory responsibilities under TSCA, including complying with protocol and requirements for sampling and cleanup of PCB spills.	
Drinking Water Primary Standards – Organic and Inorganic Chemicals	CCR, Title 22, Div. 4, Ch. 15, Article 4, § 64431 et seq., and Article 5.5, § 64444 et seq.	CA	Establishes primary MCLs to protect public drinking water supply systems.	Rel. and Approp.	These requirements are considered relevant and appropriate where the aquifer is a potential drinking water source and the State MCLs are more stringent than Federal MCLs.	
Drinking Water Secondary	CCR, Title 22, Div. 4, Ch. 15,	CA	Establishes secondary MCLs that shall not be exceeded in water supplied to the public.		Secondary MCLs are not an ARAR because they are not designed to be protective of human health.	

Standards	Article 16, § 64449				They are in place for contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.	
Water Quality Control Plan	Water Code § 13240	CA	The Porter Cologne Water Quality Act established authority of the SWRCB and RWQCB to regulate discharges into Waters of the State. The Basin Plan establishes discharge limits and procedures to protect water quality. The objective of this plan is to protect the quality of the surface and groundwater.	Applic.	.	
Policies and Procedures for Investigation and Cleanup and Abatement of Discharges (Containment Zone Policy)	SWRCB Resolution 92-49 (as amended)	CA	Requires cleanups to promote attainment of background levels or the best water quality that is reasonable considering certain factors.	Applic.	If final cleanup levels above background are proposed, justification acceptable to the RWQCB must be provided. Includes provisions for designation of a Containment Zone.	
Calif. Environmental Protection Standard	CCR, Title 22, § 66264.702 et seq.	CA	Sets concentration limits for discharges of contaminants to soil and air from permitted treatment, storage, or disposal facilities.	Applic.	Potentially applicable depending on remedial action.	
California Maximum Contaminant Levels - Organic Chemicals	CCR, title 22, § 64444 – Primary Standards		Provides numerical contaminant limits for certain organic chemicals in drinking water.	Rel and Approp	Applicable if more stringent than the 40 CFR 141.61 standard	

Requirement	Citation	Auth	Description	ARAR Status	Comments	Applicable Sites
LOCATION-SPECIFIC ARARs						
Endangered Species Act of 1973, § 7 (c)	50 CFR 200 and 402	US	Requires formal consultation with the USFWS if activities have the potential to alter the natural environment of listed endangered and threatened species.	Applic.-	Endangered or threatened species and/or critical habitat	
National Historic Preservation Act	16 USC § 470 et seq.	US	Requires federal agencies to consider the effect of any federally assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places.	Applic.-	All Federal sites are potentially eligible for inclusion in the National Register of Historic Places until determined otherwise, per § 106.	
Archeological and Historic Preservation Act	16 USC § 470 et seq.	US	Requires federal agencies to notify the Secretary of the Interior when undertakings will impact significant archeological processes.	Applic.	Significant archaeological sites	
Migratory Bird Treaty Act	50 CFR Parts 10 and 20 (16 USC § 703 et seq.)	US	Prevents taking of migratory birds, their nests, or eggs without special permits.	Applic.	Migratory birds	

Executive Order on Flood Plain Management	Executive Order No. 11988	US	Requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid adverse impacts associated with direct and indirect development of a floodplain. Could also potentially require an environmental impact statement for activities that cannot be moved.	Rel. and Approp.	Relevant and appropriate if construction is performed in a floodplain.	
Clean Water Act, (Wetland Protection) and Executive Order 11990 "Protection of Wetlands"	40 CFR Part 230.10, § 404(b)(1) and Executive Order 11990	US	Requires permit from the US Army Corps of Engineers for construction activities in wetlands and alternatives analysis to ensure selection of the least damaging practicable alternative.			
Clean Water Act, (Disposal of Dredged or Fill Material)	40 CFR Parts 230.71 through 230.76	US	Places limitations/ requirements on the management, disposal, and treatment of the dredged or fill material discharged. Applies to sites that contain wetland areas or vernal pools.			
Endangered Species	California Department of Fish and Game (CDFG) Code	CA	Establishes species, subspecies, and varieties of native California plants or animals as endangered, threatened, or rare. Prohibits the taking, importation, or sale of any species, or any part thereof, of an endangered species or a threatened species. Contains provisions concerning CDFG coordination and consultation with state and federal agencies and with project applicants. Recommends avoidance of adverse impacts on species of special concern and their habitat.		Not enforceable at Department of Defense facilities. State protected species will be protected when practicable and the appropriate state authority will be consulted if conflicts arise.	
Wildlife Species/ Habitats	CDFG Code § 1600	CA	Declares the protection and conservation of fish and wildlife to be an important public interest. This section is a general statement of policy that does not impose a substantive requirement.		Not enforceable at Department of Defense facilities. State protected species will be protected when practicable and the appropriate state authority will be consulted if conflicts arise.	

Wildlife Species/ Habitats	CDFG Code §§ 4700, 5050	CA	Prohibits the possession of mammals, reptiles, and fish that are identified as “fully protected.”		Not enforceable at Department of Defense facilities. State protected species will be protected when practicable and the appropriate state authority will be consulted if conflicts arise.	
Rare Native Plants	CDFG Code §§ 1900 et. seq. and 2080	CA	Contain provisions concerning native plant protection including: criteria for determining endangered plant species; designation of endangered plants; and other prohibitions.		Not enforceable at Department of Defense facilities. State protected species will be protected when practicable and the appropriate state authority will be consulted if conflicts arise.	
Location Standards for Owners & Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities	CCR, Title 22, Chapter 14, § 66264.18	CA	Establishes siting criteria for waste treatment, storage, or disposal units. Provides location standards including seismic considerations and floodplain restrictions.	Applic.	Applicable if treatment systems manage RCRA hazardous waste in a floodplain.	

Requirement	Citation	Auth	Description	ARAR Status	Comments	Applicable Sites
Action Specific ARARs						
Standards Applicable to Generators and Transporters of Hazardous Waste	40 CFR Parts 262 and 263	US	These regulations apply to generators and transporters of hazardous waste within the United States.	Applic.	Applicable if remedial action generates hazardous waste that is then transported off-site.	
Hazardous Air PollutantControl Requirements	Clean Air Act Amendments, § III	US	Establishes thresholds and content of air emissions.	Applic.	Air emissions resulting from any proposed treatment systems are subject to these requirements.	
Underground Injection Control Program	40 CFR Parts 144-147	US	Protects groundwater from contamination by subsurface emplacement of fluids.	Applic.	Injection of a RCRA hazardous waste resulting from any proposed treatment systems is subject to these requirements.	
Statement of Policy with Respect to Maintaining High Quality of Waters in California (Non-degradation Policy) (TI Waiver)	SWRCB Resolution Number 68-16	CA	Establishes the state's policy for maintaining the quality of water in California higher than that stated in established policies when existing quality is higher. Requires the use of best practical treatment or control of groundwater contaminant plume. May require levels of contaminants lower than state or federal MCLs. Also applies to in-situ discharge of polluted water into un-degraded Waters of the State.	Applic.	If final cleanup levels above background are proposed, justification acceptable to the RWQCB must be provided.	
Waste Discharge Requirements	Porter/Cologne Water Quality Act – California Water Code, Ch. 4, Article 4 and SWRCB Order No.	CA	Requires notification and transmittal of technical reports to the RWQCB of proposed discharges to the Waters of the State. Requires cleanup and abatement of actual or threatened pollution or new source conditions, and establishes waste discharge requirements, among other requirements.	Applic.	Several sites contain impacted groundwater. In addition, cleanup of these sites may involve re-injection of treated groundwater.	

	97-03-DWQ.					
Sources of Drinking Water Policy(TI Waiver)	SWRCB Resolution No 88-63	CA	Defines all ground and surface water as existing or potential sources of drinking water unless TDS are greater than 3,000 ppm, the well yield is less than 200 gpd from a single well, or groundwater is unreasonable to treat using best management practices or best economically achievable treatment practices.	Applic.	The identification of the underlying groundwater as a potential drinking water source provides information to determine concentration limits, cleanup levels, or treatment levels.	
Discharge Prohibitions and Stormwater Pollution Prevention	SWRCB Order 99-08-DWQ	CA	Requires control of stormwater runoff at construction sites that are greater than 5 acres in size.		Implements and enforces the Federal CWA NPDES permit program for regulating discharge of pollutants from construction activities to Waters of the United States.	
Water Quality Monitoring	CCR Title 23 §§ 2550.7 - 2550.10	CA	Requires remedial action monitoring.	Applic.	Groundwater monitoring will be performed.	
Criteria for Identifying Hazardous Waste and Persistent and Bioaccumulative Toxic Substances	CCR, Title 22, Ch. 11, § 66261.24	CA	Presents criteria for testing and identifying RCRA hazardous wastes, sets levels for TTLC and STLC.	Applic.	The criteria and TTLC and STLC levels are applicable for the characterization of excavated soils or other wastes generated by remedial actions.	
Standards Applicable to Generators of Hazardous Waste	CCR, Title 22, §§ 66262.10 and 66262.11	CA	Establishes standards for generators of hazardous wastes in California, including those for hazardous waste determination, manifesting, transportation record keeping, and reporting.	Applic.	Substantive requirements are applicable if excavated soils or treatment residuals exceed RCRA hazardous waste thresholds.	
Management of Extremely Hazardous Wastes	CCR, Title 22, § 67430.3	CA	Requires the removal of improperly disposed extremely hazardous wastes.	Applic.	Applicable to sites where extremely hazardous wastes have been identified.	
Land Disposal Restrictions	CCR, Title 22, § 66268.124, Corrective Management Rule, §§ 66264.91;	CA	Identifies hazardous wastes that are restricted from land disposal.	Applic.	Applicable if excavated soil or treatment residuals exceed limits before treatment. Soil and residuals would be tested using TTLC/STLC to determine if they exceed disposal limits, if necessary. On-site disposal actions may be exempt from treatment standards through the CAMU Rule.	

	66262.100, 66264.708; 66270.30; and 66272.1					
California Integrated Waste Management Requirements	Title 27 CCR, §§ 20510 through 21600	CA	Requirements for waste management units and landfills.	Applic.	Applicable to facilities that receive remedial action-related non-hazardous wastes.	
Standards Applicable to Transporters of Hazardous Waste	CCR, Title 22, Div.4.5, Chapter 13, §§ 66263.10-.18	CA	Establishes standards that apply to persons transporting hazardous waste in California.	Applic.	These requirements must be fully complied with when transporting hazardous waste off-site.	
Air Pollution Control District		CA	Fugitive dust and nuisance dust. Limits on-site activities so fugitive dust at the property line shall not be visible and nuisance dust is abated.	Rel. and Approp.	Relevant and appropriate if grading or soil excavation is performed at a site.	
Air Pollution Control District		CA	Requires that emissions from an air stripper be within acceptable levels.	Rel. and Approp.	Relevant and appropriate if air strippers are part of a treatment unit.	
Discharges of Waste to Land	CCR, Title 23, Chapter 15, § 2520	CA	Regulates the siting, design, construction, operation, closure, and monitoring of waste discharges to land for treatment. Storage and disposal wastes regulated include “hazardous wastes,” “non-hazardous wastes,” and “inert waste.” Includes criteria for diversion and drainage of storm water. Also establishes water quality protection standard for landfills, surface impoundments, waste piles, and land treatment sites.	Rel. and Approp.	Relevant to the on-site disposal of soils following treatment, if proposed.	
Standards for Operators of Hazardous Waste TSDFs - Waste Piles	CCR, Title 22, Div. 4.5, Chapter 14, §§ 66264.250-259.	CA	Regulates the storage and treatment of hazardous waste in piles.	Applic.	Applicable if a RCRA hazardous waste is stored or treated in piles.	

Standards for Operators of Hazardous Waste TSDFs - Miscellaneous Units	CCR, Title 22, Div. 4.5, Chapter 14, §§ 66264.171 - 66264.178, 66264.192 through 66264.199, 66264.552, and 66264.600-603.	CA	Applies to owners and operators of facilities that treat, store, or dispose of hazardous wastes in miscellaneous units. Covers environmental performance standards, monitoring, inspections, and post-closure care for miscellaneous units, containers, and tank systems.	Applic.	Applicable if a RCRA hazardous waste is treated, stored, or disposed of in a miscellaneous unit.	
Landfill Closure Requirements	CCR, Title 27, Division 2, Chapter 3, Subchapters 2, 3, and 5, and Chapter 4, Subchapter 4	CA	Classified waste management units shall be closed according to an approved closure and post-closure maintenance plan, which provides for continued compliance with the applicable standards for waste containment, precipitation, drainage controls, and monitoring. The post-closure maintenance period shall extend as long as the wastes pose a threat to water quality.	Rel. and Approp.	More stringent than 40 CFR Part 258 for landfills without liner system.	
Disposal Site Closure and Post-Closure Minimum Standards	CCR, Title 27, Division 3, Chapter 3, Subchapter 4, Article 6, and Chapter 4	CA	Sets forth the performance standards and the minimum substantive requirements for proper closure, post-closure maintenance, and ultimate reuse of solid waste disposal sites to assure that public health and safety and the environment are protected from pollution due to the disposal of solid waste.	Rel. and Approp.	More stringent than 40 CFR Part 258 for landfills without liner system.	
Wildlife Species/ Habitats	CDFG Code §§ 3005, 3511, and 3513.	CA	Prohibit the taking of birds and mammals. This code section imposes a substantive, promulgated environmental protection requirement.		State protected species will be protected when practicable and the appropriate state authority will be consulted if conflicts arise.	
Land Use Covenants	CCR Title 22, § 67391.1 a, b, & d	CA	States that if a remedy results at levels not suitable for unrestricted use, then the Remedial Action Plan/ Record of Decision is to clearly define and include limitations on land use and hazardous substances remaining on the property.			

Land Use Covenants	Civil Code § 1471, a & b	CA	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.			
Land Use Covenant	CCR, title 22, § 67391.1(a)		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.	Rel and Approp		
Land Use Covenant	CCR, title 22, § 67391.1(b)		Requires that the cleanup decision document contain an implementation and enforcement plan for land use limitations.	Rel and Approp		
Land Use Covenant	CCR, title 22, § 67391.1(d)		Requires that the land use covenant be recorded in the county where the land is located.	Rel and Approp.		
Land Use Covenant	CCR, title 22, § 67391.1(i)		Definitions	Rel and Approp		
Land Use Covenant	CA Civil Code § 1471(a) & (b)		Specifies requirements for land use covenants to apply to successors in title to the land.	Rel and Approp		
Monitoring Requirements	CCR, title 27, § 20385		Release monitoring requirements for solid waste management units	Applic.		
General Closure and Post-Closure Maintenance	CCR, title 27, § 20950(a), (e)		General closure and post-closure maintenance standards for solid waste management units	Applic.		
General Post-Closure Maintenance	CCR, title 27, § 21090(b)(1), (c), (e)(2)		Closure and post-closure maintenance requirements for solid waste landfills.	Applic.		
Gas Monitoring and Control During Closure and Post-closure	CCR, title 27, § 20921		Methane must not exceed 5% at the property boundary or other approved monitoring point	Applic.		

Gas Monitoring	CCR, title 27, § 20923		Gas monitoring program required	Applic.		
Perimeter Monitoring Network	CCR, title 27, § 20925		Perimeter subsurface monitoring wells required	Applic.		
Structure Monitoring	CCR, title 27, § 20931		If there are structures, gas monitoring required	Applic.		
Monitored Parameters	CCR, title 27, § 20932		Methane and any specified trace gases must be sampled	Applic.		
Monitoring Frequency	CCR, title 27, § 20933		Quarterly monitoring required, at a minimum	Applic.		
Reporting	CCR, title 27, § 20934		Results of monitoring to be submitted	Applic.		
Control	CCR, title 27, § 20937		Requires gas control system if methane concentrations exceed compliance levels	Applic.		
Post-closure Maintenance	CCR, title 27, § 21180		The landfill's final cover and operating systems must be maintained and monitored for no less than 30 years following closure.	Applic.		
Post-closure Land Use	CCR, title 27, § 21190		Specifies restrictions and considerations in future land use	Applic.		
Water Quality Monitoring	CCR, title 22, § 66264.97		Identifies requirements for water quality monitoring and monitoring systems for owners and operators of hazardous waste facilities	Rel and Approp.		

Requirement	Citation	Auth	Description	ARAR Status	Comments	Applicable Sites
TBCs						
USEPA, Region IX PRGs	Not promulgated –Circulated by USEPA Region IX	US	Chemical concentrations in soil, air and water that can be used as screening levels or triggers for further investigation.		PRGs are not promulgated cleanup levels but levels above which further risk characterization is recommended.	
A Compilation of Water Quality Goals and Companion Table "Recommended Numerical Limits to Apply Water Quality Objectives."	Compiled by Jon Marshack (RWQCB, Central Valley Region). Most recently updated in August 2003.	CA	A report and table prepared to "introduce California's water quality standards and to outline a system for selecting numerical water quality limits consistent with these standards." The standards consist of a beneficial use (designated in each Regional Board's Basin Plan) and water quality objectives to protect those uses. Water quality objectives are numerical or narrative. To aid in selecting numeric limits (concentration levels) for narrative objectives, Marshack has compiled water quality limits from the literature that include "drinking water standards, ambient water quality criteria, cancer risk estimates, health advisories, and other numerical values that represent concentrations of chemicals that would limit specific uses of water (for example, taste and odor thresholds).			
California Designated Level Methodology for Waste Characterization and Cleanup Level Determination	Staff Report, Calif. RWQCB	CA	Proposes a methodology for determining cleanup levels in soil based upon impact to groundwater. Designated waste is defined as non-hazardous waste, which consists of pollutants, which, under ambient environmental conditions, could cause degradation of Waters of the State.		Can be used in determining cleanup levels in soil that are protective of groundwater quality.	
LUFT Field Manual	May 24, 1988 Revised April 5, 1989	CA	Specifies the requirements for removal of USTs and assessment of potential releases of petroleum fuel-related contaminants.		This manual is guidance for considering cleanup goals for petroleum fuel-related contaminants.	
State Action Levels	DHS/ Office of	CA	Numeric limits (concentration levels) that are		DHS action levels are used as triggers to	

	Drinking Water Criteria		designed to protect human health from contaminants in drinking water.		implement corrective actions for public water systems.	
California Water Code - State of California Dept. of Water Resources	§ 13800 (Water Well Standards Supplemental Bulletin 74-90)	CA	As required by § 13800 of the California Water Code, the DWR prepared a Water Well Standards Supplemental bulletin 74-90 which sets standards for the construction and abandonment of water wells.		These guidelines will be considered if actions involve construction or abandonment of water wells.	

MEC Remediation ARARs						
Requirement	**Citation**	**Auth**	**Description**	**ARAR Status**	**Comments**	**Applicable Sites**
Location Specific						
California Endangered Species Act	Fish and Game Code §§ 2051et seq.; §2080	CA	The statute sections provide a declaration of policy and definitions. Section 2080 provides that no person shall take, possess, purchase, or sell within this state, any species, or any part or product thereof, that the commission determines to be an endangered species or a threatened species, or attempt any of those acts.	Rel and Approp. (1,2,3)/ Location	Section 2080 includes specific standards of control with respect to the taking of endangered or threatened species. The Army will need to coordinate the development of any plans with CDFG. Mitigation measures to protect both State and Federal, rare, threatened and endangered species will need to be identified and actions implemented during the Army's action of MEC remediation if selected for implementation.	
California Fish and Game Code	§3511	CA	This statute section prohibits taking or possessing fully protected birds or parts thereof, listed as: (a) American peregrine falcon (*Falco peregrinus anatum*) (b) Brown pelican (c) California black rail (*Laterallus jamaicensis coturniculus*) (d) California clapper rail (*Rallus longirostris obsoletus)* (e) California condor (*Gymnogyps californianus*) (I) California least tern (*Sterna albifrons browni*) (g) Golden eagle (h) Greater sandhill crane (*Grus canadensis tabida*) (i) Light-fooled clapper rail (*Rallus longirostris levipes*) (j) Southern bald eagle (*Haliaeetus leucocephalus leucocephalus*) (k) Trumpeter swan (*Cygnus buccinator*) (l) White-tailed kite (*Elanus leucurus*) (m) Yuma clapper rail (*Rallus longirostris yurnanensis*).	Rel and Approp. (1,2,3)/ Location	The requirement includes specific standards of control that may apply to the American peregrine falcon (some possibility), golden eagle (slight possibility), brown pelican (not likely but possible), and California least tem (not likely but possible). Vegetation clearance activities should occur outside the nesting seasons for these protected birds.	
California Fish and Game Code	§3513	CA	This statute section declares that it is unlawful to take or possess any migratory nongame bird as designated in the Migratory Bird Treaty Act or any part of such migratory nongame bird except as provided by rules and regulations adopted by the Secretary of the Interior under provisions of the Migratory Treaty Act.	Rel and Approp. (1,2,3)/ Location	The requirement includes specific standards of control.	
California Fish and Game Code	§3503.5	CA	This statute section prohibits the take, possession or destruction of any birds in the orders of Falconiformes or Strigiformes, or to take, possess, or destroy the nest or eggs of any such bird, except as provided in the code.	Rel and Approp. (1,2,3)/ Location	The requirement includes specific standards of control.	
California Fish and Game Code	Title 14, CCR §472	CA	This regulation limits the taking of nongame birds and mammals except for specified species.	Rel and Approp. (1,2,3)/ Location	The requirement includes specific standards of control.	
California Fish and Game Code	§4800 et. seq	CA	This statute section declares that it is unlawful to take, injure, possess, transport or sell any mountain lion.	Rel and Approp. (1,2,3)/ Location	The requirement includes specific standards of control. Due to the size of vegetation clearance and MEC remediation activities that may be selected for implementation, it is unlikely that mountain lions will be negatively affected. In fact, the use of fire to set back plant community succession will result in an improvement to wildlife habitat that will benefit mountain lions	
Endangered Species Act (16 USC §§ 1531 *1543*	16 USC §1536 (a) and (c); 16 USC §1538 (a)(l)	US	Federal agencies are required under Section 7 of the ESA to ensure that their actions do not jeopardize the continued existence of a listed species or result in destruction of or adverse modification of its critical habitat(l6 USC § 1536). If the proposed action may affect the listed species or its critical habitat, consultation with the USFWS and/or California Fish and Game may be required (50 CFR § 402.14). Additionally, Section 9 of the ESA prohibits the illegal taking of a listed species (16 USC I	Applic. (1,2,3)/ Location		

			538(a)(1).			
Migratory Bird Treaty Act (MBTA)	16 lJ5C §§ 703-7l2	CA	The statute sections prohibit the taking, possession of, buying, selling, purchasing, or bartering of any migratory bird, including feathers or other parts, nest eggs, or products, except as allowed by regulations.	Applic. (1,2,3)/ Location		
Action Specific						
California Health and Safety Code	Title 22, CCR §66264.601-603	CA	These regulations apply to hazardous waste treatment which is conducted in a device that does not meet the definition of a "container" in 22 CCR 66260.10 is characterized as a "Miscellaneous Unit" subject to the provisions of 22 CCR 66264.60 1-603. For activities where detonations are in a device that meet the 22 CCR 66260.10 definition of a container, the requirements for "temporary units," as set forth in 22 CCR 66264.553 apply.	Rel and Approp. (2) / Action	The regulations include generally described narrative standards. Compliance with substantive requirements is achieved through regulatory coordination of site-specific work plan and Detonation Sampling and Analysis Plan with EPA and DTSC in accordance with CERCL	
California Fish and Game Code	§ 1900 et. seq.	CA	These Statute sections sets forth programmatic and administrative provisions, and in § 1908, provides that no person shall import into the state, or take, possess, or sell within this state, except as incident to the possession or sale of the real property on which the plant is growing, any native plant, or any part or product thereof, that the commission determines to be an endangered native plant or rare native plant	Rel and Approp. (1,2,3)/ Action	The standards of control are relevant and appropriate, and the citation is therefore considered as ARAR.	
California Fish and Game Code	Title 14, CCR §783 et. seq.	CA	These regulations provide that no person shall import into the State, export out of the State or take, possess, purchase, or sell within the State, any endangered species, threatened species, or part or product thereof, or attempt any of those acts, except as otherwise provided in the California Endangered Species Act, Fish and Game Code Section 2050, et seq. ("CESA"), the Native Plant Protection Act, the Natural Community Conservation Planning Act, the California Desert Native Plants Act, or as authorized under this article in an incidental take permit. The regulations also provide programmatic and administrative procedures for incidental take permits	Rel andApprop.(1,2,3)/ Action	The standards of control are relevant and appropriate, and the citation is therefore considered as ARAR.	
California Clean Air Act (Health and Safety Code)	Title 17, CCR §80 100 et. seq.	CA	The regulations provide guidelines, programs and agency procedures for smoke management plans.	Rel and Approp. (1)/Action	The regulations are relevant and appropriate. The Army will comply with substantive elements of the regulations if this type of works proceeds.	
Chemical and Action Specific						
California Health and Safety Code, Division 20	Title 22, CCR Division 4.5	CA	The statute and regulations provide for identification of hazardous waste in §6626l. If a material is a hazardous waste, Division 4.5 provisions further regulate hazardous waste generators, transporters, and treatment, storage, and disposal facilities.	Applic. (3) / Chemical and Action	The Army will evaluate discovered items in accordance with the approved programmatic work plan to determine the presence of energetic materials or other constituents that would cause it to be characterized as a hazardous waste. Substantive requirements: ▪ Storage: onsite storage of MEC items occur in a designated bunker that meets the standard of DDESB 6055.9 STD, including security measures such as fences, signs, and an alarm system. ▪ Transportation: offsite transportation of small arms ammunition and subcaliber MEC items will incorporate applicable manifesting and placarding requirements. Conforms to Defense Reutilization and Marketing Office (DRMO) instruction. ▪ Disposal/recycling: offsite disposal or recycling facility or facilities for small arms ammunition and subcaliber MEC items will be state and/or RCRA-authorized.	

California Health and Safety Code	Title 22, CCR §66265.382	CA	Open burning of hazardous waste is prohibited except for the open burning and detonation of waste explosives. Waste explosives include waste which has the potential to detonate and bulk military propellants which cannot safely be disposed of through other modes of treatment. Detonation is an explosion in which chemical transformation passes through the material faster than the speed of sound (0.33 kilometers/second at sea level). Owners or operators choosing to open bum or detonate waste explosives shall do so in accordance with the following table and in a manner that does not threaten human health or the environment. **lb. waste explosives** **Min. Distance from OB/OD to property** 0 to 100 204 meters (670 feet) 101 to 1,000 380 meters (1,250 feet) 1,001 to 10,000 530 meters (1,730 feet) 10,001 to 30,000 690 meters (2,260 feet)	Rel and Approp. (3)/Chemical and Action	The requirement includes specific standards of control and addresses situations similar to those that may be addressed under Additional MEC Remediation. If this alternative is selected for implementation, the actions taken will comply with these requirements.	
Hazardous Materials & Transportation Act	49 CFR Part 172.101	CA	These regulations impose procedures and controls on the transportation of hazardous materials,	Applic. (3) / Chemical and Action	The regulations include specific standards of control and substantive requirements, criteria and limitations that may apply to the transport of detonation materials and Selected recyclable ordnance materials.	
Federal Resource Conservation and Recovery Act (RCRA), Subpart M (Military Munitions Rule)	40 CFR Parts 266 and 270	US	The regulations identify when military munitions become a solid waste, and if these wastes are hazardous, the management standards apply.	Rel and Approp. (2, *3)1* Chemical and Action	The rule is relevant and appropriate, particularly with regard to management of MEC that is determined to be a hazardous waste. The rule provides for the transportation and storage of waste military munitions in accordance with DDESB standards.	

1 = Vegetation Clearance; 2 = MEC Remediation; 3 = Detonation of MEC

MEC Remediation			Potential Applicable or Relevant and Appropriate Requirements (ARARs)	
Source or Authority	**Requirement Standard or Criterion**	**Type**	**Description**	**Remarks**
Regulations that were considered as potential ARARs but were not considered applicable.				
California Fish and Game Code	§3005		The statute section prohibits the taking of birds or mammals, except non-game mammals, with any net, pound, cage, trap, set line or wire, or poisonous substance. Included in the term "taking" is the killing of birds or mammals by poison.	Birds and mammals will be protected by achieving the identified Remedial Action Objectives (RAOs). Further, the scope of the remedial actions does not include intentional taking of birds and mammals with unlawful devices.
California Fish and Game Code	§4000 et. seq.		This statute section provides that a fur-bearing mammal may be taken only with a trap, firearm, bow and arrow, poison under a proper permit, or with the use of dogs.	The scope of the remedial actions does not involve intentional taking of fur-bearing mammals with unlawful devices.
California Fish and Game Code	Title 14, CCR §460		This regulation makes it unlawful to take Fisher, marten, river otter, desert kit fox and red fox.	The remedial actions will not result in the take of Fisher, marten, and river otter.
California Clean Air Act	Health and Safety Code §41701		This statute section prohibits the discharge into the atmosphere from any source whatsoever any air contaminant for a period or periods aggregated more than three minutes in any one hour which is dark or darker than No. 2 on the Ringelmann Chart or obscures the view to a degree equal to or greater than smoke.	

Solid Waste Disposal Site Excavation and Consolidation ARARs						
Source	**Standard, Requirement, Criterion, or Limitation**	**Auth**	**Description**	**ARAR Status**	**Comment**	**Associated Site**
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20435 Div. 2, Subdiv. 1, Ch. 3, Subch. 3, Art. 1., § 20435, Water Quality Monitoring and Response Programs	CA	Unsaturated Zone Monitoring and Response: methodology for establishing a background value for each monitoring parameter and each COC and for detecting any increase.			
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20510(a) Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 1., § 20510(a), **Disposal Site Operating Records**	CA	Weigh/Volume Records: the weight or volume of waste accepted must be determined loan accuracy of ±10%	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20510(b) Div. *2*, Subdiv. 1, Ch. 3, Subch. 4, Art. 1, § 20510(b), **Disposal Site Operating Records**	CA	Excavation Records: records shall be maintained for excavations which rosy effect the Safe and proper operation of the site or cause damage to adjoining properties.	Applic.	Applies to solid waste disposal Sites as defined by Public Resources Code Section 40122.	For consolidation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030.	27 CCR 20530 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 1, § 20530, **Site Security**	CA	Site Security: the site shall be designed to discourage unauthorized access by persons or vehicles by using a perimeter barrier or topographic constraints. Areas within the site where open storage or ponding of hazardous materials occurs shall be separately fenced.	Applic.	Applies to solid waste disposal Cites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020,43021 and 43030	27 CCR 20540 Div. 2, Subdiv. 1, Ch. 3, Subdiv, 4, Art. 1, § 20540, **Roads**	CA	Roads: landfill roads must minimize dust and tracking of materials onto public roads, Such roads shall be kept in safe condition and maintained such that vehicle access and unloading can be conducted during inclement weather.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation end excavation sites
California integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20630 Div. ***2,*** Subdiv, 1, Ch. 3, Subdiv. 4, Art. 1, § 20630, **Confined Unloading**	CA	Confined Unloading: Unloading of solid **wastes** shall be confined to as small an area as possible without resulting in traffic, personnel or public safety hazards. Requires normal deposition of waste at toe of fill..	Applic..	Applies to solid waste disposal sites as defined by Pubic Resources Code. Section 40122,	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20640 Div. 2, Subdiv, 1 Ch. 3, Subdiv. 4, Art. 1, § 20640, **Spreading and Compacting**	CA	Spreading and Compacting: Requires Spreading and compacting of refuse in layers.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites.
California Integrated Waste Management Act of 1989 PRC 40502,43020, 43021 and 43030	27 CCR 20650 Div. 2, Subdiv, 1, Ch, 3, Subdiv. 4, Art. 4, § 20650, **Grading of Flu Surface**	CA	Grading of Fill Surface: Covered surfaces of the disposal area shall be graded to promote firm-off and prevent ponding, accounting future settlement.	Applic.	Applies to solid waste disposal Sites as defined by Public Resources Code. Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20660 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 1, § 20660, **Stockpiling.**	CA	Stockpiling: Requires stockpiled cover material and unsuitable native materials to be placed so as not to cause problems or interference with site operations.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20700 Div. 2, Subdiv. 1, Ch. 3, Subch, 4, Art. 1, Sec. 20100, intermediate Cover	CA	Intermediate Cover: Requires compacted earthen material of at least 12 inches on all surfaces of the fill where no additional solid waste will be deposited within 180 days.	Applic.	Applies to Solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California integrated Waste Management Act of 1989 PRC 40802. 43020, 43021 and 43030	27 CCR 20710(a) Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art, 1, Sec. 20710(a), Scavenging, Salvaging and Storage	CA	Scavenging: Scavenging Is prohibited.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122,	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40602, 43020, 43021 and 43030	27 CCR 20710(b) Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 1 Sec. 20710(b), Scavenging, Salvaging and Storage	CA	Salvaging Permitted: Salvaging is permitted in a planned and controlled manner,	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20710(c) Div. 2, Subdiv. 1, Ch. 3. Subch. 4, Art. 1, Sec. 20710(c), Scavenging, Salvaging and Storage	CA	Storage of Salvage: Salvage material must be safely isolated for storage,	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	Fr consolidation and excavation sites

California integrated Waste Management Act of 1989 PRC 40502, 43020,43021 and 43030	27 CCR 20710(c) Div. 2, Subdiv. 1, Ch, 3, Subch. 4, Art. 1, Sec. 20710(c), Scavenging, Salvaging and Storage	CA	Removal: Storage time for salvage materials shall be limited to a duration specified by the enforcement agency.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20720 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 1, Sec. 20720, Non-Salvageable Items	CA	Non-Salvageable items: items capable of Impairing public health shall not be salvaged without approval by the agencies,	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California integrated Waste Management Act of 1989 PRC 40802, 43020, 43021 and 43030	27 CCR 20730 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 1, Sec. 20730, Volume Reduction & Energy Recovery	CA	Volume Reduction and Energy Recovery: Volume reduction and energy recovery are permitted in planned and controlled manners. Processing area shall be confined to specified, clearly identifiable areas of the site.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavations tea
California Integrated Waste Management Act of 1989 PRC 40502, 43020.43021 and 43030	27 CCR 20780 Div. 2, Subdiv, 1, Ch. 3, Subch. 4, Art. 1, Sec. 2071 0(c), Nuisance Control	CA	Nuisance Control: Each site shall be operated and maintained so as not to create a public nuisance.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation Sites
California Integrated Waste Management Act of 1989	27 CCR 20780(b) Div. 2, Subdiv. 1, Div. 3, Subch. 4, Art. 4, Sec.	CA	Burning Wastes: Burning wastes shall be extinguished.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
PRG 40502, 43020, 43021 and 4303.0	20780(b), Open Burning & Burning Wastes	CA				
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 end 43030	27 CCR 20790 Div. 2, Subdiv. 1, Div. 3, Subch. 4, Art. 1, Sec. 20790, Nuisance Control	CA	Leachate Control: The operator shall ensure that leachate is controlled to prevent contact with the public.	Applic.	The state does not intend that subsurface leachate monitoring and collection systems need to be installed at existing sites unless there is evidence of leachate production and/or accumulation. Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 COR 20800 Div. 2, Subdiv. I Ch. 3, Subch. 4, Art. 4, Sec. 20800, Dust Control	CA	Dust Control: The operator shall take adequate measures to minimize the creation of dust and prevent safety hazards due to obscured visibility.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 CCR 20610 Div. 2, Subdiv. 1, Oh. 3, Subch. 4, Art. 4, Sec. 20810, Dust Control	CA	Vector and Bird Control: The operator shall take adequate measures to Control or prevent the propagation harborage, or attraction of flies, rodents, or other vectors, and to minimize bird problems.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California integrated Waste Management Act of 1989 PRO 40502, 43020, 43021 and 43030	27 OCR 20820 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art, 4, Sec. 20820, Drainage end Erosion Control	CA	Drainage And Erosion Control: The drainage system shall be designed and maintained to: ensure integrity of roads, structures, and gas monitoring and control systems; prevent safety hazards; and prevent exposure of waste.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 OCR 20830 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 4, Sec. 20830, Grading of Fill Surface	CA	Liter Control: Litter and loose materials shall be routinely collected and disposed of properly,	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 OCR 20919 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 6, Sec. 20919, Gas Control	CA	Gas Control: The operator shall cause the site to be monitored for the presence and movement of landfill gas and take any necessary action to control such gases In the event that the gas causes a hazard or nuisance.	Applic.	Applies to solid waste disposal sites as defined by Public Resources Code Section 40122.	For consolidation and excavation sites
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 OCR 20919.5 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 6, Sec. 20919, Gas Control	CA	Explosive Gas Control: The concentration of methane gas generated by the facility must not exceed 25 percent of the lower explosive limit. Monitoring, reporting, and mitigation requirements.			
California Integrated Waste Management Act of 1989 PRC 40502, 43020, 43021 and 43030	27 OCR 21090 Div. 2, Subdiv. 1, Ch. 3, Subch. 4, Art. 6, Sec. 20919, Gas Control	CA	Final Cover Requirements: Construction of Cover's Layers, Grading Requirements, General Duties, Establishing baseline topography and tracking settlement.		Closure and Post-Closure Maintenance Requirements for Solid Waste Landfills	
California Integrated Waste Management Act of 1989 PRC	27 CCR 21600 Div. 2, Subdiv. ***1,*** Ch, 4, Subch. 3, Art. 2, Sec. 21600,	CA	Report of Disposal Site information The planning and procedural requirements necessary to ensure that solid waste Is handled and	Rel and Approp.	Applies to operating solid waste disposal sites as defined by Public Resources Code Section	For consolidation sites

40502, 43020, 43021 and 43030	Report of Disposal Site Info		disposed in manners that protect public health and safety and the environment most be conducted.		40122	
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21130Ch. 3 Subch. 5, Art. 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Emergency Response: potential emergency conditions that may exceed the design of the site and could endanger the public health or environment must be anticipated. Response procedures for these conditions must be addressed in the RD/RA plans.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2. Scope & Applicability pursuant 27 CCR 21100.	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21135 Ch. 3, Subch. 5, Art. 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Site Security: all points of access to the site must be restricted, except permitted entry points. All monitoring, control, and recovery systems shall be protected from unauthorized access.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2. Scope & Applicability pursuant 27 CCR 21100	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21137 Ch. 3, Subch. 5, Art. 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Structure Removal: site structures and leachate and gas control systems not Intended for reuse will be dismantled and removed at the time of closure to protect public health and safety.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art, 2. Scope & Applicability pursuant 27 CCR 21100	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21140 Ch. 3, Subch. 5, Art. 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Final Cover: the final cover shall function with minimum maintenance and provide waste containment to protect public health and safety by controlling at a minimum, vectors fire, odor, litter and landfill gas migration. The final cover shall also be compatible with postclosure land use.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Silas and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2. Scope & Applicability pursuant 27 CCR 21100	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21142 Ch, 3, Sub. 5, Article 2, Closure & Postclosure Maint, Standards for Disposal Sites and Landfills	CA	Final Grading: final grades must be designed and maintained to reduce Impacts 10 health and safety and take Into consideration any postclosure land use.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2. Scope & Applicability pursuant 27 CCR 21100	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21145 Ch. 3, Subch. 5, Art. 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Slope Stability: the operator shall ensure the integrity of final slopes under both static and dynamic conditions to protect public health & safety and prevent damage to postclosure land uses, roads, structures, utilities, gas monitoring and control systems, leachate collection and control systems to prevent public contact with leachate, and prevent exposure of waste.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2. Scope & Applicability pursuant 27 CCR 21100.	For closing Sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21150 Ch. 3. Subch. 5, Art. 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Drainage and Erosion Control: the drainage and erosion control system shall be designed and maintained to ensure Integrity of postclosure land uses, roads, and structures; to prevent public contact with waste and leachate; to ensure Integrity of gas monitoring and control systems; to prevent safety hazards: and to prevent exposure of waste.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Sub. 5, Art. 2. Scope & Applicability pursuant to 27 CCR 21100	For closing sites
California integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 21160 Ch 3, Sub. 5, Article 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Landfill Gas Control and Leachate Contact: landfill gas control shall be Implemented and maintained; leachate must be collected and controlled in a manner which prevents public contact and controls vectors, nuisance and odor.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2, Scope & Applicability pursuant 27 CCR 21100. The state does not intend that subsurface leachate monitoring and collecting systems need to be added to existing landfills unless leachate production and/or accumulation is evident.	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 20921-20937 Ch. 3, Sub. 4, Article 6, Closure & Postclosure Maint Standards for Disposal Sites and Landfills	CA	Gas Monitoring and Control During Closure and Postclosure; In protect public health and safety end the environment, landfill gases generated at a disposal site will be controlled to ensure that 1) concentrations to methane gas do not exceed 1 .25% by volume In air within on-site structures. 2) concentrations of methane do not exceed 5% by volume In air at the property or designated landfill boundary arid 3) trace gases do not pose en acute or chronic exposure to toxic or carcinogenic compounds	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3. Subch. 5, Art. 2, Scope & Applicability pursuant 27 CCR 21100	For dosing sites

California Integrated Waste Management Act of 1989 PRC 40502 & 43020	27 CCR 20950 Ch. 3, Sub. 4, Article 6, Closure & Postclosure Maint Standards for Disposal Sites and Landfills	CA	General Requirements: Supervision by registered civil engineer or certified engineering geologist, placement of surveying monuments, Establishing Financial Responsibility for Maintenance Period.			
California Integrated Waste Management Act of 1959 PRC 40502 & 43020	27 CCR 21180 Ch. 3, Sub. 5, Article 2, Closure & Postclosure Maint Standards for Disposal Sites and Landfills	CA	Postclosure Maintenance; the landfill must be maintained and monitored for no less than 30 years following closure.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 CCR, Ch. 3, Subch. 5, Art. 2, Scope & Applicability pursuant 27 CCR 21100,	For closing sites
California Integrated Waste Management Act of 1989 PRC 40602 & 43020	27 CCR 21190 Ch. 3, Sub. 5, Article 2, Closure & Postclosure Maint. Standards for Disposal Sites and Landfills	CA	Postclosure Land Use; Site Closure Design shall show one or more proposed uses of the closed site or show development that is compatible with open space. Changes In Postclosure land use must be approved by the appropriate State agency prior to Implementation.	Applic. or Rel and Approp.	Closure or Postclosure Maintenance Standards for Disposal Sites and Landfills of 27 OCR, Ch. 3, Subch. 5, Art. 2, Scope & Applicability pursuant 27 CCR 21100	For dosing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43509	27 CCR 21800 Ch. 4, Subch. 4. Final Closure Plans Contents	CA	Provides the content requirements for closure plans for solid waste disposal sites.	Rel and Approp.	Applies to solid waste disposal sites that received waste after November 1990, Relevant and appropriate for closing sites that did not receive waste after November 1990	For closing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43609	27 CCR 21830 Ch. 4, Subch. 4, Final Closure Plan Contents	CA	Provides the content requirements for Postclosure maintenance plans for solid waste disposal sites,	Rel and Approp.	Applies to solid waste disposal sites that received waste after November 1990. Relevant and appropriate for closing sites that did not receive waste after November 1990.	For dosing sites
California Integrated Waste Management Act of 1989 PRC 40502 & 43509	27 CCR 21880 Ch. 4, Subch. 4. Final Closure Plan Contents	CA	Provides the content requirements to obtain certification that the solid waste disposal site has closed pursuant to state standards.	Rel and Approp.	Applies to solid waste disposal sites that received wade after November 1990. Relevant and appropriate for closing sites that did not receive waste altar November 1990	For closing sites

ARARs	Applicable or Relevant and Appropriate Requirements
CAMU	Corrective Action Management Unit
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	Contaminates of Concern
CWA	Clean Water Act
DHS	Department of Health Services
DWR	Department of Water Resources
EPA	Environmental Protection Agency
et seq	et sequentes (and the following)
gpd	gallons per day
LUFT	Leaking Underground Fuel Tank Manual
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinate biphenyl
ppm	parts per million
PRG	Preliminary Remediation Goal
RCRA	Resource Conservation and Recovery Act
RWQCB	Regional Water Quality Control Board
STLC	soluble threshold limit concentration
SWRCB	State Water Resources Control Board
TBC	To-Be-Considered
TDS	Total Dissolved Solids
TSCA	Toxic Substances Control Act
TSDF	Transfer, Storage and Disposal Facility
TTLC	total threshold limit concentration
USC	United States Code
USTs	underground storage tanks

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Appendix B: Cost Development Summaries

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ATTACHMENTS

Attachment B-1: Detailed Cost Estimate for Alternative 2
Attachment B-2: Detailed Cost Estimate for Alternative 3
Attachment B-3: Detailed Cost Estimate for Alternative 4

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Section 1 Remedial Action Cost Engineering and Requirements (RACER)

This appendix to the *Focused Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29,* presents a brief description of the method used for estimating costs for each of the remedial alternatives. Conceptual design parameters identified in Sections 5 and 6 for each alternative were used as input where appropriate. The remedial action cost estimates are used in the evaluation of alternatives in FFS. The No Action alternative (Alternative 1) has no associated costs and therefore is not discussed in this appendix.

At the feasibility study (FS) stage, the design of the remedial action is still conceptual and not detailed design estimate. The cost estimates presented herein and summarized in the FFS are developed to be consistent with the expected accuracy for FS-level estimates, as described in United States Environmental Protection Agency (U.S. EPA) Remedial Investigation (RI) and FS technical guidance (USEPA 1988 and 2000). As a project progresses, the design becomes more complete and the cost estimates become more "definitive," thus increasing the accuracy of the cost estimate.

Cost estimates for the FFS were prepared following U.S. EPA RI and FS technical guidance (USEPA 1988 and 2000) and the National Oil and Hazardous Substances Pollution Contingency Plan. Remedial Action Cost Engineering and Requirements software (RACER) was the primary source of cost data. Costs for site-specific or unique line items were estimated based on a combination of vendor quotes, Parametric Cost Engineering System (PACES) software, and engineering judgment. Microsoft Excel spreadsheets were used to tabulate estimated costs on an annual basis for the assumed duration of each alternative and calculate present values in January 2011 United States (U.S.) dollars.

1.1 Description of RACER

RACER cost models are based on generic engineering solutions for environmental projects, technologies, and processes. The engineering solutions were derived from historical project information, government laboratories, construction management agencies, vendors, contractors, and engineering analyses. The software used for estimating cost, RACER Version 10.3 (December 2009), incorporates the most up-to-date engineering practices and procedures to accurately reflect current removal/remediation processes and pricing. When an estimate is developed in RACER, generic engineering solutions are customized by adding site-specific parameters to reflect project-specific conditions and requirements. The tailored plan is then translated into specific work items, priced using the current cost data. RACER incorporates and summarizes costs by the code of accounts that was developed by the interagency Cost Estimating Group for Hazardous, Toxic, and Radiological Waste Remediation.

Estimates for professional labor support to the remedial action are included in the capital, operation and maintenance (O&M), and periodic costs developed by RACER. This labor support is calculated based on the technology employed and includes construction oversight and preparation of work plans (e.g., health and safety, sampling, and quality control). Indirect cost estimates for the remedial action include items such as sales tax on purchased items, contractor

overhead, contractor profits, bonds, and insurance costs. Engineering, another indirect cost item, varies for each alternative depending on the complexity of the remedial action.

The cost estimates presented herein have been developed in the detailed analysis of alternatives stage as summarized in the FFS. Cost estimates have a stated accuracy of +50% to −30%, consistent with U.S. EPA RI and FS technical guidance (U.S. EPA 1988 and 2000). It is important to note that costs prepared at the FS stage of a remediation project can increase or decrease during final design and/or implementation as the design becomes more complete and the cost estimates become more definitive. Such changes in costs are usually a result of scope changes that cannot be explicitly defined due to a lack of complete, accurate, and detailed information when the FS is prepared. A 20% contingency allowance has therefore been added to the capital and O&M costs to cover increases that may occur as a result of scope-related uncertainties.

Attachments B-1 through B-3 present the detailed cost estimates for each alternative and site cost present worth reports.

1.2 User-Defined Costs

It was not possible to develop RACER cost estimates for all elements of the alternatives because of certain site-specific or unique characteristics. The costs for these elements were estimated based on quotes and other pertinent cost data from vendors and from actual costs being incurred during other remedial actions at Site 29. Costs incurred in future years were not adjusted to account for inflation. Rather, a "real" discount rate is used, which already includes an inflation adjustment.

1.3 Cost Estimate Components

Cost estimates for Site 29 remedial alternatives include capital costs, O&M costs, periodic costs, and contingency allowances. Regulatory oversight costs are not included in the cost estimates. A description of each category of costs is provided below.

1.3.1 Capital Costs

Capital costs consist of direct and indirect costs. Direct costs include expenditures incurred for equipment, labor, and materials needed to develop, construct, and implement a remedial action. Indirect costs include all other expenses necessary to support the construction that cannot be directly associated with a specific item of work. Indirect costs include the following:

- Health and safety items
- Permitting and legal fees
- Site supervision
- Engineering
- Contractor overhead and profit
- Startup costs

Costs for these indirect expenditures are included in the detailed cost analysis, either as separate line items or as a percentage of the direct cost.

1.3.2 Operation and Maintenance Costs

O&M costs refer to those post-construction items necessary to ensure the continued effectiveness of a remedial action. Typical O&M expenses include power, operating labor, consumable materials, purchased services (such as laboratory services), equipment replacement, maintenance, sampling of monitoring wells, and permit fees. O&M costs also include reporting costs.

1.3.3 Periodic Costs

Periodic costs are associated with 5-year reviews and land-use control documentation and reporting. Typical periodic costs generally include professional labor, inspection labor, travel expenses, reporting documents, document handling, and long-term storage.

1.3.4 Contingency Allowances

Contingency allowances are assumed to be 20% of the cost of each alternative. As noted in Section 1.1, contingency allowances have been added to the FFS cost estimates to account for uncertainties in project scope. The size of the contingency allowance would be expected to decrease as cost estimates are prepared during subsequent phases of design after a remedial alternative has been selected and is proceeding toward implementation.

1.4 Present Value

Present value is calculated using present worth analysis, a method of evaluating alternative remedial action solutions when expenditures occur over different time periods. The costs for the various remedial action alternatives can be compared on the basis of a single figure for each alternative by discounting all future costs to a common year. This single figure, the present value, represents the amount of money which, if invested in the initial year of a remedial action and disbursed as needed, would be sufficient to cover all the stated costs associated with that alternative.

The present worth of expenditures occurring over the life of a remedial action is determined using the formula:

$$PW = \sum_{t=1}^{n} \frac{x_t}{\left(1+i\right)^t}$$

where

PW	=	Present worth
x_t	=	Escalated expenditures for the remedial action in year t
i	=	Annual interest or discount rate
t	=	Number of years in which each expenditure occurs following start of construction
n	=	Number of years following start of construction

1.5 General Assumptions

Assumptions that influence the cost of implementing remedial alternatives for Site 29 were based on general engineering practices and the requirements of RACER, when appropriate. The following general assumptions were used to develop cost estimates for each alternative in the FFS.

- Total costs were calculated using a cost base of January 2011 U.S. dollars.
- The real discount rate used to determine present worth is 2.3%. The real discount rate is determined by adjusting the nominal discount rate for inflation.
- O&M costs would be incurred beginning in 2012 and continue thereafter as required by each alternative.
- Land needed to implement each alternative is accessible and available for use; no land would be purchased for any of the remedial alternatives. Specialized equipment or services, with the exception of those described in the FFS, would not be required.
- All operations would be conducted using U.S. EPA Level D personnel protective equipment.
- A limited amount of hazardous material disposal is included.
- Surface soils excavated for remedial system piping is assumed to be clean, will not require special handling and/or disposal, and will be used as trench and structural backfill.
- Work plan and safety and health plan preparation, technical oversight during planning, and implementation of work are included in the cost for professional labor.
- Contingency allowance of 20% is applied to capital costs, O&M costs, and periodic costs.
- Owner cost allowance to implement the alternative is applied to capital costs, O&M costs, and periodic costs.

Section 2 References

U.S. EPA (United States Environmental Protection Agency). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*. OSWER Directive 9355.1. EPA/540/G-89/004. Interim Final. October.

———. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. OSWER Directive 9355.0-75. Washington, DC. July.

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Attachment B-1

Detailed Cost Estimate for Alternative 2

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29 — Location: CONCORD, CALIFORNIA

Project ID: IRS29 — Report Option: Calendar

Site Name: Alternative 2 - SVE with MNA

Site Type: Soil & Groundwater

Site ID: IRS29-A2

Year		1	2	3	4	5	6	7	8	9	10	11
Fiscal Year		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Cost Type	**Description**											
Design	01 Remedial Design	$ 262,655										
Remedial Action	02 Land Use Controls	$ 1,693,948	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479
Remedial Action	03 Soil Vapor Extraction System		$ 1,219,417									
Remedial Action	04 Soil Vapor Monitoring Probes		$ 664,365									
Remedial Action	05 Groundwater Monitoring Wells		$ 160,002									
Operations & Maintenance	06 SVE O & M & Peformance Monitoring		$ 527,188	$ 674,536	$ 674,536	$ 674,536	$ 674,536					
Operations & Maintenance	07 Monitoring Well Maintenace								$ 11,969			
Long Term Monitoring	08 5-Year Reviews (Year 5 - 30)							$ 91,235				
Long Term Monitoring	09 Quarterly GW Monitoring (Year 1 - 2)		$ 224,423	$ 270,003	$ 65,065							
Long Term Monitoring	10 Semi-annual GW Monitoring (Year 3 - 4)				$ 130,634	$ 144,951	$ 33,802					
Long Term Monitoring	11 Annual GW Monitoring (Year 5)						$ 109,288					
Long Term Monitoring	12 MNA GW Monitoring (Year 6 - 30)							$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288
Site Closeout	13 SVE System Decommissioning (Year 6)							$ 63,131				
Site Closeout	14 Site Closeout (Year 30)											
Sub-Total		$ 1,956,603	$ 2,840,874	$ 990,018	$ 915,714	$ 864,966	$ 863,105	$ 309,133	$ 166,736	$ 154,767	$ 154,767	$ 154,767
Real Discount	2.30%	0.9795	0.9593	0.9396	0.9203	0.9014	0.8829	0.8648	0.8470	0.8296	0.8126	0.7959
Nominal Discount	5.80%	0.9452	0.8934	0.8444	0.7981	0.7543	0.7130	0.6739	0.6370	0.6020	0.5690	0.5378
Inflation	3.50%	1.0363	1.0739	1.1128	1.1532	1.1950	1.2383	1.2832	1.3298	1.3780	1.4280	1.4798
Total		$ 1,916,416	$ 2,725,374	$ 930,259	$ 842,768	$ 779,712	$ 762,054	$ 267,335	$ 141,229	$ 128,399	$ 125,761	$ 123,178

Cost Over Time

Sub-Total		$ 1,956,603	$ 2,840,874	$ 990,018	$ 915,714	$ 864,966	$ 863,105	$ 309,133	$ 166,736	$ 154,767	$ 154,767	$ 154,767
Inflation	3.50%	1.0363	1.0739	1.1128	1.1532	1.1950	1.2383	1.2832	1.3298	1.3780	1.4280	1.4798
Total		$ 2,027,568	$ 3,050,685	$ 1,101,694	$ 1,055,968	$ 1,033,624	$ 1,068,808	$ 396,693	$ 221,723	$ 213,271	$ 221,006	$ 229,022

Database Date: Jan-08

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29

Project ID: IRS29

Site Name: Alternative 2 - SVE with MNA

Site Type: Soil & Groundwater

Site ID: IRS29-A2

Year		12	13	14	15	16	17	18	19	20	21	22
Fiscal Year		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**
Cost Type	**Description**											
Design	01 Remedial Design											
Remedial Action	02 Land Use Controls	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479
Remedial Action	03 Soil Vapor Extraction System											
Remedial Action	04 Soil Vapor Monitoring Probes											
Remedial Action	05 Groundwater Monitoring Wells											
Operations & Maintenance	06 SVE O & M & Peformance Monitoring											
Operations & Maintenance	07 Monitoring Well Maintenace				$ 11,969							$ 11,969
Long Term Monitoring	08 5-Year Reviews (Year 5 - 30)	$ 42,546					$ 42,546					$ 42,546
Long Term Monitoring	09 Quarterly GW Monitoring (Year 1 - 2)											
Long Term Monitoring	10 Semi-annual GW Monitoring (Year 3 - 4)											
Long Term Monitoring	11 Annual GW Monitoring (Year 5)											
Long Term Monitoring	12 MNA GW Monitoring (Year 6 - 30)	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288
Site Closeout	13 SVE System Decommissioning (Year 6)											
Site Closeout	14 Site Closeout (Year 30)											
Sub-Total		$ 197,313	$ 154,767	$ 154,767	$ 166,736	$ 154,767	$ 197,313	$ 154,767	$ 154,767	$ 154,767	$ 154,767	$ 209,282
Real Discount	2.30%	0.7796	0.7635	0.7479	0.7325	0.7175	0.7027	0.6883	0.6741	0.6603	0.6467	0.6335
Nominal Discount	5.80%	0.5084	0.4805	0.4542	0.4293	0.4057	0.3835	0.3625	0.3426	0.3238	0.3061	0.2893
Inflation	3.50%	1.5335	1.5891	1.6467	1.7064	1.7683	1.8325	1.8989	1.9678	2.0392	2.1131	2.1898
Total		$ 153,815	$ 118,170	$ 115,743	$ 122,133	$ 111,038	$ 138,655	$ 106,523	$ 104,335	$ 102,192	$ 100,093	$ 132,570

Cost Over Time

Sub-Total		$ 197,313	$ 154,767	$ 154,767	$ 166,736	$ 154,767	$ 197,313	$ 154,767	$ 154,767	$ 154,767	$ 154,767	$ 209,282
Inflation	3.50%	1.5335	1.5891	1.6467	1.7064	1.7683	1.8325	1.8989	1.9678	2.0392	2.1131	2.1898
Total		$ 302,571	$ 245,936	$ 254,856	$ 284,524	$ 273,678	$ 361,568	$ 293,891	$ 304,550	$ 315,596	$ 327,042	$ 458,279

Database Date: Jan-08

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29

Project ID: IRS29

Site Name: Alternative 2 - SVE with MNA

Site Type: Soil & Groundwater

Site ID: IRS29-A2

Year		23	24	25	26	27	28	29	30	31	32	
Fiscal Year		**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	
Cost Type	**Description**											**Total**
Design	01 Remedial Design											$ 262,655
Remedial Action	02 Land Use Controls	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 3,103,799
Remedial Action	03 Soil Vapor Extraction System											$ 1,219,417
Remedial Action	04 Soil Vapor Monitoring Probes											$ 664,365
Remedial Action	05 Groundwater Monitoring Wells											$ 160,002
Operations & Maintenance	06 SVE O & M & Peformance Monitoring											$ 3,225,333
Operations & Maintenance	07 Monitoring Well Maintenace							$ 11,969				$ 47,876
Long Term Monitoring	08 5-Year Reviews (Year 5 - 30)					$ 42,546					$ 65,395	$ 326,815
Long Term Monitoring	09 Quarterly GW Monitoring (Year 1 - 2)											$ 559,490
Long Term Monitoring	10 Semi-annual GW Monitoring (Year 3 - 4)											$ 309,387
Long Term Monitoring	11 Annual GW Monitoring (Year 5)											$ 109,288
Long Term Monitoring	12 MNA GW Monitoring (Year 6 - 30)	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288	$ 109,288		$ 2,732,190
Site Closeout	13 SVE System Decommissioning (Year 6)											$ 63,131
Site Closeout	14 Site Closeout (Year 30)										$ 377,148	$ 377,148
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
Sub-Total		$ 154,767	$ 154,767	$ 154,767	$ 154,767	$ 197,313	$ 154,767	$ 166,736	$ 154,767	$ 154,767	$ 488,023	$ 13,160,896
Real Discount	2.30%	0.6204	0.6077	0.5952	0.5830	0.5710	0.5593	0.5478	0.5366	0.5255	0.5147	- - -
Nominal Discount	5.80%	0.2734	0.2584	0.2443	0.2309	0.2182	0.2063	0.1949	0.1843	0.1742	0.1646	- - -
Inflation	3.50%	2.2692	2.3515	2.4368	2.5252	2.6168	2.7117	2.8100	2.9119	3.0175	3.1270	- - -
Total		$ 96,024	$ 94,052	$ 92,120	$ 90,228	$ 112,669	$ 86,559	$ 91,338	$ 83,040	$ 81,335	$ 251,203	$ 11,126,320

Cost Over Time

Sub-Total		$ 154,767	$ 154,767	$ 154,767	$ 154,767	$ 197,313	$ 154,767	$ 166,736	$ 154,767	$ 154,767	$ 488,023	$ 13,160,896
Inflation	3.50%	2.2692	2.3515	2.4368	2.5252	2.6168	2.7117	2.8100	2.9119	3.0175	3.1270	- - -
Total		$ 351,196	$ 363,933	$ 377,133	$ 390,811	$ 516,318	$ 419,675	$ 468,529	$ 450,669	$ 467,015	$ 1,526,040	$ 19,373,872

Database Date: Jan-08

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Estimate Documentation Report

System:

RACER Version: 10.0.2
Database Location: C:\04 Projects\RACER 2008\RACER 2008 20121205.mdb

Folder:

Folder Name: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project:

Project ID: IRS29
Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29
Project Category: None

Location
State / Country: CALIFORNIA
City: CONCORD

Location Modifier	Default	User
	1.286	1.286

Options
Database: System Costs
Cost Database Date: 2008
Report Option: Calendar

Description

Prepared for:

U.S. Department of the Navy
Naval Facilities Engineering Command, Southwest
San Diego, California

prepared under:

Conrtract Number: N62473-10-D-0814
Task Order: 00005
DCN: AM8A-0814-0005-0001

Executive Summary

Accord MACTEC 8A JV (AM8AJV), a joint venture, and Richard Brady & Associates (Brady), in subcontract to AM8AJV, prepared this Focused

Estimate Documentation Report

Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29, on behalf of the Naval Facilities Engineering Command Base Realignment and Closure (BRAC) Program Management Office (PMO) West, in accordance with Contract Number N62473-10-D-0814, Delivery Order 0005. This FFS follows requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), related United States Environmental Protection Agency (U.S. EPA) technical guidance, and the U.S. Department of the Navy's Environmental Restoration Program Manual (Navy 2006).

The purpose of this FFS is to develop and evaluate remedial alternatives to mitigate human health and environmental risks associated with exposure to groundwater and soil gas impacted by volatile organic compounds (VOCs) at Installation Restoration (IR) Program Site 29 (Site 29 or "site"), former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California, based on the conclusions and recommendations of the Final Remedial Investigation (RI) Report (Brady 2011). This document uses an FFS format because the technologies used in a treatability study (Shaw 2011) currently underway have been proven to effectively treat chlorinated solvents in groundwater under the hydrogeologic conditions present at Site 29 and because soil-gas contamination will be treated using soil-vapor extraction (SVE) technology.

Site 29 is located within the south-central portion of the inland area, approximately 1,600 feet southwest of the intersection of L Street and Kinne Boulevard and approximately 1,000 feet southwest of Seal Creek (also known as Mt. Diablo Creek outside of the base). The site is located on the side of a hill underlain by silty clay and sandy gravel units.

As a result of the final RI and previous investigations, the area of Site 29 was found to be impacted with VOCs in soil gas (in the vicinity of Building IA-19) and groundwater extending approximately 850 feet downgradient. The VOC-impacted vadose zone soils extend over approximately 1 acre, and the estimated area of groundwater impact is over 6 acres.

Factors considered in determining remedial action objectives (RAOs) include potential human health and ecological risks and exposure pathways, chemicals of concern (COCs), affected media, and chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs). The RAOs are based on the planned, unrestricted future use of Site 29 (City of Concord 2010).

A baseline human health risk assessment (BHHRA) was performed to assess potential impacts to human health from exposure to chemicals in soil, soil gas, and groundwater at Site 29 (Brady 2011). Future residential (unrestricted) use, commercial/industrial worker, and construction/utility worker scenarios were evaluated. For future residential use, cancer risk estimates exceed the 10?4 upper limit of the risk management range, and the hazard index (HI) values exceed 1.0 for all combinations (two methods and two development scenarios). The cancer risk and noncancer hazard estimates are primarily associated with arsenic from two soil sample locations, from trichloroethene (TCE) in soil gas, and from exposure to multiple chemicals from domestic use of groundwater. The RI concluded

that the metals from those two soil locations beneath IA-25 were associated with soils impacted by lead-based paint residues. Laboratory analysis and detailed evaluation of samples via scanning electron microscope/energy dispersive x-ray spectroscopy confirmed that lead in soil beneath IA-25 is derived from lead-based paint. Paints typically contain other metals used for pigment, such as arsenic, cadmium, cobalt, chromium, and zinc. The RI concluded that the elevated concentrations of these other metals are also associated with paint residues. No further action under CERCLA was recommended for lead-based-paint-contaminated soil. For commercial/industrial worker scenarios, the risk estimates are within the risk management range and the HIs are less than 1.0. For the construction/utility worker scenarios, the risk estimates exceed the 10?4 upper limit of the risk management range, and the HI values exceed 1.0 for this highly exposed receptor. Risk to future construction workers is predominantly attributable to exposure to TCE in soil gas and groundwater.

Contaminants at Site 29 are generally considered unlikely to pose a hazard to ecological receptors with the exception of TCE and 1,1-dichloroethene (1,1-DCE) in soil gas and metals in soil beneath Building IA-25. Soils beneath Building IA-25 do not pose an unacceptable risk to ecological receptors if the soil and building remain unvegetated and left in place. Primary and secondary consumers (e.g., vole, meadowlark, robin, and shrew) are primarily exposed to metals through plant and soil invertebrate consumption. Soils beneath IA-25 only pose a risk to ecological receptors if the building is removed, the soils remain undisturbed, and the area is revegetated (Brady 2011).

The media affected by VOCs for which remediation alternatives are evaluated in this FFS are soil gas and groundwater. RAOs are medium-specific goals for protecting human health and the environment and consider affected media and COCs, existing and potential receptors, exposure pathways, and ARARs. The RAOs for Site 29 are as follows:
- Prevent residential exposure to VOCs via potential inhalation of soil gas through vapor intrusion at concentrations that result in a cancer risk that exceeds the risk management range of 1x10-4 to 1x10-6 and a HI greater than 1.0.
- For burrowing mammals, reduce the inhalation hazard of TCE and 1,1-DCE in shallow soil gas to a hazard quotient of less than 1.0.
- Prevent residential exposure to VOCs via potable use of groundwater containing concentrations that result in a cancer risk that exceeds the risk management range of 1x10-4 to 1x10-6 and a HI greater than 1.0.

Risks to potential future residents and construction/utility workers exceed the 10?4 upper limit of the risk management range and the HI of 1.0. VOCs in soil gas at the site pose a hazard to burrowing mammals. The primary pathways for human exposure were identified as inhalation of soil gas and domestic use of groundwater (Brady 2011).

The proposed remediation goals (RGs) for VOCs presented in this FFS are based on the results of the risk assessments and on unrestricted use of Site 29.

The Navy has included some form of land use controls (LUCs) in all of the remedial alternatives for Site 29, with the exception of no action. The

following four remedial action alternatives were considered for this FFS.

Alternative 1 - No Action. No remedial action of any type would be conducted; this alternative serves as the baseline against which the remaining alternatives can be compared.

Alternative 2 - SVE with Monitored Natural Attenuation (MNA). This alternative would institute an SVE presumptive remedy to remove VOC contamination from the vadose zone. SVE, also known as "soil venting" or "vacuum extraction" is an in situ remedial technology that reduces concentrations of volatile constituents adsorbed to soils in the unsaturated (vadose) zone. MNA of the groundwater plume is a technique used to monitor or test the progress of natural attenuation processes that can degrade contaminants in soil and groundwater. It can be used in conjunction with SVE as a finishing option, or if appropriate, as the only remediation process if the rate of contaminant degradation is fast enough to protect human health and the environment. Natural processes can then mitigate the remaining amount of pollution; regular monitoring of the groundwater can verify those reductions. Both institutional and engineering LUCs would be used to restrict use of groundwater for domestic supply and to implement mitigating requirements for structures built over the soil-vapor plume until RAOs are met.

Alternative 3 - SVE with Zero-Valent Iron (ZVI) Injection. Similar to Alternative 2, SVE would be the primary technology used to treat VOCs in the vadose zone. In addition to SVE, groundwater treatment would be conducted by ZVI injection. ZVI is a strong reducing agent that is injected (in solution) into contaminated groundwater to reduce VOC concentrations. LUCs, such as fencing, signage, and land use restrictions, would be implemented over the duration of treatment until RAOs are met.

Alternative 4 - SVE with In Situ (Anaerobic) Bioremediation (ISB) and Groundwater Recirculation. ISB involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as an electron acceptor in a process called chlororespiration. The ISB treatment entails injecting biodegradable substrates (e.g., vegetable-oil emulsion) into the source area at a prescribed injection spacing to achieve the desired radius of influence in the treatment area and to target low-permeability zones. A groundwater recirculation system can be constructed to optimally distribute treatment media to contaminants over the extent of the plume where direct injection is impracticable. LUCs would be implemented similarly to Alternative 3 until RAOs are met, thereby achieving unrestricted future use of the site.

The above alternatives provide a range of options for decision makers to evaluate as part of the remedy selection process. Alternative 1 involves no engineered remediation measures, LUCs, or monitoring and is included as a baseline comparison for the other alternatives. Alternatives 2, 3 and 4 are intended to achieve unrestricted future use of the site. Alternative 2 would reduce VOCs in soil gas and manage groundwater risk through MNA and LUCs until RAOs are met. Alternatives 3 and 4 would also reduce VOCs in soil gas and manage groundwater risk through treatment.

The relative performance of remedial alternatives considered in this FFS were compared against the NCP evaluation criteria to assess the merits of each alternative and to identify key trade-offs the Navy must consider when selecting a cleanup remedy. The NCP criteria are as follows:

Threshold criteria
- Overall protection of the environment
- Compliance with ARARs

Primary balancing criteria
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying criteria
- State acceptance
- Community acceptance

Alternatives 2, 3, and 4 meet the threshold criteria, while Alternative 1 does not. Alternatives 3 and 4 are similarly rated overall in satisfying the balancing criteria (i.e., lower ratings for some individual criteria are balanced by higher ratings for other individual criteria, resulting in overall similar ratings). Alternative 2 is rated lowest because, while it will reduce toxicity, mobility, and volume for VOCs in soil gas, it will not reduce toxicity, mobility, or volume of VOCs in groundwater through treatment. See Table ES-1 for a summary of rankings.
In addition to the nine CERCLA criteria, a comparative analysis of the sustainability of each alternative was also performed for this FFS. U.S. EPA (2010) currently defines "green" remediation as "the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions." The sustainability assessment used a green and sustainable remediation evaluation tool known as SiteWise. Inputs into SiteWise are segregated into four phases of work: RI, remedial action construction, operation, and long-term monitoring. Detailed inputs include vehicle mileage, personnel and equipment, construction details, residual handling, groundwater pumped, and equipment operated for each alternative. The eight sustainability factors modeled include greenhouse gas emissions, total energy used, water impacts, oxides of nitrogen (NOx) emissions, oxides of sulfur (SOx) emissions, airborne particulate (<10 micrometers in diameter) emissions (PM10), accident risk (fatality), and accident risk (injury). The sustainability of alternatives can also be considered in remedy selection and implementation. Of the active remedial alternatives, Alternative 2 is rated the most sustainable with the factors considered. A combination of alternatives may be considered during remedy selection or during remedy optimization.

Reference Documentation:

Brady. See Richard Brady & Associates.

Department of Toxic Substances Control (DTSC). California

Environmental Protection Agency. 2009. Interim Advisory for Green Remediation. December.

California Military Environmental Coordination Committee (CMECC). 1998. Institutional Control Protocol at Open Bases. January.

California Regional Water Quality Control Board (Water Board). 2007. "Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin." January. Available online at: http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

City of Concord, Concord Community Reuse Project Office (City of Concord). 2010a. Concord Community Reuse Plan, Final Environmental Impact Report. January.
City of Concord. 2010b. "Recent News and Events." Concord Community Reuse Project website. Accessed March 23. http://www.concordreuseproject.org.

Cook. 2009. Assessing the Use and Application of Zero-Valent Iron Nanoparticle Technology for Remediation at Contaminated Sites. Prepared for U.S. EPA Office of Solid Waste and Emergency Response Office of Superfund Remediation and Technology Innovation. August.

Department of Defense (DoD). 2003. Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions. October.

Department of the Navy (Navy). See Navy.

IT Corporation, 1990. Site Investigation at Building IA-25 Naval Weapons Station Concord, California. Report of Findings. February.

Natural Heritage Institute. 2006. Mt. Diablo Creek Watershed Inventory, Final Report. June 30.

Navy. 1945. Bldg. IA-25 Plan and Elevations, Drawing number 373 373, 1945

Navy. 1988. Site Approval/Explosive Safety RC1-89, N60036.

Navy. 2006. Environmental Restoration Program Manual. August.

Navy and Department of Toxic Substances Control. 2000. Memorandum of Agreement between the United States Department of the Navy and the California Department of Toxic Substances Control. Use of model "Covenant to Restrict Use of Property" at installations being closed and transferred by the Navy.

Office of Management and Budget (OMB). 2010. Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Revised December 2009.

United States Environmental Protection Agency (U.S. EPA). 1987. Remedial Action Costing Procedures Manual. EPA/600/8-87/049. October.

U.S. EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3 01. EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October.

U.S. EPA. 1993. Presumptive Remedies: Policy and Procedures. Office of Solid Waste and Emergency Response. Directive No. 9355.0-47FS. September.

U.S. EPA. 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Final. OSWER Directive 9200.4-17P. April.

U.S. EPA. 2000. Guidance for Data Quality Objectives Process for Hazardous Waste Site Investigations. Office of Environmental Information. January.

U.S. EPA. 2009a. Principles for Greener Cleanups. Office of Solid Waste and Emergency Response. August 27.

U.S. EPA. 2009b. Superfund Green Remediation Strategy. Office of Superfund Remediation and Technology Innovation. January.

Water Board. See California Regional Water Quality Control Board

Richard Brady & Associates (Brady), 2011. Final Remedial Investigation for Installation Restoration Program Site 29 Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California. March 4.

Shaw Environmental & Infrastructure Group (Shaw). 2011. Solar-powered Vapor Extraction Treatability Study Work Plan.

SulTech. 2007. Final Sampling and Analysis Plan (Field Sampling Plan/Quality Assurance Project Plan) for the Remedial Investigation at Installation Restoration Site 29 Naval Weapons Station Seal Beach Detachment Concord, Concord, California. May.

Estimate Documentation Report

Site Documentation:

Site ID: IRS29-A2
Site Name: Alternative 2 - SVE with MNA
Site Type: Soil & Groundwater

Media/Waste Type
Primary: Soil
Secondary: Groundwater

Contaminant
Primary: Volatile Organic Compounds (VOCs)
Secondary: Metals

Phase Names
Pre-Study: ☐
Study: ☐
Design: ☑
Removal/Interim Action: ☐
Remedial Action: ☑
Operations & Maintenance: ☑
Long Term Monitoring: ☑
Site Closeout: ☑

Documentation
Description: Alternative 2 - SVE with MNA

SVE would remove VOCs from the vadose zone by creating a vacuum to induce subsurface airflow through the vadose zone. The vacuum would be generated by a network of vapor extraction wells connected to a blower via the extraction wells within the treatment zone. VOC-laden soil gas would then treated in an aboveground treatment system, typically granular activated carbon (GAC) filters, to remove VOCs and discharge treated vapor effluent to the atmosphere in accordance with local emission standards and permitting. Figure 5-1 illustrates the assumed SVE treatment area and groundwater monitoring well network. A conventional power supply connected to existing power lines along Willow Pass Road was used as the means for estimating costs for all remedial alternatives in this FFS.

MNA is an enhanced monitoring program that assesses natural subsurface processes (e.g., dispersion, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials) to verify that these processes continue to reduce contaminant concentrations to acceptable levels. VOCs may be attenuated by adsorption or degraded to less toxic compounds by volatilization, biodegradation, and oxidation/reduction reactions, in addition to other physical attenuation processes. Together with chemical analytical testing, MNA can include modeling, periodic testing of groundwater for pH, oxidation-reduction potential, methane, iron, nitrate, sulfate, sulfide, and other selected indicators of chemical or biological processes. Source removal or source control also should be considered in conjunction with MNA. Both

institutional and engineering LUCs would be used to restrict use of groundwater for domestic supply and to implement possible building code requirements for structures built over the soil-vapor plume.

MNA is generally applied as a stand-alone technology when it can be used in a reasonable and predictable time frame, relative to other remedial options, to restore an aquifer to its designated beneficial uses (U.S. EPA 1999).

Effectiveness. SVE is expected to be effective at reducing concentrations of VOCs in soil gas. Risk to human receptors posed by VOCs at Site 29 would be reduced by mass removal of VOCs in the vadose zone and, to a lesser degree, groundwater. Site conditions, as demonstrated by the lack of breakdown products and low bacterial population, are not considered to be conductive to natural attenuation processes. Implementation of SVE alone would reduce risk of exposure via the inhalation pathway; LUCs would be effective in reducing risk to residential receptors via domestic use of groundwater.

Implementability. SVE is considered implementable given the site conditions. The electrical source needed to power the SVE system is accessible along Willow Pass Road. MNA is highly implementable with minor additions to the existing network. Installation of wells screened at deep and shallow intervals would add greater data resolution at the distal end of the plume. Site 29 is presently used as pasture land for cattle. Therefore, this alternative is considered technically feasible under the current land use scenario.

Cost. Costs for this alternative would include SVE installation, permitting, O&M, periodic sampling to measure effectiveness, post-treatment sampling and reporting, and LUCs. Potential capital costs associated with MNA are low. However, O&M costs could be high, depending on the duration required. The cost of MNA is therefore dependent upon its duration and effectiveness.

Conclusion. This alternative is considered a viable remedy to reduce risk to current and future receptors. Alternative 2 is expected to meet RAOs for the vadose zone only and reduces groundwater exposure risk through LUCs. A combination of this alternative with another groundwater alternative may be considered in the ROD. Alternative 2 is retained for detailed analysis.

Support Team: Shane DeGross, Richard Brady & Associates
Rain Zeng, Accord Engineering, Inc.
Max Pan, Accord Engineering, Inc.
Abram Eloskof - URS Group, Inc.

References: Focused Feasibility Study, IR Site 29, December 2011
Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California

Estimator Information

Estimator Name: Al Meyer
Estimator Title: Construction & Cost Engineering Specialist
Agency/Org./Office: URS Corporation - Denver DTC
Business Address: URS Corporation
URS Center Building
8181 East Tuffs Avenue
Denver, Colorado 80237
Telephone Number: Office 303-740-3966 Cell 303-887-8645

Estimate Documentation Report

Email Address: Albert.Meyer@urs.com
Estimate Prepared Date: 01/19/2012

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Shane DeGross
Reviewer Title: Project Manager
Agency/Org./Office: Richard Brady & Associates
Business Address: 3710 Ruffin Road
San Diego, CA 92123
Telephone Number: 916-436-8599
Email Address: sdegross@rbrady.net
Date Reviewed: 07/06/2011

Reviewer Signature: _____ **Date:** _____

Estimated Costs:

Phase Names	Direct Cost	Marked-up Cost
01 Remedial Design	$78,919	$262,655
02 Land Use Controls	$1,032,375	$3,103,799
03 Soil Vapor Extraction System	$707,121	$1,219,417
04 Soil Vapor Monitoring Probes	$410,956	$664,365
05 Groundwater Monitoring Wells	$96,615	$160,002
06 SVE O & M & Peformance Monitoring	$1,757,203	$3,225,333
07 Monitoring Well Maintenace	$16,450	$47,876
08 5-Year Reviews (Year 5 - 30)	$107,581	$326,814
09 Quarterly GW Monitoring (Year 1 - 2)	$306,560	$559,490
10 Semi-annual GW Monitoring (Year 3 - 4)	$163,667	$309,387
11 Annual GW Monitoring (Year 5)	$50,635	$109,288
12 MNA GW Monitoring (Year 6 - 30)	$1,265,877	$2,732,190
13 SVE System Decommissioning (Year 6)	$33,246	$63,131
14 Site Closeout (Year 30)	$191,630	$377,148
Total Cost:	$6,218,835	$13,160,896

Estimate Documentation Report

Phase Documentation:

Phase Type: Design - Detail
Phase Name: 01 Remedial Design
Description: Design Includes: Land Use Controls, Soil Vapor Extraction System and Work Plans.

Start Date: July, 2011
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Remedial Design	Yes	100	0

Total Marked-up Cost: $262,655

Technologies:

Estimate Documentation Report

Technology Name: **Remedial Design (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Project Approach		In-Situ Treatment	n/a
Complexity		Low	n/a
Project Planning		Yes	n/a
Treatability & Other Studies		No	n/a
Preliminary Design (30%)		Yes	n/a
Intermediate Design (60%)		Yes	n/a
Prefinal Design (90%)		Yes	n/a
Final Design (100%)		Yes	n/a
Bid Documents		Yes	n/a
Site Distance		25	MI
Level of RD Detail		Moderate	n/a
Project Planning			
Required Parameters			
Site Visit		Yes	n/a
RD Work Plan		Yes	n/a
Data Review		Yes	n/a
Public Meetings		Yes	n/a
Preliminary Design			
Required Parameters			
Design Criteria Memorandum		Yes	n/a
Basis of Design Report		Yes	n/a
Preliminary Plans & Specifications		Yes	n/a
VE Screening Report		Yes	n/a
Public Meetings		Yes	n/a
Intermediate Design			
Required Parameters			
Revised Basis of Design Report		Yes	n/a
Intermediate Plans && Specifications		Yes	n/a
VE Report		Yes	n/a
Prefinal Design			
Required Parameters			
Prefinal Plans & Specifications		Yes	n/a

Estimate Documentation Report

Technology Name: **Remedial Design (# 1)**

Description	*Default*	*Value*	*UOM*
Prefinal Design			
Required Parameters			
Construction QA Plan		Yes	n/a
Final Design			
Required Parameters			
Final Plans & Specifications		Yes	n/a
Final Report		Yes	n/a
Public Meetings		Yes	n/a
Post Design Fact Sheet		Yes	n/a
Bid Documents			
Required Parameters			
Prepare Bid Documents		Yes	n/a
Issue Invitations for Bids/Request Proposals		Yes	n/a
Contractor Bid Evaluation/Selection Support		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 02 Land Use Controls
Description: Includes: Adminstrative and Engineering Controls.

Approach: Ex Situ
Start Date: December, 2011
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
MEC Institutional Controls	Yes	30	70
LAND USE CONTROLS	Yes	100	0

Total Marked-up Cost: $3,103,799

Technologies:

Technology Name: **MEC Institutional Controls (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Planning		No	n/a
Implementation		No	n/a
Engineering Controls		Yes	n/a
Training and Follow Up		No	n/a
Quality Support Visits		No	n/a
Site Distance		50	MI (One-way)
Site Complexity		Low	n/a
Engineering Controls			
Required Parameters			
Type of Fence		Security	n/a
Length of Fence		880	LF

Comments:

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Rename Model		LAND USE CONTROLS	n/a
Planning Documents		Yes	n/a
Planning Documents: Start Date		2011	n/a
Implementation		Yes	n/a
Implementation: Start Date		2011	n/a
Monitoring & Enforcement		Yes	n/a
Monitoring & Enforcement: Start Date		2011	n/a
Modification/Termination		Yes	n/a
Modification/Termination: Start Date		2011	n/a
Type of Site		Transferring Government Installation	n/a
Planning Documents			
Required Parameters			
LUC Assurance Plan (LUCAP)		Yes	n/a
LUC Assurance Plan (LUCAP): Plan Complexity		Medium	n/a
LUC Implementation Plan (LUCIP)		Yes	n/a
LUC Implementation Plan (LUCIP): Number		1	EA
LUC Implementation Plan (LUCIP): Plan Complexity		Medium	n/a
Long-term Stewardship (LTS) Plan		Yes	n/a
Long-term Stewardship (LTS) Plan: Number		1	EA
Long-term Stewardship (LTS) Plan: Plan Complexity		Medium	n/a
Memorandum of Agreements (MOA)		Yes	n/a
Memorandum of Agreements (MOA): Number		1	EA
Memorandum of Agreements (MOA): Plan Complexity		Medium	n/a
Installation (or City) Master Plan		Yes	n/a
Installation (or City) Master Plan: Plan Complexity		Medium	n/a
Construction Permitting		Yes	n/a
Construction Permitting: Number		1	EA
Construction Permitting: Plan Complexity		Medium	n/a
Geographic Information Systems (GIS)/Overlay Maps		Yes	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Planning Documents			
Required Parameters			
Geographic Information Systems (GIS)/Overlay Maps: Number		1	EA
Geographic Information Systems (GIS)/Overlay Maps: Plan Complexity		Medium	n/a
Planning Meetings			
Required Parameters			
LUCAP: Number of Meetings		2	EA
LUCAP: Number of People		2	EA
LUCAP: Number of Days		1	EA
LUCAP: Airfare Cost		650	$
LUCAP: Mileage to Meeting Site		50	MI
LUCIP: Number of Meetings		2	EA
LUCIP: Number of People		2	EA
LUCIP: Number of Days		1	EA
LUCIP: Airfare Cost		650	$
LUCIP: Mileage to Meeting Site		50	MI
LTS: Number of Meetings		2	EA
LTS: Number of People		2	EA
LTS: Number of Days		1	EA
LTS: Airfare Cost		650	$
LTS: Mileage to Meeting Site		50	MI
MOA: Number of Meetings		2	EA
MOA: Number of People		2	EA
MOA: Number of Days		1	EA
MOA: Airfare Cost		650	$
MOA: Mileage to Meeting Site		50	MI
Master Plan: Number of Meetings		2	EA
Master Plan: Number of People		2	EA
Master Plan: Number of Days		1	EA
Master Plan: Airfare Cost		650	$
Master Plan: Mileage to Meeting Site		50	MI

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Planning Meetings			
Required Parameters			
Construction Permitting: Number of Meetings		2	EA
Construction Permitting: Number of People		2	EA
Construction Permitting: Number of Days		1	EA
Construction Permitting: Airfare Cost		650	$
Construction Permitting: Mileage to Meeting Site		50	MI
GIS/Overlay Maps: Number of Meetings		2	EA
GIS/Overlay Maps: Number of People		2	EA
GIS/Overlay Maps: Number of Days		1	EA
GIS/Overlay Maps: Airfare Cost		650	$
GIS/Overlay Maps: Mileage to Meeting Site		50	MI
Implementation			
Required Parameters			
Modify Installation (or City) Master Plan		Yes	n/a
Modify Installation (or City) Master Plan: Task Complexity		Medium	n/a
Deed Notification		Yes	n/a
Deed Notification: Number		1	EA
Deed Notification: Task Complexity		Medium	n/a
Negotiating Easements		Yes	n/a
Negotiating Easements: Number		1	EA
Negotiating Easements: Task Complexity		Medium	n/a
Restrictive Covenants		Yes	n/a
Restrictive Covenants: Number		1	EA
Restrictive Covenants: Task Complexity		Medium	n/a
Equitable Servitudes		Yes	n/a
Equitable Servitudes: Number		1	EA
Equitable Servitudes: Task Complexity		Medium	n/a
Access Control Signs		Yes	n/a
Access Control Signs: Number		4	EA
Access Control Signs: Task Complexity		Medium	n/a
Utility Notification Service		Yes	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Implementation			
Required Parameters			
Access Control Signs: Number		1	EA
Access Control Signs: Task Complexity		Medium	n/a
Geographic Information Systems (GIS)/Overlay Maps		Yes	n/a
Geographic Information Systems (GIS)/Overlay Maps: Number		1	EA
Geographic Information Systems (GIS)/Overlay Maps: Task Complexity		Medium	n/a
Develop Finding of Suitablility to Transfer (FOST)		Yes	n/a
Develop Finding of Suitablility to Transfer (FOST): Task Complexity		Medium	n/a
Monitoring & Enforcement			
Required Parameters			
Duration of Monitoring/Enforcement		32	Years
Notice Letters		Yes	n/a
Notice Letters: Number		10	EA
Notice Letters: Frequency		Annually	n/a
Guard Service/Security		No	n/a
Reports & Certifications		Yes	n/a
Reports & Certifications: Frequency		Annually	n/a
Site Visits/Inspections		Yes	n/a
Site Visits/Inspections: Number		1	EA
Site Visits/Inspections: Safety Level		D	n/a
Site Visits/Inspections: Duration		3	Days
Site Visits/Inspections: Number of People		2	EA
Site Visits/Inspections: Frequency		Annually	n/a
Site Visits/Inspections: Airfare		650	$ Per Ticket
Site Visits/Inspections: Mileage		50	MI
Modify/Termination			
Required Parameters			
Document Evaluation		Yes	n/a
Document Evaluation: Number		1	EA
Document Evaluation: Plan Complexity		Medium	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Modify/Termination			
Required Parameters			
Modify LUC Documents		Yes	n/a
Modify LUC Documents: Number		1	EA
Modify LUC Documents: Plan Complexity		Medium	n/a
Amend Decision Documents		Yes	n/a
Amend Decision Documents: Number		1	EA
Amend Decision Documents: Plan Complexity		Medium	n/a
Termination Letters		Yes	n/a
Termination Letters: Number		1	EA
Termination Letters: Plan Complexity		Medium	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 03 Soil Vapor Extraction System
Description: Includes: SVE System Installation, 1,500-ft of Underground Power Service and SVE Building.
Approach: In Situ
Start Date: January, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Soil Vapor Extraction	Yes	30	70
Carbon Adsorption (Gas)	Yes	30	70
Decontamination Facilities	Yes	30	70
Residual Waste Management	Yes	100	0
Professional Labor Management	Yes	100	0
UNDERGROUND ELECTRIC SERVICE	Yes	30	70
SVE & GW TREATMENT BUILDING	Yes	30	70

Total Marked-up Cost: $1,219,417

Technologies:

Estimate Documentation Report

Technology Name: **Soil Vapor Extraction (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Installation Type		Vertical Wells	n/a
Soil Type		Sand/Gravelly Sand Mixture	n/a
Surface Area of Contamination		48,000	SF
Depth to Base of Contamination		50	FT
Safety Level		D	n/a
Drilling			
Required Parameters			
Average Well Depth		45	LF
Formation Type		Consolidated	n/a
Drilling Method		Air Rotary	n/a
Well Diameter		4 Inch	n/a
Well Construction Material		PVC Schedule 40	n/a
Split Spoon Sample Collection		Yes	n/a
Drum Drill Cuttings		No	n/a
Average Number of Soil Samples per Well		1	EA
Soil Analytical Template		System Soil - VOCs	n/a
Drilling Safety Level		D	n/a
Vertical Wells			
Secondary Parameters			
Vertical Well: Extraction Well Spacing	50	50	FT
Vertical Well: Number of Vapor Extraction Wells	25	25	EA
Vertical Well: Average Vapor Flow Rate per Well	35	35	CFM
Vertical Well: Total Vapor Flow Rate	875	875	CFM
Vertical Well: Knockout Drums	0	1	EA
Vertical Well: Floor Slab Sawing	0	0	HR
Vertical Well: Equipment Enclosure	Yes	Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Carbon Adsorption (Gas) (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Influent Flow Rate		875	CFM
Adsorption System		Modular Carbon Adsorbers (Disposable)	n/a
Know Total Organic Concentration		No	n/a
Influent Total Organic Concentration (for O&M)		0	ppm
System Redundancy		Two Adsorbers in Series	n/a
Blower		Yes	n/a
Heater		No	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		Yes	n/a
Equipment Rating		Medium Equipment Rating	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		6	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		6	weeks
Safety Level		D	n/a
Decon Pad			
Secondary Parameters			
Area of Decontamination Pad	800	800	SF
Use Flexible Membrane Liner	Yes	Yes	n/a
Percentage of Time Decontamination Pad in Use	25	25	%
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		18,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		39	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		825,349	$
Percentage	18.5	18.5	%
Dollar Amount		152,690	$

Comments:

Estimate Documentation Report

Technology Name: **User Defined Estimate (# 1)**
User Name: **UNDERGROUND ELECTRIC SERVICE**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		UNDERGROUND ELECTRIC SERVICE	n/a
WBS Type		HTRW	n/a
Selected WBS		331.03.06	n/a
Safety Level		D	n/a

Comments:

Technology Name: **User Defined Estimate (# 2)**
User Name: **SVE & GW TREATMENT BUILDING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		SVE & GW TREATMENT BUILDING	n/a
WBS Type		HTRW	n/a
Selected WBS		331.13.23	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 04 Soil Vapor Monitoring Probes
Description: Includes: VMP Wells Installation.

Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Special Well Drilling & Installation	Yes	30	70
Residual Waste Management	Yes	100	0
Decontamination Facilities	Yes	30	70
Professional Labor Management	Yes	100	0

Total Marked-up Cost: $664,365

Technologies:

Estimate Documentation Report

Technology Name: **Special Well Drilling & Installation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Type of Well		Vertical	n/a
Safety Level		D	n/a
Vertical Wells			
Required Parameters			
Formation Type		Consolidated	n/a
Completion Type		Single Cased Well	n/a
Number of Wells/Borings		20	EA
Depth of Boring		0	FT
Depth to Bottom of Outer Casing		0	FT
Depth to Bottom of Middle Casing		0	FT
Depth to Top of Screen		50	FT
Screen Length		20	FT
Vertical Secondary			
Secondary Parameters			
Well Construction Material	PVC Schedule 40	PVC Schedule 40	n/a
Well Diameter	4	4	IN
Drilling Method	Water/Mud Rotary	Air Rotary	n/a
Drum Drill Cuttings	Yes	Yes	n/a
Soil Sample Collection	Yes	Yes	n/a
Well Development	Yes	No	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		6,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		71	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		No	n/a
Equipment Rating		n/a	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		2	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		2	weeks
Safety Level		D	n/a
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Estimate Documentation Report

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		558,290	$
Percentage	19	19	%
Dollar Amount		106,075	$

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 05 Groundwater Monitoring Wells
Description: Includes: Installation of 4 New Groundwater Monitoring Wells 70-ft average depth.
Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Groundwater Monitoring Well	Yes	30	70
Decontamination Facilities	Yes	30	70
Residual Waste Management	Yes	100	0
Professional Labor Management	Yes	100	0

Total Marked-up Cost: $160,002

Technologies:

Estimate Documentation Report

Technology Name: **Groundwater Monitoring Well (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Number of Aquifers		One	n/a
Include Guard Posts		Yes	n/a
Depth to Groundwater to Aquifer One		45	FT
Number of Wells to Aquifer One		4	EA
Safety Level		D	n/a
Aquifer One			
Required Parameters			
Aquifer One: Average Well Depth		70	LF
Aquifer One: Formation Type		Consolidated	n/a
Aquifer One: Drilling Method		Air Rotary	n/a
Aquifer One: Well Diameter		4 Inch	n/a
Aquifer One: Well Construction Material		PVC Schedule 40	n/a
Aquifer One: Split Spoon Sample Collection		Yes	n/a
Aquifer One: Average Number of Soil Samples per Well		1	EA
Aquifer One: Soil Analytical Template		System Soil - VOCs	n/a
Aquifer One: Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		No	n/a
Equipment Rating		n/a	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		1	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		1	weeks
Safety Level		D	n/a
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		3,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		10	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		133,446	$
Percentage	19.9	19.9	%
Dollar Amount		26,556	$

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: 06 SVE O & M & Peformance Monitoring
Description: SVE System Operation & Maintenance including Carbon Changeout, Preformance Monitoring at 25 SVE Wellheads plus 20 Vapor Monitoring Probes for 60 months.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Operations and Maintenance	Yes	100	0

Total Marked-up Cost: $3,225,333

Technologies:

Estimate Documentation Report

Technology Name: **Operations and Maintenance**

Description	*Default*	*Value*	*UOM*
Labor			
Secondary Parameters			
Operations Labor: Type		Moderate	n/a
Professional Labor: Type		Minimum	n/a
Analytical			
Secondary Parameters			
Wastewater/Effluent: Sampling Frequency		Exclude from Estimate	n/a
Wastewater/Effluent: Primary Analytical Template		None	n/a
Wastewater/Effluent: Secondary Analytical Template		None	n/a
Air Emissions: Sampling Frequency		Semi-annually	n/a
Air Emissions: Primary Analytical Template		System Air Emissions - VOCs	n/a
Air Emissions: Secondary Analytical Template		None	n/a
Solid Wastes: Sampling Frequency		Exclude from Estimate	n/a
Solid Wastes: Primary Analytical Template		None	n/a
Solid Wastes: Secondary Analytical Template		None	n/a
Heating Requirements			
Secondary Parameters			
Air Streams: Flow Rate		875	CFM
Air Streams: Temperature Difference		20	F
Air Streams: Months per Year		12	Month
Water Streams: Flow Rate		0	CFM
Water Streams: Temperature Difference		0	F
Water Streams: Months per Year		0	Month
Facility: Area		600	SF
Facility: Temperature Difference		20	F
Facility: Months per Year		6	Month

Comments:

Estimate Documentation Report

Technology Name: **Soil Vapor Extraction (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Installation Type		Vertical Wells	n/a
Average Well Depth		45	LF
Vertical Well: Number of Vapor Extraction Wells		25	EA
Vertical Well: Total Vapor Flow Rate		875	CFM
Horizontal Trenches: Total Vapor Flow Rate		0	CFM

Technology Name: **Carbon Adsorption (Gas) (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Influent Flow Rate		875	CFM
Adsorption System		Modular Carbon Adsorbers (Disposable)	n/a
Influent Total Organic Concentration (for O&M)		1	ppm

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: 07 Monitoring Well Maintenace
Description: Includes: Moitoring well redevelopment of 4 of 13 existing wells and 1 of 4 new wells on a 7 year-cycle.

It can be reasonably assumed that some or all of the Groundwater Long Term Monitoring wells may require redevelopment. RACER does not provide a given Technology to address this issue. However the Natural Attenuation Technology can be modified based on its "start date" and "out-year capability" to address monitoring well maintenance.

Replacement of monitoring wells is not considered in this cost estimate.

Start Date: February, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Natural Attenuation	Yes	100	0
Natural Attenuation	Yes	100	0
Natural Attenuation	Yes	100	0
Natural Attenuation	Yes	100	0

Total Marked-up Cost: $47,876

Technologies:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2018	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 1)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2025	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 2)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 3)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2032	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 3)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 4)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2039	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 4)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 08 5-Year Reviews (Year 5 - 30)
Description: Includes: 5-Year Reviews with Rebound Study and Travel for 3 people. The level of effort varies as follows: Year 2017 = High, Year 2022 thru Year 2037 = Low and Year 2042 = Medium.

Start Date: March, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	Yes	100	0
Five-Year Review	Yes	100	0
Five-Year Review	Yes	100	0

Total Marked-up Cost: $326,814

Technologies:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		High	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2017	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Low	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2022	n/a
No. Reviews		4	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 2)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 3)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Moderate	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2042	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 3)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 09 Quarterly GW Monitoring (Year 1 - 2)
Description: Includes: Quarterly Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC and MNA.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $559,490

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		4	n/a
Number of Events (Out Years)		4	n/a
Number of Years (Out Years)		1	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC & MNA - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 10 Semi-annual GW Monitoring (Year 3 - 4)
Description: Includes: Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC and MNA.

Start Date: April, 2014
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $309,387

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		2	n/a
Number of Events (Out Years)		2	n/a
Number of Years (Out Years)		1	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC & MNA - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 11 Annual GW Monitoring (Year 5)
Description: Includes: Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC and MNA.

Start Date: April, 2016
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $109,288

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		0	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		0	n/a
Number of Years (Out Years)		0	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC & MNA - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 12 MNA GW Monitoring (Year 6 - 30)
Description: Includes: Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC and MNA.

Start Date: April, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $2,732,190

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		1	n/a
Number of Years (Out Years)		24	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC & MNA - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 13 SVE System Decommissioning (Year 6)
Description: Includes: Decommissioning of the SVE System including SVE underground piping, Abandonmentof of 25 SVE Wells and Abandonment of 20 Vapor Monitoring Probes.

Start Date: March, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Demolition, Buildings	Yes	30	70
Demolition, Underground Pipes	Yes	30	70

Total Marked-up Cost: $63,131

Technologies:

Estimate Documentation Report

Technology Name: **Demolition, Buildings (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Building Area		600	SF
Type of Building		Steel	n/a
Include Load and Haul Costs		Yes	n/a
Amount of Hazardous Material		0	%
Number of Stories		Single	n/a
Safety Level		D	n/a
Height/Demo Factor			
Secondary Parameters			
Floor to Floor Height	12	12	FT
Demolition Factor	0.03	0.0339	CY/CF
Load and Haul			
Secondary Parameters			
Non-Hazardous Material: Truck Type		Highway	n/a
Non-Hazardous Material: Volume		245	CY
Non-Hazardous Material: Distance (One-way)		15	MI
Non-Hazardous Material: Dump Charge		15	$/CY
Hazardous Material: Truck Type		Off Highway	n/a
Hazardous Material: Volume		0	CY
Hazardous Material: Distance (One-way)		0	FT
Hazardous Material: Dump Charge		0	$/CY

Comments:

Estimate Documentation Report

Technology Name: **Demolition, Underground Pipes (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Pipe Material		Steel	n/a
Length of Run		1,563	LF
Bulking Factor		1.3	CY/CY
Include Load and Haul Costs		Yes	n/a
Safety Level		D	n/a
Trenching			
Secondary Parameters			
Soil Type	Silt/Silty-Clay Mixture	Silt/Silty-Clay Mixture	n/a
Moisture Content	Dry	Dry	n/a
Inside Pipe Diameter	10.2 cm (4 IN)	10.2 cm (4 IN)	n/a
Average Pipe Depth	4	4	FT
Overdig	1	1	FT
Vertical Trench Height	4	4	FT
Dewatering Pump	No	No	n/a
Load and Haul			
Secondary Parameters			
Truck Type		Highway	n/a
Load and Haul Volume		10.26138	CY
One-way Haul Distance		15	MI
Dump Charge		15	$/CY

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 14 Site Closeout (Year 30)
Description: Includes: Site Close-out documantation and Abandonment of 4 New and 13 Existing Groundwater Wells.

Start Date: May, 2042
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Site Close-Out Documentation	Yes	100	0
Well Abandonment	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $377,148

Technologies:

Estimate Documentation Report

Technology Name: **Site Close-Out Documentation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Meetings		Yes	n/a
Work Plans and Reports		Yes	n/a
Documents		Yes	n/a
Site Close-Out Complexity		Low	n/a
Meetings			
Required Parameters			
Kick Off/Scoping Meetings		Yes	n/a
Kick Off/Scoping Meetings: Number of Meetings	1	1	EA
Kick Off/Scoping Meetings: Travel		Yes	n/a
Kick Off/Scoping Meetings: Travelers		3	EA
Kick Off/Scoping Meetings: Days		2	Days
Kick Off/Scoping Meetings: Air Fare		1,950	$
Review Meetings		Yes	n/a
Review Meetings: Number of Meetings	1	2	EA
Review Meetings: Travel		Yes	n/a
Review Meetings: Travelers		3	EA
Review Meetings: Days		2	Days
Review Meetings: Air Fare		1,950	$
Regulatory Review Meetings		Yes	n/a
Regulatory Review Meetings: Number of Meetings	1	2	EA
Regulatory Review Meetings: Travel		Yes	n/a
Regulatory Review Meetings: Travelers		3	EA
Regulatory Review Meetings: Days		2	Days
Regulatory Review Meetings: Air Fare		1,950	$
Work Plans & Reports			
Required Parameters			
Work Plans		Yes	n/a
Draft Work Plan		Yes	n/a
Final Work Plan		Yes	n/a
Reports		Yes	n/a
Draft Close-Out Report		Yes	n/a

Estimate Documentation Report

Technology Name: **Site Close-Out Documentation (# 1)**

Description	*Default*	*Value*	*UOM*
Work Plans & Reports			
Required Parameters			
Draft Final Close-Out Report		Yes	n/a
Final Close-Out Report		Yes	n/a
Progress Reports		Yes	n/a
Project Duration	8	8	months
Documents			
Required Parameters			
Draft Decision Document		Yes	n/a
Draft Final Decision Document		Yes	n/a
Final Decision Document		Yes	n/a
Long Term Document Storage		Yes	n/a
Number of Boxes		20	EA
Duration of Storage		7	Yrs

Comments:

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Groundwater Monitoring Well - Aquifer One	n/a
Number of Wells		4	EA
Well Depth		70	FT
Well Diameter		2	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Consolidated	n/a
Karst Formation Type		No	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		55	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

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Attachment B-2

Detailed Cost Estimate for Alternative 3

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29 Location: CONCORD, CALIFORNIA

Project ID: IRS29 Report Option: Calendar

Site Name: Alternative 3 - SVE with ZVI Injection

Site Type: Soil & Groundwater

Site ID: IRS29-A3

Year		1	2	3	4	5	6	7	8	9	10	11
Fiscal Year		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Cost Type	**Description**											
Design	01 Remedial Design	$ 262,655										
Remedial Action	02 Land Use Controls	$ 1,712,438	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479
Remedial Action	03 Soil Vapor Extraction System		$ 1,219,417									
Remedial Action	04 Soil Vapor Monitoring Probes		$ 664,365									
Remedial Action	05 Groundwater Monitoring Wells		$ 160,002									
Remedial Action	06 ZVI Injection & Hydraulic Fracturing		$ 8,211,873									
Operations & Maintenance	07 SVE O & M & Peformance Monitoring		$ 527,188	$ 674,536	$ 674,536	$ 674,536	$ 674,536					
Operations & Maintenance	08 Monitoring Well Maintenace								$ 11,969			
Long Term Monitoring	09 5-Year Reviews (Year 5 -15)							$ 91,235				
Long Term Monitoring	10 Quarterly GW Monitoring (Year 1 - 2)		$ 270,473	$ 360,631	$ 90,158							
Long Term Monitoring	11 Semi-annual GW Monitoring (Year 3 - 4)				$ 154,033	$ 205,378	$ 51,344					
Long Term Monitoring	12 Annual GW Monitoring (Year 5)						$ 124,796					
Long Term Monitoring	13 MNA Annual GW Monitoring (Year 6 - 15)							$ 124,796	$ 124,796	$ 124,796	$ 124,796	$ 124,796
Site Closeout	14 SVE System Decommissioning (Year 6)							$ 671,492				
Site Closeout	15 Site Closeout (Year 15)											
Sub-Total		$ 1,975,094	$ 11,098,797	$ 1,080,646	$ 964,206	$ 925,393	$ 896,156	$ 933,002	$ 182,244	$ 170,275	$ 170,275	$ 170,275
Real Discount	2.30%	0.9795	0.9593	0.9396	0.9203	0.9014	0.8829	0.8648	0.8470	0.8296	0.8126	0.7959
Nominal Discount	5.80%	0.9452	0.8934	0.8444	0.7981	0.7543	0.7130	0.6739	0.6370	0.6020	0.5690	0.5378
Inflation	3.50%	1.0363	1.0739	1.1128	1.1532	1.1950	1.2383	1.2832	1.3298	1.3780	1.4280	1.4798
Total		$ 1,934,527	$ 10,647,557	$ 1,015,417	$ 887,397	$ 834,183	$ 791,235	$ 806,848	$ 154,365	$ 141,265	$ 138,363	$ 135,521

Cost Over Time

Sub-Total		$ 1,975,094	$ 11,098,797	$ 1,080,646	$ 964,206	$ 925,393	$ 896,156	$ 933,002	$ 182,244	$ 170,275	$ 170,275	$ 170,275
Inflation	3.50%	1.0363	1.0739	1.1128	1.1532	1.1950	1.2383	1.2832	1.3298	1.3780	1.4280	1.4798
Total		$ 2,046,729	$ 11,918,492	$ 1,202,546	$ 1,111,887	$ 1,105,833	$ 1,109,736	$ 1,197,268	$ 242,345	$ 234,642	$ 243,152	$ 251,971

Database Date: Jan-08

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29

Project ID: IRS29

Site Name: Alternative 3 - SVE with ZVI Injection

Site Type: Soil & Groundwater

Site ID: IRS29-A3

Year		12	13	14	15	16	17	18	19	20	21	
Fiscal Year		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	
Cost Type	**Description**											**Total**
Design	01 Remedial Design											$ 262,655
Remedial Action	02 Land Use Controls	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479					$ 2,440,104
Remedial Action	03 Soil Vapor Extraction System											$ 1,219,417
Remedial Action	04 Soil Vapor Monitoring Probes											$ 664,365
Remedial Action	05 Groundwater Monitoring Wells											$ 160,002
Remedial Action	06 ZVI Injection & Hydraulic Fracturing											$ 8,211,873
Operations & Maintenance	07 SVE O & M & Peformance Monitoring											$ 3,225,333
Operations & Maintenance	08 Monitoring Well Maintenace				$ 11,969							$ 23,938
Long Term Monitoring	09 5-Year Reviews (Year 5 -15)	$ 42,546					$ 65,395					$ 199,177
Long Term Monitoring	10 Quarterly GW Monitoring (Year 1 - 2)											$ 721,262
Long Term Monitoring	11 Semi-annual GW Monitoring (Year 3 - 4)											$ 410,755
Long Term Monitoring	12 Annual GW Monitoring (Year 5)											$ 124,796
Long Term Monitoring	13 MNA Annual GW Monitoring (Year 6 - 15)	$ 124,796	$ 124,796	$ 124,796	$ 124,796	$ 124,796						$ 1,247,960
Site Closeout	14 SVE System Decommissioning (Year 6)											$ 671,492
Site Closeout	15 Site Closeout (Year 15)						$ 367,218					$ 367,218
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
												$ -
Sub-Total		$ 212,821	$ 170,275	$ 170,275	$ 182,244	$ 170,275	$ 478,092	$ -	$ -	$ -	$ -	$ 19,950,345
Real Discount	2.30%	0.7796	0.7635	0.7479	0.7325	0.7175	0.7027	0.6883	0.6741	0.6603	0.6467	- - -
Nominal Discount	5.80%	0.5084	0.4805	0.4542	0.4293	0.4057	0.3835	0.3625	0.3426	0.3238	0.3061	- - -
Inflation	3.50%	1.5335	1.5891	1.6467	1.7064	1.7683	1.8325	1.8989	1.9678	2.0392	2.1131	- - -
Total		$ 165,905	$ 130,012	$ 127,341	$ 133,493	$ 122,164	$ 335,963	$ -	$ -	$ -	$ -	$ 18,501,556

Cost Over Time

Sub-Total		$ 212,821	$ 170,275	$ 170,275	$ 182,244	$ 170,275	$ 478,092	$ -	$ -	$ -	$ -	$ 19,950,345
Inflation	3.50%	1.5335	1.5891	1.6467	1.7064	1.7683	1.8325	1.8989	1.9678	2.0392	2.1131	- - -
Total		$ 326,352	$ 270,580	$ 280,394	$ 310,988	$ 301,102	$ 876,088	$ -	$ -	$ -	$ -	$ 23,030,104

Database Date: Jan-08

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Estimate Documentation Report

System:

RACER Version: 10.0.2
Database Location: C:\04 Projects\RACER 2008\RACER 2008 20121205.mdb

Folder:

Folder Name: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project:

Project ID: IRS29
Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29
Project Category: None

Location
State / Country: CALIFORNIA
City: CONCORD

Location Modifier	Default	User
	1.286	1.286

Options
Database: System Costs
Cost Database Date: 2008
Report Option: Calendar

Description

Prepared for:

U.S. Department of the Navy
Naval Facilities Engineering Command, Southwest
San Diego, California

prepared under:

Conrtract Number: N62473-10-D-0814
Task Order: 00005
DCN: AM8A-0814-0005-0001

Executive Summary

Accord MACTEC 8A JV (AM8AJV), a joint venture, and Richard Brady & Associates (Brady), in subcontract to AM8AJV, prepared this Focused

Estimate Documentation Report

Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29, on behalf of the Naval Facilities Engineering Command Base Realignment and Closure (BRAC) Program Management Office (PMO) West, in accordance with Contract Number N62473-10-D-0814, Delivery Order 0005. This FFS follows requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), related United States Environmental Protection Agency (U.S. EPA) technical guidance, and the U.S. Department of the Navy's Environmental Restoration Program Manual (Navy 2006).

The purpose of this FFS is to develop and evaluate remedial alternatives to mitigate human health and environmental risks associated with exposure to groundwater and soil gas impacted by volatile organic compounds (VOCs) at Installation Restoration (IR) Program Site 29 (Site 29 or "site"), former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California, based on the conclusions and recommendations of the Final Remedial Investigation (RI) Report (Brady 2011). This document uses an FFS format because the technologies used in a treatability study (Shaw 2011) currently underway have been proven to effectively treat chlorinated solvents in groundwater under the hydrogeologic conditions present at Site 29 and because soil-gas contamination will be treated using soil-vapor extraction (SVE) technology.

Site 29 is located within the south-central portion of the inland area, approximately 1,600 feet southwest of the intersection of L Street and Kinne Boulevard and approximately 1,000 feet southwest of Seal Creek (also known as Mt. Diablo Creek outside of the base). The site is located on the side of a hill underlain by silty clay and sandy gravel units.

As a result of the final RI and previous investigations, the area of Site 29 was found to be impacted with VOCs in soil gas (in the vicinity of Building IA-19) and groundwater extending approximately 850 feet downgradient. The VOC-impacted vadose zone soils extend over approximately 1 acre, and the estimated area of groundwater impact is over 6 acres.

Factors considered in determining remedial action objectives (RAOs) include potential human health and ecological risks and exposure pathways, chemicals of concern (COCs), affected media, and chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs). The RAOs are based on the planned, unrestricted future use of Site 29 (City of Concord 2010).

A baseline human health risk assessment (BHHRA) was performed to assess potential impacts to human health from exposure to chemicals in soil, soil gas, and groundwater at Site 29 (Brady 2011). Future residential (unrestricted) use, commercial/industrial worker, and construction/utility worker scenarios were evaluated. For future residential use, cancer risk estimates exceed the 10?4 upper limit of the risk management range, and the hazard index (HI) values exceed 1.0 for all combinations (two methods and two development scenarios). The cancer risk and noncancer hazard estimates are primarily associated with arsenic from two soil sample locations, from trichloroethene (TCE) in soil gas, and from exposure to multiple chemicals from domestic use of groundwater. The RI concluded

that the metals from those two soil locations beneath IA-25 were associated with soils impacted by lead-based paint residues. Laboratory analysis and detailed evaluation of samples via scanning electron microscope/energy dispersive x-ray spectroscopy confirmed that lead in soil beneath IA-25 is derived from lead-based paint. Paints typically contain other metals used for pigment, such as arsenic, cadmium, cobalt, chromium, and zinc. The RI concluded that the elevated concentrations of these other metals are also associated with paint residues. No further action under CERCLA was recommended for lead-based-paint-contaminated soil. For commercial/industrial worker scenarios, the risk estimates are within the risk management range and the HIs are less than 1.0. For the construction/utility worker scenarios, the risk estimates exceed the 10?4 upper limit of the risk management range, and the HI values exceed 1.0 for this highly exposed receptor. Risk to future construction workers is predominantly attributable to exposure to TCE in soil gas and groundwater.

Contaminants at Site 29 are generally considered unlikely to pose a hazard to ecological receptors with the exception of TCE and 1,1-dichloroethene (1,1-DCE) in soil gas and metals in soil beneath Building IA-25. Soils beneath Building IA-25 do not pose an unacceptable risk to ecological receptors if the soil and building remain unvegetated and left in place. Primary and secondary consumers (e.g., vole, meadowlark, robin, and shrew) are primarily exposed to metals through plant and soil invertebrate consumption. Soils beneath IA-25 only pose a risk to ecological receptors if the building is removed, the soils remain undisturbed, and the area is revegetated (Brady 2011).

The media affected by VOCs for which remediation alternatives are evaluated in this FFS are soil gas and groundwater. RAOs are medium-specific goals for protecting human health and the environment and consider affected media and COCs, existing and potential receptors, exposure pathways, and ARARs. The RAOs for Site 29 are as follows:
- Prevent residential exposure to VOCs via potential inhalation of soil gas through vapor intrusion at concentrations that result in a cancer risk that exceeds the risk management range of 1x10-4 to 1x10-6 and a HI greater than 1.0.
- For burrowing mammals, reduce the inhalation hazard of TCE and 1,1-DCE in shallow soil gas to a hazard quotient of less than 1.0.
- Prevent residential exposure to VOCs via potable use of groundwater containing concentrations that result in a cancer risk that exceeds the risk management range of 1x10-4 to 1x10-6 and a HI greater than 1.0.

Risks to potential future residents and construction/utility workers exceed the 10?4 upper limit of the risk management range and the HI of 1.0. VOCs in soil gas at the site pose a hazard to burrowing mammals. The primary pathways for human exposure were identified as inhalation of soil gas and domestic use of groundwater (Brady 2011).

The proposed remediation goals (RGs) for VOCs presented in this FFS are based on the results of the risk assessments and on unrestricted use of Site 29.

The Navy has included some form of land use controls (LUCs) in all of the remedial alternatives for Site 29, with the exception of no action. The

following four remedial action alternatives were considered for this FFS.

Alternative 1 - No Action. No remedial action of any type would be conducted; this alternative serves as the baseline against which the remaining alternatives can be compared.

Alternative 2 - SVE with Monitored Natural Attenuation (MNA). This alternative would institute an SVE presumptive remedy to remove VOC contamination from the vadose zone. SVE, also known as "soil venting" or "vacuum extraction" is an in situ remedial technology that reduces concentrations of volatile constituents adsorbed to soils in the unsaturated (vadose) zone. MNA of the groundwater plume is a technique used to monitor or test the progress of natural attenuation processes that can degrade contaminants in soil and groundwater. It can be used in conjunction with SVE as a finishing option, or if appropriate, as the only remediation process if the rate of contaminant degradation is fast enough to protect human health and the environment. Natural processes can then mitigate the remaining amount of pollution; regular monitoring of the groundwater can verify those reductions. Both institutional and engineering LUCs would be used to restrict use of groundwater for domestic supply and to implement mitigating requirements for structures built over the soil-vapor plume until RAOs are met.

Alternative 3 - SVE with Zero-Valent Iron (ZVI) Injection. Similar to Alternative 2, SVE would be the primary technology used to treat VOCs in the vadose zone. In addition to SVE, groundwater treatment would be conducted by ZVI injection. ZVI is a strong reducing agent that is injected (in solution) into contaminated groundwater to reduce VOC concentrations. LUCs, such as fencing, signage, and land use restrictions, would be implemented over the duration of treatment until RAOs are met.

Alternative 4 - SVE with In Situ (Anaerobic) Bioremediation (ISB) and Groundwater Recirculation. ISB involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as an electron acceptor in a process called chlororespiration. The ISB treatment entails injecting biodegradable substrates (e.g., vegetable-oil emulsion) into the source area at a prescribed injection spacing to achieve the desired radius of influence in the treatment area and to target low-permeability zones. A groundwater recirculation system can be constructed to optimally distribute treatment media to contaminants over the extent of the plume where direct injection is impracticable. LUCs would be implemented similarly to Alternative 3 until RAOs are met, thereby achieving unrestricted future use of the site.

The above alternatives provide a range of options for decision makers to evaluate as part of the remedy selection process. Alternative 1 involves no engineered remediation measures, LUCs, or monitoring and is included as a baseline comparison for the other alternatives. Alternatives 2, 3 and 4 are intended to achieve unrestricted future use of the site. Alternative 2 would reduce VOCs in soil gas and manage groundwater risk through MNA and LUCs until RAOs are met. Alternatives 3 and 4 would also reduce VOCs in soil gas and manage groundwater risk through treatment.

The relative performance of remedial alternatives considered in this FFS were compared against the NCP evaluation criteria to assess the merits of each alternative and to identify key trade-offs the Navy must consider when selecting a cleanup remedy. The NCP criteria are as follows:

Threshold criteria
- Overall protection of the environment
- Compliance with ARARs

Primary balancing criteria
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying criteria
- State acceptance
- Community acceptance

Alternatives 2, 3, and 4 meet the threshold criteria, while Alternative 1 does not. Alternatives 3 and 4 are similarly rated overall in satisfying the balancing criteria (i.e., lower ratings for some individual criteria are balanced by higher ratings for other individual criteria, resulting in overall similar ratings). Alternative 2 is rated lowest because, while it will reduce toxicity, mobility, and volume for VOCs in soil gas, it will not reduce toxicity, mobility, or volume of VOCs in groundwater through treatment. See Table ES-1 for a summary of rankings.
In addition to the nine CERCLA criteria, a comparative analysis of the sustainability of each alternative was also performed for this FFS. U.S. EPA (2010) currently defines "green" remediation as "the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions." The sustainability assessment used a green and sustainable remediation evaluation tool known as SiteWise. Inputs into SiteWise are segregated into four phases of work: RI, remedial action construction, operation, and long-term monitoring. Detailed inputs include vehicle mileage, personnel and equipment, construction details, residual handling, groundwater pumped, and equipment operated for each alternative. The eight sustainability factors modeled include greenhouse gas emissions, total energy used, water impacts, oxides of nitrogen (NOx) emissions, oxides of sulfur (SOx) emissions, airborne particulate (<10 micrometers in diameter) emissions (PM10), accident risk (fatality), and accident risk (injury). The sustainability of alternatives can also be considered in remedy selection and implementation. Of the active remedial alternatives, Alternative 2 is rated the most sustainable with the factors considered. A combination of alternatives may be considered during remedy selection or during remedy optimization.

Reference Documentation:

Brady. See Richard Brady & Associates.

Department of Toxic Substances Control (DTSC). California

Environmental Protection Agency. 2009. Interim Advisory for Green Remediation. December.

California Military Environmental Coordination Committee (CMECC). 1998. Institutional Control Protocol at Open Bases. January.

California Regional Water Quality Control Board (Water Board). 2007. "Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin." January. Available online at: http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

City of Concord, Concord Community Reuse Project Office (City of Concord). 2010a. Concord Community Reuse Plan, Final Environmental Impact Report. January.
City of Concord. 2010b. "Recent News and Events." Concord Community Reuse Project website. Accessed March 23. http://www.concordreuseproject.org.

Cook. 2009. Assessing the Use and Application of Zero-Valent Iron Nanoparticle Technology for Remediation at Contaminated Sites. Prepared for U.S. EPA Office of Solid Waste and Emergency Response Office of Superfund Remediation and Technology Innovation. August.

Department of Defense (DoD). 2003. Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions. October.

Department of the Navy (Navy). See Navy.

IT Corporation, 1990. Site Investigation at Building IA-25 Naval Weapons Station Concord, California. Report of Findings. February.

Natural Heritage Institute. 2006. Mt. Diablo Creek Watershed Inventory, Final Report. June 30.

Navy. 1945. Bldg. IA-25 Plan and Elevations, Drawing number 373 373, 1945

Navy. 1988. Site Approval/Explosive Safety RC1-89, N60036.

Navy. 2006. Environmental Restoration Program Manual. August.

Navy and Department of Toxic Substances Control. 2000. Memorandum of Agreement between the United States Department of the Navy and the California Department of Toxic Substances Control. Use of model "Covenant to Restrict Use of Property" at installations being closed and transferred by the Navy.

Office of Management and Budget (OMB). 2010. Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Revised December 2009.

United States Environmental Protection Agency (U.S. EPA). 1987. Remedial Action Costing Procedures Manual. EPA/600/8-87/049. October.

U.S. EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3 01. EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October.

U.S. EPA. 1993. Presumptive Remedies: Policy and Procedures. Office of Solid Waste and Emergency Response. Directive No. 9355.0-47FS. September.

U.S. EPA. 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Final. OSWER Directive 9200.4-17P. April.

U.S. EPA. 2000. Guidance for Data Quality Objectives Process for Hazardous Waste Site Investigations. Office of Environmental Information. January.

U.S. EPA. 2009a. Principles for Greener Cleanups. Office of Solid Waste and Emergency Response. August 27.

U.S. EPA. 2009b. Superfund Green Remediation Strategy. Office of Superfund Remediation and Technology Innovation. January.

Water Board. See California Regional Water Quality Control Board

Richard Brady & Associates (Brady), 2011. Final Remedial Investigation for Installation Restoration Program Site 29 Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California. March 4.

Shaw Environmental & Infrastructure Group (Shaw). 2011. Solar-powered Vapor Extraction Treatability Study Work Plan.

SulTech. 2007. Final Sampling and Analysis Plan (Field Sampling Plan/Quality Assurance Project Plan) for the Remedial Investigation at Installation Restoration Site 29 Naval Weapons Station Seal Beach Detachment Concord, Concord, California. May.

Estimate Documentation Report

Site Documentation:

Site ID: IRS29-A3
Site Name: Alternative 3 - SVE with ZVI Injection
Site Type: Soil & Groundwater

Media/Waste Type
Primary: Soil
Secondary: Groundwater

Contaminant
Primary: Volatile Organic Compounds (VOCs)
Secondary: Metals

Phase Names
Pre-Study: ☐
Study: ☐
Design: ☑
Removal/Interim Action: ☐
Remedial Action: ☑
Operations & Maintenance: ☑
Long Term Monitoring: ☑
Site Closeout: ☑

Documentation
Description: Alternative 3 - SVE with ZVI Injection and LUCs

Similar to Alternative 2, SVE would be the primary technology used to treat VOCs in the vadose zone. In addition to SVE, groundwater treatment would be conducted by ZVI injection. ZVI is a strong reducing agent that is injected (in solution) into contaminated groundwater to reduce VOC concentrations. ZVI particles can vary in size depending on the application and site conditions; nanoscale (less than 100 nanometers in size) to microscale (micron size) ZVI particles are typically used for direct-injection applications. ZVI is mixed at the surface into a solution or slurry and injected directly into contaminated zones. Chlorinated VOCs are degraded by reductive degradation via hydrogenolysis or beta elimination reactions. Beta elimination degrades TCE without producing the intermediate products DCE and VC (Cook 2009). ZVI injection slurry, when combined with bacteria-amended substrate, may provide a much greater net effect. Conventional ZVI (without any bio-augmented substrate) was considered for the cost basis of this FFS.

Pneumatic or hydraulic fracturing serves to greatly increase the radius of influence over conventional direct injection. Special care must be taken during injection so as to not cause unintended dispersal of groundwater contaminants. Depending on the geologic formation and based on vendor-observed outcomes, fracturing can generate a large radius of influence (30 feet). Given the variable stratigraphy at the site, a more conservative radius of influence of 17 feet was considered. Pilot testing would be necessary to determine the site-specific radius of influence since it can vary greatly depending on the soil type and

transmissivity of the formation. The current well network may be sufficient for pilot testing purposes. Figure 5-2 illustrates the assumed treatment area and groundwater monitoring well network.

LUCs, such as fencing, signage, and short-term land use restrictions, would be implemented over the duration of SVE and groundwater treatment until RAOs are met. This alternative would be effective in reducing VOCs in soil gas and groundwater such that unrestricted use could be achieved.

Alternately, if the groundwater plume is not responding to treatment within the proposed timeframe for the alternative, then additional active remedial alternatives may be considered. Further refinement of this alternative would be performed during remedial design /remedial optimization.

Effectiveness. ZVI is highly effective in treating dissolved-phase VOCs. ZVI is expected to significantly reduce contaminant mass. Risk to human receptors posed by VOCs at Site 29 would be reduced by mass removal of VOCs in soil gas via SVE and reduction of VOCs in groundwater by ZVI treatment. This alternative by itself would reduce risk of exposure via the inhalation pathway and domestic use of groundwater.

Implementability. Alternative 3 is considered implementable given the site conditions. ZVI slurry is easy to inject; however, careful handling and delivery must be performed as agglomeration of the slurry can impede even distribution in groundwater. Site 29 is presently used as pasture land for cattle. Therefore, this alternative is considered technically feasible under the current land use scenario.

Cost. Costs for SVE implementation in this alternative are similar to SVE in other alternatives. ZVI-specific costs include bench-scale testing, injection, installation of additional monitoring wells to conduct periodic sampling to measure effectiveness, post-treatment sampling and reporting, and LUCs. Additional ZVI injections may be necessary, but were not assumed in the cost development for this FFS.

Conclusion. This alternative is considered a viable remedy to reduce risk to current and future receptors. Alternative 3 is expected to meet RAOs for the vadose zone and groundwater through removal and destruction of VOCs. A combination of this alternative with another groundwater alternative may be considered in the ROD. Alternative 3 is retained for detailed analysis.

Support Team: Shane DeGross, Richard Brady & Associates
Rain Zeng, Accord Engineering, Inc.
Max Pan, Accord Engineering, Inc.
Abrams Eloskof - URS Group, Inc.

References: Focused Feasibility Study, IR Site 29, December 2011
Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California

Estimator Information

Estimator Name: Al Meyer
Estimator Title: Construction & Cost Engineering Specialist
Agency/Org./Office: URS Corporation - Denver DTC

Estimate Documentation Report

Business Address: URS Corporation
URS Center Building
8181 East Tuffs Avenue
Denver, Colorado 80237
Telephone Number: Office 303-740-3966 Cell 303-887-8645
Email Address: Albert.Meyer@urs.com
Estimate Prepared Date: 01/19/2012

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Shane DeGross
Reviewer Title: Project Manager
Agency/Org./Office: Richard Brady & Associates
Business Address: 3710 Ruffin Road
San Diego, CA 92123
Telephone Number: 916-436-8599
Email Address: sdegross@brady.net
Date Reviewed: 07/06/2011

Reviewer Signature: _____ **Date:** _____

Estimated Costs:

Phase Names	Direct Cost	Marked-up Cost
01 Remedial Design	$78,919	$262,655
02 Land Use Controls	$821,180	$2,440,104
03 Soil Vapor Extraction System	$707,121	$1,219,417
04 Soil Vapor Monitoring Probes	$410,956	$664,365
05 Groundwater Monitoring Wells	$96,615	$160,002
06 ZVI Injection & Hydraulic Fracturing	$5,527,552	$8,211,873
07 SVE O & M & Peformance Monitoring	$1,757,203	$3,225,333
08 Monitoring Well Maintenace	$8,225	$23,938
09 5-Year Reviews (Year 5 -15)	$64,508	$199,177
10 Quarterly GW Monitoring (Year 1 - 2)	$403,734	$721,262
11 Semi-annual GW Monitoring (Year 3 - 4)	$218,851	$410,755
12 Annual GW Monitoring (Year 5)	$61,416	$124,796
13 MNA Annual GW Monitoring (Year 6 - 15)	$614,156	$1,247,960
14 SVE System Decommissioning (Year 6)	$351,390	$671,492
15 Site Closeout (Year 15)	$184,807	$367,218
Total Cost:	$11,306,633	$19,950,345

Estimate Documentation Report

Phase Documentation:

Phase Type: Design - Detail
Phase Name: 01 Remedial Design
Description: Design Includes: Land Use Controls, Soil Vapor Extraction System and Work Plans.

Start Date: July, 2011
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Remedial Design	Yes	100	0

Total Marked-up Cost: $262,655

Technologies:

Estimate Documentation Report

Technology Name: **Remedial Design (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Project Approach		In-Situ Treatment	n/a
Complexity		Low	n/a
Project Planning		Yes	n/a
Treatability & Other Studies		No	n/a
Preliminary Design (30%)		Yes	n/a
Intermediate Design (60%)		Yes	n/a
Prefinal Design (90%)		Yes	n/a
Final Design (100%)		Yes	n/a
Bid Documents		Yes	n/a
Site Distance		25	MI
Level of RD Detail		Moderate	n/a
Project Planning			
Required Parameters			
Site Visit		Yes	n/a
RD Work Plan		Yes	n/a
Data Review		Yes	n/a
Public Meetings		Yes	n/a
Preliminary Design			
Required Parameters			
Design Criteria Memorandum		Yes	n/a
Basis of Design Report		Yes	n/a
Preliminary Plans & Specifications		Yes	n/a
VE Screening Report		Yes	n/a
Public Meetings		Yes	n/a
Intermediate Design			
Required Parameters			
Revised Basis of Design Report		Yes	n/a
Intermediate Plans && Specifications		Yes	n/a
VE Report		Yes	n/a
Prefinal Design			
Required Parameters			
Prefinal Plans & Specifications		Yes	n/a

Estimate Documentation Report

Technology Name: **Remedial Design (# 1)**

Description	*Default*	*Value*	*UOM*
Prefinal Design			
Required Parameters			
Construction QA Plan		Yes	n/a
Final Design			
Required Parameters			
Final Plans & Specifications		Yes	n/a
Final Report		Yes	n/a
Public Meetings		Yes	n/a
Post Design Fact Sheet		Yes	n/a
Bid Documents			
Required Parameters			
Prepare Bid Documents		Yes	n/a
Issue Invitations for Bids/Request Proposals		Yes	n/a
Contractor Bid Evaluation/Selection Support		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 02 Land Use Controls
Description: Includes: Adminstrative and Engineering Controls.

Approach: Ex Situ
Start Date: December, 2011
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
MEC Institutional Controls	Yes	30	70
LAND USE CONTROLS	Yes	100	0

Total Marked-up Cost: $2,440,104

Technologies:

Technology Name: **MEC Institutional Controls (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Planning		No	n/a
Implementation		No	n/a
Engineering Controls		Yes	n/a
Training and Follow Up		No	n/a
Quality Support Visits		No	n/a
Site Distance		50	MI (One-way)
Site Complexity		Low	n/a
Engineering Controls			
Required Parameters			
Type of Fence		Security	n/a
Length of Fence		1,048	LF

Comments:

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Rename Model		LAND USE CONTROLS	n/a
Planning Documents		Yes	n/a
Planning Documents: Start Date		2011	n/a
Implementation		Yes	n/a
Implementation: Start Date		2011	n/a
Monitoring & Enforcement		Yes	n/a
Monitoring & Enforcement: Start Date		2011	n/a
Modification/Termination		Yes	n/a
Modification/Termination: Start Date		2011	n/a
Type of Site		Transferring Government Installation	n/a
Planning Documents			
Required Parameters			
LUC Assurance Plan (LUCAP)		Yes	n/a
LUC Assurance Plan (LUCAP): Plan Complexity		Medium	n/a
LUC Implementation Plan (LUCIP)		Yes	n/a
LUC Implementation Plan (LUCIP): Number		1	EA
LUC Implementation Plan (LUCIP): Plan Complexity		Medium	n/a
Long-term Stewardship (LTS) Plan		Yes	n/a
Long-term Stewardship (LTS) Plan: Number		1	EA
Long-term Stewardship (LTS) Plan: Plan Complexity		Medium	n/a
Memorandum of Agreements (MOA)		Yes	n/a
Memorandum of Agreements (MOA): Number		1	EA
Memorandum of Agreements (MOA): Plan Complexity		Medium	n/a
Installation (or City) Master Plan		Yes	n/a
Installation (or City) Master Plan: Plan Complexity		Medium	n/a
Construction Permitting		Yes	n/a
Construction Permitting: Number		1	EA
Construction Permitting: Plan Complexity		Medium	n/a
Geographic Information Systems (GIS)/Overlay Maps		Yes	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Planning Documents			
Required Parameters			
Geographic Information Systems (GIS)/Overlay Maps: Number		1	EA
Geographic Information Systems (GIS)/Overlay Maps: Plan Complexity		Medium	n/a
Planning Meetings			
Required Parameters			
LUCAP: Number of Meetings		2	EA
LUCAP: Number of People		2	EA
LUCAP: Number of Days		1	EA
LUCAP: Airfare Cost		650	$
LUCAP: Mileage to Meeting Site		50	MI
LUCIP: Number of Meetings		2	EA
LUCIP: Number of People		2	EA
LUCIP: Number of Days		1	EA
LUCIP: Airfare Cost		650	$
LUCIP: Mileage to Meeting Site		50	MI
LTS: Number of Meetings		2	EA
LTS: Number of People		2	EA
LTS: Number of Days		1	EA
LTS: Airfare Cost		650	$
LTS: Mileage to Meeting Site		50	MI
MOA: Number of Meetings		2	EA
MOA: Number of People		2	EA
MOA: Number of Days		1	EA
MOA: Airfare Cost		650	$
MOA: Mileage to Meeting Site		50	MI
Master Plan: Number of Meetings		2	EA
Master Plan: Number of People		2	EA
Master Plan: Number of Days		1	EA
Master Plan: Airfare Cost		650	$
Master Plan: Mileage to Meeting Site		50	MI

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Planning Meetings			
Required Parameters			
Construction Permitting: Number of Meetings		2	EA
Construction Permitting: Number of People		2	EA
Construction Permitting: Number of Days		1	EA
Construction Permitting: Airfare Cost		650	$
Construction Permitting: Mileage to Meeting Site		50	MI
GIS/Overlay Maps: Number of Meetings		2	EA
GIS/Overlay Maps: Number of People		2	EA
GIS/Overlay Maps: Number of Days		1	EA
GIS/Overlay Maps: Airfare Cost		650	$
GIS/Overlay Maps: Mileage to Meeting Site		50	MI
Implementation			
Required Parameters			
Modify Installation (or City) Master Plan		Yes	n/a
Modify Installation (or City) Master Plan: Task Complexity		Medium	n/a
Deed Notification		Yes	n/a
Deed Notification: Number		1	EA
Deed Notification: Task Complexity		Medium	n/a
Negotiating Easements		Yes	n/a
Negotiating Easements: Number		1	EA
Negotiating Easements: Task Complexity		Medium	n/a
Restrictive Covenants		Yes	n/a
Restrictive Covenants: Number		1	EA
Restrictive Covenants: Task Complexity		Medium	n/a
Equitable Servitudes		Yes	n/a
Equitable Servitudes: Number		1	EA
Equitable Servitudes: Task Complexity		Medium	n/a
Access Control Signs		Yes	n/a
Access Control Signs: Number		4	EA
Access Control Signs: Task Complexity		Medium	n/a
Utility Notification Service		Yes	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Implementation			
Required Parameters			
Access Control Signs: Number		1	EA
Access Control Signs: Task Complexity		Medium	n/a
Geographic Information Systems (GIS)/Overlay Maps		Yes	n/a
Geographic Information Systems (GIS)/Overlay Maps: Number		1	EA
Geographic Information Systems (GIS)/Overlay Maps: Task Complexity		Medium	n/a
Develop Finding of Suitablility to Transfer (FOST)		Yes	n/a
Develop Finding of Suitablility to Transfer (FOST): Task Complexity		Medium	n/a
Monitoring & Enforcement			
Required Parameters			
Duration of Monitoring/Enforcement		17	Years
Notice Letters		Yes	n/a
Notice Letters: Number		10	EA
Notice Letters: Frequency		Annually	n/a
Guard Service/Security		No	n/a
Reports & Certifications		Yes	n/a
Reports & Certifications: Frequency		Annually	n/a
Site Visits/Inspections		Yes	n/a
Site Visits/Inspections: Number		1	EA
Site Visits/Inspections: Safety Level		D	n/a
Site Visits/Inspections: Duration		3	Days
Site Visits/Inspections: Number of People		2	EA
Site Visits/Inspections: Frequency		Annually	n/a
Site Visits/Inspections: Airfare		650	$ Per Ticket
Site Visits/Inspections: Mileage		50	MI
Modify/Termination			
Required Parameters			
Document Evaluation		Yes	n/a
Document Evaluation: Number		1	EA
Document Evaluation: Plan Complexity		Medium	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Modify/Termination			
Required Parameters			
Modify LUC Documents		Yes	n/a
Modify LUC Documents: Number		1	EA
Modify LUC Documents: Plan Complexity		Medium	n/a
Amend Decision Documents		Yes	n/a
Amend Decision Documents: Number		1	EA
Amend Decision Documents: Plan Complexity		Medium	n/a
Termination Letters		Yes	n/a
Termination Letters: Number		1	EA
Termination Letters: Plan Complexity		Medium	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 03 Soil Vapor Extraction System
Description: Includes: SVE System Installation, 1,500-ft of Underground Power Service and SVE Building.
Approach: In Situ
Start Date: January, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Soil Vapor Extraction	Yes	30	70
Carbon Adsorption (Gas)	Yes	30	70
Decontamination Facilities	Yes	30	70
Professional Labor Management	Yes	100	0
UNDERGROUND ELECTRIC SERVICE	Yes	30	70
SVE & GW TREATMENT BUILDING	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $1,219,417

Technologies:

Estimate Documentation Report

Technology Name: **Soil Vapor Extraction (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Installation Type		Vertical Wells	n/a
Soil Type		Sand/Gravelly Sand Mixture	n/a
Surface Area of Contamination		48,000	SF
Depth to Base of Contamination		50	FT
Safety Level		D	n/a
Drilling			
Required Parameters			
Average Well Depth		45	LF
Formation Type		Consolidated	n/a
Drilling Method		Air Rotary	n/a
Well Diameter		4 Inch	n/a
Well Construction Material		PVC Schedule 40	n/a
Split Spoon Sample Collection		Yes	n/a
Drum Drill Cuttings		No	n/a
Average Number of Soil Samples per Well		1	EA
Soil Analytical Template		System Soil - VOCs	n/a
Drilling Safety Level		D	n/a
Vertical Wells			
Secondary Parameters			
Vertical Well: Extraction Well Spacing	50	50	FT
Vertical Well: Number of Vapor Extraction Wells	25	25	EA
Vertical Well: Average Vapor Flow Rate per Well	35	35	CFM
Vertical Well: Total Vapor Flow Rate	875	875	CFM
Vertical Well: Knockout Drums	0	1	EA
Vertical Well: Floor Slab Sawing	0	0	HR
Vertical Well: Equipment Enclosure	Yes	Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Carbon Adsorption (Gas) (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Influent Flow Rate		875	CFM
Adsorption System		Modular Carbon Adsorbers (Disposable)	n/a
Know Total Organic Concentration		No	n/a
Influent Total Organic Concentration (for O&M)		0	ppm
System Redundancy		Two Adsorbers in Series	n/a
Blower		Yes	n/a
Heater		No	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		Yes	n/a
Equipment Rating		Medium Equipment Rating	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		6	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		6	weeks
Safety Level		D	n/a
Decon Pad			
Secondary Parameters			
Area of Decontamination Pad	800	800	SF
Use Flexible Membrane Liner	Yes	Yes	n/a
Percentage of Time Decontamination Pad in Use	25	25	%
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		825,349	$
Percentage	18.5	18.5	%
Dollar Amount		152,690	$

Comments:

Estimate Documentation Report

Technology Name: **User Defined Estimate (# 1)**
User Name: **UNDERGROUND ELECTRIC SERVICE**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		UNDERGROUND ELECTRIC SERVICE	n/a
WBS Type		HTRW	n/a
Selected WBS		331.03.06	n/a
Safety Level		D	n/a

Comments:

Technology Name: **User Defined Estimate (# 2)**
User Name: **SVE & GW TREATMENT BUILDING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		SVE & GW TREATMENT BUILDING	n/a
WBS Type		HTRW	n/a
Selected WBS		331.13.23	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		18,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		39	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 06 ZVI Injection & Hydraulic Fracturing
Description: Includes: 165 Injection Points, 1,955,550 Lbs ZVI total or 7,111 Lbs ZVI per injection point and Hydraulic Fracturing with guar gum. Bacteria-amended substrate is not included.
Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
REDUCTIVE DECHLORONATION	Yes	10	90

Total Marked-up Cost: $8,211,873

Technologies:

Technology Name: **User Defined Estimate (# 1)**
User Name: **REDUCTIVE DECHLORONATION**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		REDUCTIVE DECHLORONATION	n/a
WBS Type		HTRW	n/a
Selected WBS		331.11.04	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 04 Soil Vapor Monitoring Probes
Description: Includes: VMP Wells Installation.

Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Special Well Drilling & Installation	Yes	30	70
Decontamination Facilities	Yes	30	70
Residual Waste Management	Yes	100	0
Professional Labor Management	Yes	100	0

Total Marked-up Cost: $664,365

Technologies:

Estimate Documentation Report

Technology Name: **Special Well Drilling & Installation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Type of Well		Vertical	n/a
Safety Level		D	n/a
Vertical Wells			
Required Parameters			
Formation Type		Consolidated	n/a
Completion Type		Single Cased Well	n/a
Number of Wells/Borings		20	EA
Depth of Boring		0	FT
Depth to Bottom of Outer Casing		0	FT
Depth to Bottom of Middle Casing		0	FT
Depth to Top of Screen		50	FT
Screen Length		20	FT
Vertical Secondary			
Secondary Parameters			
Well Construction Material	PVC Schedule 40	PVC Schedule 40	n/a
Well Diameter	4	4	IN
Drilling Method	Water/Mud Rotary	Air Rotary	n/a
Drum Drill Cuttings	Yes	Yes	n/a
Soil Sample Collection	Yes	Yes	n/a
Well Development	Yes	No	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		No	n/a
Equipment Rating		n/a	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		2	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		2	weeks
Safety Level		D	n/a
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		6,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		71	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		558,290	$
Percentage	19	19	%
Dollar Amount		106,075	$

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 05 Groundwater Monitoring Wells
Description: Includes: Installation of 4 New Groundwater Monitoring Wells 70-ft average depth.
Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Groundwater Monitoring Well	Yes	30	70
Decontamination Facilities	Yes	30	70
Professional Labor Management	Yes	100	0
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $160,002

Technologies:

Estimate Documentation Report

Technology Name: **Groundwater Monitoring Well (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Number of Aquifers		One	n/a
Include Guard Posts		Yes	n/a
Depth to Groundwater to Aquifer One		45	FT
Number of Wells to Aquifer One		4	EA
Safety Level		D	n/a
Aquifer One			
Required Parameters			
Aquifer One: Average Well Depth		70	LF
Aquifer One: Formation Type		Consolidated	n/a
Aquifer One: Drilling Method		Air Rotary	n/a
Aquifer One: Well Diameter		4 Inch	n/a
Aquifer One: Well Construction Material		PVC Schedule 40	n/a
Aquifer One: Split Spoon Sample Collection		Yes	n/a
Aquifer One: Average Number of Soil Samples per Well		1	EA
Aquifer One: Soil Analytical Template		System Soil - VOCs	n/a
Aquifer One: Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		No	n/a
Equipment Rating		n/a	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		1	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		1	weeks
Safety Level		D	n/a
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		133,446	$
Percentage	19.9	19.9	%
Dollar Amount		26,556	$

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		3,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		10	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: 07 SVE O & M & Peformance Monitoring
Description: SVE System Operation & Maintenance including Carbon Changeout, Preformance Monitoring at 25 SVE Wellheads plus 20 Vapor Monitoring Probes for 60 months.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Operations and Maintenance	Yes	100	0

Total Marked-up Cost: $3,225,333

Technologies:

Estimate Documentation Report

Technology Name: **Operations and Maintenance**

Description	*Default*	*Value*	*UOM*
Labor			
Secondary Parameters			
Operations Labor: Type		Moderate	n/a
Professional Labor: Type		Minimum	n/a
Analytical			
Secondary Parameters			
Wastewater/Effluent: Sampling Frequency		Exclude from Estimate	n/a
Wastewater/Effluent: Primary Analytical Template		None	n/a
Wastewater/Effluent: Secondary Analytical Template		None	n/a
Air Emissions: Sampling Frequency		Semi-annually	n/a
Air Emissions: Primary Analytical Template		System Air Emissions - VOCs	n/a
Air Emissions: Secondary Analytical Template		None	n/a
Solid Wastes: Sampling Frequency		Exclude from Estimate	n/a
Solid Wastes: Primary Analytical Template		None	n/a
Solid Wastes: Secondary Analytical Template		None	n/a
Heating Requirements			
Secondary Parameters			
Air Streams: Flow Rate		875	CFM
Air Streams: Temperature Difference		20	F
Air Streams: Months per Year		12	Month
Water Streams: Flow Rate		0	CFM
Water Streams: Temperature Difference		0	F
Water Streams: Months per Year		0	Month
Facility: Area		600	SF
Facility: Temperature Difference		20	F
Facility: Months per Year		6	Month

Comments:

Estimate Documentation Report

Technology Name: **Soil Vapor Extraction (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Installation Type		Vertical Wells	n/a
Average Well Depth		45	LF
Vertical Well: Number of Vapor Extraction Wells		25	EA
Vertical Well: Total Vapor Flow Rate		875	CFM
Horizontal Trenches: Total Vapor Flow Rate		0	CFM

Technology Name: **Carbon Adsorption (Gas) (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Influent Flow Rate		875	CFM
Adsorption System		Modular Carbon Adsorbers (Disposable)	n/a
Influent Total Organic Concentration (for O&M)		1	ppm

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: 08 Monitoring Well Maintenace
Description: Includes: Moitoring well redevelopment of 4 of 13 existing wells and 1 of 4 new wells on a 7 year-cycle.

It can be reasonably assumed that some or all of the Groundwater Long Term Monitoring wells may require redevelopment. RACER does not provide a given Technology to address this issue. However the Natural Attenuation Technology can be modified based on its "start date" and "out-year capability" to address monitoring well maintenance.

Replacement of monitoring wells is not considered in this cost estimate.

Start Date: February, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Natural Attenuation	Yes	100	0
Natural Attenuation	Yes	100	0

Total Marked-up Cost: $23,938

Technologies:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2018	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 1)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2025	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 2)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 09 5-Year Reviews (Year 5 -15)
Description: Includes: 5-Year Reviews with Rebound Study and Travel for 3 people. The level of effort varies as follows: Year 2017 = High, Year 2022 = Low and Year 2027 = Medium.

Start Date: March, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	Yes	100	0
Five-Year Review	Yes	100	0
Five-Year Review	Yes	100	0

Total Marked-up Cost: $199,177

Technologies:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		High	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2017	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Low	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2022	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 2)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 3)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Moderate	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2027	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 3)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 10 Quarterly GW Monitoring (Year 1 - 2)
Description: Includes: Quarterly Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $721,262

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		4	n/a
Number of Events (Out Years)		4	n/a
Number of Years (Out Years)		1	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 11 Semi-annual GW Monitoring (Year 3 - 4)
Description: Includes: Semi-annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2014
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $410,755

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		2	n/a
Number of Events (Out Years)		2	n/a
Number of Years (Out Years)		1	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 12 Annual GW Monitoring (Year 5)
Description: Includes: Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2016
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $124,796

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		0	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		0	n/a
Number of Years (Out Years)		0	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 13 MNA Annual GW Monitoring (Year 6 - 15)
Description: Includes: MNA Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $1,247,960

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		1	n/a
Number of Years (Out Years)		9	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 14 SVE System Decommissioning (Year 6)
Description: Includes: Decommissioning of the SVE System including SVE underground piping, Abandonmentof of 25 SVE Wells and Abandonment of 20 Vapor Monitoring Probes.

Start Date: March, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Demolition, Buildings	Yes	30	70
Demolition, Underground Pipes	Yes	30	70
Well Abandonment	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $671,492

Technologies:

Estimate Documentation Report

Technology Name: **Demolition, Buildings (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Building Area		600	SF
Type of Building		Steel	n/a
Include Load and Haul Costs		Yes	n/a
Amount of Hazardous Material		0	%
Number of Stories		Single	n/a
Safety Level		D	n/a
Height/Demo Factor			
Secondary Parameters			
Floor to Floor Height	12	12	FT
Demolition Factor	0.03	0.0339	CY/CF
Load and Haul			
Secondary Parameters			
Non-Hazardous Material: Truck Type		Highway	n/a
Non-Hazardous Material: Volume		245	CY
Non-Hazardous Material: Distance (One-way)		15	MI
Non-Hazardous Material: Dump Charge		15	$/CY
Hazardous Material: Truck Type		Off Highway	n/a
Hazardous Material: Volume		0	CY
Hazardous Material: Distance (One-way)		0	FT
Hazardous Material: Dump Charge		0	$/CY

Comments:

Estimate Documentation Report

Technology Name: **Demolition, Underground Pipes (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Pipe Material		Steel	n/a
Length of Run		1,563	LF
Bulking Factor		1.3	CY/CY
Include Load and Haul Costs		Yes	n/a
Safety Level		D	n/a
Trenching			
Secondary Parameters			
Soil Type	Silt/Silty-Clay Mixture	Silt/Silty-Clay Mixture	n/a
Moisture Content	Dry	Dry	n/a
Inside Pipe Diameter	10.2 cm (4 IN)	10.2 cm (4 IN)	n/a
Average Pipe Depth	4	4	FT
Overdig	1	1	FT
Vertical Trench Height	4	4	FT
Dewatering Pump	No	No	n/a
Load and Haul			
Secondary Parameters			
Truck Type		Highway	n/a
Load and Haul Volume		10.26138	CY
One-way Haul Distance		15	MI
Dump Charge		15	$/CY

Comments:

Estimate Documentation Report

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Soil Vapor Extraction	n/a
Number of Wells		25	EA
Well Depth		45	FT
Well Diameter		4	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Consolidated	n/a
Karst Formation Type		No	n/a

Comments:

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		71	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 15 Site Closeout (Year 15)
Description: Includes:
1. Meetings, Work Plans, Reports, Documents and Documents Storage.Site Close-out documantation, and
2. Abandonment of 4 New and 13 Existing Groundwater Monitoring Wells.

Start Date: May, 2027
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Site Close-Out Documentation	Yes	100	0
Well Abandonment	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $367,218

Technologies:

Estimate Documentation Report

Technology Name: **Site Close-Out Documentation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Meetings		Yes	n/a
Work Plans and Reports		Yes	n/a
Documents		Yes	n/a
Site Close-Out Complexity		Low	n/a
Meetings			
Required Parameters			
Kick Off/Scoping Meetings		Yes	n/a
Kick Off/Scoping Meetings: Number of Meetings	1	1	EA
Kick Off/Scoping Meetings: Travel		Yes	n/a
Kick Off/Scoping Meetings: Travelers		3	EA
Kick Off/Scoping Meetings: Days		2	Days
Kick Off/Scoping Meetings: Air Fare		1,950	$
Review Meetings		Yes	n/a
Review Meetings: Number of Meetings	1	2	EA
Review Meetings: Travel		Yes	n/a
Review Meetings: Travelers		3	EA
Review Meetings: Days		2	Days
Review Meetings: Air Fare		1,950	$
Regulatory Review Meetings		Yes	n/a
Regulatory Review Meetings: Number of Meetings	1	2	EA
Regulatory Review Meetings: Travel		Yes	n/a
Regulatory Review Meetings: Travelers		3	EA
Regulatory Review Meetings: Days		2	Days
Regulatory Review Meetings: Air Fare		1,950	$
Work Plans & Reports			
Required Parameters			
Work Plans		Yes	n/a
Draft Work Plan		Yes	n/a
Final Work Plan		Yes	n/a
Reports		Yes	n/a
Draft Close-Out Report		Yes	n/a

Estimate Documentation Report

Technology Name: **Site Close-Out Documentation (# 1)**

Description	*Default*	*Value*	*UOM*
Work Plans & Reports			
Required Parameters			
Draft Final Close-Out Report		Yes	n/a
Final Close-Out Report		Yes	n/a
Progress Reports		Yes	n/a
Project Duration	8	8	months
Documents			
Required Parameters			
Draft Decision Document		Yes	n/a
Draft Final Decision Document		Yes	n/a
Final Decision Document		Yes	n/a
Long Term Document Storage		Yes	n/a
Number of Boxes		20	EA
Duration of Storage		7	Yrs

Comments:

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Groundwater Monitoring Well - Aquifer One	n/a
Number of Wells		4	EA
Well Depth		70	FT
Well Diameter		2	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Consolidated	n/a
Karst Formation Type		No	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		7	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

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Attachment B-3

Detailed Cost Estimate for Alternative 4

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29 Location: CONCORD, CALIFORNIA

Project ID: IRS29 Report Option: Calendar

Site Name: Alternative 4 - SVE with ISB and GW Recirculation

Site Type: Soil & Groundwater

Site ID: IRS29-A4

Year		1	2	3	4	5	6	7	8	9	10	11
Fiscal Year		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Cost Type	**Description**											
Design	01 Remedial Design	$ 262,655										
Remedial Action	02 Land Use Controls	$ 1,712,438	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479
Remedial Action	03 Soil Vapor Extraction System		$ 1,219,417									
Remedial Action	04 Groudwater Bioaugmentation & Recirculation		$ 1,903,247									
Remedial Action	05 Groundwater Monitoring Wells		$ 157,495									
Remedial Action	06 Soil Vapor Monitoring Probes		$ 669,920									
Remedial Action	07 ISB Injection		$ 1,168,883									
Operations & Maintenance	08 SVE O & M & Peformance Monitoring		$ 527,188	$ 674,536	$ 674,536	$ 674,536	$ 674,536					
Operations & Maintenance	09 GW Bio & Recirc O & M & Peformance Monitoring		$ 22,565	$ 30,054	$ 30,054	$ 30,054	$ 30,054					
Operations & Maintenance	10 Monitoring Well Maintenace								$ 11,969			
Long Term Monitoring	11 5-Year Reviews (Year 5 - 15)							$ 91,235				
Long Term Monitoring	12 Quarterly GW Monitoring (Year 1 - 2)		$ 270,473	$ 360,631	$ 90,158							
Long Term Monitoring	13 Semi Annual GW Monitoring (Year 3 - 4)				$ 154,033	$ 205,378	$ 51,344					
Long Term Monitoring	14 Annual GW Monitoring (Year 5)						$ 124,796					
Long Term Monitoring	15 MNA Annual GW Monitoring (Year 6 - 15)							$ 124,796	$ 124,796	$ 124,796	$ 124,796	$ 124,796
Site Closeout	16 GW Recirculation Decommissioning (Year 3)			$ 582,958								
Site Closeout	17 SVE System Decommissioning (Year 6)							$ 659,732				
Site Closeout	18 Site Closeout (Year 15)											
Sub-Total		$ 1,975,094	$ 5,984,668	$ 1,693,658	$ 994,260	$ 955,447	$ 926,210	$ 921,243	$ 182,244	$ 170,275	$ 170,275	$ 170,275
Real Discount	2.30%	0.9795	0.9593	0.9396	0.9203	0.9014	0.8829	0.8648	0.8470	0.8296	0.8126	0.7959
Nominal Discount	5.80%	0.9452	0.8934	0.8444	0.7981	0.7543	0.7130	0.6739	0.6370	0.6020	0.5690	0.5378
Inflation	3.50%	1.0363	1.0739	1.1128	1.1532	1.1950	1.2383	1.2832	1.3298	1.3780	1.4280	1.4798
Total		$ 1,934,527	$ 5,741,351	$ 1,591,428	$ 915,057	$ 861,275	$ 817,770	$ 796,679	$ 154,365	$ 141,265	$ 138,363	$ 135,521

Cost Over Time

Sub-Total		$ 1,975,094	$ 5,984,668	$ 1,693,658	$ 994,260	$ 955,447	$ 926,210	$ 921,243	$ 182,244	$ 170,275	$ 170,275	$ 170,275
Inflation	3.50%	1.0363	1.0739	1.1128	1.1532	1.1950	1.2383	1.2832	1.3298	1.3780	1.4280	1.4798
Total		$ 2,046,729	$ 6,426,662	$ 1,884,707	$ 1,146,544	$ 1,141,747	$ 1,146,952	$ 1,182,178	$ 242,345	$ 234,642	$ 243,152	$ 251,971

Database Date: Jan-08

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Present Value of Future Cost

Folder: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29

Project ID: IRS29

Site Name: Alternative 4 - SVE with ISB and GW Recirculation

Site Type: Soil & Groundwater

Site ID: IRS29-A4

Year		12	13	14	15	16	17	18	19	20	21	
Fiscal Year		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	
Cost Type	**Description**											**Total**
Design	01 Remedial Design											$ 262,655
Remedial Action	02 Land Use Controls	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479	$ 45,479					$ 2,440,104
Remedial Action	03 Soil Vapor Extraction System											$ 1,219,417
Remedial Action	04 Groudwater Bioaugmentation & Recirculation											$ 1,903,247
Remedial Action	05 Groundwater Monitoring Wells											$ 157,495
Remedial Action	06 Soil Vapor Monitoring Probes											$ 669,920
Remedial Action	07 ISB Injection											$ 1,168,883
Operations & Maintenance	08 SVE O & M & Peformance Monitoring											$ 3,225,333
Operations & Maintenance	09 GW Bio & Recirc O & M & Peformance Monitoring											$ 142,781
Operations & Maintenance	10 Monitoring Well Maintenace				$ 11,969							$ 23,938
Long Term Monitoring	11 5-Year Reviews (Year 5 - 15)	$ 42,546					$ 65,395					$ 199,177
Long Term Monitoring	12 Quarterly GW Monitoring (Year 1 - 2)											$ 721,262
Long Term Monitoring	13 Semi Annual GW Monitoring (Year 3 - 4)											$ 410,755
Long Term Monitoring	14 Annual GW Monitoring (Year 5)											$ 124,796
Long Term Monitoring	15 MNA Annual GW Monitoring (Year 6 - 15)	$ 124,796	$ 124,796	$ 124,796	$ 124,796	$ 124,796						$ 1,247,960
Site Closeout	16 GW Recirculation Decommissioning (Year 3)											$ 582,958
Site Closeout	17 SVE System Decommissioning (Year 6)											$ 659,732
Site Closeout	18 Site Closeout (Year 15)						$ 414,657					$ 414,657
												$ -
												$ -
												$ -
												$ -
												$ -
Sub-Total		$ 212,821	$ 170,275	$ 170,275	$ 182,244	$ 170,275	$ 525,531	$ -	$ -	$ -	$ -	$ 15,575,070
Real Discount	2.30%	0.7796	0.7635	0.7479	0.7325	0.7175	0.7027	0.6883	0.6741	0.6603	0.6467	- - -
Nominal Discount	5.80%	0.5084	0.4805	0.4542	0.4293	0.4057	0.3835	0.3625	0.3426	0.3238	0.3061	- - -
Inflation	3.50%	1.5335	1.5891	1.6467	1.7064	1.7683	1.8325	1.8989	1.9678	2.0392	2.1131	- - -
Total		$ 165,905	$ 130,012	$ 127,341	$ 133,493	$ 122,164	$ 369,299	$ -	$ -	$ -	$ -	$ 14,275,814

Cost Over Time

Sub-Total		$ 212,821	$ 170,275	$ 170,275	$ 182,244	$ 170,275	$ 525,531	$ -	$ -	$ -	$ -	$ 15,575,070
Inflation	3.50%	1.5335	1.5891	1.6467	1.7064	1.7683	1.8325	1.8989	1.9678	2.0392	2.1131	- - -
Total		$ 326,352	$ 270,580	$ 280,394	$ 310,988	$ 301,102	$ 963,017	$ -	$ -	$ -	$ -	$ 18,400,064

Database Date: Jan-08

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Estimate Documentation Report

System:

RACER Version: 10.0.2
Database Location: C:\04 Projects\RACER 2008\RACER 2008 20121205.mdb

Folder:

Folder Name: FORMER NAVAL WEAPONS STATION SEAL BEACH

Project:

Project ID: IRS29
Project Name: FOCUSED FEASIBILITY STUDY FOR IR SITE 29
Project Category: None

Location
State / Country: CALIFORNIA
City: CONCORD

Location Modifier	Default	User
	1.286	1.286

Options
Database: System Costs
Cost Database Date: 2008
Report Option: Calendar

Description

Prepared for:

U.S. Department of the Navy
Naval Facilities Engineering Command, Southwest
San Diego, California

prepared under:

Conrtract Number: N62473-10-D-0814
Task Order: 00005
DCN: AM8A-0814-0005-0001

Executive Summary

Accord MACTEC 8A JV (AM8AJV), a joint venture, and Richard Brady & Associates (Brady), in subcontract to AM8AJV, prepared this Focused

Estimate Documentation Report

Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29, on behalf of the Naval Facilities Engineering Command Base Realignment and Closure (BRAC) Program Management Office (PMO) West, in accordance with Contract Number N62473-10-D-0814, Delivery Order 0005. This FFS follows requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) for facilities subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), related United States Environmental Protection Agency (U.S. EPA) technical guidance, and the U.S. Department of the Navy's Environmental Restoration Program Manual (Navy 2006).

The purpose of this FFS is to develop and evaluate remedial alternatives to mitigate human health and environmental risks associated with exposure to groundwater and soil gas impacted by volatile organic compounds (VOCs) at Installation Restoration (IR) Program Site 29 (Site 29 or "site"), former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California, based on the conclusions and recommendations of the Final Remedial Investigation (RI) Report (Brady 2011). This document uses an FFS format because the technologies used in a treatability study (Shaw 2011) currently underway have been proven to effectively treat chlorinated solvents in groundwater under the hydrogeologic conditions present at Site 29 and because soil-gas contamination will be treated using soil-vapor extraction (SVE) technology.

Site 29 is located within the south-central portion of the inland area, approximately 1,600 feet southwest of the intersection of L Street and Kinne Boulevard and approximately 1,000 feet southwest of Seal Creek (also known as Mt. Diablo Creek outside of the base). The site is located on the side of a hill underlain by silty clay and sandy gravel units.

As a result of the final RI and previous investigations, the area of Site 29 was found to be impacted with VOCs in soil gas (in the vicinity of Building IA-19) and groundwater extending approximately 850 feet downgradient. The VOC-impacted vadose zone soils extend over approximately 1 acre, and the estimated area of groundwater impact is over 6 acres.

Factors considered in determining remedial action objectives (RAOs) include potential human health and ecological risks and exposure pathways, chemicals of concern (COCs), affected media, and chemical-, location-, and action-specific applicable or relevant and appropriate requirements (ARARs). The RAOs are based on the planned, unrestricted future use of Site 29 (City of Concord 2010).

A baseline human health risk assessment (BHHRA) was performed to assess potential impacts to human health from exposure to chemicals in soil, soil gas, and groundwater at Site 29 (Brady 2011). Future residential (unrestricted) use, commercial/industrial worker, and construction/utility worker scenarios were evaluated. For future residential use, cancer risk estimates exceed the 10?4 upper limit of the risk management range, and the hazard index (HI) values exceed 1.0 for all combinations (two methods and two development scenarios). The cancer risk and noncancer hazard estimates are primarily associated with arsenic from two soil sample locations, from trichloroethene (TCE) in soil gas, and from exposure to multiple chemicals from domestic use of groundwater. The RI concluded

that the metals from those two soil locations beneath IA-25 were associated with soils impacted by lead-based paint residues. Laboratory analysis and detailed evaluation of samples via scanning electron microscope/energy dispersive x-ray spectroscopy confirmed that lead in soil beneath IA-25 is derived from lead-based paint. Paints typically contain other metals used for pigment, such as arsenic, cadmium, cobalt, chromium, and zinc. The RI concluded that the elevated concentrations of these other metals are also associated with paint residues. No further action under CERCLA was recommended for lead-based-paint-contaminated soil. For commercial/industrial worker scenarios, the risk estimates are within the risk management range and the HIs are less than 1.0. For the construction/utility worker scenarios, the risk estimates exceed the 10?4 upper limit of the risk management range, and the HI values exceed 1.0 for this highly exposed receptor. Risk to future construction workers is predominantly attributable to exposure to TCE in soil gas and groundwater.

Contaminants at Site 29 are generally considered unlikely to pose a hazard to ecological receptors with the exception of TCE and 1,1-dichloroethene (1,1-DCE) in soil gas and metals in soil beneath Building IA-25. Soils beneath Building IA-25 do not pose an unacceptable risk to ecological receptors if the soil and building remain unvegetated and left in place. Primary and secondary consumers (e.g., vole, meadowlark, robin, and shrew) are primarily exposed to metals through plant and soil invertebrate consumption. Soils beneath IA-25 only pose a risk to ecological receptors if the building is removed, the soils remain undisturbed, and the area is revegetated (Brady 2011).

The media affected by VOCs for which remediation alternatives are evaluated in this FFS are soil gas and groundwater. RAOs are medium-specific goals for protecting human health and the environment and consider affected media and COCs, existing and potential receptors, exposure pathways, and ARARs. The RAOs for Site 29 are as follows:
- Prevent residential exposure to VOCs via potential inhalation of soil gas through vapor intrusion at concentrations that result in a cancer risk that exceeds the risk management range of 1x10-4 to 1x10-6 and a HI greater than 1.0.
- For burrowing mammals, reduce the inhalation hazard of TCE and 1,1-DCE in shallow soil gas to a hazard quotient of less than 1.0.
- Prevent residential exposure to VOCs via potable use of groundwater containing concentrations that result in a cancer risk that exceeds the risk management range of 1x10-4 to 1x10-6 and a HI greater than 1.0.

Risks to potential future residents and construction/utility workers exceed the 10?4 upper limit of the risk management range and the HI of 1.0. VOCs in soil gas at the site pose a hazard to burrowing mammals. The primary pathways for human exposure were identified as inhalation of soil gas and domestic use of groundwater (Brady 2011).

The proposed remediation goals (RGs) for VOCs presented in this FFS are based on the results of the risk assessments and on unrestricted use of Site 29.

The Navy has included some form of land use controls (LUCs) in all of the remedial alternatives for Site 29, with the exception of no action. The

following four remedial action alternatives were considered for this FFS.

Alternative 1 - No Action. No remedial action of any type would be conducted; this alternative serves as the baseline against which the remaining alternatives can be compared.

Alternative 2 - SVE with Monitored Natural Attenuation (MNA). This alternative would institute an SVE presumptive remedy to remove VOC contamination from the vadose zone. SVE, also known as "soil venting" or "vacuum extraction" is an in situ remedial technology that reduces concentrations of volatile constituents adsorbed to soils in the unsaturated (vadose) zone. MNA of the groundwater plume is a technique used to monitor or test the progress of natural attenuation processes that can degrade contaminants in soil and groundwater. It can be used in conjunction with SVE as a finishing option, or if appropriate, as the only remediation process if the rate of contaminant degradation is fast enough to protect human health and the environment. Natural processes can then mitigate the remaining amount of pollution; regular monitoring of the groundwater can verify those reductions. Both institutional and engineering LUCs would be used to restrict use of groundwater for domestic supply and to implement mitigating requirements for structures built over the soil-vapor plume until RAOs are met.

Alternative 3 - SVE with Zero-Valent Iron (ZVI) Injection. Similar to Alternative 2, SVE would be the primary technology used to treat VOCs in the vadose zone. In addition to SVE, groundwater treatment would be conducted by ZVI injection. ZVI is a strong reducing agent that is injected (in solution) into contaminated groundwater to reduce VOC concentrations. LUCs, such as fencing, signage, and land use restrictions, would be implemented over the duration of treatment until RAOs are met.

Alternative 4 - SVE with In Situ (Anaerobic) Bioremediation (ISB) and Groundwater Recirculation. ISB involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as an electron acceptor in a process called chlororespiration. The ISB treatment entails injecting biodegradable substrates (e.g., vegetable-oil emulsion) into the source area at a prescribed injection spacing to achieve the desired radius of influence in the treatment area and to target low-permeability zones. A groundwater recirculation system can be constructed to optimally distribute treatment media to contaminants over the extent of the plume where direct injection is impracticable. LUCs would be implemented similarly to Alternative 3 until RAOs are met, thereby achieving unrestricted future use of the site.

The above alternatives provide a range of options for decision makers to evaluate as part of the remedy selection process. Alternative 1 involves no engineered remediation measures, LUCs, or monitoring and is included as a baseline comparison for the other alternatives. Alternatives 2, 3 and 4 are intended to achieve unrestricted future use of the site. Alternative 2 would reduce VOCs in soil gas and manage groundwater risk through MNA and LUCs until RAOs are met. Alternatives 3 and 4 would also reduce VOCs in soil gas and manage groundwater risk through treatment.

The relative performance of remedial alternatives considered in this FFS were compared against the NCP evaluation criteria to assess the merits of each alternative and to identify key trade-offs the Navy must consider when selecting a cleanup remedy. The NCP criteria are as follows:

Threshold criteria
- Overall protection of the environment
- Compliance with ARARs

Primary balancing criteria
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying criteria
- State acceptance
- Community acceptance

Alternatives 2, 3, and 4 meet the threshold criteria, while Alternative 1 does not. Alternatives 3 and 4 are similarly rated overall in satisfying the balancing criteria (i.e., lower ratings for some individual criteria are balanced by higher ratings for other individual criteria, resulting in overall similar ratings). Alternative 2 is rated lowest because, while it will reduce toxicity, mobility, and volume for VOCs in soil gas, it will not reduce toxicity, mobility, or volume of VOCs in groundwater through treatment. See Table ES-1 for a summary of rankings.
In addition to the nine CERCLA criteria, a comparative analysis of the sustainability of each alternative was also performed for this FFS. U.S. EPA (2010) currently defines "green" remediation as "the practice of considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprints of cleanup actions." The sustainability assessment used a green and sustainable remediation evaluation tool known as SiteWise. Inputs into SiteWise are segregated into four phases of work: RI, remedial action construction, operation, and long-term monitoring. Detailed inputs include vehicle mileage, personnel and equipment, construction details, residual handling, groundwater pumped, and equipment operated for each alternative. The eight sustainability factors modeled include greenhouse gas emissions, total energy used, water impacts, oxides of nitrogen (NOx) emissions, oxides of sulfur (SOx) emissions, airborne particulate (<10 micrometers in diameter) emissions (PM10), accident risk (fatality), and accident risk (injury). The sustainability of alternatives can also be considered in remedy selection and implementation. Of the active remedial alternatives, Alternative 2 is rated the most sustainable with the factors considered. A combination of alternatives may be considered during remedy selection or during remedy optimization.

Reference Documentation:

Brady. See Richard Brady & Associates.

Department of Toxic Substances Control (DTSC). California

Environmental Protection Agency. 2009. Interim Advisory for Green Remediation. December.

California Military Environmental Coordination Committee (CMECC). 1998. Institutional Control Protocol at Open Bases. January.

California Regional Water Quality Control Board (Water Board). 2007. "Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin." January. Available online at: http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml

City of Concord, Concord Community Reuse Project Office (City of Concord). 2010a. Concord Community Reuse Plan, Final Environmental Impact Report. January.
City of Concord. 2010b. "Recent News and Events." Concord Community Reuse Project website. Accessed March 23. http://www.concordreuseproject.org.

Cook. 2009. Assessing the Use and Application of Zero-Valent Iron Nanoparticle Technology for Remediation at Contaminated Sites. Prepared for U.S. EPA Office of Solid Waste and Emergency Response Office of Superfund Remediation and Technology Innovation. August.

Department of Defense (DoD). 2003. Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions. October.

Department of the Navy (Navy). See Navy.

IT Corporation, 1990. Site Investigation at Building IA-25 Naval Weapons Station Concord, California. Report of Findings. February.

Natural Heritage Institute. 2006. Mt. Diablo Creek Watershed Inventory, Final Report. June 30.

Navy. 1945. Bldg. IA-25 Plan and Elevations, Drawing number 373 373, 1945

Navy. 1988. Site Approval/Explosive Safety RC1-89, N60036.

Navy. 2006. Environmental Restoration Program Manual. August.

Navy and Department of Toxic Substances Control. 2000. Memorandum of Agreement between the United States Department of the Navy and the California Department of Toxic Substances Control. Use of model "Covenant to Restrict Use of Property" at installations being closed and transferred by the Navy.

Office of Management and Budget (OMB). 2010. Discount Rates for Cost-Effectiveness, Lease Purchase, and Related Analyses. Revised December 2009.

United States Environmental Protection Agency (U.S. EPA). 1987. Remedial Action Costing Procedures Manual. EPA/600/8-87/049. October.

U.S. EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Office of Solid Waste and Emergency Response (OSWER) Directive 9355.3 01. EPA/540/G-89/004. Office of Emergency and Remedial Response. Interim Final. October.

U.S. EPA. 1993. Presumptive Remedies: Policy and Procedures. Office of Solid Waste and Emergency Response. Directive No. 9355.0-47FS. September.

U.S. EPA. 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Final. OSWER Directive 9200.4-17P. April.

U.S. EPA. 2000. Guidance for Data Quality Objectives Process for Hazardous Waste Site Investigations. Office of Environmental Information. January.

U.S. EPA. 2009a. Principles for Greener Cleanups. Office of Solid Waste and Emergency Response. August 27.

U.S. EPA. 2009b. Superfund Green Remediation Strategy. Office of Superfund Remediation and Technology Innovation. January.

Water Board. See California Regional Water Quality Control Board

Richard Brady & Associates (Brady), 2011. Final Remedial Investigation for Installation Restoration Program Site 29 Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California. March 4.

Shaw Environmental & Infrastructure Group (Shaw). 2011. Solar-powered Vapor Extraction Treatability Study Work Plan.

SulTech. 2007. Final Sampling and Analysis Plan (Field Sampling Plan/Quality Assurance Project Plan) for the Remedial Investigation at Installation Restoration Site 29 Naval Weapons Station Seal Beach Detachment Concord, Concord, California. May.

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Site Documentation:

Site ID: IRS29-A4
Site Name: Alternative 4 - SVE with ISB and GW Recirculation
Site Type: Soil & Groundwater

Media/Waste Type
Primary: Soil
Secondary: Groundwater

Contaminant
Primary: Volatile Organic Compounds (VOCs)
Secondary: Metals

Phase Names
Pre-Study: ☐
Study: ☐
Design: ☑
Removal/Interim Action: ☐
Remedial Action: ☑
Operations & Maintenance: ☑
Long Term Monitoring: ☑
Site Closeout: ☑

Documentation
Description: Alternative 4 - SVE with ISB and Groundwater Recirculation

This alternative involves groundwater treatment of TCE as well as its chlorinated degradation products (cis-1,2-DCE and vinyl chloride) through the stimulation and creation of a favorable environment for microorganisms to grow and use chlorinated ethenes as an electron acceptor in a process called chlororespiration. TCE will biodegrade to nontoxic ethene under highly reducing conditions. The reducing conditions required to facilitate chlororespiration may be created in situ by the addition of a biodegradable organic substrate (e.g., lactate, molasses, or vegetable oils) in conjunction with a dechlorinating bacteria culture. This can result in bioreduction of TCE in the source area and thereby reduce the toxicity of the plume.

The ISB treatment entails injecting a vegetable-oil emulsion or like substance into the source area at a prescribed injection spacing to achieve the desired radius of influence in the treatment area and to target low-permeability zones. An oil emulsion is used as a biodegradable substrate that will enhance degradation of the chlorinated VOCs. Microbes will use the oil emulsion as a carbon source for growth. Fermentation of the oil will result in the release of molecular hydrogen (H2). Hydrogen is used as an electron donor and chlorinated ethenes are used as an electron acceptor by dechlorinating bacteria in a biologically mediated oxidation-reduction reaction that generates energy for their life processes. During this process, the dechlorinating microbes replace the chlorine atom on the chlorinated compound with a hydrogen atom, thereby converting the relatively oxidized TCE to a more reduced compound, DCE. This

process of reductive dechlorination sequentially reduces toxic TCE to nontoxic, nonchlorinated ethene (Shaw 2011).

Depending on the outcome of the Treatability Study, alternate injection formulas may be viable (e.g., lactate or lactoil, biogeochemical augmentation, or reducing agents [as discussed in Alternative 3]) to treat the immediate source area. If injected substrate alone is inadequate in reducing chlorinated ethene concentrations, groundwater may be amended to enhance the biogeochemical degradation processes. Similar to bioaugmentation, biogeochemical amendment would be conveyed through direct injection or a groundwater recirculation system. As an option to consider, a substrate solution consisting of a soluble organic substrate (e.g., lactate/lactoil) and water amended with a sulfate source (e.g., magnesium sulfate) and a soluble iron source would be introduced through injection or recirculation. Further refinement of the injection media and recirculation cells would be performed during the full-scale remedial design /remedial optimization.

Because the size of the plume is large and the expected radius of influence for injections is low (approximately 7 feet based on the Treatability Study [Shaw 2011]), treatment of the lower-concentration downgradient margin of the plume will be facilitated by a groundwater recirculation system with a network of injection and extraction wells. Groundwater will be sequestered into upgradient, central, and downgradient recirculation zones so as not to mix source-area groundwater with lower-concentration groundwater. Groundwater would be amended with a bacterial culture and substrate such as lactate at a prescribed rate (i.e., once every 3 hours, for 1/2 hour) during recirculation (Figure 5-3). Special care must be taken during injection and recirculation to avoid unintended dispersal of groundwater contaminants.

LUCs, such as fencing, signage, and short-term land use restrictions, would be implemented over the duration of SVE and groundwater treatment until RAOs are met. This alternative would be effective in reducing VOCs in soil gas and groundwater such that unrestricted use could be achieved.

Effectiveness. SVE combined with ISB is expected to be highly effective at reducing concentrations of VOCs in soil gas and groundwater if groundwater conditions are maintained at favorable levels for bioaugmentation. Risk to human receptors posed by VOCs at Site 29 would be reduced by mass removal of VOCs in soil gas via SVE and reductive dechlorination of VOCs to inert ethene in groundwater. This alternative by itself would reduce risk of exposure via the inhalation pathway and domestic use of groundwater.

Implementability. ISB is considered implementable given the current site conditions. Site 29 is presently used as pasture land for cattle. In the absence of additional hydrogeologic data, there is some uncertainty in design of the groundwater recirculation system. The design presented in this FFS is based on professional judgment and limited hydrogeologic data obtained during the Treatability Study (Shaw 2011). Therefore, this alternative is considered technically feasible under the current land use scenario.

Cost. Costs for this alternative are similar to the other alternatives with respect to SVE. ISB-specific costs would include microbial culture, oil emulsion, drilling costs for injection and installation of additional monitoring wells to measure treatment effectiveness, O&M of wells, periodic sampling to measure effectiveness, post-treatment sampling and reporting, and LUCs. Additional ISB

Estimate Documentation Report

injections may be necessary but were not assumed in the cost development for this FFS.

Conclusion. This alternative is considered a viable remedy to reduce risk to current and future receptors. Alternative 4 is expected to meet RAOs for soil gas and groundwater. A combination of this alternative with another groundwater alternative may be considered in the ROD. Alternative 4 is retained for detailed analysis.

Support Team: Shane DeGross, Richard Brady & Associates
Rain Zeng, Accord Engineering, Inc.
Max Pan, Accord Engineering, Inc.
Abram Eloskof - URS Group, Inc.

References: Focused Feasibility Study, IR Site 29, December 2011
Former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California

Estimator Information

Estimator Name: Al Meyer
Estimator Title: Construction & Cost Engineering Specialist
Agency/Org./Office: URS Corporation - Denver DTC
Business Address: URS Corporation
URS Center Building
8181 East Tuffs Avenue
Denver, Colorado 80237
Telephone Number: Office 303-740-3966 Cell 303-887-8645
Email Address: Albert.Meyer@urs.com
Estimate Prepared Date: 01/19/2012

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Shane DeGross
Reviewer Title: Project Manager
Agency/Org./Office: Richard Brady & Associates
Business Address: 3710 Ruffin Road
San Diego, CA 92123
Telephone Number: 916-436-8599
Email Address: sdegross@rbrady.net
Date Reviewed: 07/06/2011

Reviewer Signature: _____ **Date:** _____

Estimated Costs:

Phase Names	Direct Cost	Marked-up Cost

Estimate Documentation Report

01 Remedial Design	$78,919	$262,655
02 Land Use Controls	$821,180	$2,440,104
03 Soil Vapor Extraction System	$707,121	$1,219,417
04 Groudwater Bioaugmentation &	$1,165,448	$1,903,247
Recirculation	$94,763	$157,495
05 Groundwater Monitoring Wells	$415,088	$669,920
06 Soil Vapor Monitoring Probes	$579,916	$1,168,883
07 ISB Injection	$1,686,258	$3,038,696
08 SVE O & M & Peformance Monitoring	$80,199	$142,781
09 GW Bio & Recirc O & M & Peformance	$8,225	$23,938
Monitoring	$64,508	$199,177
10 Monitoring Well Maintenace	$403,734	$721,262
11 5-Year Reviews (Year 5 - 15)	$218,851	$410,755
12 Quarterly GW Monitoring (Year 1 - 2)	$61,416	$124,796
13 Semi Annual GW Monitoring (Year 3 - 4)	$614,156	$1,247,960
14 Annual GW Monitoring (Year 5)	$309,145	$582,958
15 MNA Annual GW Monitoring (Year 6 - 15)	$343,318	$659,732
16 GW Recirculation Decommissioning (Year 3)	$211,634	$414,657
17 SVE System Decommissioning (Year 6)		
18 Site Closeout (Year 15)		
Total Cost:	$7,863,879	$15,388,433

Estimate Documentation Report

Phase Documentation:

Phase Type: Design - Detail
Phase Name: 01 Remedial Design
Description: Design Includes: Land Use Controls, Soil Vapor Extraction System and Work Plans.

Start Date: July, 2011
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Remedial Design	Yes	100	0

Total Marked-up Cost: $262,655

Technologies:

Estimate Documentation Report

Technology Name: **Remedial Design (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Project Approach		In-Situ Treatment	n/a
Complexity		Low	n/a
Project Planning		Yes	n/a
Treatability & Other Studies		No	n/a
Preliminary Design (30%)		Yes	n/a
Intermediate Design (60%)		Yes	n/a
Prefinal Design (90%)		Yes	n/a
Final Design (100%)		Yes	n/a
Bid Documents		Yes	n/a
Site Distance		25	MI
Level of RD Detail		Moderate	n/a
Project Planning			
Required Parameters			
Site Visit		Yes	n/a
RD Work Plan		Yes	n/a
Data Review		Yes	n/a
Public Meetings		Yes	n/a
Preliminary Design			
Required Parameters			
Design Criteria Memorandum		Yes	n/a
Basis of Design Report		Yes	n/a
Preliminary Plans & Specifications		Yes	n/a
VE Screening Report		Yes	n/a
Public Meetings		Yes	n/a
Intermediate Design			
Required Parameters			
Revised Basis of Design Report		Yes	n/a
Intermediate Plans && Specifications		Yes	n/a
VE Report		Yes	n/a
Prefinal Design			
Required Parameters			
Prefinal Plans & Specifications		Yes	n/a

Estimate Documentation Report

Technology Name: **Remedial Design (# 1)**

Description	*Default*	*Value*	*UOM*
Prefinal Design			
Required Parameters			
Construction QA Plan		Yes	n/a
Final Design			
Required Parameters			
Final Plans & Specifications		Yes	n/a
Final Report		Yes	n/a
Public Meetings		Yes	n/a
Post Design Fact Sheet		Yes	n/a
Bid Documents			
Required Parameters			
Prepare Bid Documents		Yes	n/a
Issue Invitations for Bids/Request Proposals		Yes	n/a
Contractor Bid Evaluation/Selection Support		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 02 Land Use Controls
Description: Includes: Adminstrative and Engineering Controls.

Approach: Ex Situ
Start Date: December, 2011
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
MEC Institutional Controls	Yes	30	70
LAND USE CONTROLS	Yes	100	0

Total Marked-up Cost: $2,440,104

Technologies:

Technology Name: **MEC Institutional Controls (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Planning		No	n/a
Implementation		No	n/a
Engineering Controls		Yes	n/a
Training and Follow Up		No	n/a
Quality Support Visits		No	n/a
Site Distance		50	MI (One-way)
Site Complexity		Low	n/a
Engineering Controls			
Required Parameters			
Type of Fence		Security	n/a
Length of Fence		1,048	LF

Comments:

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Rename Model		LAND USE CONTROLS	n/a
Planning Documents		Yes	n/a
Planning Documents: Start Date		2011	n/a
Implementation		Yes	n/a
Implementation: Start Date		2011	n/a
Monitoring & Enforcement		Yes	n/a
Monitoring & Enforcement: Start Date		2011	n/a
Modification/Termination		Yes	n/a
Modification/Termination: Start Date		2011	n/a
Type of Site		Transferring Government Installation	n/a
Planning Documents			
Required Parameters			
LUC Assurance Plan (LUCAP)		Yes	n/a
LUC Assurance Plan (LUCAP): Plan Complexity		Medium	n/a
LUC Implementation Plan (LUCIP)		Yes	n/a
LUC Implementation Plan (LUCIP): Number		1	EA
LUC Implementation Plan (LUCIP): Plan Complexity		Medium	n/a
Long-term Stewardship (LTS) Plan		Yes	n/a
Long-term Stewardship (LTS) Plan: Number		1	EA
Long-term Stewardship (LTS) Plan: Plan Complexity		Medium	n/a
Memorandum of Agreements (MOA)		Yes	n/a
Memorandum of Agreements (MOA): Number		1	EA
Memorandum of Agreements (MOA): Plan Complexity		Medium	n/a
Installation (or City) Master Plan		Yes	n/a
Installation (or City) Master Plan: Plan Complexity		Medium	n/a
Construction Permitting		Yes	n/a
Construction Permitting: Number		1	EA
Construction Permitting: Plan Complexity		Medium	n/a
Geographic Information Systems (GIS)/Overlay Maps		Yes	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Planning Documents			
Required Parameters			
Geographic Information Systems (GIS)/Overlay Maps: Number		1	EA
Geographic Information Systems (GIS)/Overlay Maps: Plan Complexity		Medium	n/a
Planning Meetings			
Required Parameters			
LUCAP: Number of Meetings		2	EA
LUCAP: Number of People		2	EA
LUCAP: Number of Days		1	EA
LUCAP: Airfare Cost		650	$
LUCAP: Mileage to Meeting Site		50	MI
LUCIP: Number of Meetings		2	EA
LUCIP: Number of People		2	EA
LUCIP: Number of Days		1	EA
LUCIP: Airfare Cost		650	$
LUCIP: Mileage to Meeting Site		50	MI
LTS: Number of Meetings		2	EA
LTS: Number of People		2	EA
LTS: Number of Days		1	EA
LTS: Airfare Cost		650	$
LTS: Mileage to Meeting Site		50	MI
MOA: Number of Meetings		2	EA
MOA: Number of People		2	EA
MOA: Number of Days		1	EA
MOA: Airfare Cost		650	$
MOA: Mileage to Meeting Site		50	MI
Master Plan: Number of Meetings		2	EA
Master Plan: Number of People		2	EA
Master Plan: Number of Days		1	EA
Master Plan: Airfare Cost		650	$
Master Plan: Mileage to Meeting Site		50	MI

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Planning Meetings			
Required Parameters			
Construction Permitting: Number of Meetings		2	EA
Construction Permitting: Number of People		2	EA
Construction Permitting: Number of Days		1	EA
Construction Permitting: Airfare Cost		650	$
Construction Permitting: Mileage to Meeting Site		50	MI
GIS/Overlay Maps: Number of Meetings		2	EA
GIS/Overlay Maps: Number of People		2	EA
GIS/Overlay Maps: Number of Days		1	EA
GIS/Overlay Maps: Airfare Cost		650	$
GIS/Overlay Maps: Mileage to Meeting Site		50	MI
Implementation			
Required Parameters			
Modify Installation (or City) Master Plan		Yes	n/a
Modify Installation (or City) Master Plan: Task Complexity		Medium	n/a
Deed Notification		Yes	n/a
Deed Notification: Number		1	EA
Deed Notification: Task Complexity		Medium	n/a
Negotiating Easements		Yes	n/a
Negotiating Easements: Number		1	EA
Negotiating Easements: Task Complexity		Medium	n/a
Restrictive Covenants		Yes	n/a
Restrictive Covenants: Number		1	EA
Restrictive Covenants: Task Complexity		Medium	n/a
Equitable Servitudes		Yes	n/a
Equitable Servitudes: Number		1	EA
Equitable Servitudes: Task Complexity		Medium	n/a
Access Control Signs		Yes	n/a
Access Control Signs: Number		4	EA
Access Control Signs: Task Complexity		Medium	n/a
Utility Notification Service		Yes	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Implementation			
Required Parameters			
Access Control Signs: Number		1	EA
Access Control Signs: Task Complexity		Medium	n/a
Geographic Information Systems (GIS)/Overlay Maps		Yes	n/a
Geographic Information Systems (GIS)/Overlay Maps: Number		1	EA
Geographic Information Systems (GIS)/Overlay Maps: Task Complexity		Medium	n/a
Develop Finding of Suitablility to Transfer (FOST)		Yes	n/a
Develop Finding of Suitablility to Transfer (FOST): Task Complexity		Medium	n/a
Monitoring & Enforcement			
Required Parameters			
Duration of Monitoring/Enforcement		17	Years
Notice Letters		Yes	n/a
Notice Letters: Number		10	EA
Notice Letters: Frequency		Annually	n/a
Guard Service/Security		No	n/a
Reports & Certifications		Yes	n/a
Reports & Certifications: Frequency		Annually	n/a
Site Visits/Inspections		Yes	n/a
Site Visits/Inspections: Number		1	EA
Site Visits/Inspections: Safety Level		D	n/a
Site Visits/Inspections: Duration		3	Days
Site Visits/Inspections: Number of People		2	EA
Site Visits/Inspections: Frequency		Annually	n/a
Site Visits/Inspections: Airfare		650	$ Per Ticket
Site Visits/Inspections: Mileage		50	MI
Modify/Termination			
Required Parameters			
Document Evaluation		Yes	n/a
Document Evaluation: Number		1	EA
Document Evaluation: Plan Complexity		Medium	n/a

Estimate Documentation Report

Technology Name: **Administrative Land Use Controls (# 1)**
User Name: **LAND USE CONTROLS**

Description	*Default*	*Value*	*UOM*
Modify/Termination			
Required Parameters			
Modify LUC Documents		Yes	n/a
Modify LUC Documents: Number		1	EA
Modify LUC Documents: Plan Complexity		Medium	n/a
Amend Decision Documents		Yes	n/a
Amend Decision Documents: Number		1	EA
Amend Decision Documents: Plan Complexity		Medium	n/a
Termination Letters		Yes	n/a
Termination Letters: Number		1	EA
Termination Letters: Plan Complexity		Medium	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 03 Soil Vapor Extraction System
Description: Includes: SVE System Installation, 1,500-ft of Underground Power Service and SVE Building.
Approach: In Situ
Start Date: January, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Soil Vapor Extraction	Yes	30	70
Carbon Adsorption (Gas)	Yes	30	70
Decontamination Facilities	Yes	30	70
Residual Waste Management	Yes	100	0
Professional Labor Management	Yes	100	0
UNDERGROUND ELECTRIC SERVICE	Yes	30	70
SVE & GW TREATMENT BUILDING	Yes	30	70

Total Marked-up Cost: $1,219,417

Technologies:

Estimate Documentation Report

Technology Name: **Soil Vapor Extraction (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Installation Type		Vertical Wells	n/a
Soil Type		Sand/Gravelly Sand Mixture	n/a
Surface Area of Contamination		48,000	SF
Depth to Base of Contamination		50	FT
Safety Level		D	n/a
Drilling			
Required Parameters			
Average Well Depth		45	LF
Formation Type		Consolidated	n/a
Drilling Method		Air Rotary	n/a
Well Diameter		4 Inch	n/a
Well Construction Material		PVC Schedule 40	n/a
Split Spoon Sample Collection		Yes	n/a
Drum Drill Cuttings		No	n/a
Average Number of Soil Samples per Well		1	EA
Soil Analytical Template		System Soil - VOCs	n/a
Drilling Safety Level		D	n/a
Vertical Wells			
Secondary Parameters			
Vertical Well: Extraction Well Spacing	50	50	FT
Vertical Well: Number of Vapor Extraction Wells	25	25	EA
Vertical Well: Average Vapor Flow Rate per Well	35	35	CFM
Vertical Well: Total Vapor Flow Rate	875	875	CFM
Vertical Well: Knockout Drums	0	1	EA
Vertical Well: Floor Slab Sawing	0	0	HR
Vertical Well: Equipment Enclosure	Yes	Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Carbon Adsorption (Gas) (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Influent Flow Rate		875	CFM
Adsorption System		Modular Carbon Adsorbers (Disposable)	n/a
Know Total Organic Concentration		No	n/a
Influent Total Organic Concentration (for O&M)		0	ppm
System Redundancy		Two Adsorbers in Series	n/a
Blower		Yes	n/a
Heater		No	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		Yes	n/a
Equipment Rating		Medium Equipment Rating	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		6	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		6	weeks
Safety Level		D	n/a
Decon Pad			
Secondary Parameters			
Area of Decontamination Pad	800	800	SF
Use Flexible Membrane Liner	Yes	Yes	n/a
Percentage of Time Decontamination Pad in Use	25	25	%
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		18,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		39	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		825,349	$
Percentage	18.5	18.5	%
Dollar Amount		152,690	$

Comments:

Estimate Documentation Report

Technology Name: **User Defined Estimate (# 1)**
User Name: **UNDERGROUND ELECTRIC SERVICE**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		UNDERGROUND ELECTRIC SERVICE	n/a
WBS Type		HTRW	n/a
Selected WBS		331.03.06	n/a
Safety Level		D	n/a

Comments:

Technology Name: **User Defined Estimate (# 2)**
User Name: **SVE & GW TREATMENT BUILDING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		SVE & GW TREATMENT BUILDING	n/a
WBS Type		HTRW	n/a
Selected WBS		331.13.23	n/a
Safety Level		D	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 04 Groudwater Bioaugmentation & Recirculation
Description: Includes: Pilot Scale Test, Bench Scale Tst, 11 Injection and 9 Extraction Wells, Associated Piping and Recirculation pumps, controls, Lactate and Bionutrients. O & M of Injection and Extraction Wells in O & M and Performance Monitoring.
Approach: In Situ
Start Date: January, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
In Situ Biodegradation	Yes	30	70
Groundwater Extraction Wells	Yes	100	0
Injection Wells	Yes	100	0
Decontamination Facilities	Yes	100	0
Residual Waste Management	Yes	100	0
Professional Labor Management	Yes	100	0

Total Marked-up Cost: $1,903,247

Technologies:

Estimate Documentation Report

Technology Name: **In Situ Biodegradation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Media of Concern		Groundwater	n/a
Soil Type		Sand-Silt/Sand-Clay Mixture	n/a
Type of Biodegradation		Anaerobic	n/a
Remedial Configuration		Entire Plume	n/a
Contaminant Concentration		Low	n/a
Treatment Area Length		150	FT
Treatment Area Width		458	FT
Depth to Top of Aquifer		40	FT
Aquifer Thickness		20	FT
Formation		Consolidated	n/a
Treatability Test		Yes	n/a
Install Monitoring Technology		Yes	n/a
Safety Level		D	n/a
Anaerobic			
Secondary Parameters			
Entire Plume Treatment Area	68,700	n/a	SF
Substrate Selection	Vegetable Oil	Lactate	n/a
Bioaugmentation	0	0	L
Nutrient	1,283	1,283	LB
Substrate Delivery Method	Injection Wells	Injection Wells	n/a
Number of Delivery Points	69	11	EA
Substrate Application Rate / Delivery Point	10	10	%
Number of Applications for First Year	6	6	EA
Outyears for O&&M Only	1	0	Years
Number of Bench-scale Tests	1	1	EA
Cost per Bench-scale Test	25,000	50,000	$
Number of Pilot-scale Tests	1	1	EA
Cost per Pilot-scale Test	50,000	250,000	$
Injection Well			
Secondary Parameters			

Estimate Documentation Report

Technology Name: **In Situ Biodegradation (# 1)**

Description	*Default*	*Value*	*UOM*
Injection Well			
Secondary Parameters			
Drilling Method	Air Rotary	Air Rotary	n/a
Screen Length per Well	20	20	FT
Substrate Mixing System Type	Batch Mixing	Batch Mixing	n/a
Average Length of Piping, per Well	100	150	FT

Comments:

Estimate Documentation Report

Technology Name: **Groundwater Extraction Wells (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Number of Wells		9	EA
Flow Rate per Well		5	GPM
Type of Formation		Consolidated	n/a
Depth to Base of Contamination		65	FT
Type of Aquifer		Unconfined	n/a
Depth to Static Water Table		40	FT
Depth to Top of Confining Layer		0	FT
Depth to Bottom of Confining Layer		0	FT
Type of Existing Cover		Soil/Gravel	n/a
Safety Level		D	n/a
Pumps & Wells			
Secondary Parameters			
Type of Submersible Pump	4" Submersible Pump, 0.3-7 GPM, Head <=140", 1/3 hp, w/ controls	4" Submersible Pump, 0.3-7 GPM, Head <=140", 1/3 hp, w/ controls	n/a
Casing Diameter	6 inches	6 inches	IN
Wells Enclosure	Restricted Zone/Above Ground	Restricted Zone/Above Ground	n/a
Wells Screen Length	20	20	FT
Drum Drill Cuttings		Yes	n/a
Pipes & Tanks			
Secondary Parameters			
Pipe Location		Below Ground	n/a
Effluent Collection Tank		Yes	n/a
Effluent Collection Tank Type	5,000 GAL, Single Wall Steel Tank	5,000 GAL, Single Wall Steel Tank	n/a
Number of Effluent Collection Tanks	1	1	EA

Comments:

Estimate Documentation Report

Technology Name: **Injection Wells (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Depth to Top of Aquifer		40	FT
Aquifer Thickness		25	FT
Injection Rate per Well		5	GPM
Number of Injection Wells		11	EA
Analytical		Yes	n/a
Number of Soil Samples per well		1	EA
Soil Analytical Template		Waste Characterization, Solids	n/a
Formation Type		Consolidated	n/a
Safety Level		D	n/a
Wells			
Secondary Parameters			
Well Construction Material	PVC Schedule 40	PVC Schedule 40	n/a
Well Diameter	2	4	IN
Screen Length per well	25	25	FT
Drilling			
Secondary Parameters			
Drilling Method	Air Rotary	Air Rotary	n/a
Drum Drill Cuttings	Yes	Yes	n/a
Pipes/Tanks			
Secondary Parameters			
Type of Pipe	2" PVC, Sch 80	2" PVC, Sch 80	n/a
Pipe Length, per Well	100	150	FT
Type of Tank	None	5,000 Gal Steel, Above Ground	n/a
Number of Tanks	0	1	EA

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		Yes	n/a
Equipment Rating		Medium Equipment Rating	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		2	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		6	per shift
Personnel Decontamination Trailers: Duration		2	weeks
Safety Level		D	n/a
Decon Pad			
Secondary Parameters			
Area of Decontamination Pad	800	800	SF
Use Flexible Membrane Liner	Yes	Yes	n/a
Percentage of Time Decontamination Pad in Use	25	25	%
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		6,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		143	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		1,628,098	$
Percentage	16.9	16.9	%
Dollar Amount		275,149	$

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 06 Soil Vapor Monitoring Probes
Description: Includes: VMP Wells Installation.

Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Special Well Drilling & Installation	Yes	30	70
Residual Waste Management	Yes	100	0
Decontamination Facilities	Yes	30	70
Professional Labor Management	Yes	100	0

Total Marked-up Cost: $669,920

Technologies:

Estimate Documentation Report

Technology Name: **Special Well Drilling & Installation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Type of Well		Vertical	n/a
Safety Level		D	n/a
Vertical Wells			
Required Parameters			
Formation Type		Consolidated	n/a
Completion Type		Single Cased Well	n/a
Number of Wells/Borings		20	EA
Depth of Boring		0	FT
Depth to Bottom of Outer Casing		0	FT
Depth to Bottom of Middle Casing		0	FT
Depth to Top of Screen		50	FT
Screen Length		20	FT
Vertical Secondary			
Secondary Parameters			
Well Construction Material	PVC Schedule 40	PVC Schedule 40	n/a
Well Diameter	4	4	IN
Drilling Method	Water/Mud Rotary	Air Rotary	n/a
Drum Drill Cuttings	Yes	Yes	n/a
Soil Sample Collection	Yes	Yes	n/a
Well Development	Yes	No	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		6,000	GAL
Transportation Type		Rail	n/a
Rail Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		71	Drums
Transportation Type		Rail	n/a
Rail Distance (One-way)		150	Miles

Comments:

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		No	n/a
Equipment Rating		n/a	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		2	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		2	weeks
Safety Level		D	n/a
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Estimate Documentation Report

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		562,958	$
Percentage	19	19	%
Dollar Amount		106,962	$

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 05 Groundwater Monitoring Wells
Description: Includes: Installation of 4 New Groundwater Monitoring Wells 70-ft average depth.
Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Groundwater Monitoring Well	Yes	30	70
Decontamination Facilities	Yes	30	70
Residual Waste Management	Yes	100	0
Professional Labor Management	Yes	100	0

Total Marked-up Cost: $157,495

Technologies:

Estimate Documentation Report

Technology Name: **Groundwater Monitoring Well (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Number of Aquifers		One	n/a
Include Guard Posts		Yes	n/a
Depth to Groundwater to Aquifer One		45	FT
Number of Wells to Aquifer One		4	EA
Safety Level		D	n/a
Aquifer One			
Required Parameters			
Aquifer One: Average Well Depth		70	LF
Aquifer One: Formation Type		Consolidated	n/a
Aquifer One: Drilling Method		Air Rotary	n/a
Aquifer One: Well Diameter		4 Inch	n/a
Aquifer One: Well Construction Material		PVC Schedule 40	n/a
Aquifer One: Split Spoon Sample Collection		Yes	n/a
Aquifer One: Average Number of Soil Samples per Well		1	EA
Aquifer One: Soil Analytical Template		System Soil - VOCs	n/a
Aquifer One: Safety Level		D	n/a

Comments:

Estimate Documentation Report

Technology Name: **Decontamination Facilities (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
New Decontamination Facility Pad Construction		No	n/a
Equipment Rating		n/a	n/a
Equipment Decontamination Operations		Yes	n/a
Equipment Decontamination Operations: Duration		1	weeks
Personnel Decontamination Trailers		Yes	n/a
Personnel Decontamination Trailers: Average Crew Size		5	per shift
Personnel Decontamination Trailers: Duration		1	weeks
Safety Level		D	n/a
Work Shifts			
Secondary Parameters			
Equipment Decontamination		One Shift per Day	n/a
Personnel Decontamination		One Shift per Day	n/a

Comments:

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Liquid	n/a
Total Quantity		3,000	GAL
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		2	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Technology Name: **Professional Labor Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Markedup Construction Cost ($)		131,355	$
Percentage	19.9	19.9	%
Dollar Amount		26,140	$

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 07 ISB Injection
Description: Includes: 200 Injection Points, 22 Gallons EOS and 2 Liters Microbial Culture per Injection Point.

Note: No Out Year Applications.

Approach: In Situ
Start Date: February, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
In Situ Biodegradation	Yes	30	70

Total Marked-up Cost: $1,168,883

Technologies:

Estimate Documentation Report

Technology Name: **In Situ Biodegradation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Media of Concern		Groundwater	n/a
Soil Type		Sand-Silt/Sand-Clay Mixture	n/a
Type of Biodegradation		Anaerobic	n/a
Remedial Configuration		Entire Plume	n/a
Contaminant Concentration		Low	n/a
Treatment Area Length		150	FT
Treatment Area Width		458	FT
Depth to Top of Aquifer		40	FT
Aquifer Thickness		30	FT
Formation		Consolidated	n/a
Treatability Test		Yes	n/a
Install Monitoring Technology		Yes	n/a
Safety Level		D	n/a
Anaerobic			
Secondary Parameters			
Entire Plume Treatment Area	68,700	n/a	SF
Substrate Selection	Vegetable Oil	Vegetable Oil	n/a
Bioaugmentation	0	2	L
Nutrient	1,924	1,924	LB
Substrate Delivery Method	Injection Wells	Direct Push	n/a
Number of Delivery Points	275	200	EA
Substrate Application Rate / Delivery Point	10	10	%
Number of Applications for First Year	1	1	EA
Outyears for O&&M Only	1	0	Years
Number of Bench-scale Tests	1	1	EA
Cost per Bench-scale Test	25,000	25,000	$
Number of Pilot-scale Tests	1	1	EA
Cost per Pilot-scale Test	50,000	50,000	$
Injection Well			
Secondary Parameters			

Estimate Documentation Report

Technology Name: **In Situ Biodegradation (# 1)**

Description	*Default*	*Value*	*UOM*
Injection Well			
Secondary Parameters			
Screen Length per Well	0	0	FT
Substrate Mixing System Type	None	None	n/a
Average Length of Piping, per Well	0	0	FT

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: 08 SVE O & M & Peformance Monitoring
Description: SVE System Operation & Maintenance including Carbon Changeout, Preformance Monitoring at 25 SVE Wellheads plus 20 Vapor Monitoring Probes for 60 months.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Operations and Maintenance	Yes	100	0

Total Marked-up Cost: $3,038,696

Technologies:

Estimate Documentation Report

Technology Name: **Operations and Maintenance**

Description	*Default*	*Value*	*UOM*
Labor			
Secondary Parameters			
Operations Labor: Type		Minimum	n/a
Professional Labor: Type		Exclude from Estimate	n/a
Analytical			
Secondary Parameters			
Wastewater/Effluent: Sampling Frequency		Exclude from Estimate	n/a
Wastewater/Effluent: Primary Analytical Template		None	n/a
Wastewater/Effluent: Secondary Analytical Template		None	n/a
Air Emissions: Sampling Frequency		Annually	n/a
Air Emissions: Primary Analytical Template		System Air Emissions - VOCs	n/a
Air Emissions: Secondary Analytical Template		None	n/a
Solid Wastes: Sampling Frequency		Exclude from Estimate	n/a
Solid Wastes: Primary Analytical Template		None	n/a
Solid Wastes: Secondary Analytical Template		None	n/a
Heating Requirements			
Secondary Parameters			
Air Streams: Flow Rate		875	CFM
Air Streams: Temperature Difference		20	F
Air Streams: Months per Year		12	Month
Water Streams: Flow Rate		0	CFM
Water Streams: Temperature Difference		0	F
Water Streams: Months per Year		0	Month
Facility: Area		400	SF
Facility: Temperature Difference		0	F
Facility: Months per Year		0	Month

Comments:

Estimate Documentation Report

Technology Name: **Soil Vapor Extraction (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Installation Type		Vertical Wells	n/a
Average Well Depth		45	LF
Vertical Well: Number of Vapor Extraction Wells		25	EA
Vertical Well: Total Vapor Flow Rate		875	CFM
Horizontal Trenches: Total Vapor Flow Rate		0	CFM

Technology Name: **Carbon Adsorption (Gas) (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Influent Flow Rate		875	CFM
Adsorption System		Modular Carbon Adsorbers (Disposable)	n/a
Influent Total Organic Concentration (for O&M)		0	ppm

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance
Phase Name: 09 GW Bio & Recirc O & M & Peformance Monitoring
Description: Groundwater Bioaugmentation & Recirculation System Operation & Mainteneance and Performance Monitoring includes 60 months of O&M for 11 injection wells, 9 extraction wells, lactate, bionutrients.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Operations and Maintenance	Yes	100	0

Total Marked-up Cost: $142,781

Technologies:

Estimate Documentation Report

Technology Name: **Operations and Maintenance**

Description	*Default*	*Value*	*UOM*
Labor			
Secondary Parameters			
Operations Labor: Type		Minimum	n/a
Professional Labor: Type		Exclude from Estimate	n/a
Analytical			
Secondary Parameters			
Wastewater/Effluent: Sampling Frequency		Monthly	n/a
Wastewater/Effluent: Primary Analytical Template		IR Site 29 Suite VOC, DHC & MNA - Water	n/a
Wastewater/Effluent: Secondary Analytical Template		None	n/a
Air Emissions: Sampling Frequency		Exclude from Estimate	n/a
Air Emissions: Primary Analytical Template		None	n/a
Air Emissions: Secondary Analytical Template		None	n/a
Solid Wastes: Sampling Frequency		Exclude from Estimate	n/a
Solid Wastes: Primary Analytical Template		None	n/a
Solid Wastes: Secondary Analytical Template		None	n/a
Heating Requirements			
Secondary Parameters			
Air Streams: Flow Rate		0	CFM
Air Streams: Temperature Difference		0	F
Air Streams: Months per Year		0	Month
Water Streams: Flow Rate		55	CFM
Water Streams: Temperature Difference		0	F
Water Streams: Months per Year		0	Month
Facility: Area		400	SF
Facility: Temperature Difference		0	F
Facility: Months per Year		0	Month

Comments:

Estimate Documentation Report

Technology Name: **Groundwater Extraction Wells (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Number of Wells		9	EA
Flow Rate per Well		5	GPM
Type of Aquifer		Unconfined	n/a
Depth to Static Water Table		40	FT
Depth to Top of Confining Layer		0	FT

Technology Name: **Injection Wells (# 1) - (O&M Parameters)**

Description	*Default*	*Value*	*UOM*
O&M Parameters			
Injection Rate per Well		5	GPM
Number of Injection Wells		11	EA

Estimate Documentation Report

Phase Documentation:

Phase Type: Operations & Maintenance

Phase Name: 10 Monitoring Well Maintenace

Description: Includes: Moitoring well redevelopment of 4 of 13 existing wells and 1 of 4 new wells on a 7 year-cycle.

It can be reasonably assumed that some or all of the Groundwater Long Term Monitoring wells may require redevelopment. RACER does not provide a given Technology to address this issue. However the Natural Attenuation Technology can be modified based on its "start date" and "out-year capability" to address monitoring well maintenance.

Replacement of monitoring wells is not considered in this cost estimate.

Start Date: February, 2017

Labor Rate Group: System Labor Rate

Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Natural Attenuation	Yes	100	0
Natural Attenuation	Yes	100	0

Total Marked-up Cost: $23,938

Technologies:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2018	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 1)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Crew Size		2 Field Technicians	n/a
Site Distance		50	MI
Analytical - Water: Groundwater		Yes	n/a
Analytical - Water: Surface Water		No	n/a
Analytical - Water: Template		MNA Water - VOCs	n/a
Analytical - Soil: Surface Soil		No	n/a
Analytical - Soil: Subsurface Soil		No	n/a
Analytical - Soil: Template		None	n/a
Include QA/QC Samples		Yes	n/a
Include Data Analysis/Reporting		Yes	n/a
Safety Level		D	n/a
Media			
Required Parameters			
Groundwater: Avg Sample Depth		70	FT
Groundwater (FIRST YEAR): # of Events		1	EA
Groundwater (FIRST YEAR): Samples per Event		17	EA
Groundwater (OUTYEARS): # of Years		0	EA
Groundwater (OUTYEARS): Events per Year		0	EA
Groundwater (OUTYEARS): Samples per Event		0	EA
Methodology			
Secondary Parameters			
Groundwater	Existing Wells - Bailers	Existing Wells - Bailers	n/a
Number of Wells Sampled/Day	4	4	EA
Drum & Sample Development Water	Yes	No	n/a
Turnaround Time		Standard (21 Days)	n/a
Quality Control		Level 1	n/a
Start Date: Month		February	n/a
Start Date: Year		2025	n/a
Data Mgt			
Required Parameters			
Develop Monitoring Plan		No	n/a

Estimate Documentation Report

Technology Name: **Natural Attenuation (# 2)**

Description	*Default*	*Value*	*UOM*
Data Mgt			
Required Parameters			
Prepare Monitoring Reports		No	n/a
Perform Data Evaluation		No	n/a
Submit Analytical Data Electronically		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 11 5-Year Reviews (Year 5 - 15)
Description: Includes: 5-Year Reviews with Rebound Study and Travel for 3 people. The level of effort varies as follows: Year 2017 = High, Year 2022 = Low and Year 2027 = Medium.

Start Date: March, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	Yes	100	0
Five-Year Review	Yes	100	0
Five-Year Review	Yes	100	0

Total Marked-up Cost: $199,177

Technologies:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		High	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2017	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 1)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 2)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Low	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2022	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 2)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Technology Name: **Five-Year Review (# 3)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Site Complexity		Moderate	n/a
Document Review		Yes	n/a
Interviews		Yes	n/a
Site Inspection		Yes	n/a
Report		Yes	n/a
Travel		Yes	n/a
Rebound Study		Yes	n/a
Start Date		April-2027	n/a
No. Reviews		1	EA
Document Review			
Required Parameters			
5-Year Review Check List		Yes	n/a
Record of Decision		Yes	n/a
Remedial Action Design & Construction		Yes	n/a
Close-Out Report		Yes	n/a
Operations & Maintenance Manuals & Reports		Yes	n/a
Consent Decree or Settlement Records		Yes	n/a
Groundwater Monitoring & Reports		Yes	n/a
Remedial Action Required		Yes	n/a
Previous 5-Year Review Reports		Yes	n/a
Interviews			
Required Parameters			
Current and Previous Staff Management		Yes	n/a
Community Groups		Yes	n/a
State Contacts		Yes	n/a
Local Government Contacts		Yes	n/a
Operations & Maintenance Contractors		Yes	n/a
PRPs		Yes	n/a
Remedial Design Consultant		Yes	n/a
Site Inspection			
Required Parameters			

Estimate Documentation Report

Technology Name: **Five-Year Review (# 3)**

Description	*Default*	*Value*	*UOM*
Site Inspection			
Required Parameters			
General Site Inspection		Yes	n/a
Containment System Inspection		Yes	n/a
Monitoring Systems Inspection		Yes	n/a
Treatment Systems Inspection		Yes	n/a
Regulatory Compliance		Yes	n/a
Site Visit Documentation (Photos, Diagrams, etc.)		Yes	n/a
Report			
Required Parameters			
Introduction		Yes	n/a
Remedial Objectives		Yes	n/a
ARARs Review		Yes	n/a
Summary of Site Visit		Yes	n/a
Areas of Non Compliance		Yes	n/a
Technology Recommendations		Yes	n/a
Statement of Protectiveness		Yes	n/a
Next Review		Yes	n/a
Implementation Requirements		Yes	n/a
Travel			
Required Parameters			
Number of Travelers		3	EA
Number of Days		2	EA
Air Fare Ticket Price		650	$
Need a rental car?		Yes	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 12 Quarterly GW Monitoring (Year 1 - 2)
Description: Includes: Quarterly Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2012
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $721,262

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		4	n/a
Number of Events (Out Years)		4	n/a
Number of Years (Out Years)		1	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 13 Semi Annual GW Monitoring (Year 3 - 4)
Description: Includes: Semi Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2014
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $410,755

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		2	n/a
Number of Events (Out Years)		2	n/a
Number of Years (Out Years)		1	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 14 Annual GW Monitoring (Year 5)
Description: Includes: Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2016
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $124,796

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		0	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		0	n/a
Number of Years (Out Years)		0	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 15 MNA Annual GW Monitoring (Year 6 - 15)
Description: Includes: MNA Annual Groundwater Monitoring of 13 existing wells and 4 new wells for VOCs, DHC, MNA and Metals.

Start Date: April, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
GROUNDWATER MONITORING	Yes	100	0

Total Marked-up Cost: $1,247,960

Technologies:

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Model Name		GROUNDWATER MONITORING	n/a
Groundwater		Yes	n/a
Surface Soil		No	n/a
Surface Water		No	n/a
Subsurface Soil		No	n/a
Sediment		No	n/a
Soil Gas		No	n/a
Air		No	n/a
Site Distance (One-way)		50	MI
Safety Level		D	n/a
Groundwater			
Required Parameters			
Average Sample Depth		70	FT
Samples per Event (First Year)		17	n/a
Samples per Event (Out Years)		17	n/a
Number of Events (First Year)		1	n/a
Number of Events (Out Years)		1	n/a
Number of Years (Out Years)		9	n/a
Secondary Parameters			
Primary Analytical Template	System Water - VOCs	IR Site 29 Suite VOC, DHC, MNA & Metals - Water	n/a
Secondary Analytical Template	System Water - VOCs	None	n/a
Turnaround Time	Standard (21 Days)	Standard (21 Days)	n/a
Data Package/QC	Stage 1	Stage 1	n/a
Sampling Method	Existing Wells - Low Flow Pump	Existing Wells - Low Flow Pump	n/a
Number of Wells/Day	6	6	EA
Contain Purge Water	Yes	Yes	n/a
QA/QC			
Secondary Parameters			
Split Samples	1: 10	1: 10	EA

Estimate Documentation Report

Technology Name: **Monitoring (# 1)**
User Name: **GROUNDWATER MONITORING**

Description	*Default*	*Value*	*UOM*
QA/QC			
Secondary Parameters			
Field Duplicate Samples	1: 10	1: 10	EA
Rinse Blanks (per Round)	1	1	EA
Trip Blanks (per Day)	1	1	EA
Matrix Spikes/Matrix Spike Duplicates	1: 20	1: 20	EA
Data Management			
Secondary Parameters			
Monitoring Plan	Standard	Standard	n/a
Lab Data Review	Stage 1	Stage 1	n/a
Submit Data Electronically	Yes	Yes	n/a
Monitoring Reports	Abbreviated	Abbreviated	n/a

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 16 GW Recirculation Decommissioning (Year 3)
Description: Includes: Well Abandonment for 11 Injection and 9 Extraction Wells, Underground Piping Removal and Pumps and Controls Removal.

Start Date: May, 2013
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Demolition, Underground Pipes	Yes	30	70
Well Abandonment	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $582,958

Technologies:

Estimate Documentation Report

Technology Name: **Demolition, Underground Pipes (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Pipe Material		Steel	n/a
Length of Run		3,000	LF
Bulking Factor		1.3	CY/CY
Include Load and Haul Costs		Yes	n/a
Safety Level		D	n/a
Trenching			
Secondary Parameters			
Soil Type	Silt/Silty-Clay Mixture	Silt/Silty-Clay Mixture	n/a
Moisture Content	Dry	Dry	n/a
Inside Pipe Diameter	10.2 cm (4 IN)	10.2 cm (4 IN)	n/a
Average Pipe Depth	4	4	FT
Overdig	1	1	FT
Vertical Trench Height	4	4	FT
Dewatering Pump	No	No	n/a
Load and Haul			
Secondary Parameters			
Truck Type		Highway	n/a
Load and Haul Volume		19.69555	CY
One-way Haul Distance		5	MI
Dump Charge		15	$/CY

Comments:

Estimate Documentation Report

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Groundwater Extraction Wells	n/a
Number of Wells		9	EA
Well Depth		65	FT
Well Diameter		6	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Consolidated	n/a
Karst Formation Type		No	n/a

Comments:

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		78	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 17 SVE System Decommissioning (Year 6)
Description: Includes: Decommissioning of the SVE System including SVE underground piping, Abandonmentof of 25 SVE Wells and Abandonment of 20 Vapor Monitoring Probes.

Start Date: March, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Demolition, Buildings	Yes	30	70
Demolition, Underground Pipes	Yes	30	70
Well Abandonment	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $659,732

Technologies:

Estimate Documentation Report

Technology Name: **Demolition, Buildings (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Building Area		600	SF
Type of Building		Steel	n/a
Include Load and Haul Costs		Yes	n/a
Amount of Hazardous Material		0	%
Number of Stories		Single	n/a
Safety Level		D	n/a
Height/Demo Factor			
Secondary Parameters			
Floor to Floor Height	12	12	FT
Demolition Factor	0.03	0.0339	CY/CF
Load and Haul			
Secondary Parameters			
Non-Hazardous Material: Truck Type		Highway	n/a
Non-Hazardous Material: Volume		245	CY
Non-Hazardous Material: Distance (One-way)		15	MI
Non-Hazardous Material: Dump Charge		15	$/CY
Hazardous Material: Truck Type		Off Highway	n/a
Hazardous Material: Volume		0	CY
Hazardous Material: Distance (One-way)		0	FT
Hazardous Material: Dump Charge		0	$/CY

Comments:

Estimate Documentation Report

Technology Name: **Demolition, Underground Pipes (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Pipe Material		Steel	n/a
Length of Run		1,563	LF
Bulking Factor		1.3	CY/CY
Include Load and Haul Costs		Yes	n/a
Safety Level		D	n/a
Trenching			
Secondary Parameters			
Soil Type	Silt/Silty-Clay Mixture	Silt/Silty-Clay Mixture	n/a
Moisture Content	Dry	Dry	n/a
Inside Pipe Diameter	10.2 cm (4 IN)	10.2 cm (4 IN)	n/a
Average Pipe Depth	4	4	FT
Overdig	1	1	FT
Vertical Trench Height	4	4	FT
Dewatering Pump	No	No	n/a
Load and Haul			
Secondary Parameters			
Truck Type		Highway	n/a
Load and Haul Volume		10.26138	CY
One-way Haul Distance		15	MI
Dump Charge		15	$/CY

Comments:

Estimate Documentation Report

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Soil Vapor Extraction	n/a
Number of Wells		25	EA
Well Depth		45	FT
Well Diameter		4	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Consolidated	n/a
Karst Formation Type		No	n/a

Comments:

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Bulk Solid	n/a
Total Quantity		33	CY
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

Estimate Documentation Report

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 18 Site Closeout (Year 15)
Description: Includes:
1. Meetings, Work Plans, Reports, Documents and Documents Storage.Site Close-out documantation, and
2. Abandonment of 4 New and 13 Existing Groundwater Monitoring Wells.

Start Date: May, 2027
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markups: Site 29 Focused Feasibility Study

Technology Markups	Markup	% Prime	% Sub.
Site Close-Out Documentation	Yes	100	0
Well Abandonment	Yes	30	70
Residual Waste Management	Yes	100	0

Total Marked-up Cost: $414,657

Technologies:

Estimate Documentation Report

Technology Name: **Site Close-Out Documentation (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Meetings		Yes	n/a
Work Plans and Reports		Yes	n/a
Documents		Yes	n/a
Site Close-Out Complexity		Low	n/a
Meetings			
Required Parameters			
Kick Off/Scoping Meetings		Yes	n/a
Kick Off/Scoping Meetings: Number of Meetings	1	1	EA
Kick Off/Scoping Meetings: Travel		Yes	n/a
Kick Off/Scoping Meetings: Travelers		3	EA
Kick Off/Scoping Meetings: Days		2	Days
Kick Off/Scoping Meetings: Air Fare		1,950	$
Review Meetings		Yes	n/a
Review Meetings: Number of Meetings	1	2	EA
Review Meetings: Travel		Yes	n/a
Review Meetings: Travelers		3	EA
Review Meetings: Days		2	Days
Review Meetings: Air Fare		1,950	$
Regulatory Review Meetings		Yes	n/a
Regulatory Review Meetings: Number of Meetings	1	2	EA
Regulatory Review Meetings: Travel		Yes	n/a
Regulatory Review Meetings: Travelers		3	EA
Regulatory Review Meetings: Days		2	Days
Regulatory Review Meetings: Air Fare		1,950	$
Work Plans & Reports			
Required Parameters			
Work Plans		Yes	n/a
Draft Work Plan		Yes	n/a
Final Work Plan		Yes	n/a
Reports		Yes	n/a
Draft Close-Out Report		Yes	n/a

Estimate Documentation Report

Technology Name: **Site Close-Out Documentation (# 1)**

Description	*Default*	*Value*	*UOM*
Work Plans & Reports			
Required Parameters			
Draft Final Close-Out Report		Yes	n/a
Final Close-Out Report		Yes	n/a
Progress Reports		Yes	n/a
Project Duration	8	8	months
Documents			
Required Parameters			
Draft Decision Document		Yes	n/a
Draft Final Decision Document		Yes	n/a
Final Decision Document		Yes	n/a
Long Term Document Storage		Yes	n/a
Number of Boxes		20	EA
Duration of Storage		7	Yrs

Comments:

Technology Name: **Well Abandonment (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Abandon Wells			
Required Parameters			
Technology/Group Name		Groundwater Monitoring Well - Aquifer One	n/a
Number of Wells		4	EA
Well Depth		70	FT
Well Diameter		4	IN
Well Abandonment Method		Overdrill / Removal	n/a
Formation Type		Consolidated	n/a
Karst Formation Type		No	n/a

Comments:

Estimate Documentation Report

Technology Name: **Residual Waste Management (# 1)**

Description	*Default*	*Value*	*UOM*
System Definition			
Required Parameters			
Safety Level		D	n/a
Non-Rad Disposal			
Required Parameters			
Waste Type / Condition		Non-Hazardous Drums	n/a
Total Quantity		61	Drums
Transportation Type		Truck	n/a
Truck Distance (One-way)		150	Miles

Comments:

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Appendix C

Sustainability Assessment Details

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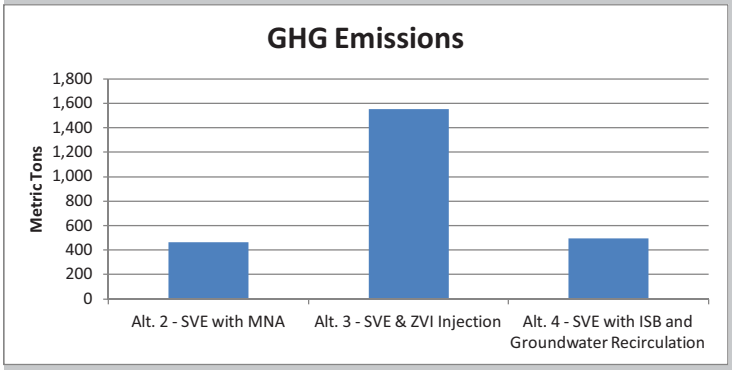
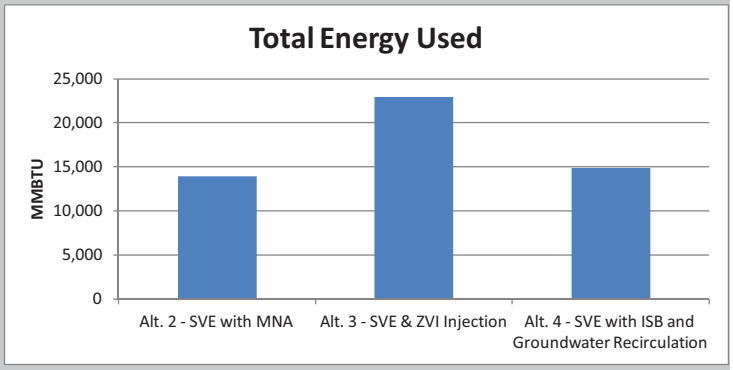
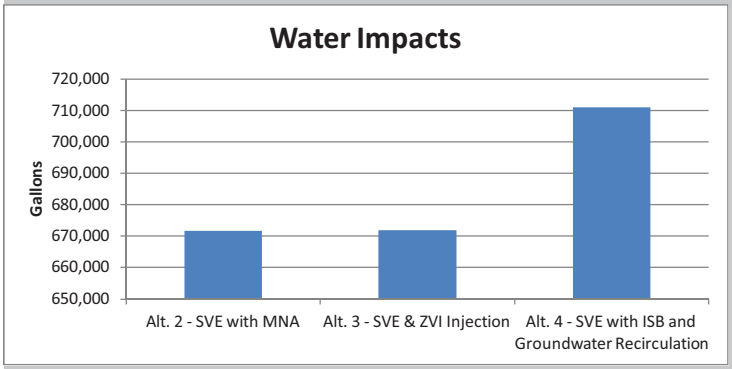
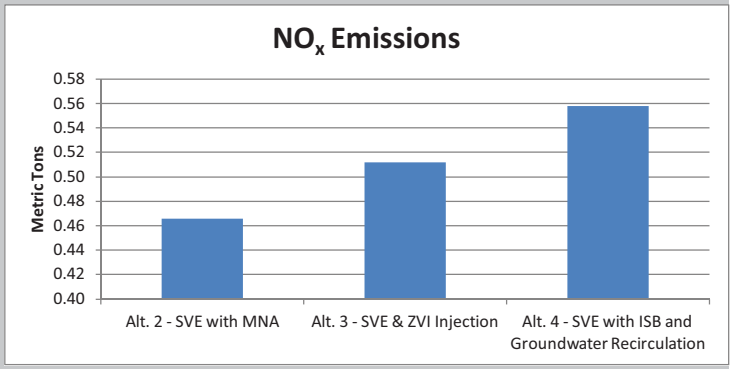
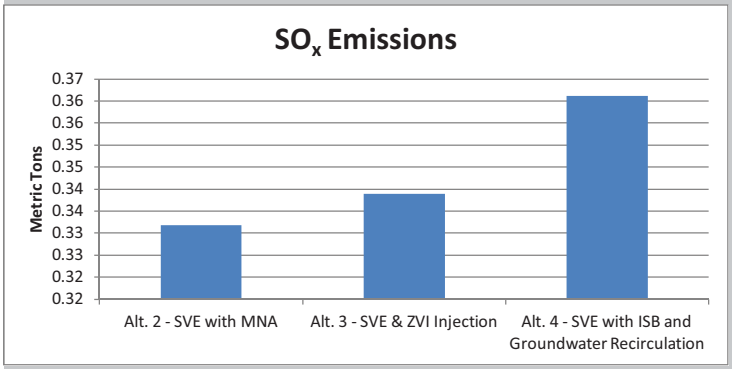
Remedial Alternatives	GHG Emissions metric ton	Total energy Used MMBTU	Water gallons	NO_x emissions metric ton	SO_x Emissions metric ton	PM_{10} Emissions metric ton	Accident Risk Fatality	Accident Risk Injury
Alt. 2 - SVE with MNA	461.47	1.39E+04	6.72E+05	4.66E-01	3.32E-01	8.36E-03	1.51E-04	1.78E-02
Alt. 3 - SVE & ZVI Injection	1553.68	2.30E+04	6.72E+05	5.12E-01	3.39E-01	1.13E-02	3.21E-04	5.19E-02
Alt. 4 - SVE with ISB and Groundwater Recirculation	495.97	1.49E+04	7.11E+05	5.58E-01	3.61E-01	1.37E-02	2.41E-04	4.15E-02

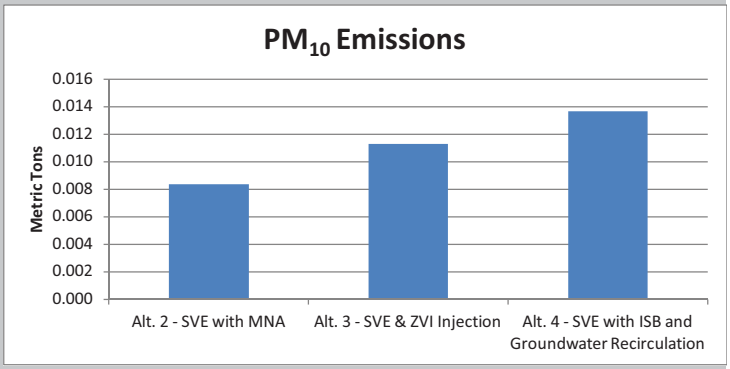


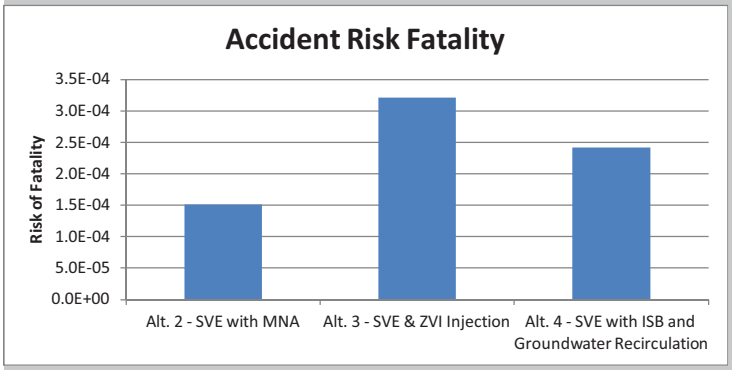


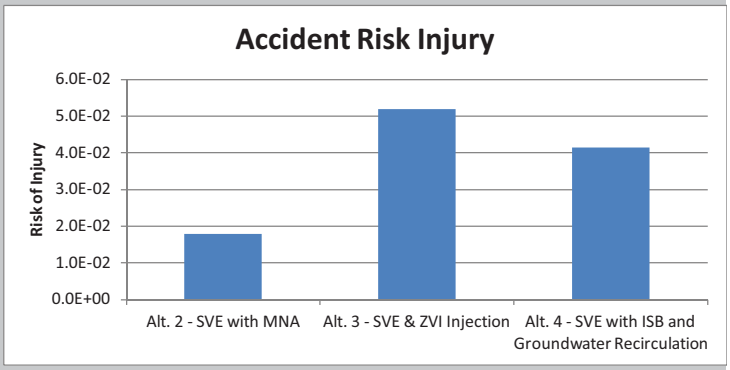






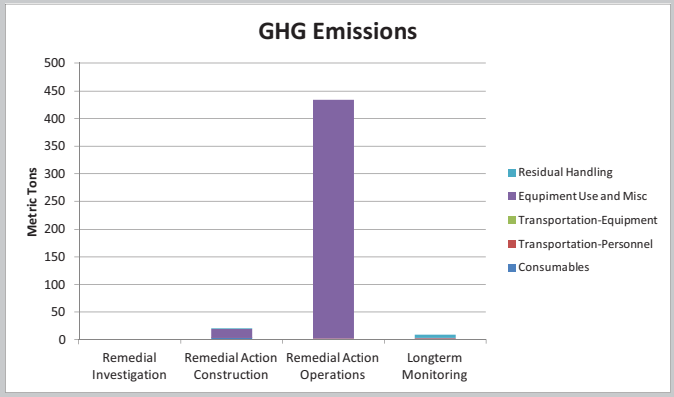


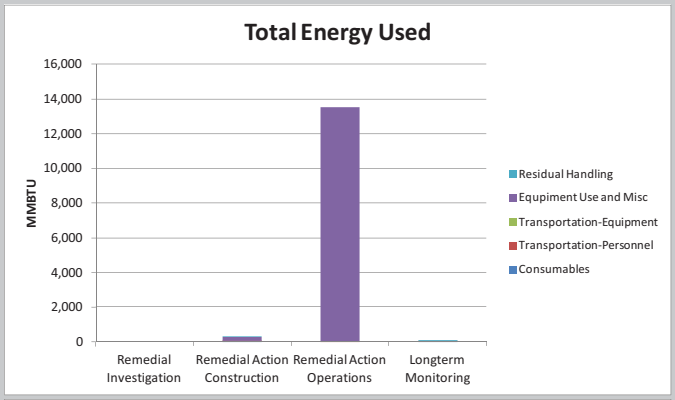


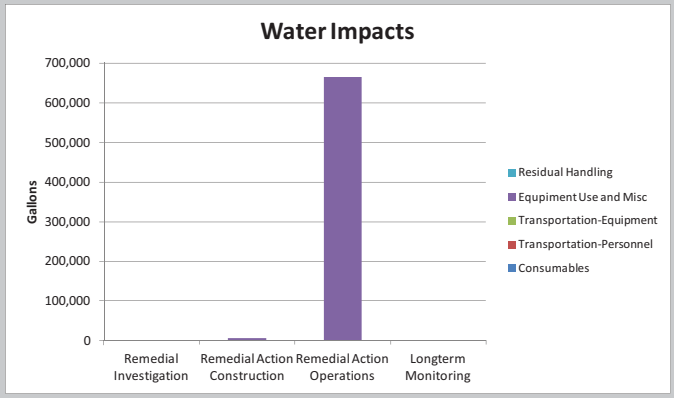


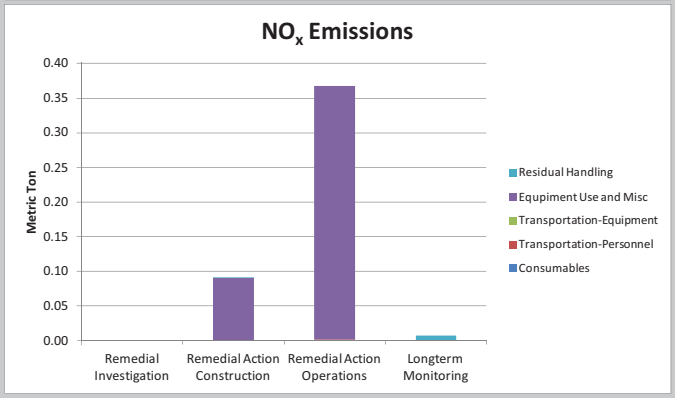
Sustainable Remediation - Environmental Footprint Summary
Alt. 2 - SVE with MNA

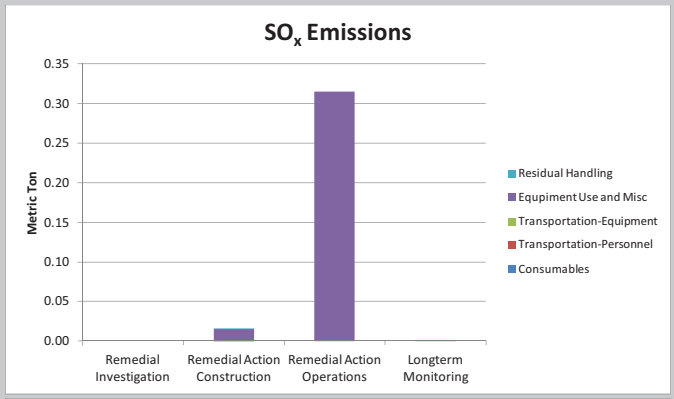
Phase	Activities	GHG Emissions metric ton	Total Energy Used MMBTU	Water Impacts gallons	NO_x Emissions metric ton	SO_x Emissions metric ton	PM_{10} Emissions metric ton	Accident Risk Fatality	Accident Risk Injury
Remedial Investigation	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equpiment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Action Construction	Consumables	3.38	6.6E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.32	3.5E+00	NA	2.5E-04	8.4E-05	5.6E-05	1.2E-05	8.3E-04
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equpiment Use and Misc	15.16	2.1E+02	5.4E+03	9.0E-02	1.5E-02	6.8E-03	1.2E-05	5.1E-03
	Residual Handling	0.71	2.2E+01	NA	8.1E-04	1.6E-04	1.1E-04	2.3E-06	4.7E-04
	Sub-Total	19.57	2.98E+02	5.39E+03	9.08E-02	1.51E-02	6.97E-03	2.57E-05	6.40E-03
Remedial Action Operations	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	2.48	2.7E+01	NA	1.9E-03	6.4E-04	4.3E-04	8.8E-05	6.3E-03
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equpiment Use and Misc	430.98	1.4E+04	6.7E+05	3.7E-01	3.1E-01	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	433.45	1.35E+04	6.66E+05	3.68E-01	3.15E-01	4.32E-04	8.84E-05	6.34E-03
Longterm Monitoring	Consumables	2.18	1.1E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.74	8.1E+00	NA	5.8E-04	1.9E-04	1.3E-04	2.0E-05	1.4E-03
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equpiment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	5.52	8.3E+01	NA	6.3E-03	1.2E-03	8.4E-04	1.8E-05	3.7E-03
	Sub-Total	8.44	1.02E+02	0.00E+00	6.86E-03	1.40E-03	9.66E-04	3.73E-05	5.07E-03
Total		**4.6E+02**	**1.4E+04**	**6.7E+05**	**4.7E-01**	**3.3E-01**	**8.4E-03**	**1.5E-04**	**1.8E-02**

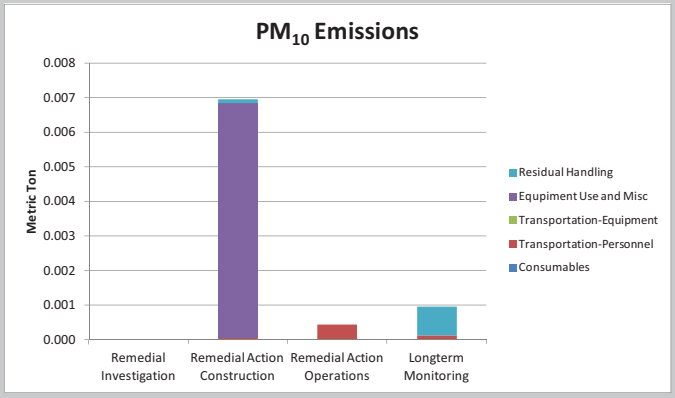

GHG Emissions
Metric Tons
500
450
400
350
300
250
200
150
100
50
0
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

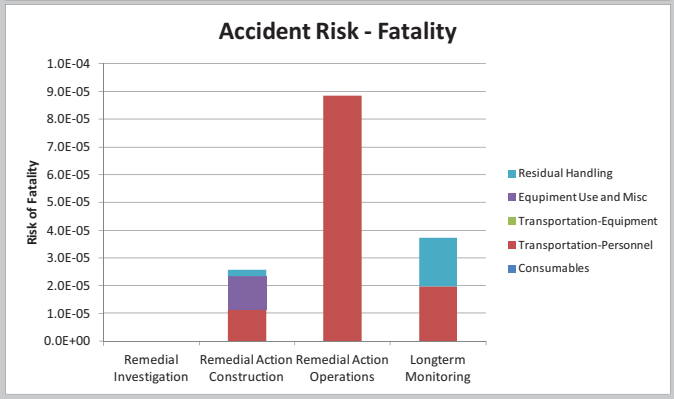

Total Energy Used
MMBTU
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

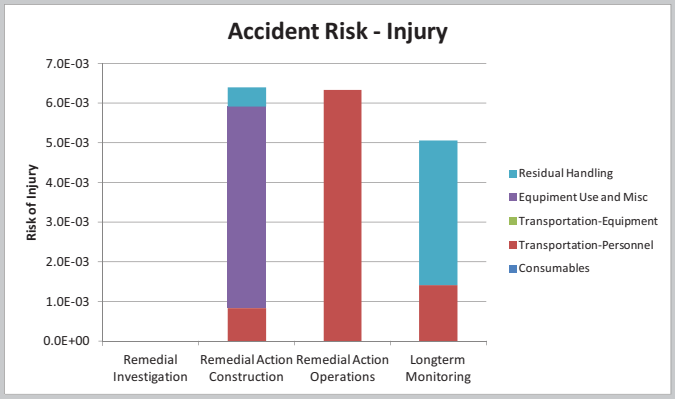

Water Impacts
Gallons
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


NOx Emissions
Metric Ton
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


SOx Emissions
Metric Ton
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

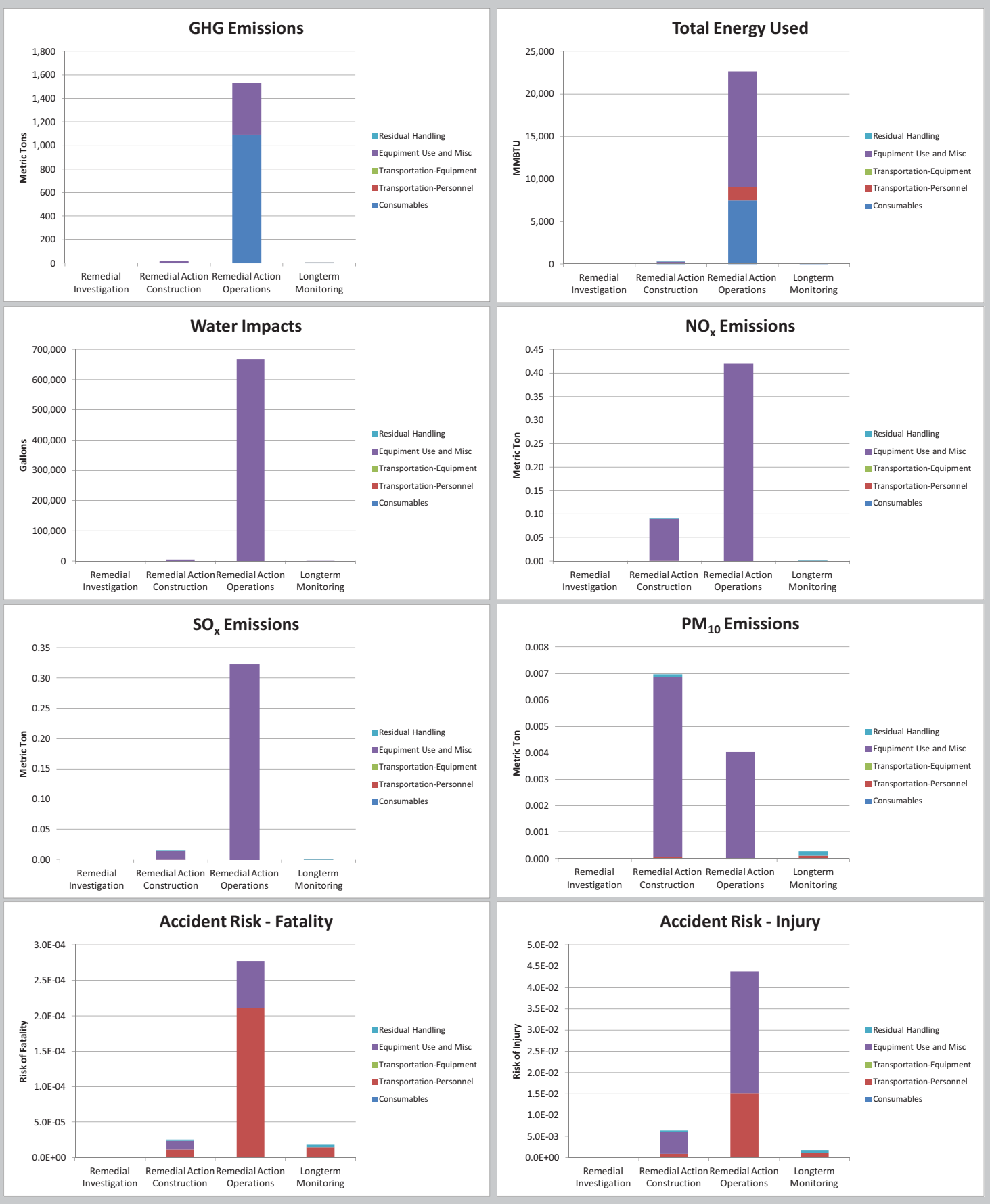

PM10 Emissions
Metric Ton
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Fatality
Risk of Fatality
1.0E-04
9.0E-05
8.0E-05
7.0E-05
6.0E-05
5.0E-05
4.0E-05
3.0E-05
2.0E-05
1.0E-05
0.0E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Injury
Risk of Injury
7.0E-03
6.0E-03
5.0E-03
4.0E-03
3.0E-03
2.0E-03
1.0E-03
0.0E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

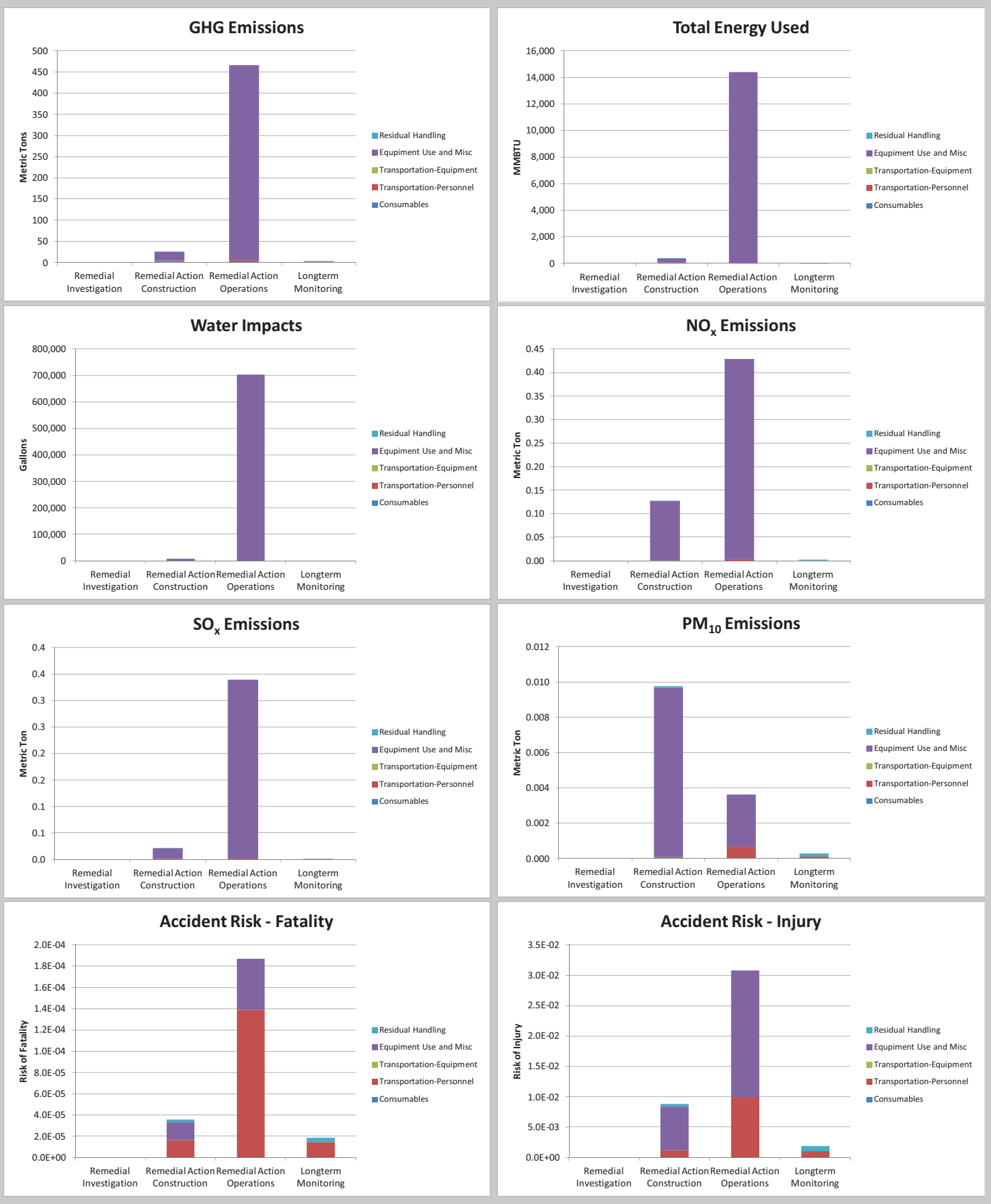
Sustainable Remediation - Environmental Footprint Summary
Alt. 3 - SVE & ZVI Injection

Phase	Activities	GHG Emissions metric ton	Total Energy Used MMBTU	Water Impacts gallons	NO_x Emissions metric ton	SO_x Emissions metric ton	PM_{10} Emissions metric ton	Accident Risk Fatality	Accident Risk Injury
Remedial Investigation	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Action Construction	Consumables	2.21	4.5E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.30	8.3E+00	NA	2.4E-04	7.9E-05	5.3E-05	1.2E-05	8.3E-04
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	15.16	2.1E+02	5.4E+03	9.0E-02	1.5E-02	6.8E-03	1.2E-05	5.1E-03
	Residual Handling	0.71	2.2E+01	NA	8.1E-04	1.6E-04	1.1E-04	2.3E-06	4.7E-04
	Sub-Total	18.38	2.82E+02	5.39E+03	9.08E-02	1.51E-02	6.96E-03	2.57E-05	6.40E-03
Remedial Action Operations	Consumables	1,091.46	7.5E+03	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.00	1.5E+03	NA	0.0E+00	0.0E+00	0.0E+00	2.1E-04	1.5E-02
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	439.99	1.4E+04	6.7E+05	4.2E-01	3.2E-01	4.0E-03	6.7E-05	2.9E-02
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	1,531.45	2.27E+04	6.66E+05	4.19E-01	3.23E-01	4.04E-03	2.77E-04	4.37E-02
Longterm Monitoring	Consumables	2.18	1.1E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.60	6.5E+00	NA	4.7E-04	1.5E-04	1.0E-04	1.5E-05	1.0E-03
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	2.8E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	1.07	1.8E+01	NA	1.2E-03	2.3E-04	1.6E-04	3.4E-06	7.1E-04
	Sub-Total	3.85	3.57E+01	2.75E+02	1.69E-03	3.88E-04	2.67E-04	1.80E-05	1.76E-03
Total		**1.6E+03**	**2.3E+04**	**6.7E+05**	**5.1E-01**	**3.4E-01**	**1.1E-02**	**3.2E-04**	**5.2E-02**


GHG Emissions
Metric Tons
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables
Total Energy Used
MMBTU
25,000
20,000
15,000
10,000
5,000
0
Water Impacts
Gallons
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
NOx Emissions
Metric Ton
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
SOx Emissions
Metric Ton
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
PM10 Emissions
Metric Ton
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Accident Risk - Fatality
Risk of Fatality
3.0E-04
2.5E-04
2.0E-04
1.5E-04
1.0E-04
5.0E-05
0.0E+00
Accident Risk - Injury
Risk of Injury
5.0E-02
4.5E-02
4.0E-02
3.5E-02
3.0E-02
2.5E-02
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00

Sustainable Remediation - Environmental Footprint Summary
Alt. 4 - SVE with ISB and Groundwater Recirculation

Phase	Activities	GHG Emissions metric ton	Total Energy Used MMBTU	Water Impacts gallons	NO_x Emissions metric ton	SO_x Emissions metric ton	PM_{10} Emissions metric ton	Accident Risk Fatality	Accident Risk Injury
Remedial Investigation	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Remedial Action Construction	Consumables	3.74	7.7E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.45	9.8E+00	NA	3.5E-04	1.2E-04	7.8E-05	1.7E-05	1.2E-03
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	21.34	2.9E+02	7.6E+03	1.3E-01	2.1E-02	9.6E-03	1.7E-05	7.2E-03
	Residual Handling	0.71	2.3E+01	NA	8.1E-04	1.6E-04	1.1E-04	2.3E-06	4.7E-04
	Sub-Total	26.25	4.00E+02	7.59E+03	1.28E-01	2.12E-02	9.76E-03	3.56E-05	8.84E-03
Remedial Action Operations	Consumables	0.83	2.0E+01	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	3.88	4.2E+01	NA	3.1E-03	1.0E-03	6.8E-04	1.4E-04	1.0E-02
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	461.55	1.4E+04	7.0E+05	4.3E-01	3.4E-01	2.9E-03	4.8E-05	2.1E-02
	Residual Handling	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	466.27	1.44E+04	7.03E+05	4.28E-01	3.40E-01	3.62E-03	1.87E-04	3.08E-02
Longterm Monitoring	Consumables	1.61	8.4E+00	NA	NA	NA	NA	NA	NA
	Transportation-Personnel	0.60	6.5E+00	NA	4.7E-04	1.5E-04	1.0E-04	1.5E-05	1.0E-03
	Transportation-Equipment	0.00	0.0E+00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	1.25	2.5E+01	NA	1.4E-03	2.7E-04	1.9E-04	4.0E-06	8.3E-04
	Sub-Total	3.45	3.98E+01	0.00E+00	1.89E-03	4.27E-04	2.94E-04	1.86E-05	1.87E-03
Total		**5.0E+02**	**1.5E+04**	**7.1E+05**	**5.6E-01**	**3.6E-01**	**1.4E-02**	**2.4E-04**	**4.1E-02**


GHG Emissions
Metric Tons
500
450
400
350
300
250
200
150
100
50
0
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables
Total Energy Used
MMBTU
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Water Impacts
Gallons
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
NOx Emissions
Metric Ton
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
SOx Emissions
Metric Ton
0.4
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
PM10 Emissions
Metric Ton
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Accident Risk - Fatality
Risk of Fatality
2.0E-04
1.8E-04
1.6E-04
1.4E-04
1.2E-04
1.0E-04
8.0E-05
6.0E-05
4.0E-05
2.0E-05
0.0E+00
Accident Risk - Injury
Risk of Injury
3.5E-02
3.0E-02
2.5E-02
2.0E-02
1.5E-02
1.0E-02
5.0E-03
0.0E+00

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Attachment 1

Proposed Human Health and Ecological Remedial Goals

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FINAL REPORT

PROPOSED HUMAN HEALTH AND ECOLOGICAL REMEDIAL GOALS

INSTALLATION RESTORATION SITE 29,
FORMER NAVAL WEAPONS STATION SEAL BEACH,
DETACHMENT CONCORD,
CONCORD, CALIFORNIA

June 2011

Table 1 Revised January 2013

URS Corporation
1333 Broadway, Suite 800
Oakland, California 94612

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IR Site 29, Former NAVWPSTA Concord
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IR Site 29, Former NAVWPSTA Concord

List of Attachments

Attachment A: Attenuation Factors and Supporting Johnson and Ettinger Models

ACRONYM & ABBREVIATION LIST

AFB	Air Force Base
alpha	attenuation factor
ARARs	Applicable or Relevant and Appropriate Requirements
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
Brady	Richard Brady & Associates
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
COCs	Chemicals of Concern
1,1-DCE	1,1-Dichloroethene
DTSC	Department of Toxic Substances Control
FFS	Focused Feasibility Study
hr	hour
JEM	Johnson and Ettinger Model
LOAEL	Lowest observable adverse effects level
MCL	Maximum Contaminant Level
Method 1	USEPA approach method
Method 2	DTSC approach method
NAVWPNSTA	Naval Weapons Station
NOAEL	no observable adverse effects level
PAHs	Polycyclic Aromatic Hydrocarbons
RG	Remedial Goal
RI	Remedial Investigation
RSL	Regional Screening Level (USEPA, 2011)
SLs	Screening Levels
TCE	Trichloroethene
TRVs	Toxicity Reference Values

ACRONYM & ABBREVIATION LIST (CONTINUED)

µg/L	microgram per liter
$\mu g/m^3$	microgram per cubic meter
UCL	upper confidence limit of the mean
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Chemicals

1 INTRODUCTION

A Remedial Investigation (RI), including a baseline human health risk assessment (BHHRA) and baseline ecological risk assessment (BERA), was conducted for Installation Restoration Site 29, former Naval Weapons Station Seal Beach, Detachment Concord, Concord, California (former NAVWPNSTA Concord). In the RI, chemicals of concern (COCs) in groundwater and soil gas that pose a potential threat to human health or the environment under current and reasonably likely future land uses were identified (Richard Brady & Associates [Brady], 2011). Inorganics in soil were ultimately demonstrated to be present at naturally-occurring background levels, with the exception of lead-based paint-related inorganics identified under building IA-25. The lead-based paint-related inorganics do not originate from a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) release and, therefore, will be addressed under the lead-based paint program (Brady, 2011).

Remedial Goals (RGs) are clean-up goals established for those particular COCs, media, and receptors that warranted further consideration beyond the RI and risk assessment phase. The RGs discussed in this technical memorandum were developed to support the Focused Feasibility Study (FFS) for remediation work that will be performed at Site 29. This memorandum focuses on the methods used to develop site-specific RGs for Site 29 that are protective of human health and the environment under current and planned future land uses, although many factors are involved in the final establishment of RGs (such as managerial considerations and technical feasibility, in addition to health–protectiveness).

The methodology for calculating and selecting the proposed RGs builds upon the approach, findings, and recommendations of the BHHRA and BERA that were presented in the RI (Brady, 2011). Consistent with the BHHRA, the RG methods followed a “dual tracking” approach to address the different regulatory requirements of the United States Environmental Protection Agency (USEPA) (Method 1) and the California Department of Toxic Substances Control (DTSC) (Method 2) for evaluating human health risk. Although both regulatory agencies use the same basic four steps for the BHHRA process (i.e., data evaluation, exposure assessment, toxicity assessment, and risk characterization), minor variations are needed to meet the different agency protocols. The final human-health RGs are the more health-protective (conservative) concentrations between both methods. Dual-tracking methods were neither part of the BERA nor used in derivation of the ecological RGs.

A summary of the proposed RGs protective of human and ecological receptors is presented in Table 1, and Table 2 presents the more detailed list of initial RGs that were considered for the project.

2 METHODS

The methods for calculating and selecting recommended human health- and ecologically-based RGs is described in this section. Many variables are considered when selecting or developing RGs for any site. Establishing RGs for certain media, COCs, and receptors may simply entail choosing from agency guidelines, while others may require calculation of site-specific risk-based concentrations.

2.1 Human Health Remedial Goals

Receptors need to be identified for calculating the chemical-specific RGs, which are often based on multiple future land use scenarios (such as open space, recreational use, commercial development, or residential zoning). Each future scenario might have its own set of receptors, resulting in the need for specific RGs. Development of RGs also entails a specified level of protectiveness, i.e., the target risk or target hazard (i.e., excess cancer risk of $1x10^{-5}$ or $1x10^{-6}$ and/or noncancer hazard index of 0.1 or 1) appropriate for the scenario and acceptable to regulatory oversight agencies. Toxicity data for COCs may need to be gathered from sources that are often dependent on regulatory agency requirements. For exposure characterization, the values may be selected from those promulgated by specific regulatory agencies, recognized published sources, and/or site specific values (based on professional judgment) for each receptor. Site-specific data can also be used to support modeling predictions for exposure media that are not directly measurable, such as indoor air for a future hypothetical building.

The following subsections present the details for development of the Site 29 proposed human health RGs.

2.1.1 Selection of Media

The RI for Site 29 concluded the following:

> "based on the results of site characterization and the BHHRA, National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations [CFR] Part 300), EPA guidance (EPA, 1988), and DTSC's interpretation of the NCP risk range, a Feasibility Study is recommended to identify and evaluate potential remedial alternatives to address chlorinated solvents (primarily trichloroethene [TCE]) in soil gas and groundwater" (Brady, 2011).

Consequently, groundwater and soil gas require development of human-health-protective RGs.

2.1.1.1 Groundwater

The human health RGs for groundwater are based on two exposure scenarios: 1) use as a potable water supply source (drinking water and domestic uses, such as showering and washing), 2) as a source medium for volatile organic chemicals (VOCs) that could migrate into buildings and lead to indoor vapor exposure. The lower of the RGs for potable use and vapor intrusion was selected as the final RG for VOCs. For non-volatile chemicals, RGs were selected to be protective of potable use.

The VOC concentrations in indoor air were estimated from concentrations in groundwater based on the USEPA's implementation of the groundwater version of the Johnson and Ettinger model (JEM) of vapor intrusion (model version GW-ADV 3.1; USEPA, 2004a). The model inputs, outputs, chemical values, and intermediate calculations are presented in Attachment A to this memorandum. Discussions on the input parameters for the model are presented in Appendix G of the Site 29 RI (Brady, 2011).

2.1.1.2 Soil Gas

The human health RGs for soil gas were developed based on the predicted migration of VOCs from soil gas into indoor air, using the JEM model version SG-ADV 3.1 (USEPA, 2004b).

Discussions on the input parameters for the model are presented in Appendix G of the Site 29 RI (Brady, 2011).

2.1.2 Selection of Chemicals of Concern (COCs)

The COCs are different for groundwater versus soil gas, based on the conclusions of the Site 29 RI (Brady, 2011). For the most part, the COCs identified in the BHHRA contributed to excess cancer risk levels of greater than 1×10^{-6} (Appendix G of the RI). Additional consideration was given for chemicals with concentrations in exceedance of their Applicable or Relevant and Appropriate Requirements (ARARs). Although some inorganics, pesticides, and polycyclic aromatic hydrocarbons (PAHs) were initially identified in the BHHRA as potential contributors to risk for groundwater, ultimately these chemical classes were eliminated from further consideration. In the BHHRA, it was concluded that inorganics in groundwater are attributable to background. PAHs and pesticides were very infrequently detected in groundwater and were eliminated as COCs. PAHs were detected only once in 45 samples and dismissed based on low detection frequency (see Section 5 of the Site 29 RI [Brady, 2011]). Regulatory approval was given during the first phase of field work and again prior to commencement of the risk assessment to remove pesticides from the groundwater monitoring program. Prior to commencement of the risk assessment, regulatory concurrence was again confirmed to remove pesticides and PAHs as COCs (Brady, 2011).

Chemicals of concern identified in the Site 29 BHHRA in groundwater are those that posed an excess cancer risk of 1×10^{-6} or greater for potable use of groundwater by residential or commercial receptors. Volatile organic compounds in groundwater were not directly evaluated for the vapor intrusion pathway since soil gas data were available. However, the COCs identified from the soil gas evaluation were carried forward to develop RGs in both soil gas and groundwater that would be protective of the vapor intrusion pathway.

Chemicals of concern for soil gas are those that posed excess cancer risk of 1×10^{-6} or greater via vapor intrusion for residential or commercial receptors, based on modeling from soil gas (not from groundwater, because there is greater confidence in predicted indoor air concentrations via vapor intrusion from soil gas than from groundwater). There were no COCs identified on the basis of unacceptable noncancer health hazards; all COCs were carcinogens. The list of human health COCs include:

- 1,1,2-Trichloroethane (only in groundwater)
- 1,2-Dichloroethane (only in groundwater)
- Benzene (groundwater and soil gas)
- Chloroform (groundwater and soil gas)
- cis-1,2-Dichloroethene (only in groundwater)
- Tetrachloroethene (only in groundwater)
- TCE (groundwater and soil gas)

2.1.3 Human Health Receptors

Based on planned land uses for the site, the human receptors identified for the Site 29 RI are future residents, commercial/industrial workers, and construction workers. Remedial goals were not developed for the construction worker because it was concluded in the BHHRA that exposures for such receptors are typically short-term and occur under conditions that are

overseen by occupational health and safety regulations. The risk estimates for construction workers are highly dependent on conservative trench air modeling results, and the BHHRA recommends health and safety measures to address potential exposure to VOCs (see Section 5.0 of Appendix G in the Site 29 RI). Personal protective equipment and engineering controls would further mitigate exposure and reduce the risk of chemical exposure for construction workers. Therefore, RGs were developed for the residential and commercial/industrial receptors.

2.1.4 ARARs for Groundwater: Maximum Contaminant Levels (MCLs)

Potable use of groundwater is a potentially complete exposure pathway. There are state and federal requirements for drinking water quality for certain chemicals in the form of maximum contaminant levels (MCLs). The MCLs are the "maximum permissible level of a contaminant in water which is delivered to any user of a public water system", according to the Safe Drinking Water Act (40 CFR Part 141.2). The MCLs are protective of human health but also take available treatment technology into account. The California MCLs were chosen preferentially over the federal MCLs for the RGs. For chloroform, there is no chemical-specific MCL; there is an MCL for total trihalomethanes (by-products of chlorine-based disinfection, and which includes chloroform). The MCL for total trihalomethanes is 80 micrograms per liter (µg/L), but this non-specific MCL was not selected as an RG for chloroform in drinking water since its primary focus is on disinfection by-products. The USEPA Regional Screening Level (RSL), a risk-based value of 0.19 µg/L in tapwater, was chosen instead (USEPA, 2011).

California MCLs are listed at the following website:

http://www.cdph.ca.gov/certlic/drinkingwater/pages/chemicalcontaminants.aspx

Federal MCLs are listed at the following website:

http://water.epa.gov/drink/contaminants/index.cfm

2.1.5 Exposure Parameters

As discussed in Section 2.1, RGs are necessary for groundwater (potable use and source of VOCs for indoor vapor exposure) and soil gas (indoor air exposure). For the potable use of groundwater, the MCLs and the tapwater RSL for chloroform were used for the RGs, and exposure parameter values were not needed for this pathway. Exposure parameter values were needed for the VOC inhalation pathway; the human health exposure parameter values are presented in Table 3 and discussed in Appendix G of the Site 29 RI.

2.1.6 Toxicity Values and Benchmark Values

The cancer toxicity values used in the BHHRA were also used for the development of the RGs. The toxicity values for human health are presented in Table 4 and are identical for residential and commercial receptors; toxicity factors are further discussed in Appendix G of the Site 29 RI.

2.1.7 Calculations for Human Health RGs

The RGs protective of human health were derived through three key steps: Step 1: base equation, Step 2: incorporate receptor-specific exposure parameters and toxicity values, and Step 3: incorporate site-specific vapor-intrusion factors.

Step 1: Base Equation. The RG equation is similar to the equation used by the USEPA to derive the RSLs, and was obtained from the following website:

http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/equations.htm

The base equation (Equation 1) is that used to estimate the concentration in indoor air for a specified target cancer-risk level for each receptor:

$$SL_{(r\ or\ c)} = \frac{TR \times AT_c \times \frac{365\ days}{1\ year}}{EF_{(r\ or\ c)} \times ED_{(r\ or\ c)} \times ET_{(r\ or\ c)} \times \frac{1\ day}{24\ hours} \times IUR} \quad (1)$$

Values for Equation 1:

$SL_{(r\ or\ c)}$	=	Screening Level in indoor air for resident (r) or commercial (c) receptors (micrograms per cubic meter [µg/m^3])
TR	=	Target Risk (1 x 10^{-6}; dimensionless probability)
AT_c	=	Average Time for carcinogens (lifetime, 70 years)
$EF_{(r\ or\ c)}$	=	Exposure Frequency for resident (r) or commercial (c) receptors (days per year)
$ED_{(r\ or\ c)}$	=	Exposure Duration for resident (r) or commercial (c) receptors (years)
$ET_{(r\ or\ c)}$	=	Exposure Time for resident (r) or commercial (c) receptors (hours per day)
IUR	=	Inhalation Unit Risk (chemical specific; [µg/m^3]$^{-1}$)

Step 2: Receptor-Specific Interim Screening Levels. Receptor-specific exposure parameters from Table 3, inhalation unit risk values from Table 4, and a specified target risk level (1×10^{-6}) were used in the base equation to derive interim receptor-specific screening levels (SLs) (Equations 2 and 3):

$$SL_r = \frac{10^{-6} \times 70\ years \times \frac{365\ days}{1\ year}}{350\frac{days}{year} \times 30\ years \times 24\frac{hours}{day} \times \frac{1\ day}{24\ hours} \times COC\text{-}specific\ IUR} \quad (2)$$

$$SL_c = \frac{10^{-6} \times 70\ years \times \frac{365\ days}{1\ year}}{250\frac{days}{year} \times 25\ years \times 8\frac{hours}{day} \times \frac{1\ day}{24\ hours} \times COC\text{-}specific\ IUR} \quad (3)$$

Step 3: Incorporate Site-Specific Vapor Intrusion Factors. Site-specific data were used in the JEM model to calculate an inter-media transfer (attenuation) factor called the alpha (α) value. Alpha values represent the COC-specific ratios of the indoor air concentration to the soil-vapor or groundwater source term concentration. Attenuation factors are, perhaps, the most sensitive parameters used in calculating risk from vapor intrusion into indoor air because they are highly dependent upon the site-specific subsurface characteristics (which influence chemical movement in and through the vadose zone) and site-specific structural characteristics (which influence the rate and extent of vapor intrusion into the indoor environment). The model was run to estimate alpha using the following soil parameters: soil gas samples were collected from 9.5 feet (290 centimeters [cm]) below ground surface (bgs), the depth to groundwater was 1400 cm; soil temperature was 25° Celsius; Soil Stratum Sand(S); Indoor Air Exchange Rate for USEPA Method 1 (1/hour [hr] for commercial and 0.25/hr for residential) and for DTSC Method 2 (1/hr for commercial and 0.5/hr for residential).

The JEM was used to calculate attenuation factors for multiple scenarios (listed in Attachment A):

JEM Scenarios

- EPA Method 1: Soil Gas to Indoor Air for residential exposure;
- EPA Method 1: Soil Gas to Indoor Air for commercial exposure;
- EPA Method 1: Groundwater to Indoor Air for residential exposure;
- EPA Method 1: Groundwater to Indoor Air for commercial exposure;
- DTSC Method 2: Soil Gas to Indoor Air for residential exposure;
- DTSC Method 2: Soil Gas to Indoor Air for commercial exposure;
- DTSC Method 2: Groundwater to Indoor Air for residential exposure;
- DTSC Method 2: Groundwater to Indoor Air for commercial exposure;

The following generalized equations were used to calculate RGs from the SLs using the scenario-specific attenuation factors (alpha):

$$Soil\ Gas\ RG = \frac{SL_{(r\ or\ c)}}{Alpha} \tag{4}$$

$$Groundwater\ RG = \frac{SL_{(r\ or\ c)}}{Alpha \times H' \times CF} \tag{5}$$

where:

H' = Henry's law constant (so-called "dimensionless", but actual units are L_{air}/L_{water})

CF = unit conversion factor, 1000 L/m^3

2.2 Ecological Remedial Goals

Based on the findings of the BERA that was performed for Site 29, only two COCs in soil gas were recommended for risk management: TCE and 1,1-DCE (Brady, 2011). Hazard quotients for these two VOCs were above 1.0 based on a comparison to the site-wide average concentrations, i.e., the 95 percent upper confidence limit on the mean [UCL]) calculated for soil gas samples collected from the extent of the burrowing mammal zone (0 to 6 feet bgs) (DTSC, 1998). No other media or COCs were recommended for risk management to protect ecological receptors.

These findings were summarized in Section 7.2 of the RI and presented in detail in Appendix H to the RI, which comprises the stand-alone BERA. Elevated concentrations of TCE and 1,1-DCE were primarily noted in the immediate vicinity of Buildings IA-19 and IA-25. As previously stated, some inorganics in soil were identified as potential COCs for ecological receptors, but these inorganics were ultimately demonstrated to be present at naturally-occurring background levels, with the exception of lead-based paint-related inorganics identified under building IA-25. The lead-based paint-related inorganics do not originate from a CERCLA release and, therefore, will be addressed under the lead-based paint program (Brady, 2011).

2.2.1 Ecological Receptors of Concern

In the BERA, VOCs reported in shallow soil gas (0 to 6 feet bgs) were used to evaluate the potential for adverse effects associated with the inhalation of vapor phase VOCs by burrowing mammals. Exposure to VOCs in burrow air is a pathway of concern because mammals that inhabit and nest in underground burrows are present at Site 29, such as the California vole

(*Microtus californicus*). No threatened or endangered burrowing mammals are known to be present at Site 29.

In addition, although the upland habitat at Site 29 does not have any surface water bodies (Seal Creek is not within the site boundary and is approximately 800 feet from the samples collected in the pasture area across the road from the site buildings), the California tiger salamander (*Ambystoma californiense*) and California red-legged frog (*Rana draytonii*) could seek refuge in abandoned ground squirrel burrows at the site (Smallwood and Morrison, 2007; EDAW, 2008). This would be more likely to occur during the wet season when moisture and moist litter is present in the burrows and other similar depressions. The California red-legged frog is currently a federally-listed threatened species and is a state species of special concern, while the California tiger salamander is a federally-listed endangered species in Santa Barbara and Sonoma Counties and threatened in the central valley (which refers to the population at Site 29). The tiger salamander is also a state-listed threatened species in all three areas. Neither the red-legged frog nor the tiger salamander has been sighted within the immediate vicinity of Site 29, but both are known to inhabit certain areas of the inland area of former NAVWPNSTA Concord.

2.2.2 Selection of Ecological Remedial Goals

Within the last several years, the DTSC and Region IX EPA have promoted use of the inhalation-based toxicity reference values (TRVs) developed at Edwards Air Force Base (AFB) to evaluate soil gas data for burrowing mammals at sites in California when VOC contamination of soil or groundwater is a potential concern (Tetra Tech 2004). Toxicity reference values for soil gas are concentration-based thresholds (i.e., $\mu g/m^3$) that are protective of mammals exposed to VOCs in burrow air. Although groundwater is considered the source for potential migration of VOCs through soil into the underground breathing space of burrowing mammals, confidence in directly measured soil gas concentrations is higher than in predicted burrow air concentrations modeled from groundwater concentrations of VOCs. Therefore, the RGs for soil gas are recommended to assess the adequacy of measures taken to remediate groundwater for protection of ecological receptors exposed to burrow air.

During development of the inhalation-based TRVs for Edwards AFB, uncertainty factors were applied to convert the literature-based daily exposure concentrations to chemical-specific no observed adverse effect level (NOAEL)-equivalent TRVs (Tetra Tech 2004). High uncertainty factors were applied in the development of these TRVs to establish conservative screening levels that are based on the assumption that small mammals occupy their burrows 24 hours/day, 7 days/week. The NOAEL-equivalent TRVs for burrow air are presented in Table 2 and are referred to as the “low” ecological RGs for soil gas. “High” TRVs for mammals were developed in the Site 29 BERA by adjusting the Low TRVs with an uncertainty factor of 10 for conversion of a NOAEL to a lowest-observable-adverse-effects-level (LOAEL). These LOAEL-equivalent TRVs for burrow air are referred to as “high” RGs in Table 2.

In the absence of toxicity data for amphibians that may be exposed through the inhalation of VOCs in burrow air, the ecological RGs developed for burrowing mammals are recommended for the protection of both common species of burrowing mammals and threatened species of amphibians that may be seasonally present in abandoned mammal burrows. For this reason, the low RGs for TCE of 6,429 $\mu g/m^3$ and for 1,1-DCE of 600 $\mu g/m^3$ are the final proposed RGs to protect burrowing animals at Site 29 (Table 1).

3 SUMMARY OF PROPOSED REMEDIAL GOALS

The proposed RGs selected for each COC within the applicable medium are based on likely site reuse and the most health- or ecologically-protective values for the appropriate receptors. RGs protective of human health were developed for groundwater and soil gas, while RGs protective of ecological receptors were only developed for soil gas.

For groundwater, human health-based RGs can be based on two use scenarios: as potable water, or contributing VOCs that migrate into indoor air (vapor intrusion). Groundwater RGs based on potable use were more health-protective than those based on vapor intrusion; consequently, groundwater RGs are presented in Table 1 only for the potable-use scenario. Table 2 presents additional information which, for groundwater, illustrates the comparison between RGs based on either potable water use or vapor intrusion exposure.

Two types of RGs protective of ecological receptors that may be exposed to VOCs in burrow air through the inhalation pathway are presented in Table 2: low RG (NOAEL-equivalent) and high RG (LOAEL-equivalent). Due to the potential for threatened species of amphibians to be present near Site 29, the low RGs are recommended for consideration as the proposed ecologically-protective RGs for the FFS (Table 1).

4 REFERENCES

California Department of Toxic Substances Control (DTSC). 1998. "EcoNote 1: Depth of Burrows for Burrowing Mammals". Retrieved in 2006 from http://www.dtsc.ca.gov/AssessingRisk/eco.cfm

Code of Federal Regulations (CFR). 40 CFR Part 141.2. National Primary Drinking Water Regulations. Accessed at: http://edocket.access.gpo.gov/cfr_2002/julqtr/pdf/40cfr141.2.pdf

EDAW, 2008. California Tiger Salamander Upland Habitat Study Report, Prepared for U.S. Department of the Navy, Naval Base Realignment and Closure Program Management Office. Seal Beach, Detachment Concord, California, December 3.

Johnson, P.C., and R.A. Ettinger (JEM). 1991. Heuristic Model for the Predicting the Intrusion of Contaminant Vapors into Buildings. Environ. Sci. Technol. (25) 8: 1445-1452.

Office of Environmental Health Hazard Assessment (OEHHA). No date. Toxicity Criteria Database. Available at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp.

Richard Brady & Associates (Brady), 2011. Remedial Investigation for Installation Restoration Program Site 29 Former Naval Weapons Station Seal Beach Detachment Concord. Concord, CA. March 4.

Smallwood, K. S. and M. L. Morrison. 2007. A Monitoring Effort to Detect the Presence of the Federally Listed Species California Tiger Salamander and California Red-legged Frog at The Naval Weapons Station, Seal Beach, Detachment Concord, California, Letter Agreements. January 22.

Tetra Tech. 2004. Final Predictive Ecological Risk Assessment (PERA) – Operable Unit (OU) 2, Edwards Air Force Base, CA. Tetra Tech, Inc., January.

USEPA (United States Environmental Protection Agency). 1988. "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA." October.

USEPA. 2004a. Advanced Groundwater Model for Evaluation of Vapor Intrusion to Indoor Air. GW-ADV. 3.1, 02/04. http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm

USEPA. 2004b. Advanced Soil Gas Model for Evaluation of Vapor Intrusion to Indoor Air. SG-ADV 3.1, February. Available at: http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm.

USEPA. 2010. Integrated Risk Information System (IRIS) Office of Emergency and Remedial Response. Available at: http://www.epa.gov/iris/index.html.

USEPA. 2011. Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites. RSL Table update. May 2011.

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Table 1. Proposed Remediation Goals Protective of Human Health and Ecological Receptors

Proposed RGs for Groundwater (Based on Potential Exposures for Human Receptors)			
Chemical of Concern[a]	**CAS #**	**Remediation Goal (µg/L)**	**Basis[b]**
1,1,2-trichloroethane	79-00-5	5	MCL
1,2-dichloroethane	107-06-2	0.5	MCL
benzene[c]	71-43-2	1	MCL
chloroform	67-66-3	0.19	risk-based
cis-1,2-dichloroethene	156-59-2	6	MCL
tetrachloroethene	127-18-4	5	MCL
trichloroethene	79-01-6	5	MCL

Proposed RGs for Soil Gas (Based on Potential Exposures for Human and Ecological Receptors)				
		Remediation Goal (µg/m^3)		
Chemical of Concern[d]	**CAS #**	**U.S. EPA Method 1 Residential[e]**	**U.S. EPA Method 1 Commercial/Industrial[f]**	**Ecological**
1,1-dichloroethene	75-35-4	--	--	600
benzene	71-43-2	160	4,800	--
chloroform	67-66-3	50	1,500	--
trichloroethene	79-01-6	660	20,000	6,429

Notes:

--	Not an unacceptable risk contributor for this receptor; no remediation goal needed.
µg/L	microgram(s) per liter
µg/m^3	micrograms per cubic meter
CAS	Chemical Abstract Service
MCL	Maximum Contaminant Level
RG	remediation goal
U.S. EPA	United States Environmental Protection Agency

a Only chemicals of concern identified for risk management in the baseline human and ecological risk assessments are presented in this table. Although some inorganics, pesticides, and polycyclic aromatic hydrocarbons (PAHs) were initially identified in the human health risk assessment as potential risk drivers for groundwater, it was concluded that inorganics are attributed to background concentrations. Pesticides and PAHs were infrequently detected and not considered chemicals of concern. Regulatory approval was given to remove pesticides from the groundwater monitoring program and PAHs were detected once in 45 samples (see Section 5 of the *Final Remedial Investigation* [Brady 2011]).

b Most stringent of Federal and California promulgated MCL value is presented. If federal or California MCLs were not available, the U.S. EPA tap-water regional screening level from U.S. EPA (2012) was used, which is a risk-based value.

c Benzene was not detected in groundwater above the remediation goal, but was included due to elevated soil-gas detections.

d For vapor intrusion based on soil-gas data, only chemicals that were identified as chemicals of concern in the human health or ecological risk assessments are included (i.e., contributing cancer risk greater than 1×10^{-6} [applies to human health] or noncancer hazard greater than 1 [applies to ecological health]).

e Residential RGs based on the federal (U.S. EPA Method 1) approach are listed. Residential RGs based on DTSC Method 2 that differ include benzene (87 µg/m^3), chloroform (430 µg/m^3), and trichloroethene (1,300 µg/m^3). Differences between methods are detailed in Section 3 of the human health risk assessment (Attachment G to the RI; Brady 2011). In addition, table and footnote soil-gas RGs differ from those originally presented in this table; during agency review of a previous version, it was noted that an inconsistent residence mixing volume was used in

development of the soil-gas attenuation factors, differing from that used in groundwater modeling. Values in this table and footnote have been down-adjusted to correct for the prior inconsistency (see the response to the City of Concord's Comment #6).

f Commercial/industrial RGs based on the federal (U.S. EPA Method 1) approach are listed. Commercial/industrial RGs based on DTSC Method 2 that differ include benzene (1,300 $\mu g/m^3$) and chloroform (6,500 $\mu g/m^3$). Differences between methods are detailed in Section 3 of the human health risk assessment (Attachment G of the RI; Brady 2011).

Table 2. Preliminary Remedial Goals Considered for Chemicals of Concern Identified in the Human Health and Ecological Risk Assessments
IR Site 29, Former NAVWPSTA Concord

Remedial Goals For Groundwater

Chemicals of Concern [a]	CAS #	Detection Rate [b]	Matrix	Units	Max Conc [b]	95UCL [b]	Future Human Receptor [c]							
							Resident				Commercial Worker			
							GW Potable Use		GW Vapor Intrusion (VI) [e, f]		GW Potable Use		GW Vapor Intrusion [e, f]	
							Remedial Goal	Basis	Remedial Goal	Basis	Remedial Goal	Basis	Remedial Goal	Basis
1,1,2-TRICHLOROETHANE	79-00-5	13%	Water	µg/L	3	0.806	5	MCL (California)	not a primary risk driver for VI		5	MCL (California)	not a primary risk driver for VI	
1,2-DICHLOROETHANE	107-06-2	11%	Water	µg/L	3.1	1.848	0.5	MCL (California)	not a primary risk driver for VI		0.5	MCL (California)	not a primary risk driver for VI	
BENZENE	71-43-2	4%	Water	µg/L	0.36	0.448	1	MCL (California)	1.72	risk-based	1	MCL (California)	17	risk-based
CHLOROFORM	67-66-3	34%	Water	µg/L	9.5	1.323	0.19	risk-based	1.40	risk-based	0.19	risk-based	28	risk-based
CIS-1,2-DICHLOROETHENE	156-59-2	19%	Water	µg/L	530	134.1	6	MCL (California)	not a primary risk driver for VI		6	MCL (California)	not a primary risk driver for VI	
TETRACHLOROETHENE	127-18-4	2%	Water	µg/L	0.2	NA	5	MCL (California)	not a primary risk driver for VI		5	MCL (California)	not a primary risk driver for VI	
TRICHLOROETHENE	79-01-6	64%	Water	µg/L	8,200	970.4	5	MCL (California)	7.43	risk-based	5	MCL (California)	150	risk-based

Remedial Goals for Soil Gas

Chemicals of Concern	CAS #	Detection Rate [b]	Matrix	Units	Max Conc [b]	95UCL [b]	Future Human Receptor [d, e, f, g, h]		Burrowing Mammals	
							Resident	Commercial	Low [i]	High [j]
Risk Drivers from either USEPA and/or DTSC Methods (Risk Thresholds: Cancer Risk >10^{-6} and/or HI >1)										
BENZENE	71-43-2	93%	Soil Gas	µg/m3	770	358.9	129.0	1,300	not a primary risk driver	
CHLOROFORM	67-66-3	39%	Soil Gas	µg/m3	1,100	323.3	73.8	1,487	not a primary risk driver	
TRICHLOROETHENE (TCE)	79-01-6	96% (93%)	Soil Gas	µg/m3	300,000 (190,000)	187,193 (151,591)	999.3	20,145	6,429	64,300
1,1-DICHLOROETHENE	75-35-4	89% (79%)	Soil Gas	µg/m3	7,100 (2,400)	2,678 (1,404)	Below Risk Threshold		600	6,000

Notes:

95UCL = 95-percent upper confidence limit [on the mean]
CAS = Chemical Abstracts Service
GW = groundwater
Max Conc = maximum concentration
MCL = maximum contaminant level
NA = Not available
NE = Not evaluated
µg/L =micrograms per liter
µg/m3 = micrograms per cubic meter

a) Only chemicals of concern identified for risk management in the baseline human and ecological risk assessments are presented in this table. Although some inorganics, pesticides, and polycyclic aromatic hydrocarbons (PAHs) were initially identified in the human health risk assessment as potential risk drivers for groundwater, it was concluded that inorganics are attributed to background. Pesticides and PAHs were infrequently detected and not considered chemicals of concern. Regulatory approval was given to remove pesticides from the groundwater monitoring program and PAHs were detected once in 45 samples (See Section 5 of main Remedial Investigation report [Richard Brady & Associates, 2011]).
b) Values are based on all depth intervals for water and 0-10 feet below ground surface (bgs) for soil gas. Values in parentheses are from the 0-6 feet bgs interval; burrowing mammal Remedial Goals (RGs) are applicable only to this depth interval.
c) The RGs for potable use of groundwater were California MCLs as a primary source, Federal MCLs as a secondary source, and then USEPA Regional Screening Levels (RSLs) if no MCLs were available. The risk-based remedial goal for chloroform is the tapwater RSL for both Residential and Commercial receptors, and is health protective for ingestion and domestic use (e.g., washing).
Remedial goals are calculated at the agencies point-of-departure thresholds (10^{-6} cancer risk, or 1.0 noncancer hazard).
d) Values presented are shown with additional significant figures for calculation review purposes and were rounded to two significant figures in Table 1.
e) Soil gas data, as source concentrations for vapor intrusion, have less uncertainty than soil gas concentrations modeled from groundwater. Remedial goals based on vapor intrusion from groundwater are presented for comparative purposes, relative to potable use of groundwater.
f) The following soil parameters were used in calculating the attenuation factor relating soil gas concentrations to indoor air (see Attachment A for J & E Model Runs; also see text Section 2.1.7 discussing the vapor intrusion modeling): Soil gas samples were collected at 9.5 ft bgs; depth to groundwater = 1400cm; soil temp 25°C; Soil Stratum Sand(S); Indoor Air Exchange Rate for USEPA Method 1 (1/hr for commercial and 0.25/hr for residential) and for DTSC Method 2 (1/hr for commercial and 0.5/hr for residential).
g) The lower RG concentration calculated between USEPA Method 1 and DTSC Method 2 was chosen.
h) The chemicals are listed based on soil gas concentrations that exceed cancer risk or noncancer health hazard thresholds.
i) Low TRVs for mammals are obtained from the Final Ecological Risk Assessment conducted for Edwards Air Force Base (Tetra Tech 2004).
j) High TRVs for mammals are developed by adjusting Low TRVs by use of an uncertainty factor of 10 for conversion of a NOAEL to LOAEL.

References:

Richard Brady & Associates. 2011. Remedial Investigation for Installation Restoration Program Site 29 Former Naval Weapons Station Seal Beach Detachment Concord. Concord, CA.
Tetra Tech. 2004. Final Predictive Ecological Risk Assessment (PERA) – Operable Unit (OU) 2, Edwards Air Force Base, CA. Tetra Tech, Inc., January.
USEPA (United States Environmental Protection Agency), 2011. Regional Screening Levels (RSL) for Chemical Contaminants at Superfund Sites. RSL Table update. May 2011.

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Table 3. Human Health Exposure Factors
IR Site 29, Former NAVWPSTA Concord

Equation Symbol	Parameter	Value	Units	Reference
a	Attenuation factor	chemical-specific	dimensionless	chemical-specific
AT_c	Averaging Time, carcinogens	70	years	USEPA (2010a)
$C_{indoor\ air}$	COPC Concentration in indoor air	chemical-specific	$\mu g/m^3$	chemical-specific
$C_{soil\ gas}$	COPC Concentration in soil gas	chemical-specific	$\mu g/m^3$	chemical-specific
ED_r	Exposure Duration, resident	30	years	USEPA (2010a)
ED_w	Exposure Duration, worker	25	years	USEPA (2010a)
EF_r	Exposure Frequency, resident	350	days/year	USEPA (2010a)
EF_w	Exposure Frequency, worker	250	days/year	USEPA (2010a)
ET_r	Exposure Time, resident	24	hours/day	USEPA (2010a)
ET_w	Exposure Time, worker	8	hours/day	USEPA (2010a)
IUR	Inhalation Unit-Risk Factor	chemical-specific	$(\mu g/m^3)^{-1}$	chemical-specific

$\mu g/m^3$ = micrograms per cubic meter
COPC = Chemical of potential concern

Table 4. Human Health Toxicity Values: Inhalation Unit Risk Values
IR Site 29, Former NAVWPSTA Concord

Chemicals of Concern	USEPA Method 1 Toxicity Value [a]	Units	Source	DTSC Method 2 Toxicity Value [a, b]	Units	Source
Benzene	7.80E-06	$(\mu g/m^3)^{-1}$	IRIS	2.90E-05	$(\mu g/m^3)^{-1}$	OEHHA
Chloroform	2.30E-05	$(\mu g/m^3)^{-1}$	IRIS	5.30E-06	$(\mu g/m^3)^{-1}$	OEHHA
Trichloroethene	2.00E-06	$(\mu g/m^3)^{-1}$	OEHHA	--	--	--

Notes:

a) Between cancer and noncancer toxicity values, cancer risk produces the more conservative Remedial Goals for the list of chemicals of concern. In all cases, the cancer risk value, inhalation unit risk (IUR) was used.

b) Values presented when the DTSC Method 2 used an alternative toxicity value, those that were the same are shown with the "--".

IRIS = USEPA. 2010. Integrated Risk Information System (IRIS) Office of Emergency and Remedial Response. Available at: http://www.epa.gov/iris/index.html.

OEHHA = Office of Environmental Health Hazard Assessment (OEHHA). No date. Toxicity Criteria Database. Available at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp.

Attachment A: Attenuation Factors and Supporting Johnson & Ettinger Models

Attachment A Table of Contents

A1: Table of Attenuation Factors

Johnson and Ettinger Model Scenarios
A2: EPA Method 1: Soil Gas to Indoor Air for residential exposure;
A3: EPA Method 1: Soil Gas to Indoor Air for commercial exposure;
A4: EPA Method 1: Groundwater to Indoor Air for residential exposure;
A5: EPA Method 1: Groundwater to Indoor Air for commercial exposure;
A6: DTSC Method 2: Soil Gas to Indoor Air for residential exposure;
A7: DTSC Method 2: Soil Gas to Indoor Air for commercial exposure;
A8: DTSC Method 2: Groundwater to Indoor Air for residential exposure;
A9: DTSC Method 2: Groundwater to Indoor Air for commercial exposure;

References:

USEPA (United States Environmental Protection Agency). 2004a. Advanced Groundwater Model for Evaluation of Vapor Intrusion to Indoor Air. GW-ADV. 3.1, 02/04.
http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm

USEPA 2004b. Advanced Soil Gas Model for Evaluation of Vapor Intrusion to Indoor Air. SG-ADV 3.1, February. Available at:
http://www.epa.gov/oswer/riskassessment/airmodel/johnson_ettinger.htm.

* Only the attenuation factors and values used to support the calculation of attenuation factors from the models were utilized in the development of Site 29 remedial goals. The other functions of the model, such as calculating risk, were not used.

Attachment A1:
Table of Attenuation Factors

Chemicals of Concern	CAS #	Residential		Commercial	
		DTSC	EPA	DTSC	EPA
Soil Gas					
Benzene	71-43-2	0.00065061	0.001301212	0.000325305	0.000325303
Chloroform	67-66-3	0.000717177	0.0014343	0.000358589	0.000358575
Trichloroethylene	79-01-6	0.000608777	0.001217553	0.000304389	0.000304388
Groundwater					
1,1,2-Trichloroethane	79-00-5	0.00020294	0.000405881	0.00010147	0.00010147
1,2-Dichloroethane	107-06-2	0.000262922	0.000525839	0.000131461	0.00013146
Benzene	71-43-2	0.000225111	0.000450221	0.000112555	0.000112555
Chloroform	67-66-3	0.000261784	0.000523564	0.000130892	0.000130891
cis-1,2-Dichloroethylene	156-59-2	0.000191351	0.000382701	9.56754E-05	9.56753E-05
Tetrachloroethylene	127-18-4	0.000187132	0.000374264	9.3566E-05	9.35659E-05
Trichloroethylene	79-01-6	0.000203882	0.000407764	0.000101941	0.000101941

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432			1.00E+00	Benzene
75274			1.00E+00	Bromodichloromethane
75252			1.00E+00	Bromoform
124481			1.00E+00	Chlorodibromomethane
75003			1.00E+00	Chloroethane (ethyl chloride)
67663			1.00E+00	Chloroform
74873			1.00E+00	Methyl chloride (chloromethane)
95501			1.00E+00	1,2-Dichlorobenzene
106467			1.00E+00	1,4-Dichlorobenzene
75343			1.00E+00	1,1-Dichloroethane
107062			1.00E+00	1,2-Dichloroethane
75354			1.00E+00	1,1-Dichloroethylene
156592			1.00E+00	cis-1,2-Dichloroethylene
156605			1.00E+00	trans-1,2-Dichloroethylene
1634044			1.00E+00	MTBE
100414			1.00E+00	Ethylbenzene
74839			1.00E+00	Methyl bromide
75092			1.00E+00	Methylene chloride
91576			1.00E+00	2-Methylnaphthalene
91203			1.00E+00	Naphthalene
127184			1.00E+00	Tetrachloroethylene
108883			1.00E+00	Toluene
71556			1.00E+00	1,1,1-Trichloroethane
79005			1.00E+00	1,1,2-Trichloroethane
79016			1.00E+00	Trichloroethylene
76131			1.00E+00	1,1,2-Trichloro-1,2,2-trifluoroethane
95636			1.00E+00	1,2,4-Trimethylbenzene
95476			1.00E+00	o-Xylene
1330207			1.00E+00	Xylenes

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	290 (9.5 ft)	24	290			S		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.25	5

0.25 Resident
1.0 Commercial

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Molecular weight, MW (g/mol)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	78.11	7.8E-06	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	163.83	1.8E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	252.75	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	208.28	2.4E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	64.51	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	119.38	2.3E-05	0.0E+00	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	50.49	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	147.00	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	147.00	0.0E+00	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	98.96	0.0E+00	5.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	98.96	2.6E-05	0.0E+00	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	96.94	0.0E+00	2.0E-01	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	96.94	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	96.94	0.0E+00	7.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	88.15	0.0E+00	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	106.17	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	94.94	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	84.93	4.7E-07	3.0E+00	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	142.21	0.0E+00	7.0E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	128.18	0.0E+00	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	165.83	5.9E-06	6.0E-01	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	92.14	0.0E+00	4.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	133.40	0.0E+00	2.2E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	133.41	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	131.39	1.1E-04	4.0E-02	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	187.38	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	120.20	0.0E+00	6.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	106.17	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	106.17	0.0E+00	1.0E-01	Xylenes

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.20E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.72E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	1.04E+04	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	8.54E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.65E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.90E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.07E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.62E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.89E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.48E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.83E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.26E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.80E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.78E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.39E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	7.69E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.93E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	2.54E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	2.54E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.06E+06	3.77E-04	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	275
1.06E+06	3.77E-04	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	4.82E-03	275
1.06E+06	3.77E-04	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	2.41E-03	275
1.06E+06	3.77E-04	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	3.17E-03	275
1.06E+06	3.77E-04	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	4.38E-02	275
1.06E+06	3.77E-04	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	3.77E-04	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	2.04E-02	275
1.06E+06	3.77E-04	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	3.77E-04	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	3.77E-04	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	1.20E-02	275
1.06E+06	3.77E-04	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	3.77E-04	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	275
1.06E+06	3.77E-04	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	275
1.06E+06	3.77E-04	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	275
1.06E+06	3.77E-04	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	1.66E-02	275
1.06E+06	3.77E-04	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	275
1.06E+06	3.77E-04	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	275
1.06E+06	3.77E-04	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	1.63E-02	275
1.06E+06	3.77E-04	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	8.44E-03	275
1.06E+06	3.77E-04	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	9.54E-03	275
1.06E+06	3.77E-04	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	275
1.06E+06	3.77E-04	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	3.77E-04	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	3.77E-04	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	3.77E-04	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	275
1.06E+06	3.77E-04	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	3.77E-04	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	9.80E-03	275
1.06E+06	3.77E-04	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	3.77E-04	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	1.13E-02	275

INTERMEDIATE CALCULATIONS SHEET

A2 - EPA Method 1: Soil Gas to Indoor Air for Residential Exposure

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	3.20E+03	0.10	8.33E+01	1.42E-02	4.00E+02	3.99E+63	1.30E-03	4.17E+00	7.8E-06	3.0E-02	Benzene
15	6.72E+03	0.10	8.33E+01	4.82E-03	4.00E+02	6.47E+187	5.97E-04	4.01E+00	1.8E-05	7.0E-02	Bromodichloromethane
15	1.04E+04	0.10	8.33E+01	2.41E-03	4.00E+02	#NUM!	3.29E-04	3.41E+00	1.1E-06	7.0E-02	Bromoform
15	8.54E+03	0.10	8.33E+01	3.17E-03	4.00E+02	3.47E+285	4.19E-04	3.58E+00	2.4E-05	7.0E-02	Chlorodibromomethane
15	2.65E+03	0.10	8.33E+01	4.38E-02	4.00E+02	4.49E+20	2.20E-03	5.81E+00	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	4.90E+03	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	1.43E-03	7.02E+00	2.3E-05	NA	Chloroform
15	2.07E+03	0.10	8.33E+01	2.04E-02	4.00E+02	2.63E+44	1.59E-03	3.29E+00	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
15	6.03E+03	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	1.12E-03	6.73E+00	NA	2.0E-01	1,2-Dichlorobenzene
15	6.03E+03	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	1.12E-03	6.73E+00	NA	8.0E-01	1,4-Dichlorobenzene
15	4.06E+03	0.10	8.33E+01	1.20E-02	4.00E+02	2.69E+75	1.17E-03	4.75E+00	NA	5.0E-01	1,1-Dichloroethane
15	4.06E+03	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	1.43E-03	5.82E+00	2.6E-05	NA	1,2-Dichloroethane
15	3.98E+03	0.10	8.33E+01	1.45E-02	4.00E+02	1.54E+62	1.32E-03	5.24E+00	NA	2.0E-01	1,1-Dichloroethylene
15	3.98E+03	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	1.16E-03	4.63E+00	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.98E+03	0.10	8.33E+01	1.14E-02	4.00E+02	1.46E+79	1.13E-03	4.51E+00	NA	7.0E-02	trans-1,2-Dichloroethylene
15	3.62E+03	0.10	8.33E+01	1.66E-02	4.00E+02	4.53E+54	1.42E-03	5.14E+00	NA	3.0E+00	MTBE
15	4.35E+03	0.10	8.33E+01	1.21E-02	4.00E+02	4.21E+74	1.18E-03	5.13E+00	2.5E-06	1.0E+00	Ethylbenzene
15	3.89E+03	0.10	8.33E+01	1.18E-02	4.00E+02	7.58E+76	1.16E-03	4.50E+00	NA	5.0E-03	Methyl bromide
15	3.48E+03	0.10	8.33E+01	1.63E-02	4.00E+02	2.60E+55	1.41E-03	4.91E+00	4.7E-07	3.0E+00	Methylene chloride
15	5.83E+03	0.10	8.33E+01	8.44E-03	4.00E+02	1.65E+107	9.20E-04	5.37E+00	NA	7.0E-02	2-Methylnaphthalene
15	5.26E+03	0.10	8.33E+01	9.54E-03	4.00E+02	7.25E+94	1.00E-03	5.28E+00	NA	3.0E-03	Naphthalene
15	6.80E+03	0.10	8.33E+01	1.16E-02	4.00E+02	5.42E+77	1.15E-03	7.80E+00	5.9E-06	6.0E-01	Tetrachloroethylene
15	3.78E+03	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	1.29E-03	4.88E+00	NA	4.0E-01	Toluene
15	5.47E+03	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	1.21E-03	6.61E+00	NA	2.2E+00	1,1,1-Trichloroethane
15	5.47E+03	0.10	8.33E+01	1.26E-02	4.00E+02	5.67E+71	1.21E-03	6.61E+00	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	5.39E+03	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	1.22E-03	6.56E+00	1.1E-04	4.0E-02	Trichloroethylene
15	7.69E+03	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	1.21E-03	9.28E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	4.93E+03	0.10	8.33E+01	9.80E-03	4.00E+02	2.28E+92	1.02E-03	5.04E+00	NA	6.0E-03	1,2,4-Trimethylbenzene
15	4.35E+03	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	1.29E-03	5.63E+00	NA	1.0E-01	o-Xylene
15	4.35E+03	0.10	8.33E+01	1.13E-02	4.00E+02	9.01E+79	1.13E-03	4.91E+00	NA	1.0E-01	Xylenes

END

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432			1.00E+00	Benzene
75274			1.00E+00	Bromodichloromethane
75252			1.00E+00	Bromoform
124481			1.00E+00	Chlorodibromomethane
75003			1.00E+00	Chloroethane (ethyl chloride)
67663			1.00E+00	Chloroform
74873			1.00E+00	Methyl chloride (chloromethane)
95501			1.00E+00	1,2-Dichlorobenzene
106467			1.00E+00	1,4-Dichlorobenzene
75343			1.00E+00	1,1-Dichloroethane
107062			1.00E+00	1,2-Dichloroethane
75354			1.00E+00	1,1-Dichloroethylene
156592			1.00E+00	cis-1,2-Dichloroethylene
156605			1.00E+00	trans-1,2-Dichloroethylene
1634044			1.00E+00	MTBE
100414			1.00E+00	Ethylbenzene
74839			1.00E+00	Methyl bromide
75092			1.00E+00	Methylene chloride
91576			1.00E+00	2-Methylnaphthalene
91203			1.00E+00	Naphthalene
127184			1.00E+00	Tetrachloroethylene
108883			1.00E+00	Toluene
71556			1.00E+00	1,1,1-Trichloroethane
79005			1.00E+00	1,1,2-Trichloroethane
79016			1.00E+00	Trichloroethylene
76131			1.00E+00	1,1,2-Trichloro-1,2,2-trifluoroethane
95636			1.00E+00	1,2,4-Trimethylbenzene
95476			1.00E+00	o-Xylene
1330207			1.00E+00	Xylenes

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	290 (9.5 ft)	24	290			S		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	1 0.25 Resident 1.0 Commercial	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Molecular weight, MW (g/mol)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	78.11	7.8E-06	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	163.83	1.8E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	252.75	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	208.28	2.4E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	64.51	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	119.38	2.3E-05	0.0E+00	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	50.49	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	147.00	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	147.00	0.0E+00	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	98.96	0.0E+00	5.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	98.96	2.6E-05	0.0E+00	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	96.94	0.0E+00	2.0E-01	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	96.94	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	96.94	0.0E+00	7.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	88.15	0.0E+00	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	106.17	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	94.94	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	84.93	4.7E-07	3.0E+00	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	142.21	0.0E+00	7.0E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	128.18	0.0E+00	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	165.83	5.9E-06	6.0E-01	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	92.14	0.0E+00	4.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	133.40	0.0E+00	2.2E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	133.41	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	131.39	1.1E-04	4.0E-02	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	187.38	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	120.20	0.0E+00	6.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	106.17	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	106.17	0.0E+00	1.0E-01	Xylenes

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.20E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.72E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	1.04E+04	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	8.54E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.65E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.90E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.07E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.62E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.89E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.48E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.83E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.26E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.80E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.78E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.39E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	7.69E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.93E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	1.02E+05

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.06E+06	3.77E-04	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	275
1.06E+06	3.77E-04	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	4.82E-03	275
1.06E+06	3.77E-04	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	2.41E-03	275
1.06E+06	3.77E-04	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	3.17E-03	275
1.06E+06	3.77E-04	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	4.38E-02	275
1.06E+06	3.77E-04	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	3.77E-04	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	2.04E-02	275
1.06E+06	3.77E-04	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	3.77E-04	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	3.77E-04	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	1.20E-02	275
1.06E+06	3.77E-04	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	3.77E-04	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	275
1.06E+06	3.77E-04	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	275
1.06E+06	3.77E-04	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	275
1.06E+06	3.77E-04	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	1.66E-02	275
1.06E+06	3.77E-04	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	275
1.06E+06	3.77E-04	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	275
1.06E+06	3.77E-04	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	1.63E-02	275
1.06E+06	3.77E-04	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	8.44E-03	275
1.06E+06	3.77E-04	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	9.54E-03	275
1.06E+06	3.77E-04	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	275
1.06E+06	3.77E-04	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	3.77E-04	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	3.77E-04	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	3.77E-04	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	275
1.06E+06	3.77E-04	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	3.77E-04	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	9.80E-03	275
1.06E+06	3.77E-04	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	3.77E-04	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	1.13E-02	275

INTERMEDIATE CALCULATIONS SHEET **A3 - EPA Method 1: Soil Gas to Indoor Air for Commercial Exposure**

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	3.20E+03	0.10	8.33E+01	1.42E-02	4.00E+02	3.99E+63	3.25E-04	1.04E+00	7.8E-06	3.0E-02	Benzene
15	6.72E+03	0.10	8.33E+01	4.82E-03	4.00E+02	6.47E+187	1.49E-04	1.00E+00	1.8E-05	7.0E-02	Bromodichloromethane
15	1.04E+04	0.10	8.33E+01	2.41E-03	4.00E+02	#NUM!	8.22E-05	8.52E-01	1.1E-06	7.0E-02	Bromoform
15	8.54E+03	0.10	8.33E+01	3.17E-03	4.00E+02	3.47E+285	1.05E-04	8.95E-01	2.4E-05	7.0E-02	Chlorodibromomethane
15	2.65E+03	0.10	8.33E+01	4.38E-02	4.00E+02	4.49E+20	5.49E-04	1.45E+00	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	4.90E+03	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	3.59E-04	1.76E+00	2.3E-05	NA	Chloroform
15	2.07E+03	0.10	8.33E+01	2.04E-02	4.00E+02	2.63E+44	3.98E-04	8.23E-01	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
15	6.03E+03	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	2.79E-04	1.68E+00	NA	2.0E-01	1,2-Dichlorobenzene
15	6.03E+03	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	2.79E-04	1.68E+00	NA	8.0E-01	1,4-Dichlorobenzene
15	4.06E+03	0.10	8.33E+01	1.20E-02	4.00E+02	2.69E+75	2.92E-04	1.19E+00	NA	5.0E-01	1,1-Dichloroethane
15	4.06E+03	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	3.59E-04	1.46E+00	2.6E-05	NA	1,2-Dichloroethane
15	3.98E+03	0.10	8.33E+01	1.45E-02	4.00E+02	1.54E+62	3.30E-04	1.31E+00	NA	2.0E-01	1,1-Dichloroethylene
15	3.98E+03	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	2.91E-04	1.16E+00	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.98E+03	0.10	8.33E+01	1.14E-02	4.00E+02	1.46E+79	2.83E-04	1.13E+00	NA	7.0E-02	trans-1,2-Dichloroethylene
15	3.62E+03	0.10	8.33E+01	1.66E-02	4.00E+02	4.53E+54	3.55E-04	1.29E+00	NA	3.0E+00	MTBE
15	4.35E+03	0.10	8.33E+01	1.21E-02	4.00E+02	4.21E+74	2.95E-04	1.28E+00	2.5E-06	1.0E+00	Ethylbenzene
15	3.89E+03	0.10	8.33E+01	1.18E-02	4.00E+02	7.58E+76	2.89E-04	1.13E+00	NA	5.0E-03	Methyl bromide
15	3.48E+03	0.10	8.33E+01	1.63E-02	4.00E+02	2.60E+55	3.53E-04	1.23E+00	4.7E-07	3.0E+00	Methylene chloride
15	5.83E+03	0.10	8.33E+01	8.44E-03	4.00E+02	1.65E+107	2.30E-04	1.34E+00	NA	7.0E-02	2-Methylnaphthalene
15	5.26E+03	0.10	8.33E+01	9.54E-03	4.00E+02	7.25E+94	2.51E-04	1.32E+00	NA	3.0E-03	Naphthalene
15	6.80E+03	0.10	8.33E+01	1.16E-02	4.00E+02	5.42E+77	2.87E-04	1.95E+00	5.9E-06	6.0E-01	Tetrachloroethylene
15	3.78E+03	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	3.23E-04	1.22E+00	NA	4.0E-01	Toluene
15	5.47E+03	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	3.02E-04	1.65E+00	NA	2.2E+00	1,1,1-Trichloroethane
15	5.47E+03	0.10	8.33E+01	1.26E-02	4.00E+02	5.67E+71	3.02E-04	1.65E+00	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	5.39E+03	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	3.04E-04	1.64E+00	1.1E-04	4.0E-02	Trichloroethylene
15	7.69E+03	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	3.02E-04	2.32E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	4.93E+03	0.10	8.33E+01	9.80E-03	4.00E+02	2.28E+92	2.56E-04	1.26E+00	NA	6.0E-03	1,2,4-Trimethylbenzene
15	4.35E+03	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	3.23E-04	1.41E+00	NA	1.0E-01	o-Xylene
15	4.35E+03	0.10	8.33E+01	1.13E-02	4.00E+02	9.01E+79	2.82E-04	1.23E+00	NA	1.0E-01	Xylenes

END

GW-ADV
Version 3.1; 02/04

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [x]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_w (µg/L)		Chemical
	lesser of maximum or 95%UCL		
71432			Benzene
75274			Bromodichloromethane
75252			Bromoform
124481			Chlorodibromomethane
75003			Chloroethane (ethyl chloride)
67663			Chloroform
74873			Methyl chloride (chloromethane)
95501			1,2-Dichlorobenzene
106467			1,4-Dichlorobenzene
75343			1,1-Dichloroethane
107062			1,2-Dichloroethane
75354			1,1-Dichloroethylene
156592			cis-1,2-Dichloroethylene
156605			trans-1,2-Dichloroethylene
1634044			MTBE
100414			Ethylbenzene
74839			Methyl bromide
75092			Methylene chloride
91576			2-Methylnaphthalene
91203			Naphthalene
127184			Tetrachloroethylene
108883			Toluene
71556			1,1,1-Trichloroethane
79005			1,1,2-Trichloroethane
79016			Trichloroethylene
76131			1,1,2-Trichloro-1,2,2-trifluoroethane
95636			1,2,4-Trimethylbenzene
95476			o-Xylene
1330207			Xylenes

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, h_B (cm)	ENTER Thickness of soil stratum C, h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
24	15	1400	1400			A	S	S		
		approx. 46 feet								

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.25	5
						0.25/hr Residential 1.0/hr Commercial	

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	5.89E+01	1.79E+03	7.8E-06	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	5.50E+01	6.74E+03	1.8E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	8.71E+01	3.10E+03	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	6.31E+01	2.60E+03	2.4E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	4.40E+00	5.68E+03	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	3.98E+01	7.92E+03	2.3E-05	0.0E+00	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	2.12E+00	5.33E+03	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	6.17E+02	1.56E+02	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	6.17E+02	7.90E+01	0.0E+00	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	3.16E+01	5.06E+03	0.0E+00	5.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	1.74E+01	8.52E+03	2.6E-05	0.0E+00	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	5.89E+01	2.25E+03	0.0E+00	2.0E-01	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	3.55E+01	3.50E+03	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	5.25E+01	6.30E+03	0.0E+00	7.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	7.26E+00	5.10E+04	0.0E+00	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	3.63E+02	1.69E+02	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	1.05E+01	1.52E+04	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	1.17E+01	1.30E+04	4.7E-07	3.0E+00	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	2.81E+03	2.46E+01	0.0E+00	7.0E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	2.00E+03	3.10E+01	0.0E+00	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	1.55E+02	2.00E+02	5.9E-06	6.0E-01	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	1.82E+02	5.26E+02	0.0E+00	4.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	1.10E+02	1.33E+03	0.0E+00	2.2E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	5.01E+01	4.42E+03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	1.1E-04	4.0E-02	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	1.11E+04	1.70E+02	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	1.35E+03	5.70E+01	0.0E+00	6.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	3.63E+02	1.78E+02	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	4.43E+02	2.42E+02	0.0E+00	1.0E-01	Xylenes

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)	
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Benzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromodichloromethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromoform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chlorodibromomethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroethane (ethyl chloride)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl chloride (chloromethane)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,4-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	cis-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	trans-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	MTBE
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Ethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl bromide
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methylene chloride
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	2-Methylnaphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Naphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Tetrachloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Toluene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,1-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Trichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloro-1,2,2-trifluoroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2,4-Trimethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	o-Xylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Xylenes

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	
1.69E+04	1.06E+06	3.77E-04	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	5.67E-04	1.10E-02	1385	Benzene
1.69E+04	1.06E+06	3.77E-04	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	2.03E-04	3.77E-03	1385	Bromodichloromethane
1.69E+04	1.06E+06	3.77E-04	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	1.29E-04	1.98E-03	1385	Bromoform
1.69E+04	1.06E+06	3.77E-04	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	1.51E-04	2.54E-03	1385	Chlorodibromomethane
1.69E+04	1.06E+06	3.77E-04	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	1.74E-03	3.38E-02	1385	Chloroethane (ethyl chloride)
1.69E+04	1.06E+06	3.77E-04	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.71E-04	1.30E-02	1385	Chloroform
1.69E+04	1.06E+06	3.77E-04	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	8.08E-04	1.57E-02	1385	Methyl chloride (chloromethane)
1.69E+04	1.06E+06	3.77E-04	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.50E-04	8.63E-03	1385	1,2-Dichlorobenzene
1.69E+04	1.06E+06	3.77E-04	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.48E-04	8.62E-03	1385	1,4-Dichlorobenzene
1.69E+04	1.06E+06	3.77E-04	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	4.79E-04	9.25E-03	1385	1,1-Dichloroethane
1.69E+04	1.06E+06	3.77E-04	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.85E-04	1.30E-02	1385	1,2-Dichloroethane
1.69E+04	1.06E+06	3.77E-04	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	5.77E-04	1.12E-02	1385	1,1-Dichloroethylene
1.69E+04	1.06E+06	3.77E-04	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	4.77E-04	9.19E-03	1385	cis-1,2-Dichloroethylene
1.69E+04	1.06E+06	3.77E-04	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	4.55E-04	8.81E-03	1385	trans-1,2-Dichloroethylene
1.69E+04	1.06E+06	3.77E-04	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	6.87E-04	1.29E-02	1385	MTBE
1.69E+04	1.06E+06	3.77E-04	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	4.82E-04	9.35E-03	1385	Ethylbenzene
1.69E+04	1.06E+06	3.77E-04	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	4.70E-04	9.08E-03	1385	Methyl bromide
1.69E+04	1.06E+06	3.77E-04	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	6.57E-04	1.26E-02	1385	Methylene chloride
1.69E+04	1.06E+06	3.77E-04	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	3.64E-04	6.63E-03	1385	2-Methylnaphthalene
1.69E+04	1.06E+06	3.77E-04	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	4.08E-04	7.48E-03	1385	Naphthalene

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1.69E+04	1.06E+06	3.77E-04	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	4.62E-04	8.97E-03	1385	Tetrachloroethylene
1.69E+04	1.06E+06	3.77E-04	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.60E-04	1.08E-02	1385	Toluene
1.69E+04	1.06E+06	3.77E-04	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.72E-03	1385	1,1,1-Trichloroethane
1.69E+04	1.06E+06	3.77E-04	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.18E-04	9.79E-03	1385	1,1,2-Trichloroethane
1.69E+04	1.06E+06	3.77E-04	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	5.08E-04	9.84E-03	1385	Trichloroethylene
1.69E+04	1.06E+06	3.77E-04	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.71E-03	1385	1,1,2-Trichloro-1,2,2-trifluoroethane
1.69E+04	1.06E+06	3.77E-04	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	3.91E-04	7.56E-03	1385	1,2,4-Trimethylbenzene
1.69E+04	1.06E+06	3.77E-04	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.61E-04	1.08E-02	1385	o-Xylene
1.69E+04	1.06E+06	3.77E-04	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	4.51E-04	8.73E-03	1385	Xylenes

A4 - EPA Method 1: Groundwater to Indoor Air for Residential Exposure

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	2.17E+02	0.10	8.33E+01	1.42E-02	4.00E+02	3.99E+63	4.50E-04	9.77E-02	7.8E-06	3.0E-02	Benzene
15	6.24E+01	0.10	8.33E+01	4.82E-03	4.00E+02	6.47E+187	1.64E-04	1.03E-02	1.8E-05	7.0E-02	Bromodichloromethane
15	2.27E+01	0.10	8.33E+01	2.41E-03	4.00E+02	#NUM!	8.77E-05	1.99E-03	1.1E-06	7.0E-02	Bromoform
15	3.08E+01	0.10	8.33E+01	3.17E-03	4.00E+02	3.47E+285	1.12E-04	3.46E-03	2.4E-05	7.0E-02	Chlorodibromomethane
15	3.49E+02	0.10	8.33E+01	4.38E-02	4.00E+02	4.49E+20	1.16E-03	4.06E-01	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	1.44E+02	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	5.24E-04	7.54E-02	2.3E-05	NA	Chloroform
15	3.52E+02	0.10	8.33E+01	2.04E-02	4.00E+02	2.63E+44	6.20E-04	2.18E-01	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
15	7.28E+01	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	3.61E-04	2.63E-02	NA	2.0E-01	1,2-Dichlorobenzene
15	9.22E+01	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	3.61E-04	3.33E-02	NA	8.0E-01	1,4-Dichlorobenzene
15	2.21E+02	0.10	8.33E+01	1.20E-02	4.00E+02	2.69E+75	3.85E-04	8.50E-02	NA	5.0E-01	1,1-Dichloroethane
15	3.82E+01	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	5.26E-04	2.01E-02	2.6E-05	NA	1,2-Dichloroethane
15	1.03E+03	0.10	8.33E+01	1.45E-02	4.00E+02	1.54E+62	4.59E-04	4.73E-01	NA	2.0E-01	1,1-Dichloroethylene
15	1.60E+02	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	3.83E-04	6.12E-02	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.69E+02	0.10	8.33E+01	1.14E-02	4.00E+02	1.46E+79	3.68E-04	1.36E-01	NA	7.0E-02	trans-1,2-Dichloroethylene
15	2.46E+01	0.10	8.33E+01	1.66E-02	4.00E+02	4.53E+54	5.21E-04	1.28E-02	NA	3.0E+00	MTBE
15	3.05E+02	0.10	8.33E+01	1.21E-02	4.00E+02	4.21E+74	3.89E-04	1.18E-01	2.5E-06	1.0E+00	Ethylbenzene
15	2.47E+02	0.10	8.33E+01	1.18E-02	4.00E+02	7.58E+76	3.79E-04	9.37E-02	NA	5.0E-03	Methyl bromide
15	8.62E+01	0.10	8.33E+01	1.63E-02	4.00E+02	2.60E+55	5.11E-04	4.40E-02	4.7E-07	3.0E+00	Methylene chloride
15	1.93E+01	0.10	8.33E+01	8.44E-03	4.00E+02	1.65E+107	2.82E-04	5.46E-03	NA	7.0E-02	2-Methylnaphthalene
15	1.84E+01	0.10	8.33E+01	9.54E-03	4.00E+02	7.25E+94	3.16E-04	5.81E-03	NA	3.0E-03	Naphthalene
15	7.14E+02	0.10	8.33E+01	1.16E-02	4.00E+02	5.42E+77	3.74E-04	2.67E-01	5.9E-06	6.0E-01	Tetrachloroethylene
15	2.58E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	4.45E-04	1.15E-01	NA	4.0E-01	Toluene
15	6.73E+02	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	4.03E-04	2.71E-01	NA	2.2E+00	1,1,1-Trichloroethane
15	3.54E+01	0.10	8.33E+01	1.26E-02	4.00E+02	5.67E+71	4.06E-04	1.44E-02	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	4.02E+02	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	4.08E-04	1.64E-01	1.1E-04	4.0E-02	Trichloroethylene
15	1.89E+04	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	4.03E-04	7.62E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	2.36E+02	0.10	8.33E+01	9.80E-03	4.00E+02	2.28E+92	3.19E-04	7.53E-02	NA	6.0E-03	1,2,4-Trimethylbenzene
15	2.00E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	4.46E-04	8.93E-02	NA	1.0E-01	o-Xylene
15	2.56E+02	0.10	8.33E+01	1.13E-02	4.00E+02	9.01E+79	3.65E-04	9.33E-02	NA	1.0E-01	Xylenes

END

GW-ADV
Version 3.1; 02/04

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES: X

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES:

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)		Chemical
	lesser of maximum or 95%UCL		
71432			Benzene
75274			Bromodichloromethane
75252			Bromoform
124481			Chlorodibromomethane
75003			Chloroethane (ethyl chloride)
67663			Chloroform
74873			Methyl chloride (chloromethane)
95501			1,2-Dichlorobenzene
106467			1,4-Dichlorobenzene
75343			1,1-Dichloroethane
107062			1,2-Dichloroethane
75354			1,1-Dichloroethylene
156592			cis-1,2-Dichloroethylene
156605			trans-1,2-Dichloroethylene
1634044			MTBE
100414			Ethylbenzene
74839			Methyl bromide
75092			Methylene chloride
91576			2-Methylnaphthalene
91203			Naphthalene
127184			Tetrachloroethylene
108883			Toluene
71556			1,1,1-Trichloroethane
79005			1,1,2-Trichloroethane
79016			Trichloroethylene
76131			1,1,2-Trichloro-1,2,2-trifluoroethane
95636			1,2,4-Trimethylbenzene
95476			o-Xylene
1330207			Xylenes

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
24	15	1400	1400			A	S	S		
		approx. 46 feet								

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	1	5
						0.25/hr Residential 1.0/hr Commercial	

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	5.89E+01	1.79E+03	7.8E-06	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	5.50E+01	6.74E+03	1.8E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	8.71E+01	3.10E+03	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	6.31E+01	2.60E+03	2.4E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	4.40E+00	5.68E+03	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	3.98E+01	7.92E+03	2.3E-05	0.0E+00	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	2.12E+00	5.33E+03	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	6.17E+02	1.56E+02	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	6.17E+02	7.90E+01	0.0E+00	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	3.16E+01	5.06E+03	0.0E+00	5.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	1.74E+01	8.52E+03	2.6E-05	0.0E+00	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	5.89E+01	2.25E+03	0.0E+00	2.0E-01	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	3.55E+01	3.50E+03	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	5.25E+01	6.30E+03	0.0E+00	7.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	7.26E+00	5.10E+04	0.0E+00	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	3.63E+02	1.69E+02	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	1.05E+01	1.52E+04	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	1.17E+01	1.30E+04	4.7E-07	3.0E+00	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	2.81E+03	2.46E+01	0.0E+00	7.0E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	2.00E+03	3.10E+01	0.0E+00	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	1.55E+02	2.00E+02	5.9E-06	6.0E-01	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	1.82E+02	5.26E+02	0.0E+00	4.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	1.10E+02	1.33E+03	0.0E+00	2.2E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	5.01E+01	4.42E+03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	1.1E-04	4.0E-02	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	1.11E+04	1.70E+02	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	1.35E+03	5.70E+01	0.0E+00	6.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	3.63E+02	1.78E+02	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	4.43E+02	2.42E+02	0.0E+00	1.0E-01	Xylenes

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)	
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Benzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromodichloromethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromoform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chlorodibromomethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroethane (ethyl chloride)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl chloride (chloromethane)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,4-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	cis-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	trans-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	MTBE
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Ethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl bromide
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methylene chloride
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	2-Methylnaphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Naphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Tetrachloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Toluene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,1-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Trichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloro-1,2,2-trifluoroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2,4-Trimethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	o-Xylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Xylenes

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	
6.78E+04	1.06E+06	3.77E-04	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	5.67E-04	1.10E-02	1385	Benzene
6.78E+04	1.06E+06	3.77E-04	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	2.03E-04	3.77E-03	1385	Bromodichloromethane
6.78E+04	1.06E+06	3.77E-04	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	1.29E-04	1.98E-03	1385	Bromoform
6.78E+04	1.06E+06	3.77E-04	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	1.51E-04	2.54E-03	1385	Chlorodibromomethane
6.78E+04	1.06E+06	3.77E-04	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	1.74E-03	3.38E-02	1385	Chloroethane (ethyl chloride)
6.78E+04	1.06E+06	3.77E-04	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.71E-04	1.30E-02	1385	Chloroform
6.78E+04	1.06E+06	3.77E-04	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	8.08E-04	1.57E-02	1385	Methyl chloride (chloromethane)
6.78E+04	1.06E+06	3.77E-04	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.50E-04	8.63E-03	1385	1,2-Dichlorobenzene
6.78E+04	1.06E+06	3.77E-04	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.48E-04	8.62E-03	1385	1,4-Dichlorobenzene
6.78E+04	1.06E+06	3.77E-04	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	4.79E-04	9.25E-03	1385	1,1-Dichloroethane
6.78E+04	1.06E+06	3.77E-04	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.85E-04	1.30E-02	1385	1,2-Dichloroethane
6.78E+04	1.06E+06	3.77E-04	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	5.77E-04	1.12E-02	1385	1,1-Dichloroethylene
6.78E+04	1.06E+06	3.77E-04	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	4.77E-04	9.19E-03	1385	cis-1,2-Dichloroethylene
6.78E+04	1.06E+06	3.77E-04	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	4.55E-04	8.81E-03	1385	trans-1,2-Dichloroethylene
6.78E+04	1.06E+06	3.77E-04	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	6.87E-04	1.29E-02	1385	MTBE
6.78E+04	1.06E+06	3.77E-04	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	4.82E-04	9.35E-03	1385	Ethylbenzene
6.78E+04	1.06E+06	3.77E-04	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	4.70E-04	9.08E-03	1385	Methyl bromide
6.78E+04	1.06E+06	3.77E-04	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	6.57E-04	1.26E-02	1385	Methylene chloride
6.78E+04	1.06E+06	3.77E-04	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	3.64E-04	6.63E-03	1385	2-Methylnaphthalene
6.78E+04	1.06E+06	3.77E-04	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	4.08E-04	7.48E-03	1385	Naphthalene

A5 - EPA Method 1: Groundwater to Indoor Air for Commercial Exposure

6.78E+04	1.06E+06	3.77E-04	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	4.62E-04	8.97E-03	1385	Tetrachloroethylene
6.78E+04	1.06E+06	3.77E-04	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.60E-04	1.08E-02	1385	Toluene
6.78E+04	1.06E+06	3.77E-04	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.72E-03	1385	1,1,1-Trichloroethane
6.78E+04	1.06E+06	3.77E-04	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.18E-04	9.79E-03	1385	1,1,2-Trichloroethane
6.78E+04	1.06E+06	3.77E-04	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	5.08E-04	9.84E-03	1385	Trichloroethylene
6.78E+04	1.06E+06	3.77E-04	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.71E-03	1385	1,1,2-Trichloro-1,2,2-trifluoroethane
6.78E+04	1.06E+06	3.77E-04	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	3.91E-04	7.56E-03	1385	1,2,4-Trimethylbenzene
6.78E+04	1.06E+06	3.77E-04	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.61E-04	1.08E-02	1385	o-Xylene
6.78E+04	1.06E+06	3.77E-04	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	4.51E-04	8.73E-03	1385	Xylenes

A5 - EPA Method 1: Groundwater to Indoor Air for Commercial Exposure

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	2.17E+02	0.10	8.33E+01	1.42E-02	4.00E+02	3.99E+63	1.13E-04	2.44E-02	7.8E-06	3.0E-02	Benzene
15	6.24E+01	0.10	8.33E+01	4.82E-03	4.00E+02	6.47E+187	4.11E-05	2.56E-03	1.8E-05	7.0E-02	Bromodichloromethane
15	2.27E+01	0.10	8.33E+01	2.41E-03	4.00E+02	#NUM!	2.19E-05	4.97E-04	1.1E-06	7.0E-02	Bromoform
15	3.08E+01	0.10	8.33E+01	3.17E-03	4.00E+02	3.47E+285	2.80E-05	8.65E-04	2.4E-05	7.0E-02	Chlorodibromomethane
15	3.49E+02	0.10	8.33E+01	4.38E-02	4.00E+02	4.49E+20	2.91E-04	1.02E-01	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	1.44E+02	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	1.31E-04	1.88E-02	2.3E-05	NA	Chloroform
15	3.52E+02	0.10	8.33E+01	2.04E-02	4.00E+02	2.63E+44	1.55E-04	5.45E-02	1.0E-06	9.0E-02	Methyl chloride (chloromethane)
15	7.28E+01	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	9.03E-05	6.57E-03	NA	2.0E-01	1,2-Dichlorobenzene
15	9.22E+01	0.10	8.33E+01	1.12E-02	4.00E+02	1.30E+81	9.02E-05	8.31E-03	NA	8.0E-01	1,4-Dichlorobenzene
15	2.21E+02	0.10	8.33E+01	1.20E-02	4.00E+02	2.69E+75	9.63E-05	2.12E-02	NA	5.0E-01	1,1-Dichloroethane
15	3.82E+01	0.10	8.33E+01	1.68E-02	4.00E+02	6.54E+53	1.31E-04	5.02E-03	2.6E-05	NA	1,2-Dichloroethane
15	1.03E+03	0.10	8.33E+01	1.45E-02	4.00E+02	1.54E+62	1.15E-04	1.18E-01	NA	2.0E-01	1,1-Dichloroethylene
15	1.60E+02	0.10	8.33E+01	1.19E-02	4.00E+02	1.11E+76	9.57E-05	1.53E-02	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.69E+02	0.10	8.33E+01	1.14E-02	4.00E+02	1.46E+79	9.21E-05	3.40E-02	NA	7.0E-02	trans-1,2-Dichloroethylene
15	2.46E+01	0.10	8.33E+01	1.66E-02	4.00E+02	4.53E+54	1.30E-04	3.20E-03	NA	3.0E+00	MTBE
15	3.05E+02	0.10	8.33E+01	1.21E-02	4.00E+02	4.21E+74	9.72E-05	2.96E-02	2.5E-06	1.0E+00	Ethylbenzene
15	2.47E+02	0.10	8.33E+01	1.18E-02	4.00E+02	7.58E+76	9.46E-05	2.34E-02	NA	5.0E-03	Methyl bromide
15	8.62E+01	0.10	8.33E+01	1.63E-02	4.00E+02	2.60E+55	1.28E-04	1.10E-02	4.7E-07	3.0E+00	Methylene chloride
15	1.93E+01	0.10	8.33E+01	8.44E-03	4.00E+02	1.65E+107	7.05E-05	1.36E-03	NA	7.0E-02	2-Methylnaphthalene
15	1.84E+01	0.10	8.33E+01	9.54E-03	4.00E+02	7.25E+94	7.90E-05	1.45E-03	NA	3.0E-03	Naphthalene
15	7.14E+02	0.10	8.33E+01	1.16E-02	4.00E+02	5.42E+77	9.36E-05	6.68E-02	5.9E-06	6.0E-01	Tetrachloroethylene
15	2.58E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	1.11E-04	2.87E-02	NA	4.0E-01	Toluene
15	6.73E+02	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	1.01E-04	6.78E-02	NA	2.2E+00	1,1,1-Trichloroethane
15	3.54E+01	0.10	8.33E+01	1.26E-02	4.00E+02	5.67E+71	1.01E-04	3.59E-03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	4.02E+02	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	1.02E-04	4.10E-02	1.1E-04	4.0E-02	Trichloroethylene
15	1.89E+04	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	1.01E-04	1.91E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	2.36E+02	0.10	8.33E+01	9.80E-03	4.00E+02	2.28E+92	7.98E-05	1.88E-02	NA	6.0E-03	1,2,4-Trimethylbenzene
15	2.00E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	1.11E-04	2.23E-02	NA	1.0E-01	o-Xylene
15	2.56E+02	0.10	8.33E+01	1.13E-02	4.00E+02	9.01E+79	9.12E-05	2.33E-02	NA	1.0E-01	Xylenes

END

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432			1.00E+00	Benzene
75274			1.00E+00	Bromodichloromethane
75252			1.00E+00	Bromoform
124481			1.00E+00	Chlorodibromomethane
75003			1.00E+00	Chloroethane (ethyl chloride)
67663			1.00E+00	Chloroform
74873			1.00E+00	Methyl chloride (chloromethane)
95501			1.00E+00	1,2-Dichlorobenzene
106467			1.00E+00	1,4-Dichlorobenzene
75343			1.00E+00	1,1-Dichloroethane
107062			1.00E+00	1,2-Dichloroethane
75354			1.00E+00	1,1-Dichloroethylene
156592			1.00E+00	cis-1,2-Dichloroethylene
156605			1.00E+00	trans-1,2-Dichloroethylene
1634044			1.00E+00	MTBE
100414			1.00E+00	Ethylbenzene
74839			1.00E+00	Methyl bromide
75092			1.00E+00	Methylene chloride
91576			1.00E+00	2-Methylnaphthalene
91203			1.00E+00	Naphthalene
127184			1.00E+00	Tetrachloroethylene
108883			1.00E+00	Toluene
71556			1.00E+00	1,1,1-Trichloroethane
79005			1.00E+00	1,1,2-Trichloroethane
79016			1.00E+00	Trichloroethylene
76131			1.00E+00	1,1,2-Trichloro-1,2,2-trifluoroethane
95636			1.00E+00	1,2,4-Trimethylbenzene
95476			1.00E+00	o-Xylene
1330207			1.00E+00	Xylenes

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Totals must add up to value of Ls (cell F24) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	290 (9.5 ft)	24	290			S		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	0.5	5

0.5/hr Residential
1.0/hr Commercial

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Molecular weight, MW (g/mol)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	78.11	2.9E-05	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	163.83	3.7E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	252.75	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	208.28	2.7E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	64.51	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	119.38	5.3E-06	3.0E-01	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	50.49	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	147.00	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	147.00	1.1E-05	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	98.96	1.6E-06	7.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	98.96	2.1E-05	4.0E-01	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	96.94	0.0E+00	7.0E-02	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	96.94	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	96.94	0.0E+00	6.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	88.15	2.6E-07	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	106.17	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	94.94	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	84.93	1.0E-06	4.0E-01	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	142.21	0.0E+00	1.4E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	128.18	3.4E-05	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	165.83	5.9E-06	3.5E-02	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	92.14	0.0E+00	3.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	133.40	0.0E+00	5.0E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	133.41	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	131.39	2.0E-06	6.0E-01	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	187.38	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	120.20	0.0E+00	7.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	106.17	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	106.17	0.0E+00	1.0E-01	Xylenes

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.20E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.72E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	1.04E+04	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	8.54E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.65E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.90E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.07E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.62E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.89E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.48E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.83E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.26E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.80E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.78E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.39E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	7.69E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.93E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	5.08E+04
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	5.08E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.06E+06	5.00E-03	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	275
1.06E+06	5.00E-03	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	4.82E-03	275
1.06E+06	5.00E-03	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	2.41E-03	275
1.06E+06	5.00E-03	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	3.17E-03	275
1.06E+06	5.00E-03	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	4.38E-02	275
1.06E+06	5.00E-03	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	5.00E-03	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	2.04E-02	275
1.06E+06	5.00E-03	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	5.00E-03	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	5.00E-03	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	1.20E-02	275
1.06E+06	5.00E-03	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	5.00E-03	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	275
1.06E+06	5.00E-03	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	275
1.06E+06	5.00E-03	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	275
1.06E+06	5.00E-03	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	1.66E-02	275
1.06E+06	5.00E-03	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	275
1.06E+06	5.00E-03	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	275
1.06E+06	5.00E-03	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	1.63E-02	275
1.06E+06	5.00E-03	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	8.44E-03	275
1.06E+06	5.00E-03	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	9.54E-03	275
1.06E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	275
1.06E+06	5.00E-03	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	5.00E-03	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	5.00E-03	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	5.00E-03	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	275
1.06E+06	5.00E-03	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	5.00E-03	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	9.80E-03	275
1.06E+06	5.00E-03	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	5.00E-03	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	1.13E-02	275

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	3.20E+03	1.33	8.33E+01	1.42E-02	5.30E+03	6.31E+04	6.5061E-04	2.08E+00	2.9E-05	3.0E-02	Benzene
15	6.72E+03	1.33	8.33E+01	4.82E-03	5.30E+03	1.49E+14	2.9873E-04	2.01E+00	3.7E-05	7.0E-02	Bromodichloromethane
15	1.04E+04	1.33	8.33E+01	2.41E-03	5.30E+03	2.22E+28	1.6435E-04	1.70E+00	1.1E-06	7.0E-02	Bromoform
15	8.54E+03	1.33	8.33E+01	3.17E-03	5.30E+03	3.55E+21	2.0956E-04	1.79E+00	2.7E-05	7.0E-02	Chlorodibromomethane
15	2.65E+03	1.33	8.33E+01	4.38E-02	5.30E+03	3.62E+01	1.1183E-03	2.96E+00	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	4.90E+03	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	7.1718E-04	3.51E+00	5.3E-06	3.0E-01	Chloroform
15	2.07E+03	1.33	8.33E+01	2.04E-02	5.30E+03	2.25E+03	7.9543E-04	1.65E+00	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
15	6.03E+03	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	5.5794E-04	3.36E+00	NA	2.0E-01	1,2-Dichlorobenzene
15	6.03E+03	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	5.5794E-04	3.36E+00	1.1E-05	8.0E-01	1,4-Dichlorobenzene
15	4.06E+03	1.33	8.33E+01	1.20E-02	5.30E+03	4.93E+05	5.8499E-04	2.37E+00	1.6E-06	7.0E-01	1,1-Dichloroethane
15	4.06E+03	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	7.1718E-04	2.91E+00	2.1E-05	4.0E-01	1,2-Dichloroethane
15	3.98E+03	1.33	8.33E+01	1.45E-02	5.30E+03	4.94E+04	6.5945E-04	2.62E+00	NA	7.0E-02	1,1-Dichloroethylene
15	3.98E+03	1.33	8.33E+01	1.19E-02	5.30E+03	5.48E+05	5.8194E-04	2.31E+00	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.98E+03	1.33	8.33E+01	1.14E-02	5.30E+03	9.43E+05	5.6694E-04	2.25E+00	NA	6.0E-02	trans-1,2-Dichloroethylene
15	3.62E+03	1.33	8.33E+01	1.66E-02	5.30E+03	1.33E+04	7.1093E-04	2.57E+00	2.6E-07	3.0E+00	MTBE
15	4.35E+03	1.33	8.33E+01	1.21E-02	5.30E+03	4.29E+05	5.8903E-04	2.56E+00	2.5E-06	1.0E+00	Ethylbenzene
15	3.89E+03	1.33	8.33E+01	1.18E-02	5.30E+03	6.34E+05	5.7784E-04	2.25E+00	NA	5.0E-03	Methyl bromide
15	3.48E+03	1.33	8.33E+01	1.63E-02	5.30E+03	1.52E+04	7.0538E-04	2.46E+00	1.0E-06	4.0E-01	Methylene chloride
15	5.83E+03	1.33	8.33E+01	8.44E-03	5.30E+03	1.24E+08	4.6024E-04	2.68E+00	NA	1.4E-02	2-Methylnaphthalene
15	5.26E+03	1.33	8.33E+01	9.54E-03	5.30E+03	1.44E+07	5.0184E-04	2.64E+00	3.4E-05	3.0E-03	Naphthalene
15	6.80E+03	1.33	8.33E+01	1.16E-02	5.30E+03	7.36E+05	5.7371E-04	3.90E+00	5.9E-06	3.5E-02	Tetrachloroethylene
15	3.78E+03	1.33	8.33E+01	1.41E-02	5.30E+03	7.16E+04	6.4613E-04	2.44E+00	NA	3.0E-01	Toluene
15	5.47E+03	1.33	8.33E+01	1.26E-02	5.30E+03	2.60E+05	6.0391E-04	3.30E+00	NA	5.0E+00	1,1,1-Trichloroethane
15	5.47E+03	1.33	8.33E+01	1.26E-02	5.30E+03	2.60E+05	6.0391E-04	3.30E+00	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	5.39E+03	1.33	8.33E+01	1.28E-02	5.30E+03	2.22E+05	6.0878E-04	3.28E+00	2.0E-06	6.0E-01	Trichloroethylene
15	7.69E+03	1.33	8.33E+01	1.26E-02	5.30E+03	2.60E+05	6.0391E-04	4.64E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	4.93E+03	1.33	8.33E+01	9.80E-03	5.30E+03	9.34E+06	5.1120E-04	2.52E+00	NA	7.0E-03	1,2,4-Trimethylbenzene
15	4.35E+03	1.33	8.33E+01	1.41E-02	5.30E+03	7.16E+04	6.4613E-04	2.81E+00	NA	1.0E-01	o-Xylene
15	4.35E+03	1.33	8.33E+01	1.13E-02	5.30E+03	1.08E+06	5.6325E-04	2.45E+00	NA	1.0E-01	Xylenes

END

SG-ADV
Version 3.1; 02/04

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g ($\mu g/m^3$)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical
71432			1.00E+00	Benzene
75274			1.00E+00	Bromodichloromethane
75252			1.00E+00	Bromoform
124481			1.00E+00	Chlorodibromomethane
75003			1.00E+00	Chloroethane (ethyl chloride)
67663			1.00E+00	Chloroform
74873			1.00E+00	Methyl chloride (chloromethane)
95501			1.00E+00	1,2-Dichlorobenzene
106467			1.00E+00	1,4-Dichlorobenzene
75343			1.00E+00	1,1-Dichloroethane
107062			1.00E+00	1,2-Dichloroethane
75354			1.00E+00	1,1-Dichloroethylene
156592			1.00E+00	cis-1,2-Dichloroethylene
156605			1.00E+00	trans-1,2-Dichloroethylene
1634044			1.00E+00	MTBE
100414			1.00E+00	Ethylbenzene
74839			1.00E+00	Methyl bromide
75092			1.00E+00	Methylene chloride
91576			1.00E+00	2-Methylnaphthalene
91203			1.00E+00	Naphthalene
127184			1.00E+00	Tetrachloroethylene
108883			1.00E+00	Toluene
71556			1.00E+00	1,1,1-Trichloroethane
79005			1.00E+00	1,1,2-Trichloroethane
79016			1.00E+00	Trichloroethylene
76131			1.00E+00	1,1,2-Trichloro-1,2,2-trifluoroethane
95636			1.00E+00	1,2,4-Trimethylbenzene
95476			1.00E+00	o-Xylene
1330207			1.00E+00	Xylenes

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of Ls (cell F24)					
15	290 (9.5 ft)	24	290			S		

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	366	0.1	1	5
						0.5/hr Residential 1.0/hr Commercial	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)
70	30	30	350

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Molecular weight, MW (g/mol)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	78.11	2.9E-05	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	163.83	3.7E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	252.75	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	208.28	2.7E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	64.51	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	119.38	5.3E-06	3.0E-01	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	50.49	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	147.00	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	147.00	1.1E-05	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	98.96	1.6E-06	7.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	98.96	2.1E-05	4.0E-01	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	96.94	0.0E+00	7.0E-02	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	96.94	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	96.94	0.0E+00	6.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	88.15	2.6E-07	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	106.17	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	94.94	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	84.93	1.0E-06	4.0E-01	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	142.21	0.0E+00	1.4E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	128.18	3.4E-05	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	165.83	5.9E-06	3.5E-02	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	92.14	0.0E+00	3.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	133.40	0.0E+00	5.0E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	133.41	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	131.39	2.0E-06	6.0E-01	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	187.38	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	120.20	0.0E+00	7.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	106.17	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	106.17	0.0E+00	1.0E-01	Xylenes

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.20E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.72E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	1.04E+04	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	8.54E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.65E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.90E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	2.07E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.03E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.06E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.98E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.62E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.89E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.48E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.83E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.26E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	6.80E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	3.78E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.47E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	5.39E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	7.69E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.93E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	1.02E+05
9.46E+08	275	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	4,000	4.35E+03	1.02E+05

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
1.06E+06	5.00E-03	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	275
1.06E+06	5.00E-03	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	4.82E-03	275
1.06E+06	5.00E-03	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	2.41E-03	275
1.06E+06	5.00E-03	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	3.17E-03	275
1.06E+06	5.00E-03	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	4.38E-02	275
1.06E+06	5.00E-03	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	5.00E-03	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	2.04E-02	275
1.06E+06	5.00E-03	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	5.00E-03	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	1.12E-02	275
1.06E+06	5.00E-03	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	1.20E-02	275
1.06E+06	5.00E-03	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	1.68E-02	275
1.06E+06	5.00E-03	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	1.45E-02	275
1.06E+06	5.00E-03	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	1.19E-02	275
1.06E+06	5.00E-03	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	1.14E-02	275
1.06E+06	5.00E-03	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	1.66E-02	275
1.06E+06	5.00E-03	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	1.21E-02	275
1.06E+06	5.00E-03	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	1.18E-02	275
1.06E+06	5.00E-03	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	1.63E-02	275
1.06E+06	5.00E-03	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	8.44E-03	275
1.06E+06	5.00E-03	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	9.54E-03	275
1.06E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	1.16E-02	275
1.06E+06	5.00E-03	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	5.00E-03	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	5.00E-03	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	5.00E-03	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	1.28E-02	275
1.06E+06	5.00E-03	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	1.26E-02	275
1.06E+06	5.00E-03	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	9.80E-03	275
1.06E+06	5.00E-03	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	1.41E-02	275
1.06E+06	5.00E-03	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	1.13E-02	275

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	3.20E+03	1.33	8.33E+01	1.42E-02	5.30E+03	6.31E+04	3.2531E-04	1.04E+00	2.9E-05	3.0E-02	Benzene
15	6.72E+03	1.33	8.33E+01	4.82E-03	5.30E+03	1.49E+14	1.4937E-04	1.00E+00	3.7E-05	7.0E-02	Bromodichloromethane
15	1.04E+04	1.33	8.33E+01	2.41E-03	5.30E+03	2.22E+28	8.2174E-05	8.52E-01	1.1E-06	7.0E-02	Bromoform
15	8.54E+03	1.33	8.33E+01	3.17E-03	5.30E+03	3.55E+21	1.0478E-04	8.95E-01	2.7E-05	7.0E-02	Chlorodibromomethane
15	2.65E+03	1.33	8.33E+01	4.38E-02	5.30E+03	3.62E+01	5.5917E-04	1.48E+00	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	4.90E+03	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	3.5859E-04	1.76E+00	5.3E-06	3.0E-01	Chloroform
15	2.07E+03	1.33	8.33E+01	2.04E-02	5.30E+03	2.25E+03	3.9772E-04	8.24E-01	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
15	6.03E+03	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	2.7897E-04	1.68E+00	NA	2.0E-01	1,2-Dichlorobenzene
15	6.03E+03	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	2.7897E-04	1.68E+00	1.1E-05	8.0E-01	1,4-Dichlorobenzene
15	4.06E+03	1.33	8.33E+01	1.20E-02	5.30E+03	4.93E+05	2.9249E-04	1.19E+00	1.6E-06	7.0E-01	1,1-Dichloroethane
15	4.06E+03	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	3.5859E-04	1.46E+00	2.1E-05	4.0E-01	1,2-Dichloroethane
15	3.98E+03	1.33	8.33E+01	1.45E-02	5.30E+03	4.94E+04	3.2972E-04	1.31E+00	NA	7.0E-02	1,1-Dichloroethylene
15	3.98E+03	1.33	8.33E+01	1.19E-02	5.30E+03	5.48E+05	2.9097E-04	1.16E+00	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.98E+03	1.33	8.33E+01	1.14E-02	5.30E+03	9.43E+05	2.8347E-04	1.13E+00	NA	6.0E-02	trans-1,2-Dichloroethylene
15	3.62E+03	1.33	8.33E+01	1.66E-02	5.30E+03	1.33E+04	3.5546E-04	1.29E+00	2.6E-07	3.0E+00	MTBE
15	4.35E+03	1.33	8.33E+01	1.21E-02	5.30E+03	4.29E+05	2.9451E-04	1.28E+00	2.5E-06	1.0E+00	Ethylbenzene
15	3.89E+03	1.33	8.33E+01	1.18E-02	5.30E+03	6.34E+05	2.8892E-04	1.13E+00	NA	5.0E-03	Methyl bromide
15	3.48E+03	1.33	8.33E+01	1.63E-02	5.30E+03	1.52E+04	3.5269E-04	1.23E+00	1.0E-06	4.0E-01	Methylene chloride
15	5.83E+03	1.33	8.33E+01	8.44E-03	5.30E+03	1.24E+08	2.3012E-04	1.34E+00	NA	1.4E-02	2-Methylnaphthalene
15	5.26E+03	1.33	8.33E+01	9.54E-03	5.30E+03	1.44E+07	2.5092E-04	1.32E+00	3.4E-05	3.0E-03	Naphthalene
15	6.80E+03	1.33	8.33E+01	1.16E-02	5.30E+03	7.36E+05	2.8686E-04	1.95E+00	5.9E-06	3.5E-02	Tetrachloroethylene
15	3.78E+03	1.33	8.33E+01	1.41E-02	5.30E+03	7.16E+04	3.2307E-04	1.22E+00	NA	3.0E-01	Toluene
15	5.47E+03	1.33	8.33E+01	1.26E-02	5.30E+03	2.60E+05	3.0195E-04	1.65E+00	NA	5.0E+00	1,1,1-Trichloroethane
15	5.47E+03	1.33	8.33E+01	1.26E-02	5.30E+03	2.60E+05	3.0196E-04	1.65E+00	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	5.39E+03	1.33	8.33E+01	1.28E-02	5.30E+03	2.22E+05	3.0439E-04	1.64E+00	2.0E-06	6.0E-01	Trichloroethylene
15	7.69E+03	1.33	8.33E+01	1.26E-02	5.30E+03	2.60E+05	3.0195E-04	2.32E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	4.93E+03	1.33	8.33E+01	9.80E-03	5.30E+03	9.34E+06	2.5560E-04	1.26E+00	NA	7.0E-03	1,2,4-Trimethylbenzene
15	4.35E+03	1.33	8.33E+01	1.41E-02	5.30E+03	7.16E+04	3.2307E-04	1.41E+00	NA	1.0E-01	o-Xylene
15	4.35E+03	1.33	8.33E+01	1.13E-02	5.30E+03	1.08E+06	2.8163E-04	1.23E+00	NA	1.0E-01	Xylenes

END

GW-ADV
Version 3.1; 02/04

DATA ENTRY SHEET

A8 - DTSC Method 2: Groundwater to Indoor Air for Residential Exposure

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [x]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
	Maximum Detected Concentration	
71432		Benzene
75274		Bromodichloromethane
75252		Bromoform
124481		Chlorodibromomethane
75003		Chloroethane (ethyl chloride)
67663		Chloroform
74873		Methyl chloride (chloromethane)
95501		1,2-Dichlorobenzene
106467		1,4-Dichlorobenzene
75343		1,1-Dichloroethane
107062		1,2-Dichloroethane
75354		1,1-Dichloroethylene
156592		cis-1,2-Dichloroethylene
156605		trans-1,2-Dichloroethylene
1634044		MTBE
100414		Ethylbenzene
74839		Methyl bromide
75092		Methylene chloride
91576		2-Methylnaphthalene
91203		Naphthalene
127184		Tetrachloroethylene
108883		Toluene
71556		1,1,1-Trichloroethane
79005		1,1,2-Trichloroethane
79016		Trichloroethylene
76131		1,1,2-Trichloro-1,2,2-trifluoroethane
95636		1,2,4-Trimethylbenzene
95476		o-Xylene
1330207		Xylenes

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G77)							

A8 - DTSC Method 2: Groundwater to Indoor Air for Residential Exposure

24	15	1400 approx. 46 feet	1400			A	S	S			

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	0.5 0.5/hr Residential 1.0/hr Commercial	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	5.89E+01	1.79E+03	2.9E-05	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	5.50E+01	6.74E+03	3.7E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	8.71E+01	3.10E+03	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	6.31E+01	2.60E+03	2.7E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	4.40E+00	5.68E+03	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	3.98E+01	7.92E+03	5.3E-06	3.0E-01	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	2.12E+00	5.33E+03	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	6.17E+02	1.56E+02	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	6.17E+02	7.90E+01	1.1E-05	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	3.16E+01	5.06E+03	1.6E-06	7.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	1.74E+01	8.52E+03	2.1E-05	4.0E-01	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	5.89E+01	2.25E+03	0.0E+00	7.0E-02	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	3.55E+01	3.50E+03	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	5.25E+01	6.30E+03	0.0E+00	6.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	7.26E+00	5.10E+04	2.6E-07	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	3.63E+02	1.69E+02	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	1.05E+01	1.52E+04	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	1.17E+01	1.30E+04	1.0E-06	4.0E-01	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	2.81E+03	2.46E+01	0.0E+00	1.4E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	2.00E+03	3.10E+01	3.4E-05	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	1.55E+02	2.00E+02	5.9E-06	3.5E-02	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	1.82E+02	5.26E+02	0.0E+00	3.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	1.10E+02	1.33E+03	0.0E+00	5.0E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	5.01E+01	4.42E+03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	2.0E-06	6.0E-01	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	1.11E+04	1.70E+02	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	1.35E+03	5.70E+01	0.0E+00	7.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	3.63E+02	1.78E+02	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	4.43E+02	2.42E+02	0.0E+00	1.0E-01	Xylenes

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)	
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Benzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromodichloromethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromoform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chlorodibromomethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroethane (ethyl chloride)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl chloride (chloromethane)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,4-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	cis-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	trans-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	MTBE
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Ethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl bromide
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methylene chloride
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	2-Methylnaphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Naphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Tetrachloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Toluene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,1-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Trichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloro-1,2,2-trifluoroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2,4-Trimethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	o-Xylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Xylenes

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	
3.39E+04	1.06E+06	5.00E-03	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	5.67E-04	1.10E-02	1385	Benzene
3.39E+04	1.06E+06	5.00E-03	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	2.03E-04	3.77E-03	1385	Bromodichloromethane
3.39E+04	1.06E+06	5.00E-03	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	1.29E-04	1.98E-03	1385	Bromoform
3.39E+04	1.06E+06	5.00E-03	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	1.51E-04	2.54E-03	1385	Chlorodibromomethane
3.39E+04	1.06E+06	5.00E-03	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	1.74E-03	3.38E-02	1385	Chloroethane (ethyl chloride)
3.39E+04	1.06E+06	5.00E-03	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.71E-04	1.30E-02	1385	Chloroform
3.39E+04	1.06E+06	5.00E-03	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	8.08E-04	1.57E-02	1385	Methyl chloride (chloromethane)
3.39E+04	1.06E+06	5.00E-03	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.50E-04	8.63E-03	1385	1,2-Dichlorobenzene
3.39E+04	1.06E+06	5.00E-03	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.48E-04	8.62E-03	1385	1,4-Dichlorobenzene
3.39E+04	1.06E+06	5.00E-03	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	4.79E-04	9.25E-03	1385	1,1-Dichloroethane
3.39E+04	1.06E+06	5.00E-03	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.85E-04	1.30E-02	1385	1,2-Dichloroethane
3.39E+04	1.06E+06	5.00E-03	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	5.77E-04	1.12E-02	1385	1,1-Dichloroethylene
3.39E+04	1.06E+06	5.00E-03	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	4.77E-04	9.19E-03	1385	cis-1,2-Dichloroethylene
3.39E+04	1.06E+06	5.00E-03	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	4.55E-04	8.81E-03	1385	trans-1,2-Dichloroethylene
3.39E+04	1.06E+06	5.00E-03	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	6.87E-04	1.29E-02	1385	MTBE
3.39E+04	1.06E+06	5.00E-03	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	4.82E-04	9.35E-03	1385	Ethylbenzene
3.39E+04	1.06E+06	5.00E-03	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	4.70E-04	9.08E-03	1385	Methyl bromide
3.39E+04	1.06E+06	5.00E-03	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	6.57E-04	1.26E-02	1385	Methylene chloride
3.39E+04	1.06E+06	5.00E-03	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	3.64E-04	6.63E-03	1385	2-Methylnaphthalene
3.39E+04	1.06E+06	5.00E-03	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	4.08E-04	7.48E-03	1385	Naphthalene

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3.39E+04	1.06E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	4.62E-04	8.97E-03	1385	Tetrachloroethylene
3.39E+04	1.06E+06	3.77E-04	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.60E-04	1.08E-02	1385	Toluene
3.39E+04	1.06E+06	3.77E-04	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.72E-03	1385	1,1,1-Trichloroethane
3.39E+04	1.06E+06	3.77E-04	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.18E-04	9.79E-03	1385	1,1,2-Trichloroethane
3.39E+04	1.06E+06	3.77E-04	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	5.08E-04	9.84E-03	1385	Trichloroethylene
3.39E+04	1.06E+06	3.77E-04	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.71E-03	1385	1,1,2-Trichloro-1,2,2-trifluoroethane
3.39E+04	1.06E+06	3.77E-04	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	3.91E-04	7.56E-03	1385	1,2,4-Trimethylbenzene
3.39E+04	1.06E+06	3.77E-04	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.61E-04	1.08E-02	1385	o-Xylene
3.39E+04	1.06E+06	3.77E-04	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	4.51E-04	8.73E-03	1385	Xylenes

A8 - DTSC Method 2: Groundwater to Indoor Air for Residential Exposure

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	2.17E+02	1.33	8.33E+01	1.42E-02	5.30E+03	6.31E+04	2.251E-04	4.88E-02	2.9E-05	3.0E-02	Benzene
15	6.24E+01	1.33	8.33E+01	4.82E-03	5.30E+03	1.49E+14	8.220E-05	5.13E-03	3.7E-05	7.0E-02	Bromodichloromethane
15	2.27E+01	1.33	8.33E+01	2.41E-03	5.30E+03	2.22E+28	4.387E-05	9.95E-04	1.1E-06	7.0E-02	Bromoform
15	3.08E+01	1.33	8.33E+01	3.17E-03	5.30E+03	3.55E+21	5.609E-05	1.73E-03	2.7E-05	7.0E-02	Chlorodibromomethane
15	3.49E+02	1.33	8.33E+01	4.38E-02	5.30E+03	3.62E+01	5.857E-04	2.05E-01	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	1.44E+02	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	2.618E-04	3.77E-02	5.3E-06	3.0E-01	Chloroform
15	3.52E+02	1.33	8.33E+01	2.04E-02	5.30E+03	2.25E+03	3.098E-04	1.09E-01	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
15	7.28E+01	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	1.805E-04	1.31E-02	NA	2.0E-01	1,2-Dichlorobenzene
15	9.22E+01	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	1.804E-04	1.66E-02	1.1E-05	8.0E-01	1,4-Dichlorobenzene
15	2.21E+02	1.33	8.33E+01	1.20E-02	5.30E+03	4.93E+05	1.926E-04	4.25E-02	1.6E-06	7.0E-01	1,1-Dichloroethane
15	3.82E+01	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	2.629E-04	1.00E-02	2.1E-05	4.0E-01	1,2-Dichloroethane
15	1.03E+03	1.33	8.33E+01	1.45E-02	5.30E+03	4.94E+04	2.295E-04	2.36E-01	NA	7.0E-02	1,1-Dichloroethylene
15	1.60E+02	1.33	8.33E+01	1.19E-02	5.30E+03	5.48E+05	1.914E-04	3.06E-02	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.69E+02	1.33	8.33E+01	1.14E-02	5.30E+03	9.43E+05	1.841E-04	6.79E-02	NA	6.0E-02	trans-1,2-Dichloroethylene
15	2.46E+01	1.33	8.33E+01	1.66E-02	5.30E+03	1.33E+04	2.603E-04	6.39E-03	2.6E-07	3.0E+00	MTBE
15	3.05E+02	1.33	8.33E+01	1.21E-02	5.30E+03	4.29E+05	1.944E-04	5.92E-02	2.5E-06	1.0E+00	Ethylbenzene
15	2.47E+02	1.33	8.33E+01	1.18E-02	5.30E+03	6.34E+05	1.893E-04	4.68E-02	NA	5.0E-03	Methyl bromide
15	8.62E+01	1.33	8.33E+01	1.63E-02	5.30E+03	1.52E+04	2.554E-04	2.20E-02	1.0E-06	4.0E-01	Methylene chloride
15	1.93E+01	1.33	8.33E+01	8.44E-03	5.30E+03	1.24E+08	1.411E-04	2.73E-03	NA	1.4E-02	2-Methylnaphthalene
15	1.84E+01	1.33	8.33E+01	9.54E-03	5.30E+03	1.44E+07	1.580E-04	2.90E-03	3.4E-05	3.0E-03	Naphthalene
15	7.14E+02	1.33	8.33E+01	1.16E-02	5.30E+03	7.36E+05	1.871E-04	1.34E-01	5.9E-06	3.5E-02	Tetrachloroethylene
15	2.58E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	2.23E-04	5.75E-02	NA	3.0E-01	Toluene
15	6.73E+02	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	2.01E-04	1.36E-01	NA	5.0E+00	1,1,1-Trichloroethane
15	3.54E+01	0.10	8.33E+01	1.26E-02	4.00E+02	5.67E+71	2.03E-04	7.18E-03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	4.02E+02	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	2.04E-04	8.19E-02	2.0E-06	6.0E-01	Trichloroethylene
15	1.89E+04	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	2.01E-04	3.81E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	2.36E+02	0.10	8.33E+01	9.80E-03	4.00E+02	2.28E+92	1.60E-04	3.77E-02	NA	7.0E-03	1,2,4-Trimethylbenzene
15	2.00E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	2.23E-04	4.46E-02	NA	1.0E-01	o-Xylene
15	2.56E+02	0.10	8.33E+01	1.13E-02	4.00E+02	9.01E+79	1.82E-04	4.66E-02	NA	1.0E-01	Xylenes

END

GW-ADV
Version 3.1; 02/04

DATA ENTRY SHEET

A9 - DTSC Method 2: Groundwater to Indoor Air for Commercial Exposure

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [x]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [ ]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
	Maximum Detected Concentration	
71432		Benzene
75274		Bromodichloromethane
75252		Bromoform
124481		Chlorodibromomethane
75003		Chloroethane (ethyl chloride)
67663		Chloroform
74873		Methyl chloride (chloromethane)
95501		1,2-Dichlorobenzene
106467		1,4-Dichlorobenzene
75343		1,1-Dichloroethane
107062		1,2-Dichloroethane
75354		1,1-Dichloroethylene
156592		cis-1,2-Dichloroethylene
156605		trans-1,2-Dichloroethylene
1634044		MTBE
100414		Ethylbenzene
74839		Methyl bromide
75092		Methylene chloride
91576		2-Methylnaphthalene
91203		Naphthalene
127184		Tetrachloroethylene
108883		Toluene
71556		1,1,1-Trichloroethane
79005		1,1,2-Trichloroethane
79016		Trichloroethylene
76131		1,1,2-Trichloro-1,2,2-trifluoroethane
95636		1,2,4-Trimethylbenzene
95476		o-Xylene
1330207		Xylenes

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G77)							

A9 - DTSC Method 2: Groundwater to Indoor Air for Commercial Exposure

24	15	1400	1400			A	S	S			
		approx. 46 feet									

MORE ↓

ENTER Stratum A SCS soil type	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s^2)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
10	40	1000	1000	244	0.1	1	5
						0.5/hr Residential 1.0/hr Commercial	

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	30	30	350	1.0E-06	1
				Used to calculate risk-based groundwater concentration.	

END

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	5.89E+01	1.79E+03	2.9E-05	3.0E-02	Benzene
2.98E-02	1.06E-05	1.60E-03	25	7,800	363.15	585.85	5.50E+01	6.74E+03	3.7E-05	7.0E-02	Bromodichloromethane
1.49E-02	1.03E-05	5.88E-04	25	9,479	422.35	696.00	8.71E+01	3.10E+03	1.1E-06	7.0E-02	Bromoform
1.96E-02	1.05E-05	7.81E-04	25	5,900	416.14	678.20	6.31E+01	2.60E+03	2.7E-05	7.0E-02	Chlorodibromomethane
2.71E-01	1.15E-05	8.80E-03	25	5,879	285.30	460.40	4.40E+00	5.68E+03	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
1.04E-01	1.00E-05	3.66E-03	25	6,988	334.32	536.40	3.98E+01	7.92E+03	5.3E-06	3.0E-01	Chloroform
1.26E-01	6.50E-06	8.80E-03	25	5,115	249.00	416.25	2.12E+00	5.33E+03	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
6.90E-02	7.90E-06	1.90E-03	25	9,700	453.57	705.00	6.17E+02	1.56E+02	0.0E+00	2.0E-01	1,2-Dichlorobenzene
6.90E-02	7.90E-06	2.39E-03	25	9,271	447.21	684.75	6.17E+02	7.90E+01	1.1E-05	8.0E-01	1,4-Dichlorobenzene
7.42E-02	1.05E-05	5.61E-03	25	6,895	330.55	523.00	3.16E+01	5.06E+03	1.6E-06	7.0E-01	1,1-Dichloroethane
1.04E-01	9.90E-06	9.77E-04	25	7,643	356.65	561.00	1.74E+01	8.52E+03	2.1E-05	4.0E-01	1,2-Dichloroethane
9.00E-02	1.04E-05	2.60E-02	25	6,247	304.75	576.05	5.89E+01	2.25E+03	0.0E+00	7.0E-02	1,1-Dichloroethylene
7.36E-02	1.13E-05	4.07E-03	25	7,192	333.65	544.00	3.55E+01	3.50E+03	0.0E+00	3.5E-02	cis-1,2-Dichloroethylene
7.07E-02	1.19E-05	9.36E-03	25	6,717	320.85	516.50	5.25E+01	6.30E+03	0.0E+00	6.0E-02	trans-1,2-Dichloroethylene
1.02E-01	1.05E-05	6.23E-04	25	6,678	328.30	497.10	7.26E+00	5.10E+04	2.6E-07	3.0E+00	MTBE
7.50E-02	7.80E-06	7.86E-03	25	8,501	409.34	617.20	3.63E+02	1.69E+02	2.5E-06	1.0E+00	Ethylbenzene
7.28E-02	1.21E-05	6.22E-03	25	5,714	276.71	467.00	1.05E+01	1.52E+04	0.0E+00	5.0E-03	Methyl bromide
1.01E-01	1.17E-05	2.18E-03	25	6,706	313.00	510.00	1.17E+01	1.30E+04	1.0E-06	4.0E-01	Methylene chloride
5.22E-02	7.75E-06	5.17E-04	25	12,600	514.26	761.00	2.81E+03	2.46E+01	0.0E+00	1.4E-02	2-Methylnaphthalene
5.90E-02	7.50E-06	4.82E-04	25	10,373	491.14	748.40	2.00E+03	3.10E+01	3.4E-05	3.0E-03	Naphthalene
7.20E-02	8.20E-06	1.84E-02	25	8,288	394.40	620.20	1.55E+02	2.00E+02	5.9E-06	3.5E-02	Tetrachloroethylene
8.70E-02	8.60E-06	6.62E-03	25	7,930	383.78	591.79	1.82E+02	5.26E+02	0.0E+00	3.0E-01	Toluene
7.80E-02	8.80E-06	1.72E-02	25	7,136	347.24	545.00	1.10E+02	1.33E+03	0.0E+00	5.0E+00	1,1,1-Trichloroethane
7.80E-02	8.80E-06	9.11E-04	25	8,322	386.15	602.00	5.01E+01	4.42E+03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
7.90E-02	9.10E-06	1.03E-02	25	7,505	360.36	544.20	1.66E+02	1.47E+03	2.0E-06	6.0E-01	Trichloroethylene
7.80E-02	8.20E-06	4.80E-01	25	6,463	320.70	487.30	1.11E+04	1.70E+02	0.0E+00	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
6.06E-02	7.92E-06	6.14E-03	25	9,369	442.30	649.17	1.35E+03	5.70E+01	0.0E+00	7.0E-03	1,2,4-Trimethylbenzene
8.70E-02	1.00E-05	5.18E-03	25	8,661	417.60	630.30	3.63E+02	1.78E+02	0.0E+00	1.0E-01	o-Xylene
7.00E-02	7.80E-06	6.56E-03	25	7,897	375.41	566.58	4.43E+02	2.42E+02	0.0E+00	1.0E-01	Xylenes

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)	
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Benzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromodichloromethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Bromoform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chlorodibromomethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroethane (ethyl chloride)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Chloroform
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl chloride (chloromethane)
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,4-Dichlorobenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2-Dichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	cis-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	trans-1,2-Dichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	MTBE
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Ethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methyl bromide
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Methylene chloride
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	2-Methylnaphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Naphthalene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Tetrachloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Toluene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,1-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Trichloroethylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,1,2-Trichloro-1,2,2-trifluoroethane
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	1,2,4-Trimethylbenzene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	o-Xylene
9.46E+08	1385	0.321	ERROR	ERROR	0.003	1.02E-07	0.998	1.01E-07	17.05	0.375	0.122	0.253	4,000	Xylenes

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	
6.78E+04	1.06E+06	5.00E-03	15	7,977	5.29E-03	2.17E-01	1.80E-04	1.42E-02	0.00E+00	0.00E+00	5.67E-04	1.10E-02	1385	Benzene
6.78E+04	1.06E+06	5.00E-03	15	8,526	1.52E-03	6.24E-02	1.80E-04	4.82E-03	0.00E+00	0.00E+00	2.03E-04	3.77E-03	1385	Bromodichloromethane
6.78E+04	1.06E+06	5.00E-03	15	10,746	5.53E-04	2.27E-02	1.80E-04	2.41E-03	0.00E+00	0.00E+00	1.29E-04	1.98E-03	1385	Bromoform
6.78E+04	1.06E+06	5.00E-03	15	6,696	7.52E-04	3.08E-02	1.80E-04	3.17E-03	0.00E+00	0.00E+00	1.51E-04	2.54E-03	1385	Chlorodibromomethane
6.78E+04	1.06E+06	5.00E-03	15	5,740	8.52E-03	3.49E-01	1.80E-04	4.38E-02	0.00E+00	0.00E+00	1.74E-03	3.38E-02	1385	Chloroethane (ethyl chloride)
6.78E+04	1.06E+06	5.00E-03	15	7,407	3.51E-03	1.44E-01	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.71E-04	1.30E-02	1385	Chloroform
6.78E+04	1.06E+06	5.00E-03	15	4,578	8.57E-03	3.52E-01	1.80E-04	2.04E-02	0.00E+00	0.00E+00	8.08E-04	1.57E-02	1385	Methyl chloride (chloromethane)
6.78E+04	1.06E+06	5.00E-03	15	11,546	1.77E-03	7.28E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.50E-04	8.63E-03	1385	1,2-Dichlorobenzene
6.78E+04	1.06E+06	5.00E-03	15	11,098	2.25E-03	9.22E-02	1.80E-04	1.12E-02	0.00E+00	0.00E+00	4.48E-04	8.62E-03	1385	1,4-Dichlorobenzene
6.78E+04	1.06E+06	5.00E-03	15	7,294	5.38E-03	2.21E-01	1.80E-04	1.20E-02	0.00E+00	0.00E+00	4.79E-04	9.25E-03	1385	1,1-Dichloroethane
6.78E+04	1.06E+06	5.00E-03	15	8,368	9.31E-04	3.82E-02	1.80E-04	1.68E-02	0.00E+00	0.00E+00	6.85E-04	1.30E-02	1385	1,2-Dichloroethane
6.78E+04	1.06E+06	5.00E-03	15	6,299	2.51E-02	1.03E+00	1.80E-04	1.45E-02	0.00E+00	0.00E+00	5.77E-04	1.12E-02	1385	1,1-Dichloroethylene
6.78E+04	1.06E+06	5.00E-03	15	7,592	3.90E-03	1.60E-01	1.80E-04	1.19E-02	0.00E+00	0.00E+00	4.77E-04	9.19E-03	1385	cis-1,2-Dichloroethylene
6.78E+04	1.06E+06	5.00E-03	15	6,986	8.99E-03	3.69E-01	1.80E-04	1.14E-02	0.00E+00	0.00E+00	4.55E-04	8.81E-03	1385	trans-1,2-Dichloroethylene
6.78E+04	1.06E+06	5.00E-03	15	7,113	5.99E-04	2.46E-02	1.80E-04	1.66E-02	0.00E+00	0.00E+00	6.87E-04	1.29E-02	1385	MTBE
6.78E+04	1.06E+06	5.00E-03	15	9,994	7.43E-03	3.05E-01	1.80E-04	1.21E-02	0.00E+00	0.00E+00	4.82E-04	9.35E-03	1385	Ethylbenzene
6.78E+04	1.06E+06	5.00E-03	15	5,508	6.03E-03	2.47E-01	1.80E-04	1.18E-02	0.00E+00	0.00E+00	4.70E-04	9.08E-03	1385	Methyl bromide
6.78E+04	1.06E+06	5.00E-03	15	6,884	2.10E-03	8.62E-02	1.80E-04	1.63E-02	0.00E+00	0.00E+00	6.57E-04	1.26E-02	1385	Methylene chloride
6.78E+04	1.06E+06	5.00E-03	15	16,057	4.72E-04	1.93E-02	1.80E-04	8.44E-03	0.00E+00	0.00E+00	3.64E-04	6.63E-03	1385	2-Methylnaphthalene
6.78E+04	1.06E+06	5.00E-03	15	12,768	4.48E-04	1.84E-02	1.80E-04	9.54E-03	0.00E+00	0.00E+00	4.08E-04	7.48E-03	1385	Naphthalene

A9 - DTSC Method 2: Groundwater to Indoor Air for Commercial Exposure

6.78E+04	1.06E+06	5.00E-03	15	9,410	1.74E-02	7.14E-01	1.80E-04	1.16E-02	0.00E+00	0.00E+00	4.62E-04	8.97E-03	1385	Tetrachloroethylene
6.78E+04	1.06E+06	3.77E-04	15	9,001	6.29E-03	2.58E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.60E-04	1.08E-02	1385	Toluene
6.78E+04	1.06E+06	3.77E-04	15	7,732	1.64E-02	6.73E-01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.72E-03	1385	1,1,1-Trichloroethane
6.78E+04	1.06E+06	3.77E-04	15	9,419	8.63E-04	3.54E-02	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.18E-04	9.79E-03	1385	1,1,2-Trichloroethane
6.78E+04	1.06E+06	3.77E-04	15	8,382	9.80E-03	4.02E-01	1.80E-04	1.28E-02	0.00E+00	0.00E+00	5.08E-04	9.84E-03	1385	Trichloroethylene
6.78E+04	1.06E+06	3.77E-04	15	6,787	4.62E-01	1.89E+01	1.80E-04	1.26E-02	0.00E+00	0.00E+00	5.00E-04	9.71E-03	1385	1,1,2-Trichloro-1,2,2-trifluoroethane
6.78E+04	1.06E+06	3.77E-04	15	11,516	5.76E-03	2.36E-01	1.80E-04	9.80E-03	0.00E+00	0.00E+00	3.91E-04	7.56E-03	1385	1,2,4-Trimethylbenzene
6.78E+04	1.06E+06	3.77E-04	15	10,245	4.88E-03	2.00E-01	1.80E-04	1.41E-02	0.00E+00	0.00E+00	5.61E-04	1.08E-02	1385	o-Xylene
6.78E+04	1.06E+06	3.77E-04	15	8,979	6.23E-03	2.56E-01	1.80E-04	1.13E-02	0.00E+00	0.00E+00	4.51E-04	8.73E-03	1385	Xylenes

A9 - DTSC Method 2: Groundwater to Indoor Air for Commercial Exposure

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	
15	2.17E+02	1.33	8.33E+01	1.42E-02	5.30E+03	6.31E+04	1.126E-04	2.44E-02	2.9E-05	3.0E-02	Benzene
15	6.24E+01	1.33	8.33E+01	4.82E-03	5.30E+03	1.49E+14	4.110E-05	2.56E-03	3.7E-05	7.0E-02	Bromodichloromethane
15	2.27E+01	1.33	8.33E+01	2.41E-03	5.30E+03	2.22E+28	2.194E-05	4.97E-04	1.1E-06	7.0E-02	Bromoform
15	3.08E+01	1.33	8.33E+01	3.17E-03	5.30E+03	3.55E+21	2.804E-05	8.65E-04	2.7E-05	7.0E-02	Chlorodibromomethane
15	3.49E+02	1.33	8.33E+01	4.38E-02	5.30E+03	3.62E+01	2.929E-04	1.02E-01	8.3E-07	1.0E+01	Chloroethane (ethyl chloride)
15	1.44E+02	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	1.309E-04	1.88E-02	5.3E-06	3.0E-01	Chloroform
15	3.52E+02	1.33	8.33E+01	2.04E-02	5.30E+03	2.25E+03	1.549E-04	5.45E-02	1.8E-06	9.0E-02	Methyl chloride (chloromethane)
15	7.28E+01	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	9.027E-05	6.57E-03	NA	2.0E-01	1,2-Dichlorobenzene
15	9.22E+01	1.33	8.33E+01	1.12E-02	5.30E+03	1.32E+06	9.020E-05	8.31E-03	1.1E-05	8.0E-01	1,4-Dichlorobenzene
15	2.21E+02	1.33	8.33E+01	1.20E-02	5.30E+03	4.93E+05	9.632E-05	2.12E-02	1.6E-06	7.0E-01	1,1-Dichloroethane
15	3.82E+01	1.33	8.33E+01	1.68E-02	5.30E+03	1.15E+04	1.315E-04	5.02E-03	2.1E-05	4.0E-01	1,2-Dichloroethane
15	1.03E+03	1.33	8.33E+01	1.45E-02	5.30E+03	4.94E+04	1.148E-04	1.18E-01	NA	7.0E-02	1,1-Dichloroethylene
15	1.60E+02	1.33	8.33E+01	1.19E-02	5.30E+03	5.48E+05	9.568E-05	1.53E-02	NA	3.5E-02	cis-1,2-Dichloroethylene
15	3.69E+02	1.33	8.33E+01	1.14E-02	5.30E+03	9.43E+05	9.207E-05	3.40E-02	NA	6.0E-02	trans-1,2-Dichloroethylene
15	2.46E+01	1.33	8.33E+01	1.66E-02	5.30E+03	1.33E+04	1.302E-04	3.20E-03	2.6E-07	3.0E+00	MTBE
15	3.05E+02	1.33	8.33E+01	1.21E-02	5.30E+03	4.29E+05	9.720E-05	2.96E-02	2.5E-06	1.0E+00	Ethylbenzene
15	2.47E+02	1.33	8.33E+01	1.18E-02	5.30E+03	6.34E+05	9.465E-05	2.34E-02	NA	5.0E-03	Methyl bromide
15	8.62E+01	1.33	8.33E+01	1.63E-02	5.30E+03	1.52E+04	1.277E-04	1.10E-02	1.0E-06	4.0E-01	Methylene chloride
15	1.93E+01	1.33	8.33E+01	8.44E-03	5.30E+03	1.24E+08	7.055E-05	1.36E-03	NA	1.4E-02	2-Methylnaphthalene
15	1.84E+01	1.33	8.33E+01	9.54E-03	5.30E+03	1.44E+07	7.901E-05	1.45E-03	3.4E-05	3.0E-03	Naphthalene
15	7.14E+02	1.33	8.33E+01	1.16E-02	5.30E+03	7.36E+05	9.357E-05	6.68E-02	5.9E-06	3.5E-02	Tetrachloroethylene
15	2.58E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	1.11E-04	2.87E-02	NA	3.0E-01	Toluene
15	6.73E+02	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	1.01E-04	6.78E-02	NA	5.0E+00	1,1,1-Trichloroethane
15	3.54E+01	0.10	8.33E+01	1.26E-02	4.00E+02	5.67E+71	1.01E-04	3.59E-03	1.6E-05	1.4E-02	1,1,2-Trichloroethane
15	4.02E+02	0.10	8.33E+01	1.28E-02	4.00E+02	7.02E+70	1.02E-04	4.10E-02	2.0E-06	6.0E-01	Trichloroethylene
15	1.89E+04	0.10	8.33E+01	1.26E-02	4.00E+02	5.68E+71	1.01E-04	1.91E+00	NA	3.0E+01	1,1,2-Trichloro-1,2,2-trifluoroethane
15	2.36E+02	0.10	8.33E+01	9.80E-03	4.00E+02	2.28E+92	7.98E-05	1.88E-02	NA	7.0E-03	1,2,4-Trimethylbenzene
15	2.00E+02	0.10	8.33E+01	1.41E-02	4.00E+02	2.15E+64	1.11E-04	2.23E-02	NA	1.0E-01	o-Xylene
15	2.56E+02	0.10	8.33E+01	1.13E-02	4.00E+02	9.01E+79	9.12E-05	2.33E-02	NA	1.0E-01	Xylenes

END

Attachment 2

Responses to Agency Comments on Draft FFS

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Response to Comments

Draft Focused Feasibility Study for Groundwater and Soil Gas Installation Restoration Program Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord

The following are comments from the United States Environmental Protection Agency (US EPA) on the Navy's Response to Comments ("RTCs") for the Draft Focused Feasibility Study for Groundwater and Soil Gas at IR Site 29 ("Site 29 FFS").

- The US EPA provided comments to the Draft Site 29 FFS in a letter dated August 29, 2012. Responses to the August 29, 2012 comments were distributed via email by Scott Anderson, BRAC Environmental Coordinator, on January 4, 2013.
- Additional comments from US EPA in response to the January 4, 2013 RTCs were issued in a letter on February 4, 2013. The US EPA letter referred to specific comments by number in a tracked-changes / commented file attached to the letter. Responses to these additional comments are provided below the corresponding comment number.
- Additionally, the Navy has clarified some responses to the August 29, 2012 comments distributed to the agencies on January 4, 2013.
- Additional revisions to these RTCs were incorporated after a RTC resolution conference call with US EPA on April 4, 2013.

This RTC matrix serves as the current Navy position, supersedes the RTCs distributed on April 22, 2013, provides responses to the additional February 4, 2013 comments, and incorporates the changes based on the April 4, 2013 conference call.

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated February 4, 2013 ***General comment***	**Response**
1.	We have reviewed the Navy's January 4, 2013 responses to our August 29, 2012 comment letter regarding the Draft Focused Feasibility Study (FFS) for Groundwater and Soil Gas, IR Site 29, Former Naval Weapons Station Seal Beach Detachment Concord, Concord, California, (Concord NWS) dated May 2012, including the redline-strike out version of the document emailed by you on January 24, 2013. EPA is concerned that several of the remediation goals (RG) proposed in the FFS, in particular, the soil gas RG of 1000 $\mu g/m^3$ for trichloroethylene (TCE) are not protective of human health. As you know, on September 28, 2011, EPA released its final health assessment for TCE to the Integrated Risk Information System (IRIS) database. The revised toxicity values impact our understanding of the risks associated with TCE, including the risks from vapor intrusion into the indoor	Regarding the use of 2009 toxicity values, the Navy agrees that the March 2012 NAVFAC Toxicity Values Factsheet for TCE EPA attached to their comment letter aptly states, for HHRAs (and any other risk calculations generated during the investigation phase) conducted after September 2011, the new Integrated Risk Information System (IRIS) toxicity values should be applied. However, the HHRA for Site 29 was finalized March 4, 2011. The development of the RGs (Attachment 1 of the Draft FFS) was conducted in June 2011 prior to the September 28, 2011 update to toxicity values in IRIS. Therefore, the Draft FFS was issued with Attachment 1 as is, consistent with the aforementioned NAVFAC fact sheet. The Navy agrees that the 2011 IRIS toxicity values (or the most

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated February 4, 2013 ***General comment***	**Response**
	air of buildings overlying contaminated groundwater plumes. The Navy response indicates that the Navy has decided to retain the soil gas RG for TCE of 1000 µg/m^3 "in accordance with current Navy policy and implementation at other sites." The 1000 µg/m^3 RG is based on 2009 toxicity values, rather than the 2011 toxicity value. The Navy response appears to conflict with the attached NAVFAC Fact Sheet which states that the Department of Defense (DOD) endorses IRIS toxicity values as preferred values for use in CERCLA human health risk assessments (HHRAs) and that HHRAs conducted after September 2011 should use IRIS toxicity values for TCE. The 1000 µg/m^3 RG for TCE proposed in the FFS does not adequately address the risk from TCE in indoor air and is unacceptable to EPA, particularly in light of the planned residential reuse of the site.	recent IRIS toxicity values) will be used in the derivation of the RG during the Record of Decision process. The Navy expects that the contaminants of concern will decrease due to the aggressive nature of the NTCRA, and therefore will require a revisit of the baseline risk assessments and characterization as appropriate to support a final selection of the remedy in the forthcoming Record of Decision.A footnote will be added to Table 3-1 that recognizes that the Proposed RG Technical Memorandum (June 2011) is based on the 2009 toxicity values, and a RG revision considering revised (September, 28 2011) toxicity values for TCE in soil gas will be considered before the Record of Decision is finalized. In addition the value for TCE (with the City's building height adjustment of 244 cm) will be listed (and footnoted) in the RG cell for TCE. The revised Table 3-1 reflects the RG for TCE in soil gas based on both the 2009 TCE toxicity value, and the more recent 2011 TCE toxicity value, which when applied is 323 µg/m^3. The 2009 TCE toxicity value based RG is 660 µg/m^3 when the following agency comments are incorporated: a. Correcting a typographical error (City of Concord Comment #5, EPA General Comment #7, and Water Board Specific Comment #3) that corrects the value to 1,000 µg/m^3. b. The second correction to the RG addresses City of Concord #6; which is a 2/3 downwards adjustment correcting for building mixing volume (this correction affects all three COCs).

Response to Comments

Draft Focused Feasibility Study for Groundwater and Soil Gas Installation Restoration Program Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated August 29, 2012 **Additional comments February 4, 2013** ***General comments***	**Response** Note, additional comments from EPA's 2/4/2013 letter pertaining to individual responses to comments are listed below the comment and noted by "[comment number] 2/4/13 Additional Comment".
1.	**Point of Departure:** The Executive Summary and Section 3 include RAOs to "Prevent residential exposure to VOCs via potential inhalation of soil gas through vapor intrusion at concentrations that result in a cancer risk that exceeds $1x10^{-4}$ and a HI greater than 1.0" and to "Prevent residential exposure to VOCs via potable use of groundwater containing concentrations that result in a cancer risk that exceeds $1x10^{-4}$ and a HI greater than 1.0." However, this is not consistent with EPA's stated point of departure as presented in the National Contingency Plan (NCP), 40 CFR 300 and Preamble at 55 FR 8866 (Preamble) or with EPA and DoD guidance. According to the Preamble, remediation goals should be based on total risk due to carcinogens that represent an excess upper bound lifetime cancer risk to an individual between $1x10^{-4}$ to $1x10^{-6}$ excess lifetime cancer risk and that a cancer risk of $1x10^{-6}$ should serve as the point of departure for these remediation goals. Once risk assessments determine that a remedial action is warranted, clean-up should strive to reduce risks to the lower end of the risk range, $1x10^{-6}$ for cancer risk and HI=1 for noncancer risk. Please revise the FFS to utilize $1x10^{-6}$ as the point of departure for RAOs. The RG derivations presented in Attachment 1 should also be summarized in the main body of the FFS.	The text will be revised to state the risk management range of 10^{-4} to 10^{-6}, in accordance with 40 CFR § 300.430, which states, "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response. The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at a site or multiple pathways of exposure." The remedial goals do consider the most protective cleanup goals (i.e. MCLs) which are ARARs where appropriate, thereby striving to achieve the 10^{-6} point of departure.
2.	**Monitored Natural Attenuation (MNA):** MNA is listed as a general response action in Section 4.2.1.2; however, information to substantiate that natural attenuation is occurring at Site 29 is not	The current (and almost complete) in situ bioremediation treatability study has generated site specific data that can be used in performing the methodology outlined in the EPA Technical

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	provided and/or referenced. The Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, EPA/600/R-98/128, dated September 1998 (Natural Attenuation Protocol) provides a methodology to assess whether natural attenuation is occurring at a site by awarding points for dissolved oxygen (DO), oxidation reduction potential (ORP), methane, iron, nitrate, ferrous iron, sulfate, sulfide, pH, total organic carbon, temperature, carbon dioxide, alkalinity, chloride, dissolved hydrogen, volatile fatty acids, chlorinated VOCs, benzene, toluene, ethylene, and xylene (BTEX), and ethane/ethane. In addition, when MNA is employed as a remedy, there is an expectation that MNA will achieve remedial goals within a reasonable time period. Please revise the FFS to provide information to show that methodology consistent with the Natural Attenuation Protocol was used to assess whether natural attenuation is a viable remedial alternative that will achieve RGs in a timely manner at Site 29. Also see Specific Comment 8 below.	Protocol. It is assumed that some form of plume attenuation is taking place when considering the age of the plume and the generally flat gradient of the site. The determination of whether there is sufficient evidence to support an MNA partial remedy at Site 29 is best presented in the Treatability Study Completion Report as the data collected for the determination will be generated during the Treatability Study. Please note that MNA was paired with an active type of remediation in the last two alternatives presented in the FFS (e.g. ZVI and ISB). The Navy designed the alternatives with a treatment train approach to remediation in mind, allowing for a post-ROD discussion with the regulatory and City stakeholders when the active remediation component of the selected remedy's cost outweighs the benefits. It is assumed at this point in the remediation life cycle that COC mass and concentrations will be at low levels, and geochemical conditions at the site will allow for a more conducive environment for MNA, given the establishment of reducing conditions and viable microbial population.
2. 2/4/13 Additional Comment The RTC does not address whether or not the Navy will conduct a MNA demonstration with the pilot study data according to the referenced guidance.		The determination of whether an there is "evidence for anaerobic biodegradation of chlorinated organics" (per the EPA MNA protocol) at Site 29 is best presented in the Treatability Study Completion Report as the data collected for the determination will be generated during the Treatability Study. At the time of writing of this FFS, MNA demonstration data was

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		not available.
3.	**Zero-Valent Iron (ZVI) Injection and Fracturing:** Implementation of ZVI involves pneumatic or hydraulic formation fracturing to deliver ZVI to contaminants in situ. Extreme care should be taken when utilizing this technology to ensure preferential pathways or conduits are not created which could disperse groundwater contaminants and cause plume migration. Should ZVI injection be selected as a remedial alternative at Site 29, it is recommended that the ZVI be injected from the lower part of the aquifer and outside the plume to prevent contaminant migration. The ZVI injection design should also include sufficient monitoring to ensure plume migration is not occurring.	Please also see the response to Water Board Comment 2, and response to City of Concord Comment 1. Hydraulic fracturing methods would use significantly less fluid volume than pneumatic typically requires. The remedial design work plan will consider the most effective and safe injection plan if selected.
4.	**Comparative Analysis:** Section 7 provides a narrative discussion of the Comparative Analysis. Together with Tables 7-1 and 7-2 which rank the proposed alternatives by the criteria "Low," "Medium," and "High," the FFS does not provide adequate information to differentiate between the alternatives, particularly between Alternatives 3 and 4. With regard to a Comparative Analysis, the RI/FS Guidance states in Section 6.2.5 (Comparative Analysis of Alternatives) on page 6-14, "[a]n effective way of organizing this section is, under each individual criterion, to discuss the alternative(s) that performs the best overall in that category, with other alternatives discussed in the relative order in which they perform [emphasis added] ... the presentation of differences among alternatives can be measured either qualitatively or quantitatively, as appropriate, and should identify	Section 7 text will be revised to discuss the alternatives in order of their ranking (from best to least).

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	substantive differences." Throughout Section 7, Alternatives 3 and 4 are presented as being "similarly rated." Further discrimination between factors, perhaps through the use of a 5 point ranking system, is needed to make the evaluation process more transparent. Please revise the FFS to provide a system of rating that allows for better differentiation between the alternatives (i.e., use a range of terminology and identify the differentiating features) so that a straightforward determination of the relative performance of the alternatives and identification of major trade-offs can be made.	
4. 2/4/13 Additional Comment Based on changes to the redline/strike-out version of the FFS, there is still not much differentiation between Alternatives 3 and 4. (Tables 7-1 and 7-2 were not included in the redline/strike-out version for review.) Please see highlighted text in the excerpt from the redline/strike-out FS to see why it is difficult to discern the basis for the Navy preferring one alternative over the other. In particular, slight differences between Alternatives 3 and 4 are only noted for: 1) Overall Protection of Human Health and the Environment and 2) Cost. Furthermore, these differences appear to ultimately balance each other out.		Please refer to the revised Tables 7-1 and 7-2 in the most recent redline/strike-out version of the FFS attached to these RTCs. The tables rank the alternatives on a five-point scale. The reviewer is correct, Alternatives 3 and 4 are similarly rated, they are very similar in approach, anticipated outcome, variables affecting implementability; cost is the major delimiter. Alternative 3 may have fewer variables for success over Alternative 4 (injection radius, unknown hydrogeologic factors, favorable aquifer conditions for bacterial growth, etc…) however in the absence of pilot study data these differences are hypothetical. There are differences in the relative ranking for short-term effectiveness; implementability; and cost for Alternatives 2, 3 and 4; Table 7-1 and 7-2 as well as the text reflect these changes using a five-point system.
5.	**Remedial Goals:** Table 3-1 does not utilize the most stringent remedial goals (RGs). As noted in the table's footnote b,	The most stringent promulgated MCL value for COCs identified at Site 29 will be identified as the selected RG. The remedial

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	California maximum contaminant levels (MCLs) and RGs are more stringent for several chemicals of concern (COCs) [e.g., 1,2-dichloroethane (groundwater), benzene (groundwater and soil gas), cis-1,2-dichloroethene (groundwater), chloroform (soil gas), and TCE (soil gas)]. Please revise the FFS to use the more stringent RGs.	goals table for soil gas was designed to feature the USEPA Method 1-based RGs. When results from the DTSC Method 2 differ, the information is provided to risk managers in footnotes to Table 3-1.
5. 2/4/13 Additional Comment The RTC is not responsive. Furthermore, the modeling effort used to determine the soil gas RG from the 2009 RI has been superseded by current guidance that is reflected in the Vapor Intrusion Screening Level calculator (the Vapor Intrusion Screening Level (VISL) Calculator (XLSM) current version May 2012. Please replace the RGs in Table 3-1 using the VISL calculator for all COCs to be consistent with current guidance.		It is the Navy's opinion that the VISL calculator is not appropriate to use to derive RGs as it is a calculator that yields screening levels based on a generic site conceptual model, which, by definition, assumes "worst case scenarios" in the absence of site specific data. According to the VISL user guide, "This document describes the calculation of recommended, but not mandatory, screening levels for use in evaluating the vapor intrusion pathway at Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) sites." Furthermore, it states, "The screening level concentrations in the spreadsheet are not intended to be used as cleanup levels" and "In general, it is recommended that the user consider whether the assumptions underlying the generic conceptual model are applicable at each site, and use professional judgment to make whatever adjustments (including not considering the model at all) are appropriate." The Navy's derivation of the RG included site specific parameters such as sampling depth and soil types, as well as

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		building parameters based on the most current knowledge of future use at the site. As noted above in February 4, 2013 RTC #1, these RGs were derived prior to update in TCE toxicity by USEPA. The 2011 toxicity criteria will be used to update the RGs in the ROD. Therefore, it is the Navy's opinion that the existing RGs presented are appropriate for the purposes of this FFS.
6.	**In-situ Chemical Oxidation (ISCO):** ISCO is an in situ treatment process option described in Table 4-1 (page 4 of 5) that was eliminated during the screening process in favor of ISB. Although ISB is currently being pilot-tested and shows promise as a treatment technology, ISCO should be reconsidered if ISB is proven unsuccessful or presents difficulties in broader implementation.	ISCO, although a well proven technology, was not selected because there is high likelihood that fugitive metals that could be generated from soils with naturally occurring high metals content such as chromium and arsenic. Under oxidizing conditions Cr(III) can be oxidized to dissolved Cr(VI), which is mobile and stable in groundwater. Soils in the San Francisco Bay area are naturally high in chromium. Additionally, based on soil oxidant demand, the likelihood of additional injections is high.
6. 2/4/13 Additional Comment While there are a number of technical limitations to successful implementation of ISCO, the intent of the original comment was to clarify that ISCO may be a suitable alternative if ISB is shown to be unsuccessful or difficult to implement. Please revise the RTC to note ISCO may warrant reconsideration based on any future experience with ISB.		ISCO, although a suitable technology in many cases, is not a suitable technology at this site. Fugitive Cr(VI) in groundwater produced from oxidation of Cr(III) would compound the cleanup at the site and possibly could result in a new and larger problem of having to clean up toxic Cr(VI) created by the remediation process.
7.	**Toxicity Values:** The Remedial Investigation (RI), including the baseline human health risk assessment (BHHRA) and baseline ecological risk assessment (BERA), were conducted for Site 29 in	**<u>TCE Toxicity Values</u>** **RGs for Soil Gas:** Please see General Comment #1 dated February 4, 2013 above.

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	2011 (Brady & Associates, 2011). Since that time, toxicity values for COCs such as tetrachloroethene (PCE) and TCE have been revised by the EPA. Under the "dual tracking" approach described in the Introduction of Attachment 1, it appears that both EPA and California Office of Environmental Health Hazard Assessment (OEHHA) toxicity values were used; however, it appears that the toxicity values used for the 2011 BHHRA were not updated for purposes of establishing RGs. According to Table 4 of Attachment 1, Human Health Toxicity Values: Inhalation Unit Risk Values, the toxicity values were obtained for Method 1 from EPA's Integrated Risk Information System (IRIS) in 2010. The IRIS toxicity values were updated for PCE and TCE on September 28, 2011 and February 10, 2012, respectively, resulting in more stringent cancer and noncancer toxicity values. Without further validation, it is not appropriate to use the Johnson and Ettinger model output as screening levels as presented in Table 3-1 of the main text and Table 1 of Attachment 1. Using the new toxicity value for TCE, the unrestricted drinking water level is 0.44 µg/L for cancer and 2.6 µg /L for noncancer, respectively, and the indoor air level of concern is 0.43 µg/m^3 for cancer and 2 µg/m^3 for noncancer risks. The new EPA Regional Screening Level for indoor air is 0.43 µg/m^3 for cancer and 2 µg/m^3 for noncancer risks. Applying the groundwater-to-indoor air attenuation coefficient of 0.001 results in a groundwater level of concern for vapor intrusion of 1.5 µg/L for cancer and 7.3 µg/L for noncancer risks. A soil gas RG can also be determined using the indoor air to soil gas attenuation coefficient of 0.01 resulting in 43 µg/m^3 and	**RGs for Groundwater:** There are two possible exposure pathways related to groundwater: domestic water use (drinking, bathing) and vapor intrusion. For domestic use of groundwater, the commenter recommends that the existing enforceable MCL of 5 µg/L for TCE should be replaced by risk-based values using the new toxicity value for TCE. These new values are USEPA's current tapwater RSLs (0.44 µg/L [cancer] and 2.6 µg/L [non-cancer]). They are based on default conservative assumptions and are not intended for cleanup goals, as these should be based on site specific factors, and are significantly lower than the MCL. The Federal MCLs are enforceable requirement ARARs, risk-based values are not. The most stringent promulgated MCL value for COCs identified at Site 29 will be identified as the selected RG. **<u>PCE Toxicity Values</u>** **RGs for Soil Gas:** No changes to the soil gas RGs are required with regard to the February 2012 changes to PCE toxicity values because soil gas RGs are not required for PCE. PCE was not identified as a chemical of concern in soil gas due to the extremely low levels of risk associated with PCE in the earlier risk assessment (URS 2009), which used the toxicity values of 2009 that are more conservative than the February 2012 values. **RGs for Groundwater:** No changes to the groundwater RG for required for PCE. PCE is a chemical of concern in groundwater only for the drinking water pathway and not for the vapor intrusion pathway. The proposed RG is the Federal- and

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	260 μg/m^3, respectively. Please revise the RGs for PCE and TCE to ensure that the most current toxicity values are used in the FFS for Site 29.	California MCL of 5 μg/L as enforceable ARARs; the existing MCL value would not be affected by the recent changes in PCE toxicity values.
7. 2/4/13 Additional Comment The current IRIS TCE toxicity value must be reflected in the FFS RGs. Furthermore, the modeling effort used to determine the soil gas RG from the 2009 RI has been superseded by current guidance that is reflected in the Vapor Intrusion Screening Level calculator (the Vapor Intrusion Screening Level (VISL) Calculator (XLSM) current version May 2012. Please replace the soil gas RGs in Table 3-1 using the VISL calculator for all COCs to be consistent with current guidance.		Regarding TCE toxicity criteria, please see the response General Comment #1 dated February 4, 2013 above. Regarding the VISL calculator, please see the response Comment #5 dated February 4, 2013 above.
8.	**Lead-impacted Soils:** The document states in several places that lead under the building at Site 29 is from lead-based paint. This may be true but the valence form of lead in paint and the valence form used in munitions initiators would be the same suggesting that the soils under the site buildings were also impacted by site operations and not solely by lead paint. Regardless, the FFS concludes that there are risks associated with lead in soils; however, there is no discussion, other than in Section 1 of Attachment 1, of how LUCs or other regulatory approaches will be used to ensure there is no exposure to lead-impacted soils. Please address the possibility of operations-based lead contamination and discuss the controls that will ensure that the exposure pathways for human and ecological receptors to lead impacted soils remain incomplete.	The source of lead in soil is well documented in the Final RI for Site 29 as being derived from lead based paint, which is not a CERCLA contaminant. The purpose of this FFS was to focus on CERCLA contaminants as they pertain to groundwater and soil gas. Lead in soil will be addressed under the lead-based paint program. The following text will be added to the end of Section 4.2.1.1: At the time of transfer, the FOST and deed will contain a restriction that the transferee in its use and occupancy of the property including but not limited to, demolition of buildings, structures or facilities and identification and/or evaluation of any lead-based paint hazards, shall be responsible for managing lead-based paint and lead-based

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		paint hazards in accordance with applicable federal, state, and local laws and other requirements relating to lead-based paint and lead-based paint hazards. Further, the transferee will prohibit occupancy and use of buildings and structures, or portions thereof, prior to identification and/or evaluation of any lead-based paint hazards, and abatement of any hazards identified as required. For non-residential buildings, the transferee agrees to restrict use of buildings to non-residential use until the building is demolished. If the building or land is to be used or developed for residential use, the constituents driving risk, namely lead-based paint on surfaces or in soils, must be remediated, if necessary, and the remedy must be demonstrated to present no risk for residential use. Should a future transferee desire to release these restrictions, they would be obliged to separately remediate lead-based paint on surfaces or in soils and petition both the Navy and EPA/DTSC independently to obtain a release of the restriction from each party.
9.	**Sustainability Assessment:** The FFS does not follow current guidance [i.e., Methodology for Understanding and Reducing a Project's Environmental Footprint, EPA 542-R-12-002, dated February 2012 (Sustainability Methodology)] in evaluating the environmental effects of the proposed remedial alternatives. For example, the Sustainability Methodology requires an assessment	As the lead agency the Navy has set forth guidance for assessing sustainability. The FFS follows the Navy's guidance for completing a sustainability assessment. SiteWise appropriately considers the CERCLA guidance requirement for short-term effectiveness criterion that specifically calls out potential impacts on workers during remedial action.

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	of energy consumption, greenhouse gas emissions (carbon dioxide, methane, and nitrous oxides), pollutant emissions (carbon monoxide, oxides of sulfur, oxides of nitrogen, and particulate matter), water consumption, ecological impacts/change in resource use, resource consumption, and worker safety; however, Appendix C (Sustainability Assessment Details) only assesses greenhouse gas emissions, pollutant emissions (oxides of sulfur, oxides of nitrogen, and particulate matter), water impacts, total energy use, accident risk fatality, and accident risk injury. Please revise the FFS to meet the level of detail specified in the current guidance for assessing sustainability.	As noted in the opening disclaimer to the referenced EPA document (EPA 542-R-12-002): *"This document provides topical introductory information rather than guidance and does not impose legally binding requirements, nor does it confer legal rights, impose legal obligations, implement any statutory or regulatory provisions, or change or substitute for any statutory or regulatory provisions."* The Navy believes the sustainability assessment in this FFS is sufficient to provide a relative comparison and ranking between the alternatives while also considering key short-term effectiveness criterion. No further sustainability assessment will be conducted on the remedial alternatives.

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1.	**Executive Summary, Page ES-3:** In the discussion of Alternative 2, the text at the end of the paragraph indicates that LUCs would be included. Please add text similar to that found in the discussions for Alternatives 3 and 4 to indicate that LUCs under Alternative 2 would be "implemented…until RAOs are met."	The phrase "until RAOs are met" will be added to the last sentence of the second bullet of ES-3.
2.	**Section 2.3.1.1, Summary of RI Risk Assessments, Page 2-4:** The last paragraph of this section describes the risks to ecological receptors from site contaminants and states that soils beneath IA-25 "only pose a risk to ecological receptors if the building is removed, impacted soils are left in place, and the area is naturally revegetated over those undisturbed soils." Please discuss how these conditions will be maintained given the planned redevelopment of the site which would most likely result in the demolition of buildings at the site and further soil disturbance.	The following (italicized) text will be added to Section 2.3.1.1: "…only pose a risk to ecological receptors if the building is removed, impacted soils are left in place, and the area is naturally revegetated over those undisturbed soils. *However, these conditions are not anticipated to occur because future development at the site would likely include demolition of the building, followed by demolition of the berm area and re-grading. After demolishing the building and berm area, existing surface soil would either be removed or covered with several feet of clean fill minimizing ecological exposure to residual levels of constituents in soil.*"
3.	**Section 2.3.1.1, Summary of RI Risk Assessments, Page 2-4:** Section 1 (Introduction) of Attachment 1 indicates lead-based paint-related inorganics identified under IA-25 will be addressed under the lead-based paint program as they did not originate from a CERCLA release; however, Section 2.3.1.1 only indicates that no further action under CERCLA was recommended for lead-based-paint-contaminated soil beneath IA-25. Similarly, Section 3.1 (Affected Media and Chemicals of Concern) indicates that metals are present in shallow soils but that the RI recommended no further action under CERCLA for VOCs and metal	The following sentence will be added to the end of the third paragraph Section 2.3.1.1: Lead-based paint related inorganics will be addressed under the lead-based paint program as they are not a CERCLA release. Upon transfer, the new property owner will be responsible for ensuring lead-based paint related contamination is appropriately addressed. The last sentence of Section 3.1 will be replaced with a list of VOCs that are COCs (See comment 5).

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	contaminated soil. Please revise the FFS to clarify that lead-based paint-related inorganics identified under IA-25 will be addressed under the lead-based paint program.	
3. 2/4/13 Additional Comment It seems confusing to make the list of VOCs the last sentence of the section. It seems like the list would be better placed after the first sentence of the section.		Based on Comment 5, Section 3.1 was expanded. The placement of the list of COCs is appropriate at the end of the section.
4.	**Section 2.5, Conceptual Site Model, Page 2-8:** The second paragraph on Page 2-8 states that *Dihalococcoides* sp. (DHC) samples were collected during the RI from seven monitoring wells where chlorinated solvents were previously detected; however, seven monitoring wells may not be sufficient to characterize the DHC population at Site 29. In addition, DHC samples were collected from seven wells to help establish where DHC cell counts were below the 1,000 cell per milliliter threshold considered to be the minimum count necessary to sustain dechlorination rates, but these wells are not identified in the text or on a figure in the FFS. Please revise the FFS to clarify how samples from only seven monitoring wells sufficiently characterize the DHC population at Site 29. In addition, please revise the FFS to identify in the text and on a figure the seven monitoring wells where DHC samples were collected.	The seventh paragraph, second sentence of Section 2.5 will be modified as follows: DHC samples were collected during the RI in September 2009 from seven monitoring wells where chlorinated solvents were previously detected **downgradient and within the source area at S29MW009D, -09S, -08, -07, and 06**. The second paragraph, first sentence of Section 5.5 will be modified as follows: The ISB treatment entails injecting a vegetable-oil emulsion or like substance and a dechlorinating bioaugmentation culture into the source area at a prescribed injection spacing to achieve the desired ROI in the treatment area and to target low-permeability zones. In addition, the current (and almost completed) treatability study collected DHC data. Paired with the information presented in the RI, the Navy contends that there is sufficent information to characterize the DHC population. The Navy has presented DHC

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		data, along with other remediation parameters, during previous conference calls with the regulatory and City stakeholders.
5.	**Section 3.1, Affected Media and Chemicals of Concern, Page 3-1:** The text states that, "The affected media are soil gas and groundwater, and the chemicals of concern are VOCs;" however, the text does not specify which VOCs are COCs for Site 29. Based on Section 2.1.2 [Selection of Chemicals of Concern (COCs)] of Attachment 1, the human health COCs include 1,1,2-trichloroethane (groundwater), 1,2-dichloroethane (groundwater), benzene (groundwater and soil gas), chloroform (groundwater and soil gas), cis-1,2-dichloroethene (groundwater), PCE (groundwater) and TCE (groundwater and soil gas). Please revise Section 3.1 to specify the VOCs which are COCs for Site 29 by affected media.	Section 3.1 will be modified to include the list of COCs as requested.
6.	**Section 4.1, General Response Actions, Page 4-1:** MNA is listed as a general response action (GRA) in Section 4.1; however, MNA is a process option not a GRA. Please revise the FFS to include MNA as a process option under a monitoring GRA.	The second bullet of Section 4.1 will be modified as follows: • Monitoring of site conditions provides useful information about remediation progress.
6. 2/4/13 Additional Comment The revision to the second bullet of Section 4.1 addresses the comment; however, the bulleted list should be reorganized. The order of Bullets 3 and 4 should be reversed to correspond to the order in which these process options are presented in the text that follows the list.		The order of bullets in Section 4.2.1 was ordered as requested.

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7.	**Section 5, Development and Screening of Remedial Alternatives:** Throughout this section, the various remedial alternatives are evaluated based on the "current land use scenario," particularly in regard to the Effectiveness and Implementability criteria. Remedy selection is ultimately based on current and potential future land use so the FFS should address future land use scenarios. Please revise the FFS to also evaluate the remedial alternatives based on the planned future land use scenario.	The FFS does consider future residential use (See Section 2.4.2). Because the property is not yet transferred and developed, and won't be until the selected remedy is in place (and/or RAOs are met), therefore the land use will remain in its current state. The future land use does not affect the remedy design such as the spacing of injections or recirculation wells because the property is under Navy ownership until it is suitable for transfer.
8.	**Section 6.3.1, Description, Page 6-9:** The text indicates that the assumed duration of Alternative 2 (SVE with MNA) is 30 years including post-remediation performance monitoring; however, this timeframe is not substantiated in the text and therefore may impact the assessment of remedial alternatives and costs estimates. Please revise the FFS to provide and/or reference information to substantiate that the assumed duration of Alternative 2 is 30 years. Please also reconcile the assumed 30-year duration of this alternative against the statement in the first paragraph on the page which contends that "MNA may proceed *indefinitely*."	Because Alternative 2 is a long term remedial alternative, the US EPA recommended maximum of 30 years was used as the cost comparison metric. Currently it would not be beneficial to estimate the MNA timeframe in this FFS since the Treatability Study and Non-Time Critical Removal Action (NTCRA) has and/or will introduce ISB into the source area, therefore, site conditions will significantly change. The statement "MNA may proceed indefinitely" will be removed.
8. 2/4/13 Additional Comment Please include a statement about using this assumption [EPA recommended maximum of 30 years] in the text.		The following sentence was added before the last sentence of the second paragraph of Section 4.2.1.2. The maximum timeframe for MNA considered for cost development in is based on the EPA recommended maximum of 30 years (EPA 1988).

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated August 29, 2012 **Additional comments February 4, 2013** ***Specific Comments***	**Response**
9.	**Section 6.4, Alternative 3 – SVE with ZVI Injection, Page 6-12:** This section states that "In addition to the same SVE components mentioned above in Alternative 2, Alternative 3 would involve injecting ZVI…*Additionally,* this alternative would require installation of up to four additional groundwater monitoring wells." These statements seem to suggest that as many as 8 groundwater monitoring wells may be installed; however, based on the discussion of Alternative 4, it appears that all "active" remedial alternatives would include, at most 4 new groundwater monitoring wells. Please restructure the discussion of Alternative 3 so it [is] clear which components of the remedy are distinct from components of the other alternatives and clarify the number of new groundwater wells that may be installed.	The number of new groundwater monitoring wells is stated in the bulleted lists of 6.4.1 and 6.5.1. The second sentence of Section 6.4 has been changed as follows: Similar to Alternative 2, this alternative would require installation of up to four additional groundwater monitoring wells to measure performance of the ZVI treatment of the plume.
10	**Appendix B, Cost Development Summaries:** The costs associated with granular activated carbon (GAC) disposal do not appear to be included in Appendix B. As such, the costs presented in Appendix B may be biased low. Please revise Appendix B to include the costs associated with the disposal of GAC and all other remediation wastes.	The current working RACER cost estimate, dated 20-Jan-12, was reviewed. Alternatives No.2 and No.3, item Nos.06 & 07 SVE O&M does allow for removal and disposal of spent GAC. However, in Alternative No.4, item 08 SVE O&M and Peformance Monitoring, the removal and disposal of spent GAC was inadvertantly excluded in the estimate. Alternative No.4 will be revised accordingly.
11	**Appendix B, Cost Development Summaries:** Based on Appendix B, cuttings from drilling soil vapor extraction (SVE) wells will not be drummed and disposed of offsite. However, information to clarify why this waste will not need to be drummed and disposed of offsite is not provided. Considering the average depth of the SVE wells is 45 feet and within contaminated soil, the	Being a CERCLA site, it has been assumed that all drill cuttings will be drummed and disposed of offsite. However, additional text will be included as requested (see follow-up response below).

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated August 29, 2012 **Additional comments February 4, 2013** ***Specific Comments***	**Response**
	drill cuttings should be drummed and disposed of offsite. Please revise the FFS to clarify that all drill cuttings will be drummed and disposed of offsite or provide information to show that the drill cuttings are not contaminated.	
11. 2/4/13 Additional Comment Please include a statement with regard to off-site disposal of all site wastes in the text.		The sixth bullet of Appendix B, Section 1.5 has been revised to state: • A limited amount of off-site hazardous and non-hazardous material disposal is included.
12	**Appendix B, Cost Development Summaries:** While Appendix B includes the costs associated with ongoing operating and maintenance (O&M), the costs associated with maintaining, redeveloping or potentially replacing monitoring wells are not included. Please provide the expected lifespan of the monitoring wells at the site and justification for the lack of costs associated with maintaining, redeveloping or potentially replacing the monitoring wells.	It can be reasonably assumed that some or all of the Groundwater Long Term Monitoring wells may require redevelopment. Based on this the cost estimates will be revised using a 7 year-cycle for redevelopment. Replacement of monitoring may be overly conservative. RACER does not provide a given Technology to address this issue. However, from experience, the Natural Attenuation Technology can be modified based on its "start date" and "out-year capability" to address this possible isuue. This approach will be used for four (4) cycles (Year 7, 14, 21 and 28) of monitoring well redevelopment for Alternative No.2, item 11 MNA GW Monitoring (Year 6 - 30); and for one (1) cycle (Year 7) of monitoring well redevelopment for Alternative No.3, item 12 MNA GW Monitoring (Year 6 - 15) and Alternative No.4, item 14 MNA GW Monitoring (Year 6 - 15). Please note that all other monitoring and performance monitoring plans provided in the FFS are less than 7-years.

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated August 29, 2012 **Additional comments February 4, 2013** ***Specific Comments***	**Response**
13	**Appendix B, Cost Development Summaries, Page 27 of 58:** The depth of the soil vapor monitoring probes (VMP) is listed as 0 feet despite the depth to the top of screen being listed at 50 feet. Please revise Appendix B to provide the depth for the soil VMPs and adjust costs as necessary.	In all Soil Vapor Monitoring Probe installations for the Alternatives Nos. 2, 3 and 4, a conservative 50-ft depth and 20-ft screen interval was used. Due to the varying lithology at the site, it is assumed that actual depth and screen interval will be determined during future drilling operations. A possible error in the RACER Reporting system may exist. This will be reviewed and addressed in the next submittal.
14	**Attachment 1, Proposed Human Health and Ecological Remedial Goals, Section 2.1.6, Toxicity Values and Benchmark Values, Page 4:** Section 2.1.6 references Table 4 as the source of toxicity values used in the development of the RGs; however, Table 4 requires clarification as follows: a. The USEPA Method 1 Toxicity Value column includes a toxicity value for TCE that cites OEHHA as the source of the Inhalation Unit Risk (IUR). An IUR for TCE is available from the EPA in IRIS so it is not clear why the OEHHA IUR is cited. Please revise Table 4 to include the most current IUR for TCE and cite the IRIS IUR for TCE since the intent of Method 1 is to utilize EPA toxicity values. b. The USEPA (Method 1) and the California DTSC (Method 2) are shown as header columns in Table 4 but are not defined in the notes for the table. Further, although there is discussion of a "dual tracking" approach in Section 1 of Attachment 1, the differences in these regulatory approaches are not explained. For clarity and completeness, please add notes to Table 4 to	a. The sources of toxicity values were current at the time of publication of Attachment 1 (June 2011). See the Response to General Comment #7 for a discussion of the recent changes to toxicity values for TCE and PCE. b. Attachment 1 and the main text of the FFS rely on historical documents developed through the chronology of investigation at Site 29. Most notably, the details of the Method 1 and Method 2 approaches are fully developed in the human health risk assessment of the RI. Table 3-1 of the FFS will be modified with

	Comments of Yvonne Fong, Remedial Project Manager, US EPA, dated August 29, 2012 **Additional comments February 4, 2013** ***Specific Comments***	**Response**
	explain the difference in these approaches or include this information in Section 2 of Attachment 1 and cross-reference the discussion in Table 4.	a footnote referencing the methodological discussion in the RI.
14. 2/4/13 Additional Comment Please see our evaluation of the RTC to General Comment #7.		Please see response to General Comment #1 dated 2/4/2013, and the response to General Comment #7 above.
15	**Attachment 1, Proposed Human Health and Ecological Remedial Goals, Section 2.1.7, Calculations for Human Health RGs, Page 5:** In equation 2 and Table 3, the resident exposure duration (ED) is shown as 30 years; however, it is not clear whether this ED is based adult and child exposures. For clarity, please indicate whether the calculation of the screening level for the residential receptor was based on EDs that incorporated both the adult and child and provide this information in Table 3.	Equation 2 and Table 3 present cancer-based screening levels based on residential inhalation exposure. The exposure metric, an air concentration averaged over a lifetime, is independent of child- or adult-specific factors.
16	**Attachment 1, Proposed Human Health and Ecological Remedial Goals, Table 1, Remedial Goals Protective of Human Health and Ecological Receptors:** According to Section 2.1.7, RGs for soil gas were based on the development of soil gas to indoor air attenuation factors using the Johnson and Ettinger Model using the dual tracking approach. However, Table 1 lists only one set of RGs and does not differentiate if the RGs are based on Method 1 or Method 2. Please provide additional clarification in Table 1 and in Section 2.1.7 regarding the process for selecting the final RGs following the Method 1 and Method 2 approaches.	Table 3-1 in the FFS and Table 1 of Attachment 1 will be modified to more clearly indicate that the body of the remedial goals table generally features the USEPA Method 1-based RGs. When results from the DTSC Method 2 differ, the information is provided to risk managers in footnotes to Table 3-1 and Table 1.

Response to Comments

Draft Focused Feasibility Study for Groundwater and Soil Gas Installation Restoration Program Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord

The following are comments from the City of Concord on the Navy's Response to Comments ("RTCs") for the Draft Focused Feasibility Study for Groundwater and Soil Gas IR Site 29 ("Site 29 FFS").

- The City of Concord provided comments to the Draft Site 29 FFS in a letter dated August 14, 2012. Responses to the August 14, 2012 comments were distributed via email by Scott Anderson, BRAC Environmental Coordinator, on January 4, 2013.
- The City of Concord submitted two additional comments to the January 4, 2013 RTCs on January 22, 2013. The Navy's responses to these two additional comments are included below. Additionally, the Navy has clarified some responses to the August 14, 2012 comments.

This RTC matrix serves as the current Navy position, supersedes the RTCs distributed on January 4, 2013, and provides responses to the additional January 22, 2013 comments.

Comments of Michael Wright, dated January 22, 2013 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Injection Remedies***	**Response**
1/22/2013 Comment #1. The Site 29 FFS selects remediation of volatile organic compounds ("VOCs") by (1) injecting zero-valent iron ("ZVI") with hydraulic fracturing and (2) injecting a vegetable oil or a like substance to achieve in situ bioremediation ("ISB"). The City is concerned that the three dimensional heterogeneity of the water-bearing units makes prediction of the performance of either remedial approach difficult. The City requested that the Navy perform site-specific field assessments to aid in remedial design, including assessment of the radius of influence ("ROI") and development of channels during injection. In the RTCs, the Navy concurs that the site is complex. However, in the RTCs, the Navy is unclear whether field pilot tests will be conducted to investigate the ROI and the development of channels. In the 16 January 2013 RPM meeting, you [the Navy] indicated that field pilot tests would be implemented prior to	The selection of a remedy is done within a Record of Decision (ROD). The FFS presents remedies that are evaluated based on the NCP's nine criteria, setting the stage for a final selection in the ROD. In the Pre-Draft Work Plan for the Non Time-Critical Removal Action, Shaw has proposed a "design optimization test" to assess conditions in the field that differ from the Treatability Study. Specifically, Shaw will be assessing: • radius of distribution • injection depths and pressures • substrate (including buffer) quantities -time for reducing conditions -and other injection logistics (including bottom up injections vs. top down). The results from this design optimization test will be used to

Comments of Michael Wright, dated January 22, 2013 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Injection Remedies***	**Response**
performance of full-scale injections. Please confirm that field assessments will be conducted to evaluate ZVI and ISB distributions that are achieved prior to full scale implementation. Please also confirm that adjustments to the final design will be made if the ZVI and ISB distributions are not as anticipated or required to achieve remedial goals.	modify the injection approach and injection frequency (horizontal and vertical). It is Shaw's intention to assess the radius of distribution, but to inject at intervals less than the calculated maximum radius of distribution in order to have an overlap of treated areas for better coverage. Creating preferential channels during the injection is a concern. Shaw plans to address this via proper choice of the horizontal treatment intervals and in addition, by injecting throughout the saturated zone in vertical increments (approximately 2-foot). The Navy believes that the data collected during the design optimization test proposed by Shaw and the Treatability Study will be sufficient in assessing ROI. The technical approach for the removal action will be customized based on the results of the design optimization test.

Comments of Michael Wright, dated January 22, 2013 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Remediation Goals***	**Response**
1/22/2013 Comment #2. The City appreciates the corrections that the Navy is making to the RGs, as described in the RTCs. However, the City reiterates its request for the Navy to modify the TCE RG to reflect the more stringent carcinogenic toxicity criteria adopted by EPA in September 2011. The City understands that the TCE RGs will be reduced by approximately a factor of two. The City does not understand why the Navy is resistant to changing the TCE RG at Site 29. At the 16 January 2012 RPM meeting, the Navy proposed to change the arsenic RG at Site 22A due to the new U.S. EPA December 2012 arsenic bioavailability guidance. Site 22A is much further along in the CERCLA process than Site 29 and a RG for arsenic has already been approved at several sites. The concern that the Navy has expressed in the RTCs regarding consistency of RGs across all sites does not seem to apply to arsenic. The Navy seems very interested in updating the RG for arsenic to a less stringent value, yet for TCE, where the RG will become more stringent, the Navy seems resistant to change the value.	From the 2/4/2012 EPA General Comment to Navy RTCs: Regarding the use of 2009 toxicity values, the Navy agrees that the March 2012 NAVFAC Toxicity Values Factsheet for TCE EPA attached to their comment letter aptly states, for HHRAs (and any other risk calculations generated during the investigation phase) conducted after September 2011, the new Integrated Risk Information System (IRIS) toxicity values should be applied. However, the HHRA for Site 29 was finalized March 4, 2011. The development of the RGs (Attachment 1 of the Draft FFS) was conducted in June 2011 prior to the September 28, 2011 update to toxicity values in IRIS. Therefore, the Draft FFS was issued with Attachment 1 as is, consistent with the aforementioned NAVFAC fact sheet. The Navy agrees that the use of the 2011 IRIS toxicity values, or the most recent IRIS toxicity values, in the derivation of the RG should be considered and finalized during the Record of Decision process, as conditions at the site will be affected by the Non Time-Critical Removal Action. A footnote will be added to Table 3-1 that recognizes that the Proposed RG Technical Memorandum (June 2011) is based on the 2009 toxicity values, and a RG revision considering revised (September, 28 2011) toxicity values for TCE in soil gas will be considered before the Record of Decision is finalized. In addition the value for TCE (with the City's building height adjustment of 244 cm) will be listed (and footnoted) in the RG cell for TCE.

Comments of Michael Wright, dated January 22, 2013 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Remediation Goals***	**Response**
	Therefore, the revised Table 3-1 reflects the RG for TCE in soil gas as 660 μg/m^3 when applying the 2009 TCE toxicity value, and 323 μg/m^3 when applying the most recent 2011 TCE toxicity value, when the following agency comments are incorporated: a. Correcting a typographical error (City of Concord Comment #5, EPA General Comment #7, and Water Board Specific Comment #3) that corrects the value to 1,000 μg/m^3. b. The second correction to the RG addresses City of Concord #6; which is a 2/3 downwards adjustment correcting for building mixing volume (this correction affects all three COCs).

Comments of Michael Wright, dated August 14, 2012 **Executive Director, Local Reuse Authority** **City of Concord** ***General comment***	**Response**
The following are comments from the City of Concord on the May 2012 Draft Focused Feasibility Study for Groundwater and Soil Gas IR Site 29 ("Site 29 FFS"). At Site 29, the Navy's approach to defining the nature and extent of volatile organic compound ("VOC") contamination has been thorough. A very focused and practical Triad approach in 2007 turned the site conceptual model on its head and answered important questions about the nature and distribution of VOCs in soil gas and groundwater. The Site 29 FFS builds upon that solid foundation. It also builds on a year-long treatability study, which is currently evaluating the effectiveness of soil vapor extraction ("SVE") and in situ bioremediation ("ISB") in the Site 29 source area. The City's comments focus on (a) the challenges associated with injection remedies under Alternatives 3 and 4 and (b) the development of site-specific Remediation Goals ("RGs").	The Navy appreciates the City's recognition of the thorough Remedial Investigation conducted using the Triad approach. The Navy will look for opportunities to continue implementing elements of Triad through the cleanup process.

Comments of Michael Wright, dated August 14, 2012 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Injection Remedies***	**Response**
Because both Alternatives 3 and 4 involve injection of fluids as part of the groundwater treatment, one of the site fundamentals mentioned in the Site 29 FFS (as well as the Remedial Investigation or RI) relates to the heterogeneity of the subsurface geologic units present. The Site 29 FFS states the following: > Based on the site-specific geologic data obtained during the RI, the groundwater system underlying the site (to the depth investigated) is heterogeneous and consists of coarser, permeable layers (sands and gravels) interbedded with fine-grained, low-permeability layers (silts and clays) that would restrict groundwater flow. This heterogeneity has implications for the effectiveness of either the injection of zero-valent iron ("ZVI") with hydraulic fracturing (Alternative 3) or the injection of a vegetable oil or a like substance (Alternative 4). This three dimensional heterogeneity makes prediction of the performance of either remedial approach difficult.	The Navy agrees with this assessment; the site is certainly complex but not altogether unique from other sites. Assessment of any injection approach should be performed in systematic approach such that the expected ROI at each injection point can be well understood. As stated in 1/22/2013 Comment #1, a design optimization test will be conducted prior to the implementation of the removal action. At that time, the Navy will ascertain which remedial approach is most optimal for site conditions. The results of the NTCRA will influence post-ROD remediation, if necessary.
Comment 1: For Alternative 3, the Site 29 FFS assumes 275 injection points spaced on 30-foot centers to an average depth of 80 feet below ground surface ("bgs"). The assumed radius of influence in the Site 29 FFS is 17 feet with hydraulic fracturing; the FFS acknowledges this radius of influence is possibly not achievable because of geologic heterogeneity. In Erler & Kalinowski, Inc.'s experience, VOCs have to be in immediate proximity to ZVI for ZVI to be effective. The spacing assumed in	The FFS states that for Alternative 4 (ISB via direct injection) the radius of influence will be less than what is expected for formation fracturing techniques (See Section 7.3, last sentence of the first paragraph on page 7-2). The FFS used a conservative ROI based on the demonstrated experience of ZVI (hydraulic and pneumatic) service providers at sites with similar lithologic conditions. Hydraulic fracturing may actually result in a greater ROI due to the nature of the proppant used to keep fractures open.

Comments of Michael Wright, dated August 14, 2012 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Injection Remedies***	**Response**
the Site 29 FFS means that a significant proportion of the targeted subsurface volume may not be exposed to ZVI. It is our understanding that hydraulic fracturing works better in fine-grained materials than in coarse-grained materials. Hence, we would say that this approach is not successfully proven for the conditions present in the subsurface of Site 29. The Navy should either provide examples of sites with similar heterogeneous conditions where ZVI and hydraulic fracturing were effective or perform a pilot test.	The ROI can only be determined in the field and will likely vary throughout the treatment area depending on the soil type fractured. The volume of fracturing fluid necessary to deliver ZVI is significantly greater using pneumatic means, which can translate to negative vadose zone effects (VOC vapor migration) as well as poor placement of ZVI through the fracture network (which will collapse after the gas is injected). Using hydraulic fracturing technology the fractures will be held open by the fluid and sand proppant itself. Since groundwater is moving through the site, albeit slower in the distal portion, TCE-impacted groundwater will eventually come into contact with the emplaced ZVI as it migrates downgradient. Placement of ZVI by hydraulic means is preferred as it is considered to be the more effective technology for the site conditions. The understanding of the geologic CSM, and expected ROI should be considered at each injection point during the injection phase. The Navy will provide examples under separate cover of sites where hydraulic fracturing has been successfully utilized. A comparison of the two fracturing technologies is provided on the Frac Rite website http://www.fracrite.ca/faq.php#faq10.
Comment 2: Pilot/bench scale testing is mentioned for Alternative 3 in the Site 29 FFS. However, it is unclear whether this actually applies to lab testing to determine minimum target	Prior to the implementation of the ZVI post-ROD remedial action (should it be selected in the ROD), it is anticipated that the (future) contractor will conduct bench-scale tests to determine the

Comments of Michael Wright, dated August 14, 2012 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Injection Remedies***	**Response**
doses of ZVI and evaluation of byproduct species. In the absence of a meaningful site analog, the "pilot" testing should be expanded to include some hydraulic fracturing tests in the field, such as tests that include step-out boreholes in which the distribution of ZVI is visually assessed (i.e., has it been evenly distributed to the subsurface or is it confined to discrete "veins"?).	appropriate iron to soil ratio and the optimal injection slurry mix. The expected ROI will be monitored and adjusted in the field as the remedy is implemented throughout the treatment area.
Comment 3: If ZVI is the proposed full-scale alternative that is selected for implementation, the alternative should include some step-out boreholes to visually assess the ZVI distribution under the actual fracturing and injection conditions.	The Navy agrees that the ROI should be evaluated throughout remedy implementation. The means by which ROI is measured will largely depend upon the fracturing technology selected.
Comment 4: For Alternative 4, the ISB injection, the Site 29 FFS states that the radius of influence for injections is low (approximately 7 feet based on the Treatability Study). A network of 20 injection and extraction wells spaced approximately 150 feet apart will be used to establish a groundwater recirculation system. The Site 29 FFS points out that in absence of additional hydrogeologic data, there is some uncertainty in the recirculation system design. Specifically, with the limited number of monitoring wells, the potential for channelization of the ISB injection substrate will not be adequately assessed. Additional wells should be added to the monitoring program if Alternative 4 is the selected alternative.	Additional wells may be necessary and should be addressed in the remedial design once the results of the Treatability Study are published.

Comments of Michael Wright, dated August 14, 2012 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Remediation Goals***	**Response**
The RGs are calculated in Attachment 1 of Site 29 FFS, entitled *Proposed Human Health and Ecological Remedial Goals*, dated June 2011, and prepared by URS Corporation.	
Comment 5: The RGs were calculated in June 2011, before U.S. EPA published new, more stringent, toxicity criteria for trichloroethene ("TCE") in September 2011. Therefore, the soil gas RG calculations do not include the new TCE toxicity criteria. Furthermore, RGs were only calculated for carcinogens, so it should be verified that the non-carcinogenic RG for TCE in soil gas is not more stringent than the carcinogenic RG using the new toxicity data.	Regarding the inclusion of the September 2011 EPA IRIS toxicity criteria for TCE, please see the Navy's response to 01/22/2013 Comment #2. Regarding the topic of the most stringent RGs; the RGs were reviewed in consideration of the changes to TCE toxicity values that occurred after publication of Attachment 1 and during development of the FFS. Use of the new inhalation unit-risk factor for TCE would approximately halve the USEPA Method 1-based RGs for TCE currently displayed in the RG table. Based on a preliminary evaluation, the new cancer-based RGs for the residential and commercial/industrial receptors would continue to be more stringent than the non-cancer-based RGs, even when the new non-cancer reference concentration is used.
Comment 6: The URS Johnson & Ettinger modeling uses 366 cm (12 feet) as enclosed space height for soil gas runs, but uses the default of 244 cm (8 feet) for the groundwater runs. Given that the planned use of Site 29 includes residential, an 8 foot enclosed space height is appropriate. The attenuation factors for soil gas should be recalculated using the default value of 244 cm (8 feet).	It is agreed that building dimensions should be consistent between the soil gas and groundwater modeling efforts and that use of a default 244 cm building height is more appropriate for the planned residential uses. Within the modeling computations, the mixing volume is a linear factor, and correction can be accomplished simply by ratio-adjusting the soil gas RGs presented in Table 3-1 of the draft FFS. The mixing volume would be two-thirds (=244/366) of that used in the modeling computations and, accordingly, the soil gas RGs will be adjusted

Comments of Michael Wright, dated August 14, 2012 **Executive Director, Local Reuse Authority** **City of Concord** ***Comments Associated with Remediation Goals***	**Response**
	downward by two-thirds. These changes will be documented and incorporated into the main text and tables of the final FFS report.

Response to Comments

Draft Focused Feasibility Study for Groundwater and Soil Gas Installation Restoration Program Site 29, Former Naval Weapons Station Seal Beach, Detachment Concord

Dated: May 2012

	Comments of Tina Low, dated September 6, 2012 **Water Resources Control Engineer, California Regional Water Quality Control Board, San Francisco Bay Region** ***Specific comments***	**Response**
1.	**Section 5.3 Alternative 2- SVE with MNA.** This alternative proposes to remove VOCs from the vadose zone with soil vapor extraction (SVE) and utilize monitored natural attenuation (MNA) to address VOCs in the 6-acre groundwater plume. As presented, MNA is the only groundwater treatment alternative within this alternative. However, information presented in Section 2.5 Conceptual Site Model indicates natural biodegradation is not occurring at Site 29. Therefore, it appears unlikely that groundwater remedial goals (including the remedial goal for TCE of 5 µg/L) will be achieved through MNA in a reasonable and predictable time frame. Please clarify, in all relevant sections (including Section 6.3.1.2 Monitored Natural Attenuation) that Alternative 2 is retained as a potential component of the remedy and is not intended to be considered a stand-alone alternative.	The FFS was produced with limited knowledge of the early Treatability Study findings, but under the presumption that the results would be favorable. Biodegradation is now taking place due to the injections conducted in the source area. A new sentence at the end of the seventh paragraph of Section 2.5 will be added as follows: Early results of the Treatability Study indicate that reductive dechlorination is now taking place, the results of which are forthcoming.
2.	**Sections 5.4 and 6.4 Alternative 3- SVE with ZVI Injection.** Section 6.4.3.4 states that this Focused Feasibility Study considers hydraulic fracturing the most viable option for ZVI delivery. We concur with U.S. EPA's comment that extreme care should be taken to not cause unintended dispersal of groundwater contaminants when implementing hydraulic fracturing. In sections 5.4 and 6.4, please expand the discussion of Alternative 3's implementability to consider the challenge of delivering the ZVI without causing preferential	Please see the response to EPA General Comment 3, and response to City of Concord Comment 1. Any injection methodology (pneumatic, hydraulic, or direct injection and recirculation [with Alt. 4]) would influence plume mobility if not conducted in a manner to mitigate plume migration. The remedial design work plan will consider the most effective delivery approach (e.g. injecting from the outside inward) for the selected remedial alternative.

	Comments of Tina Low, dated September 6, 2012 **Water Resources Control Engineer, California Regional Water Quality Control Board, San Francisco Bay Region** ***Specific comments***	**Response**
	pathways and/or conduits that could uncontrollably spread the contaminant plume.	Similar care must also be taken with Alternative 4 injections, as well as influencing an undesired groundwater gradient between injection and extraction wells. The relative ranking of the implementability of alternatives 3 and 4 does not change, as they all have unique challenges. Sections 5.4, 5.5, 6.4.3.4 and 6.5.3.4 will include a statement that special care must be taken during injection [and recirculation] so as to not cause unintended dispersal of groundwater contaminants.
3.	**Table 3-1. Proposed Remediation Goals Protective of Human Health and Ecological Receptors.** The proposed remedial goals (RGs) for several chemicals of concern are higher (and less protective) than California MCLs. Please revise the RGs, to use California MCLs and methods where they are more stringent, for both groundwater and soil gas. In particular, the proposed groundwater RGs for 1, 2-dicholoroethane, benzene, and cis-1,2-dicholoroethene should be revised to use California MCLs.	The most stringent promulgated MCL value for COCs identified at Site 29 will be identified as the selected RG. Table 3-1 will be modified to correct the typographical error noted in response to EPA comment #7.

Response to Comments

Draft Focused Feasibility Study for Groundwater and Soil Gas Installation Restoration Program Site 29,
Former Naval Weapons Station Seal Beach, Detachment Concord
Dated: May 2012

	Comments of Jim Pinasco, dated September 5, 2012 **Remedial Project Manager, DTSC**	**Response**
	General Comments	**Response**
1.	**Remedial Action Objective (RAO):** The FFS identifies the RAOS for the use of potable groundwater at a $1x10^{-4}$ cancer risk. Furthermore, the cancer risk associate with the residential exposure from VOCs via soil gas was also $1x10^{-4}$. DTSC recommends that a cancer risk of $1x10^{-6}$ be used for both VOCs and potable groundwater.	Please see response to EPA General Comment 1.
2.	**California maximum contaminant levels (MCLs):** The California MCLs are more rigorous for the following chemicals of concern (COCs): 1,2-dichloroethane, benzene, cis-1,2-dichloroethene, chloroform, and TCE. Please revise the FFS to use the California MCLs.	The most stringent promulgated MCL value for COCs identified at Site 29 will be identified as the selected RG. Table 3-1 will be modified to correct the typographical error noted in response to EPA General Comment #7.
	Specific Comments	**Response**
1.	**Screening of Remedial Alternatives:** In Section 5 the remedial alternatives are compared using the current land use scenario. However the City of Concord has solidified the remedial alternatives for transfer, please modify the FFS to incorporate these land use scenarios.	The remedial alternatives were developed under the current land use scenario, but also with the understanding that unrestricted (residential) was the preferred reuse (See section 2.4.2).
2.	**Screening duration:** In Section 6.3.1 the FFS indicates the SVE with MNA alternative is planned for a period of 30 years. The Navy should address the post-remediation period with some discussion.	As with all other remedial alternatives, decomissioning of wells and the SVE system would occur once RAOs are met. A bullet will be added to the list in 6.3.1, 6.4.1 and 6.5.1 as follows: • System decomissioning.

Response to Comments

Draft Focused Feasibility Study for Groundwater and Soil Gas Installation Restoration Program Site 29,
Former Naval Weapons Station Seal Beach, Detachment Concord
Dated: May 2012

	Comments of Jim Pinasco, dated September 5, 2012 **Remedial Project Manager, DTSC**	**Response**
	Specific Comments	**Response**
3.	**Disposal of debris:** In Appendix B, FFS states that cuttings from drilling soil vapor extraction (SVE) wells will not be drummed and disposed of offsite. Please provide rational why the cuttings will not be disposed of in a typical manner used during hazardous waste investigations.	Please see response to EPA Specific Comment 11.
4.	**California DTSC Method 2:** In Table 4 Method 2 is identified but the protocols are not presented. Please provide a brief discussion of method 2 in the table.	Attachment 1 and the main text of the FFS, rely on historical documents developed through the chronology of investigation at Site 29. Most notably, the details of the Method 1 and Method 2 approaches are fully developed in the human health risk assessment of the RI. Table 3-1 of the FFS will be modified with a footnote referencing the methodological discussion in the RI.